

[54] **COPYING AND DUPLICATING APPARATUS**

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Related U.S. Application Data

[63] Continuation of Ser. No. 640,547, May 23, 1967, abandoned.

[52] U.S. Cl. 355/3, 355/64, 355/72, 95/17

[51] Int. Cl. G03g 15/00

[58] Field of Search 355/3, 64, 72; 95/17

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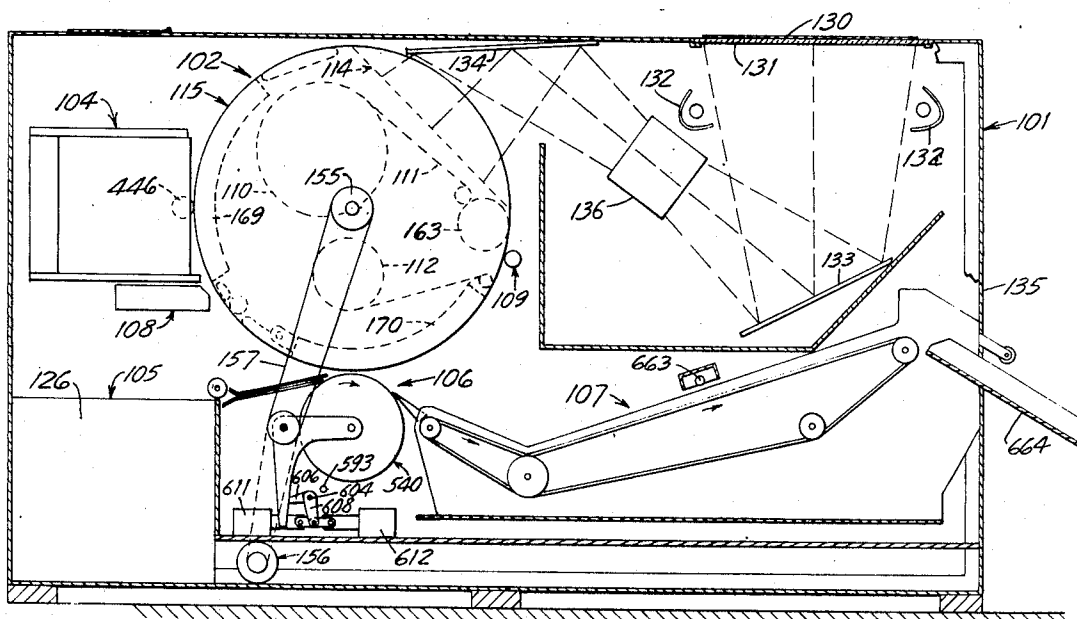
Primary Examiner—John M. Horan

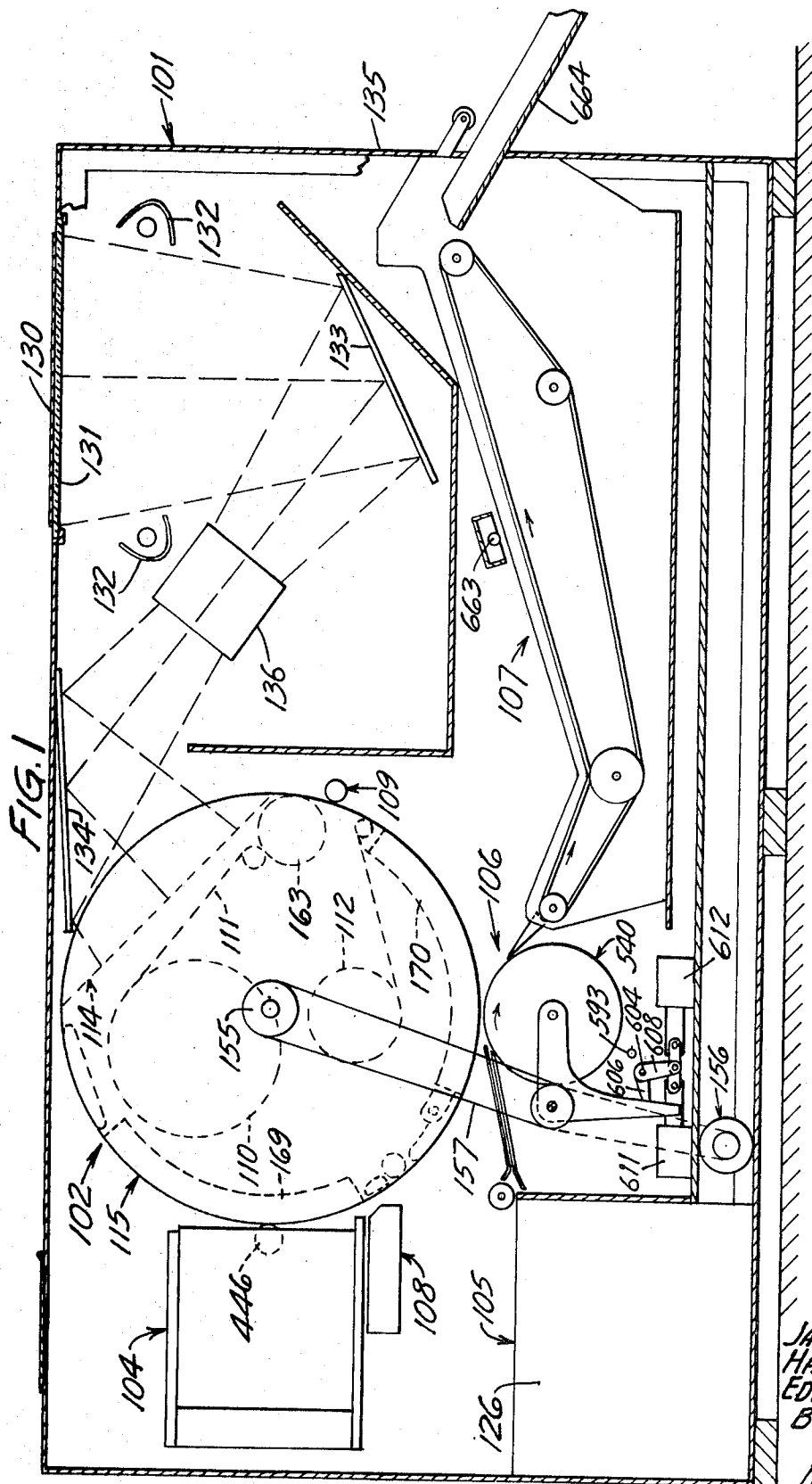
Attorney—Kinney, Alexander, Sell, Steldt & Delahunt

[57] **ABSTRACT**

An electrographic copying apparatus and process for producing copies of graphic originals utilizing the electropowder process. The apparatus comprises a pod assembly for storing a supply of a photosensitive web material and for supporting sections thereof during imaging and development. The web material during development supported on the outer peripheral surface of the pod assembly and the developing surface is conductive to permit the electric field to be developed at the developing station. The pod preferably has a flat planar surface upon which the web is placed during imaging and a curved surface where the web is placed as the pod is moved during development. The pod is adapted for supporting two imaged sections to afford the production of two copies on each revolution of the pod.

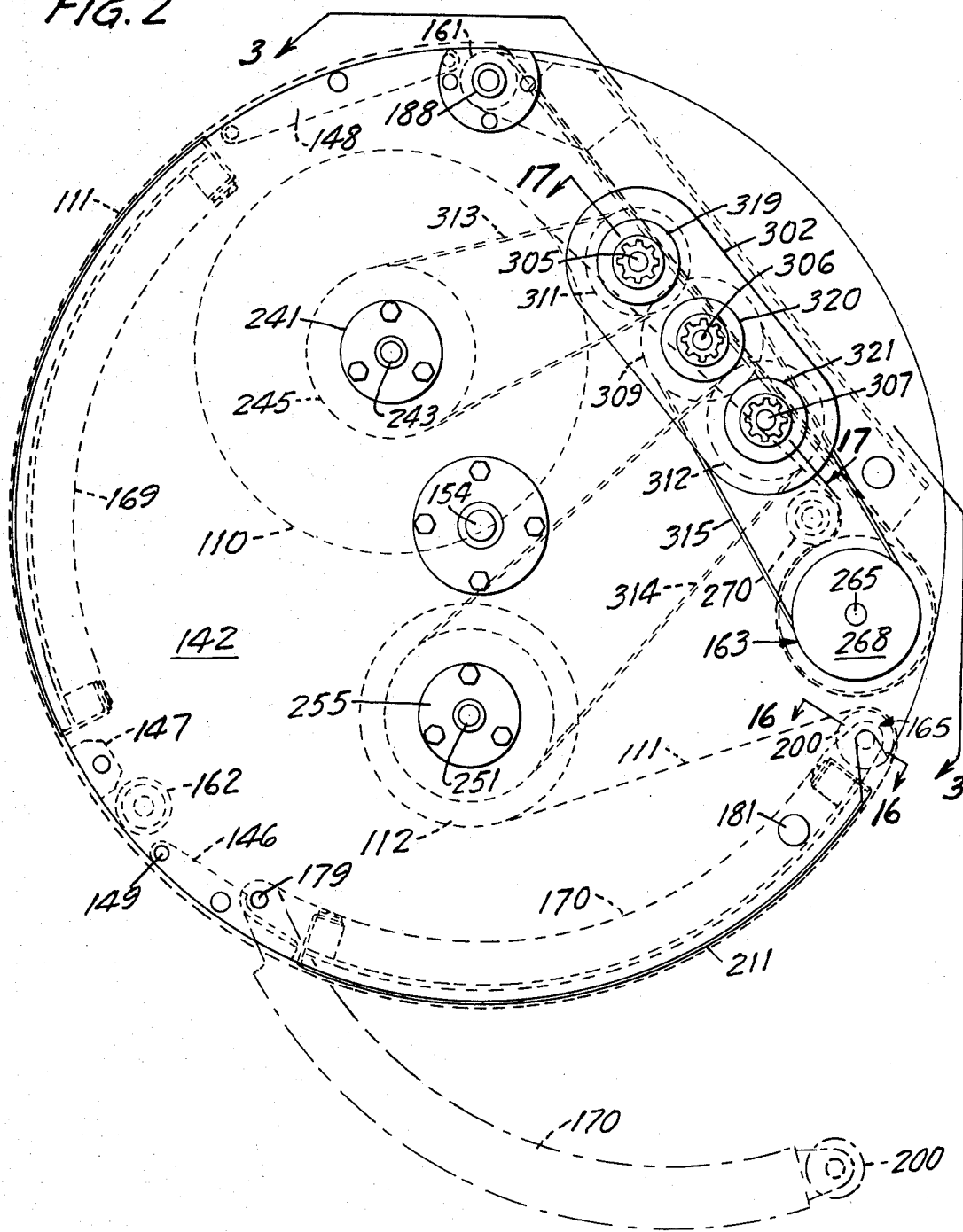
15 Claims, 37 Drawing Figures





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FIG. 2



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FIG. 3

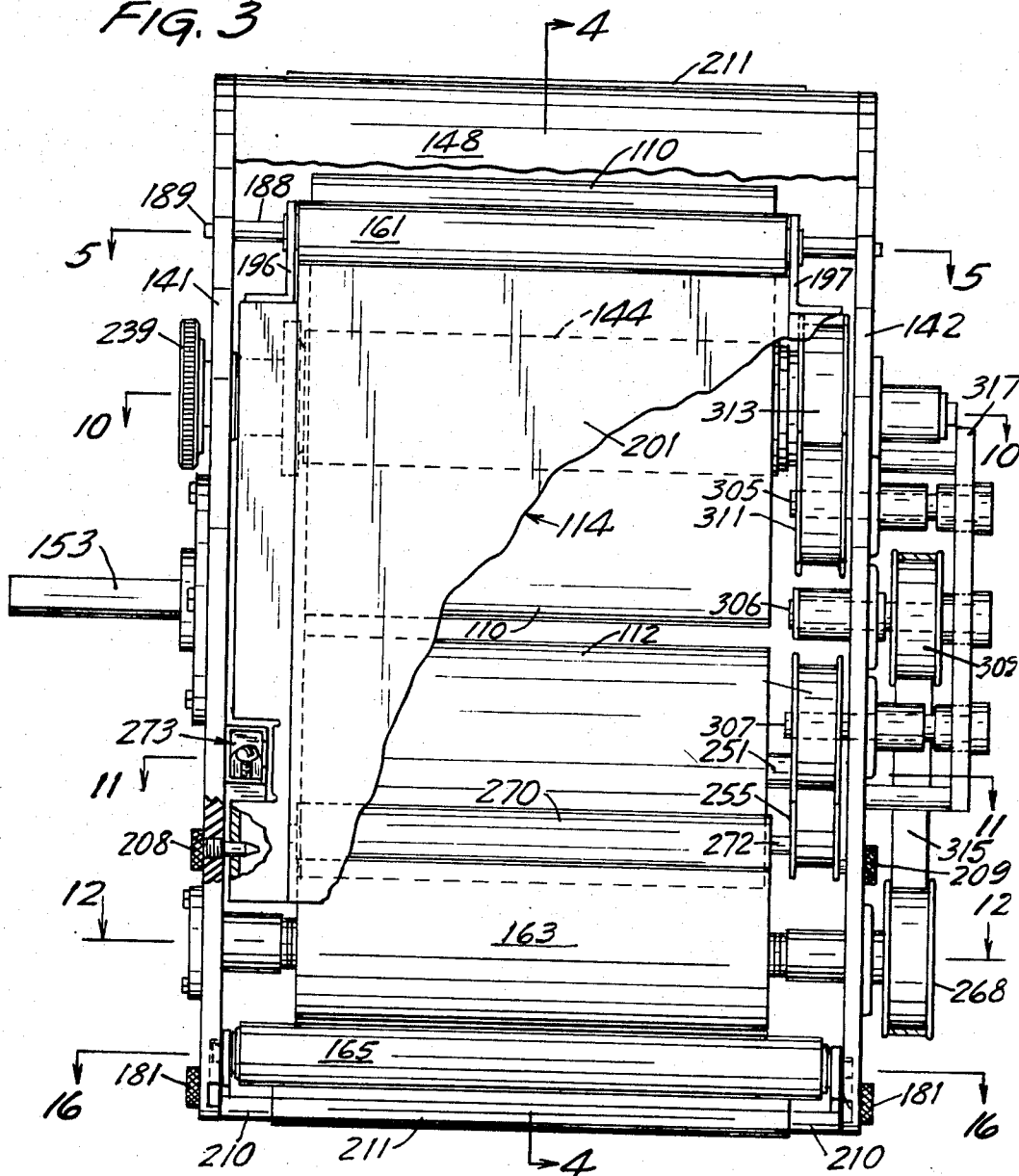


FIG. 6

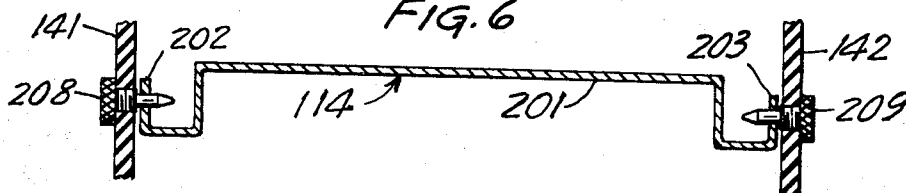
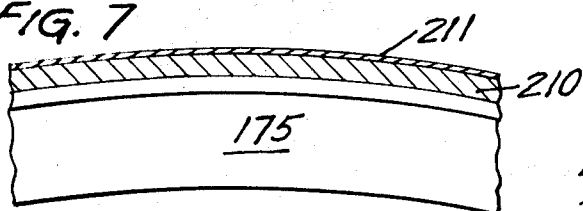
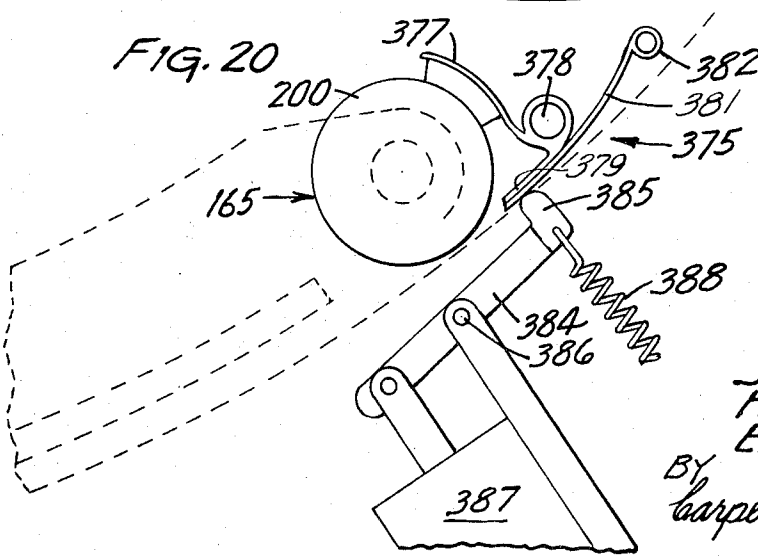
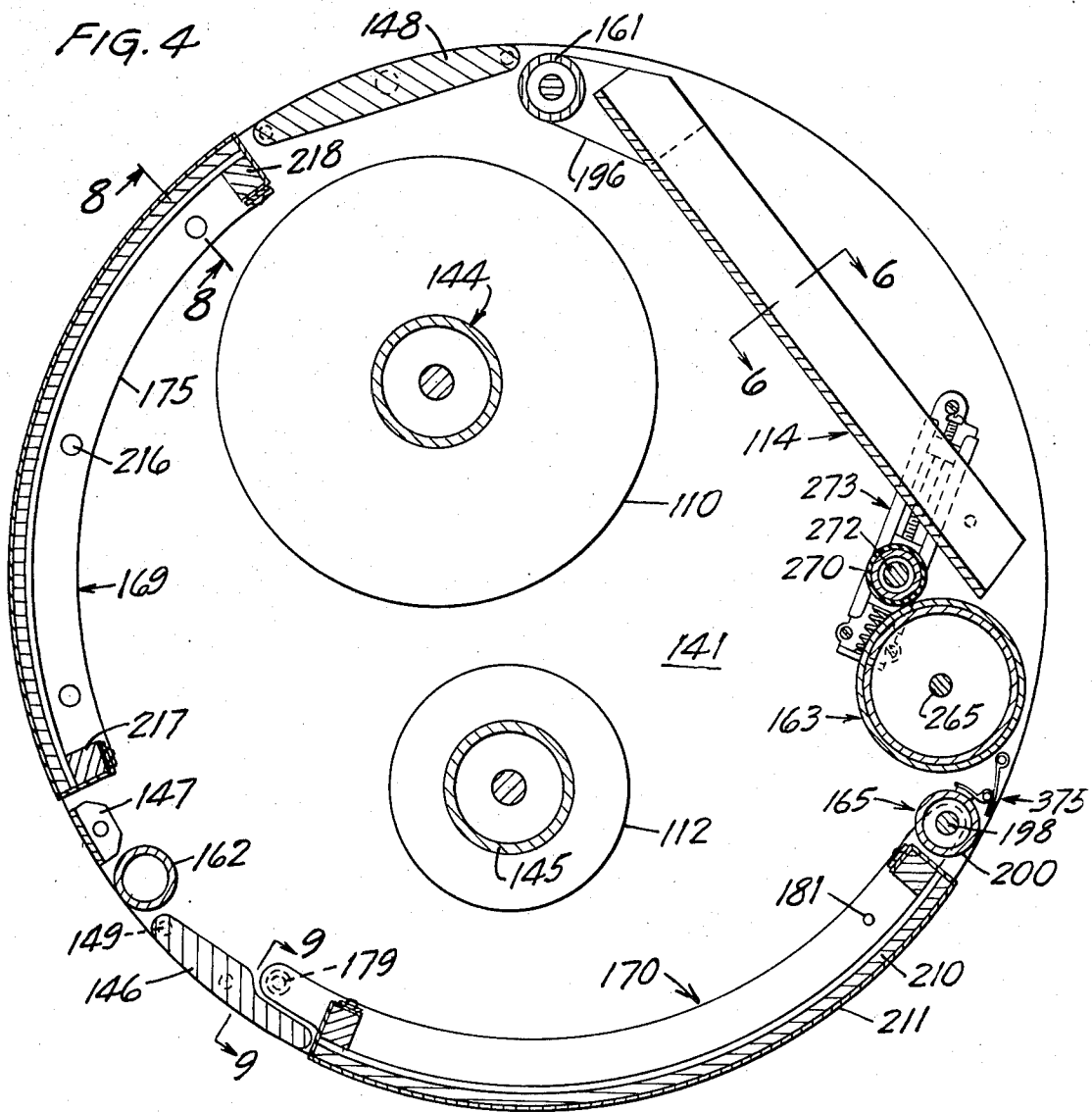


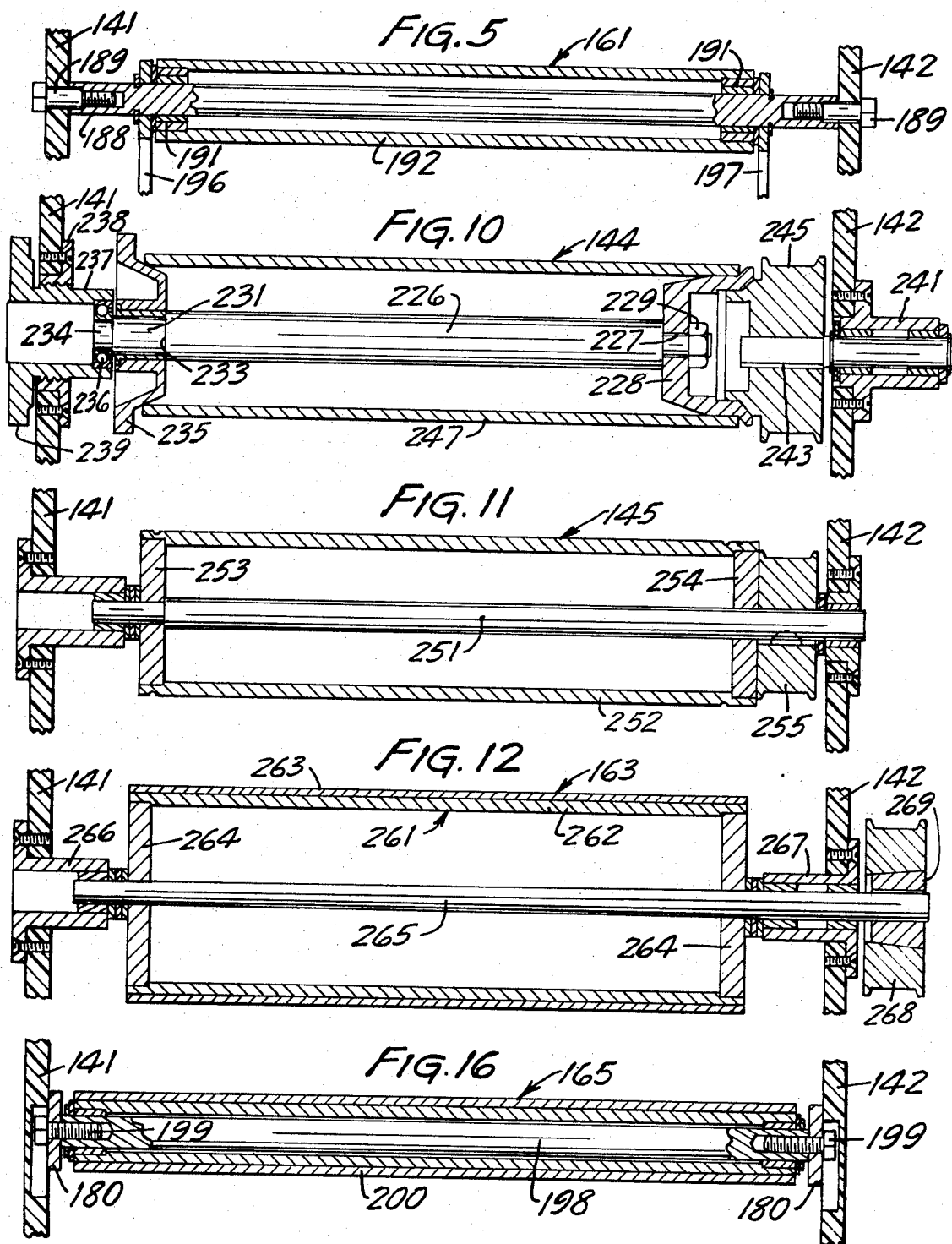
FIG. 7



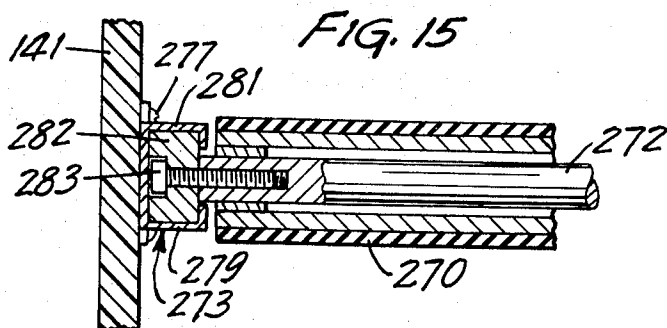
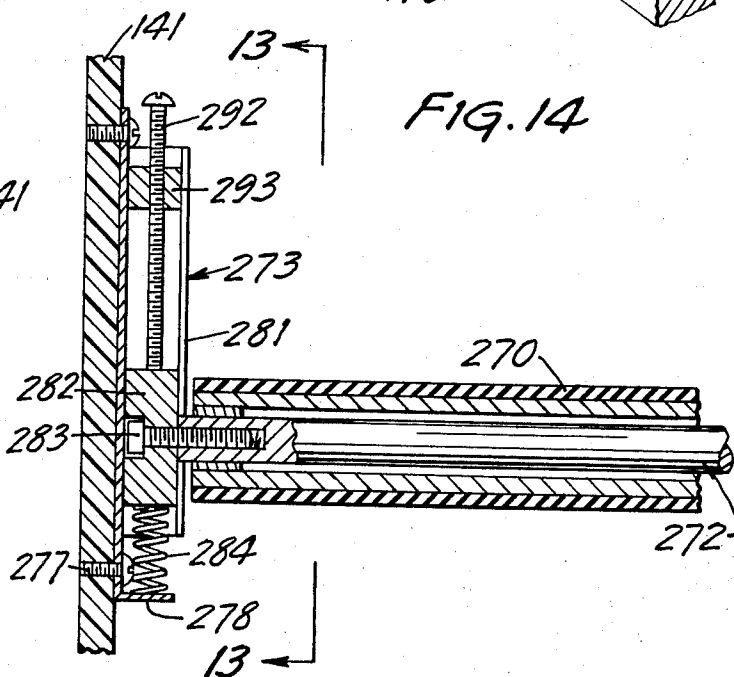
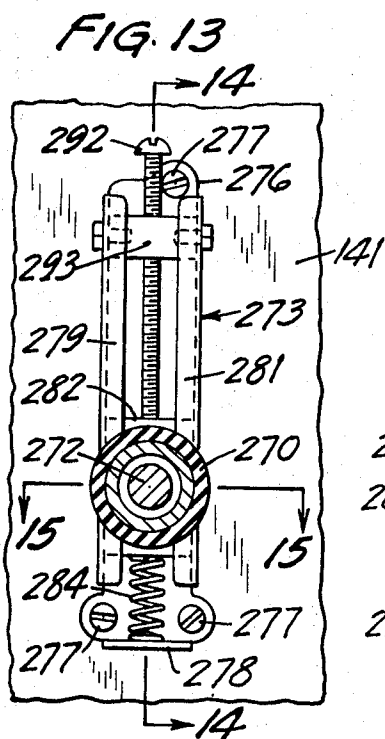
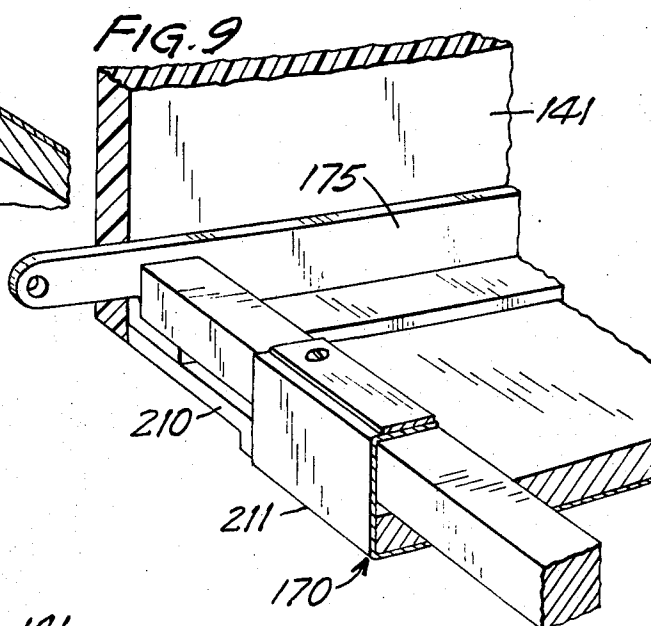
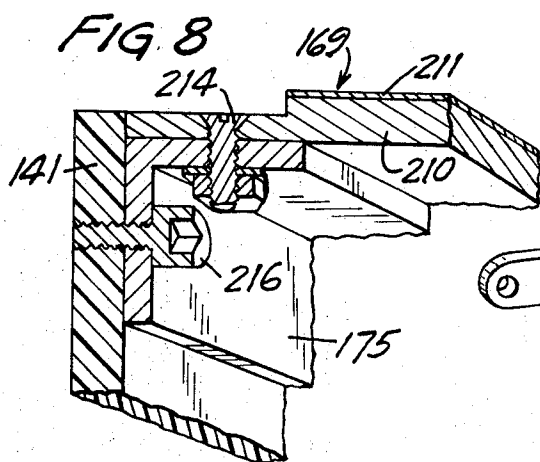
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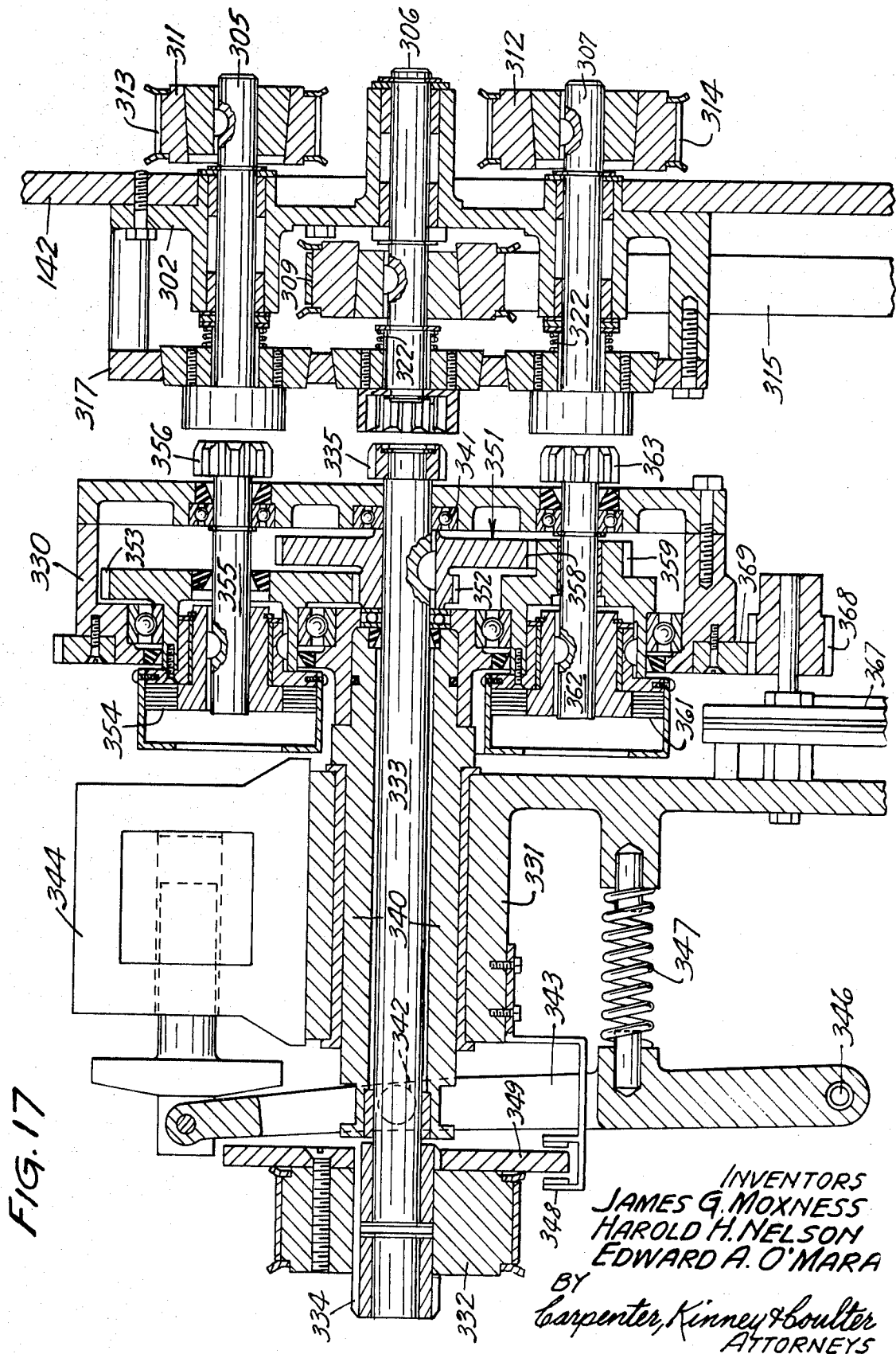
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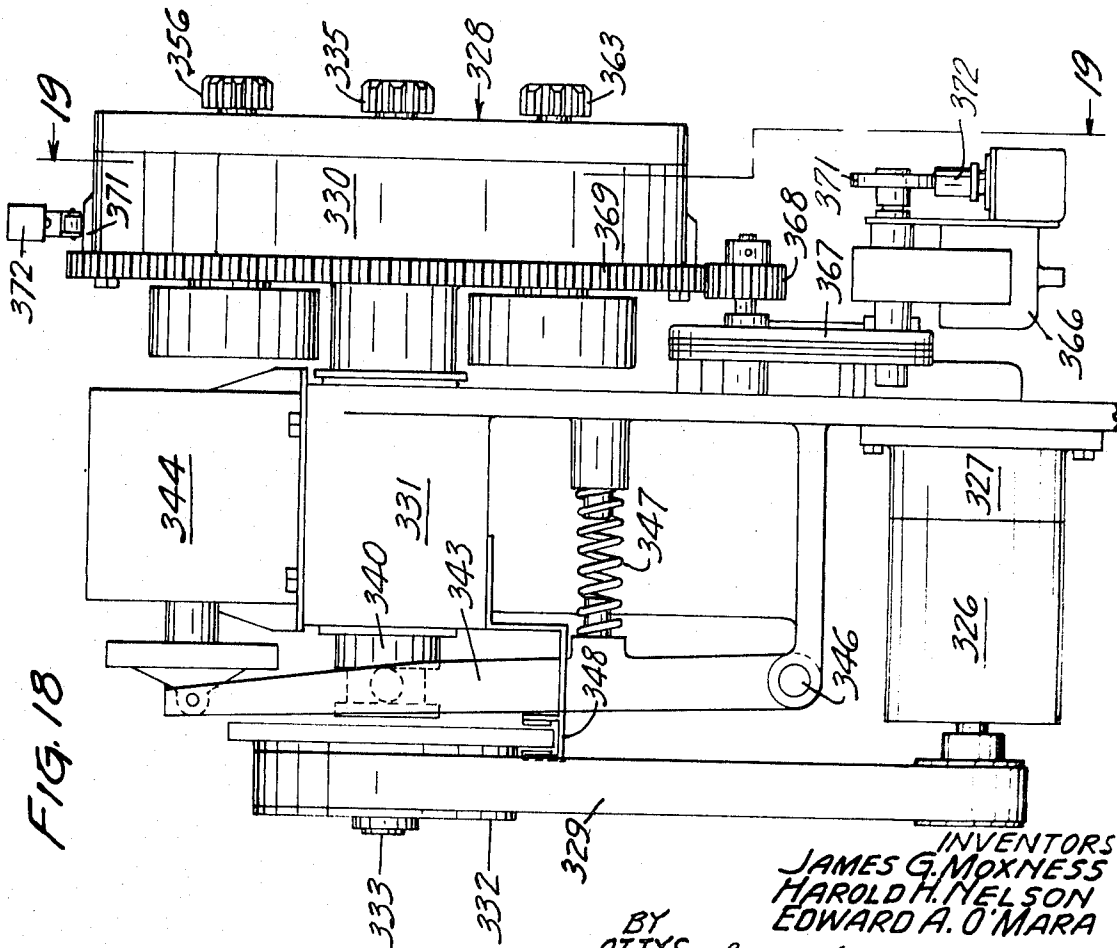
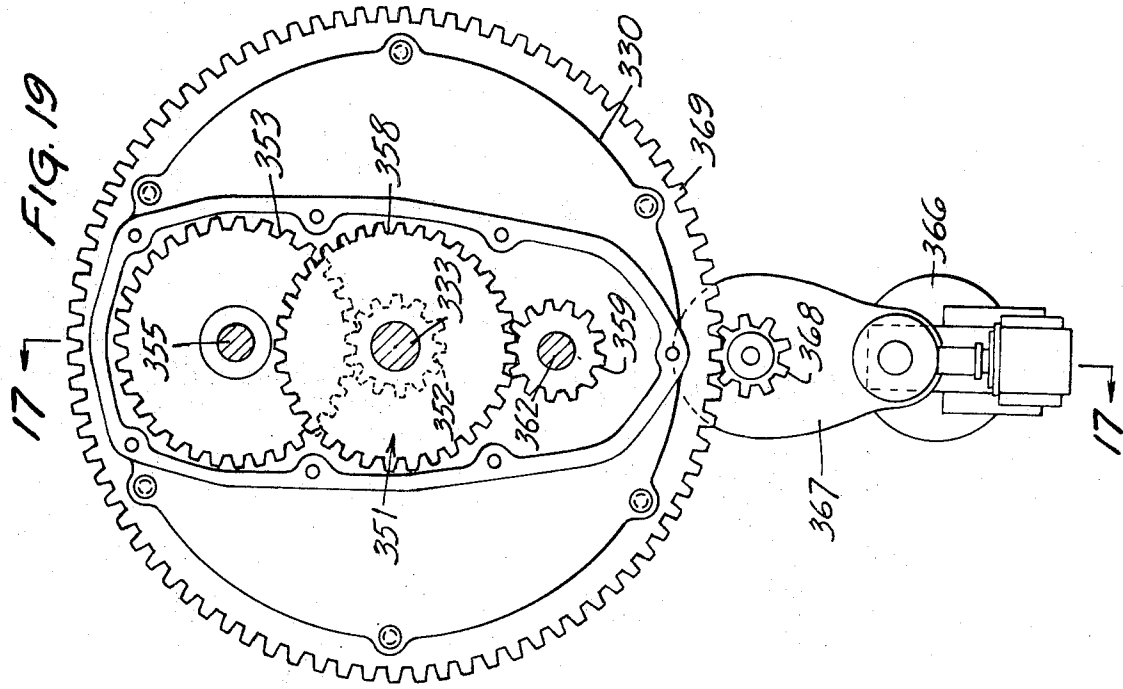


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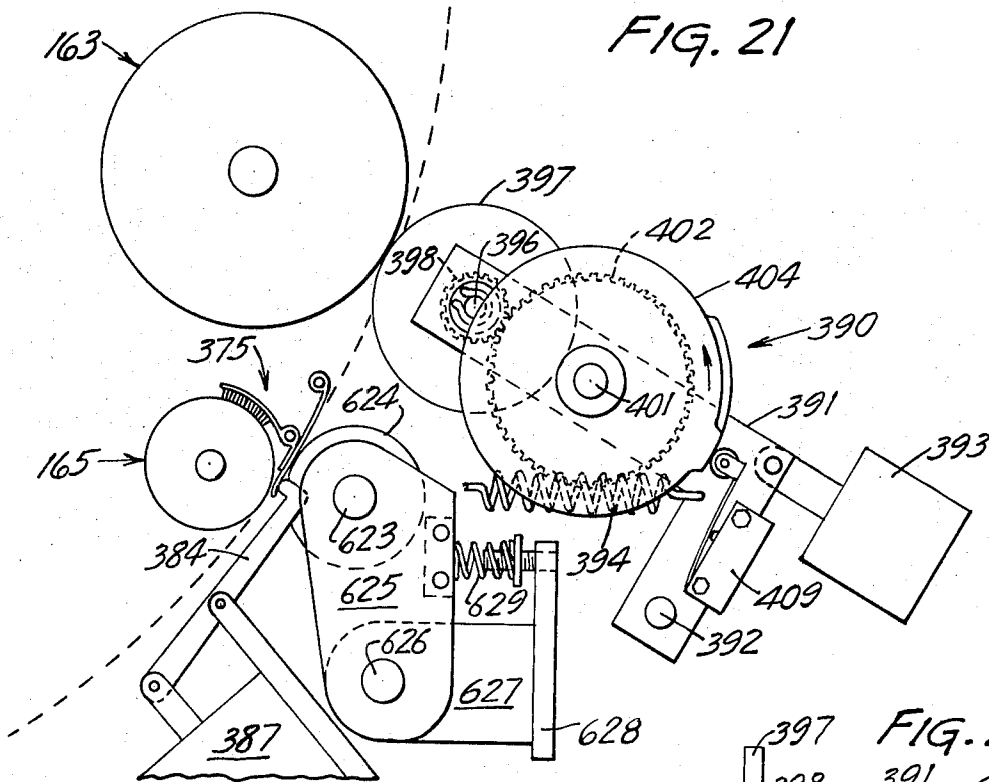


FIG. 23

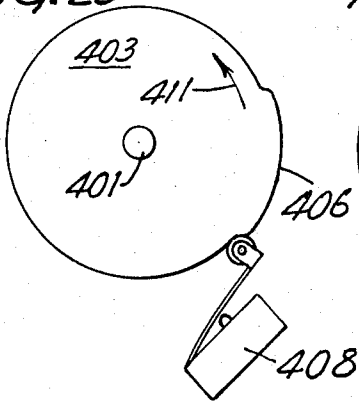
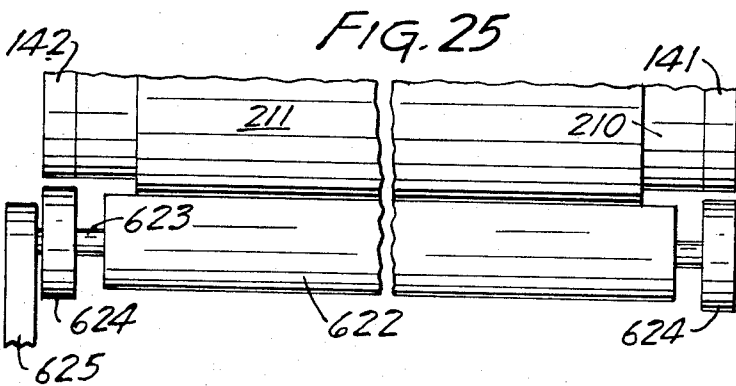
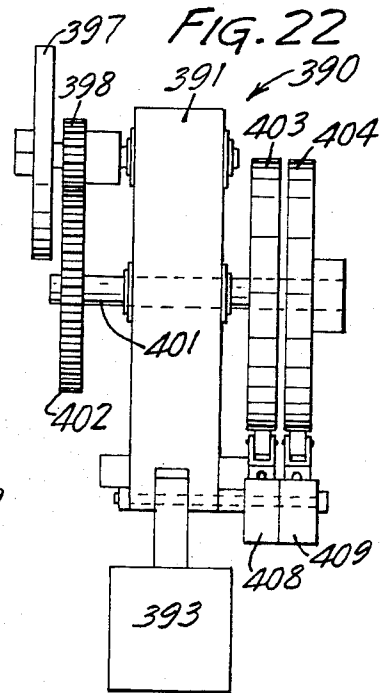
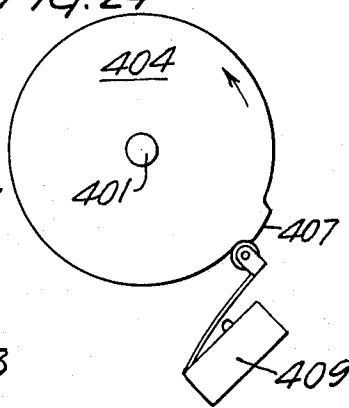
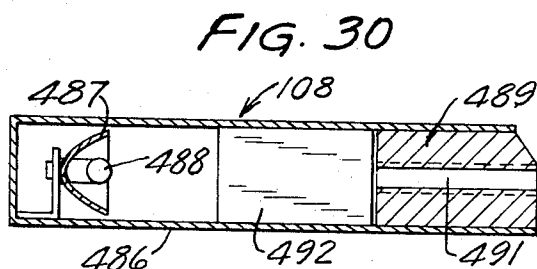
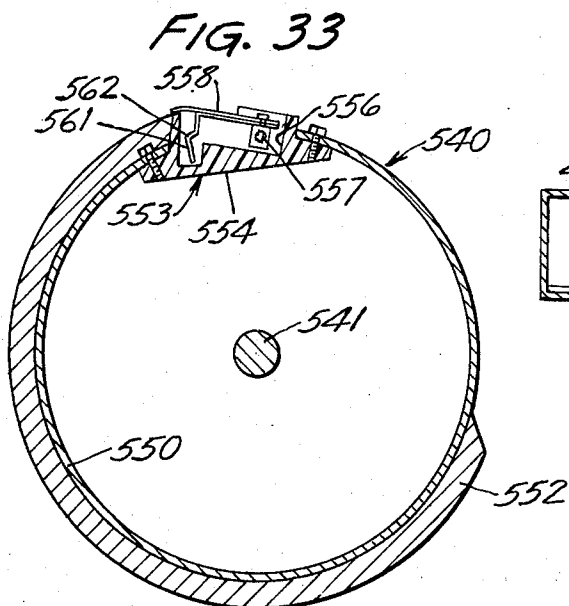
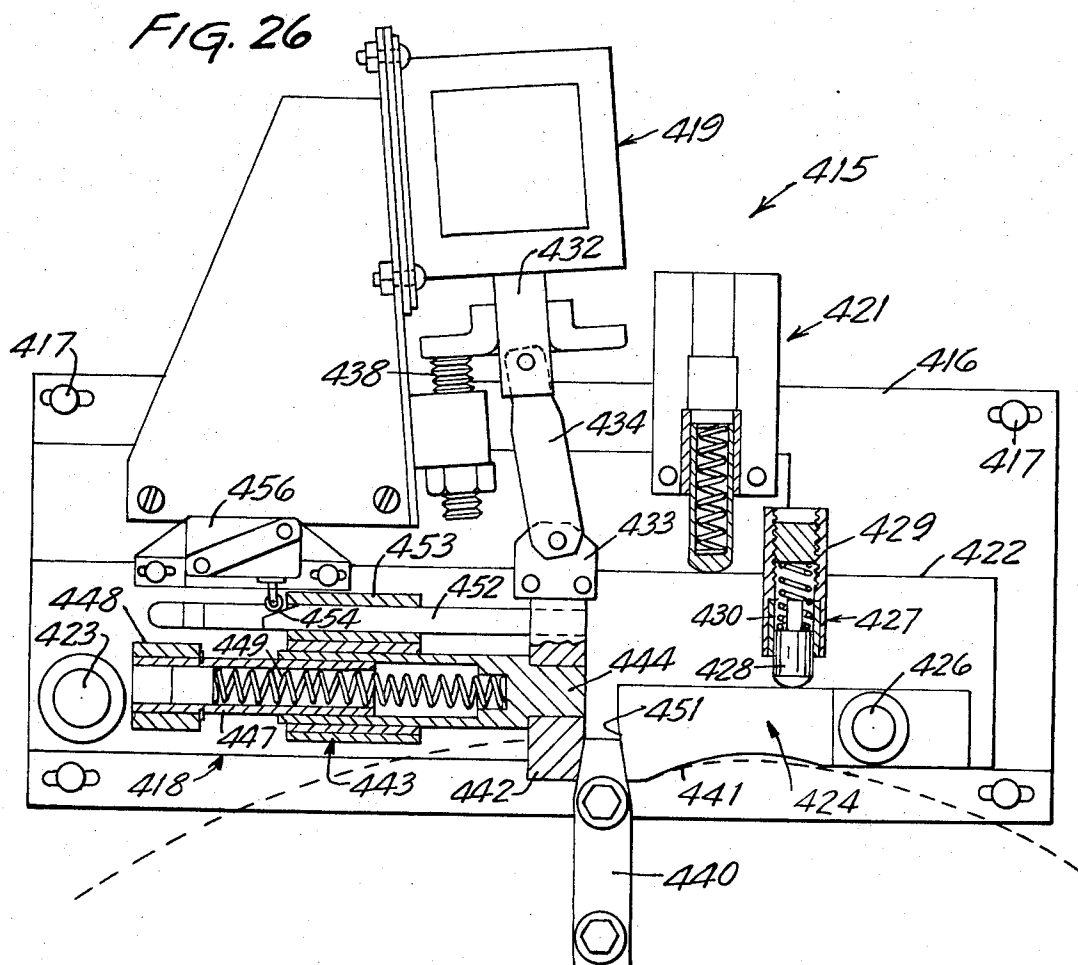


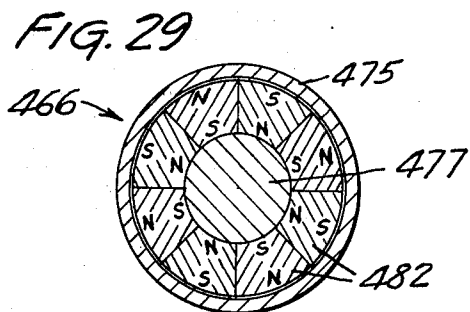
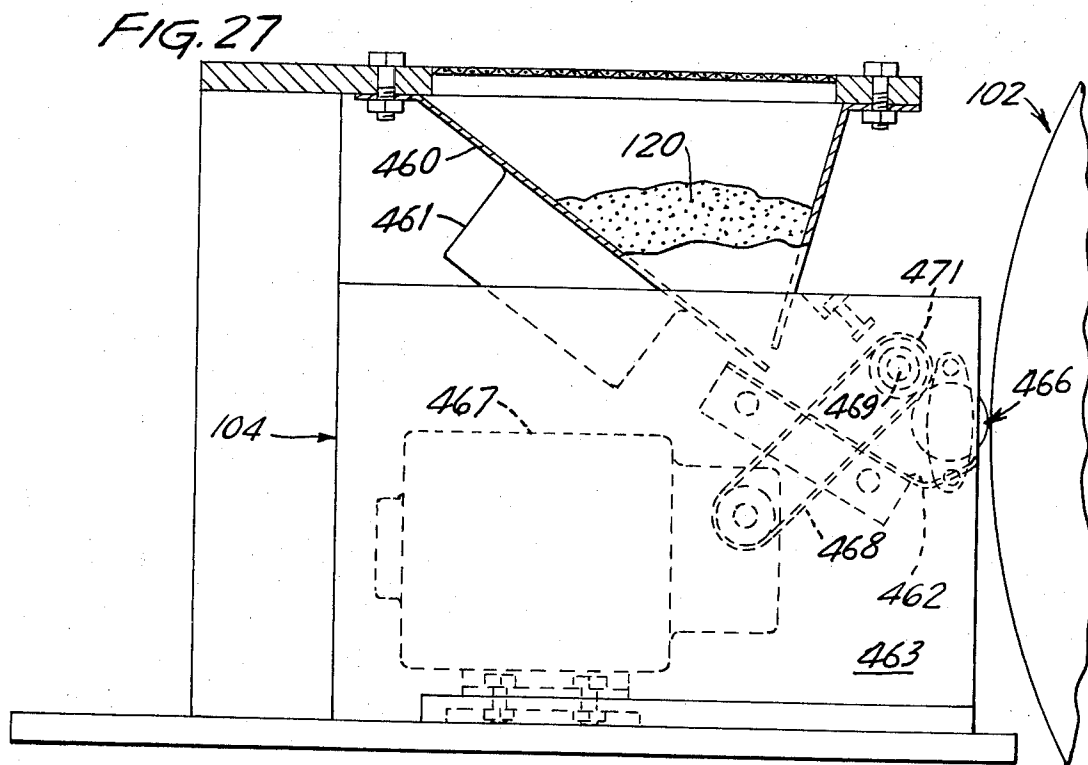
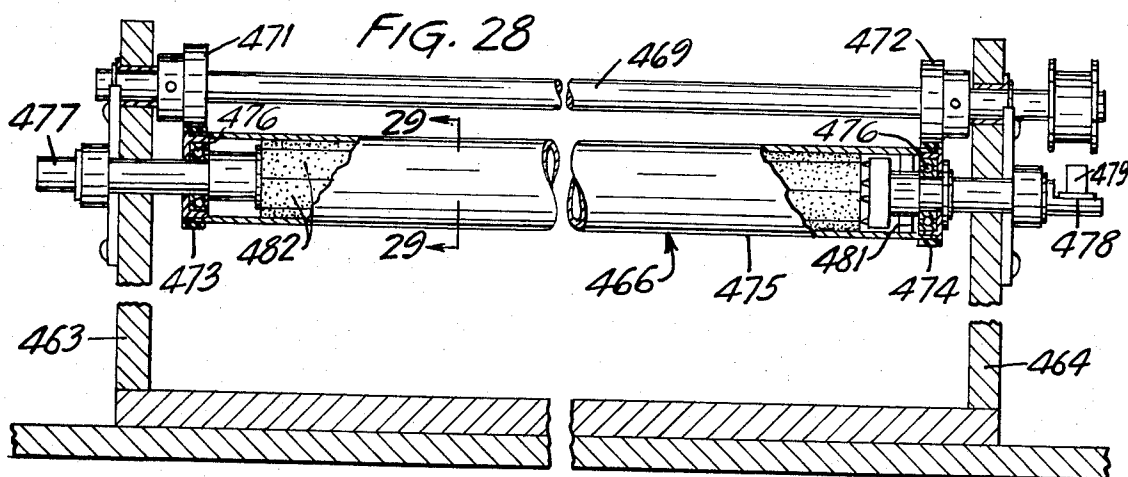
FIG. 24



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FIG. 31

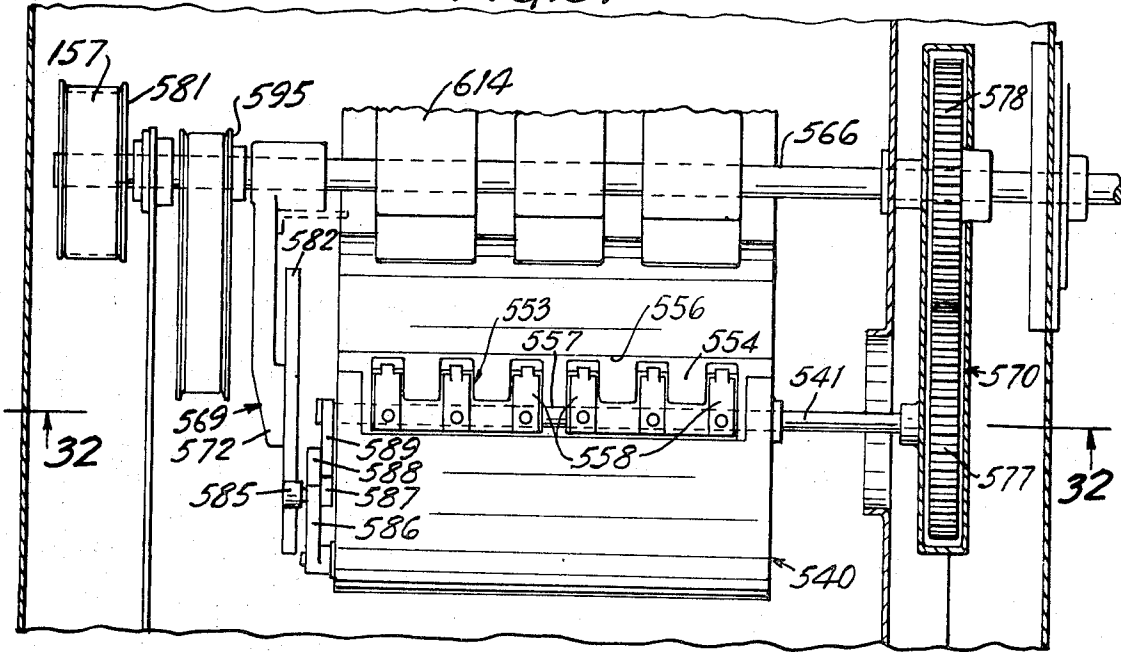
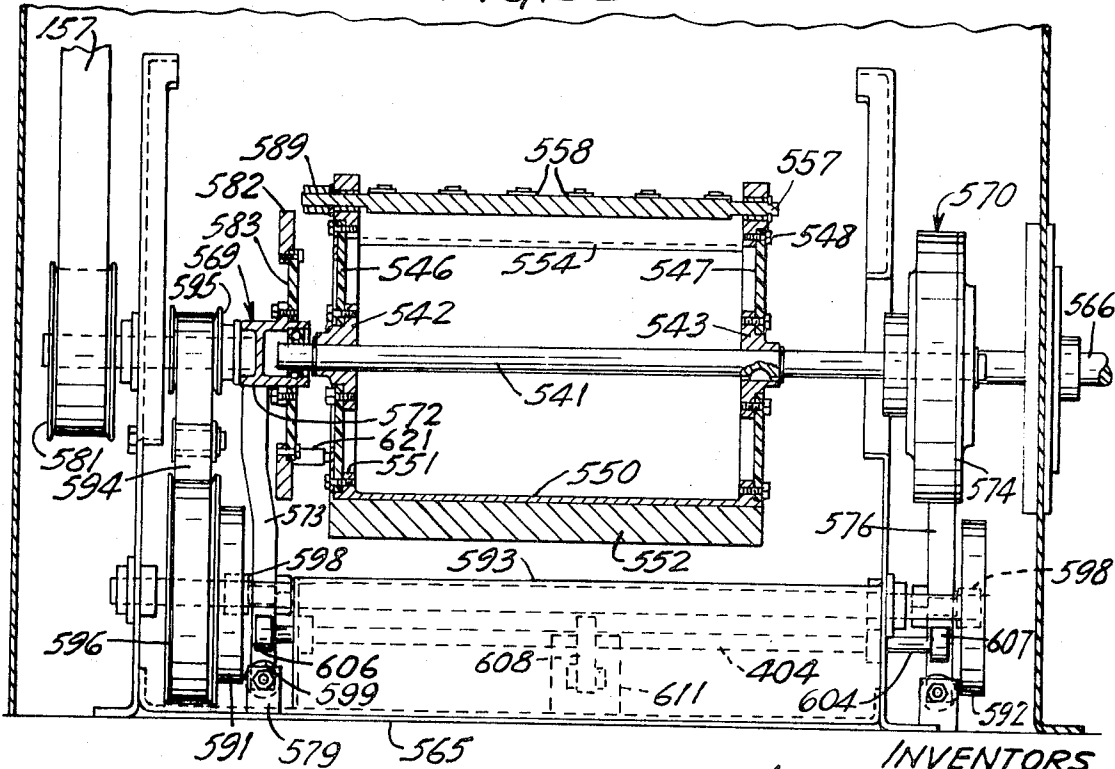


FIG. 32



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FIG. 34

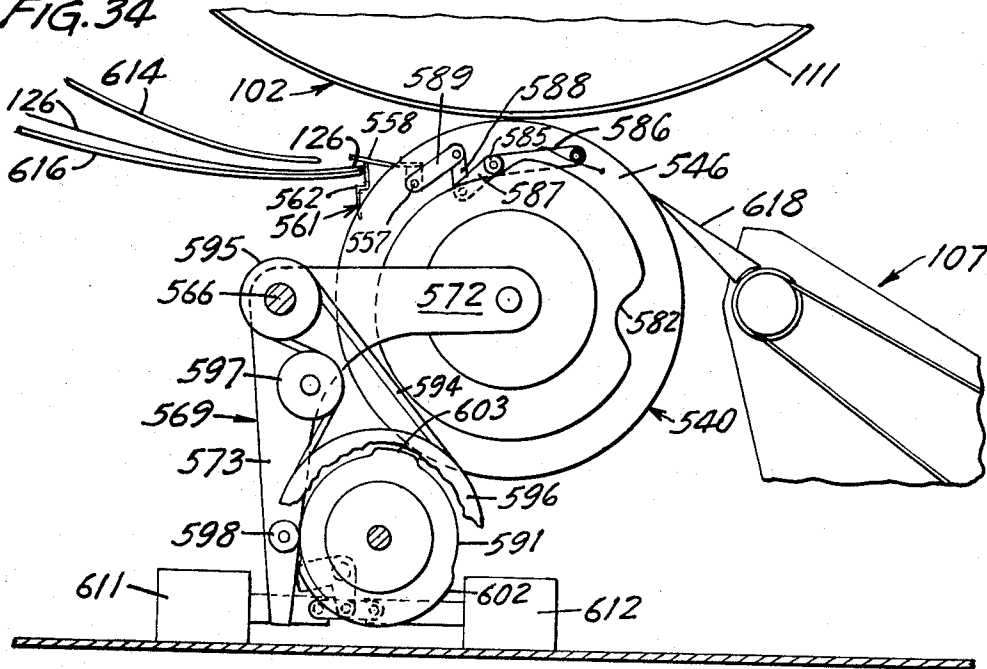


FIG. 35

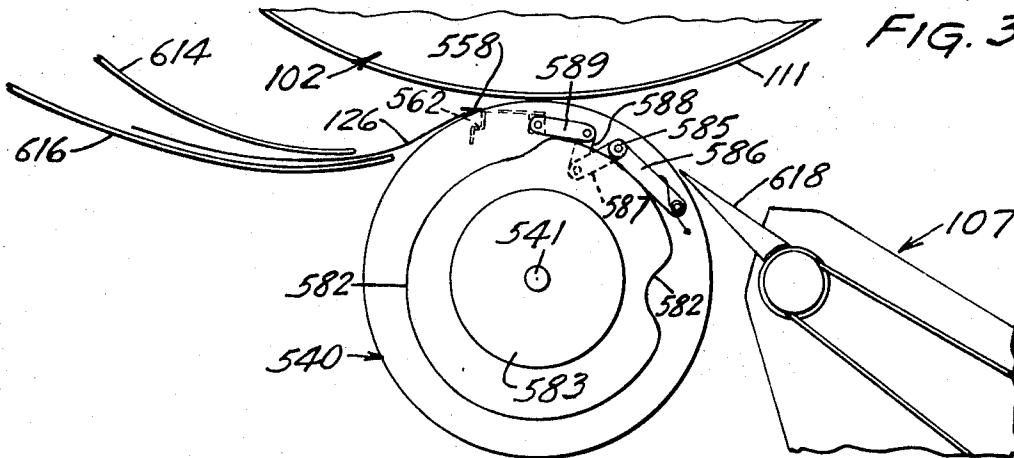
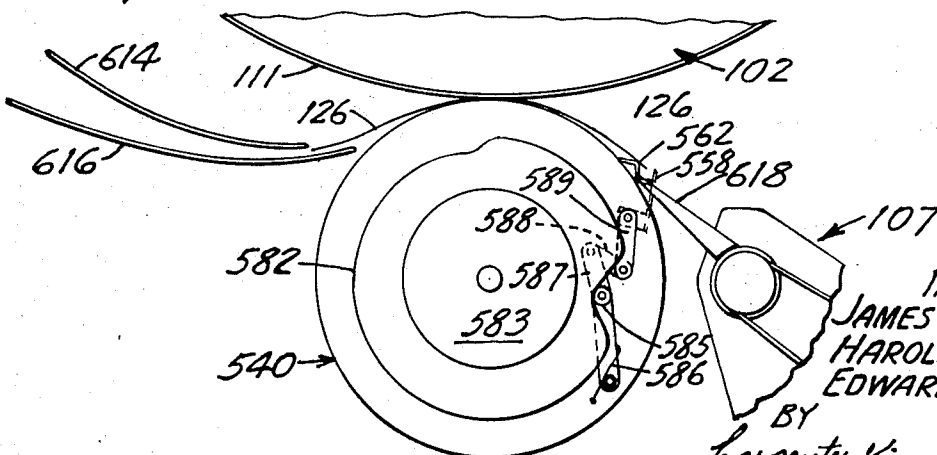
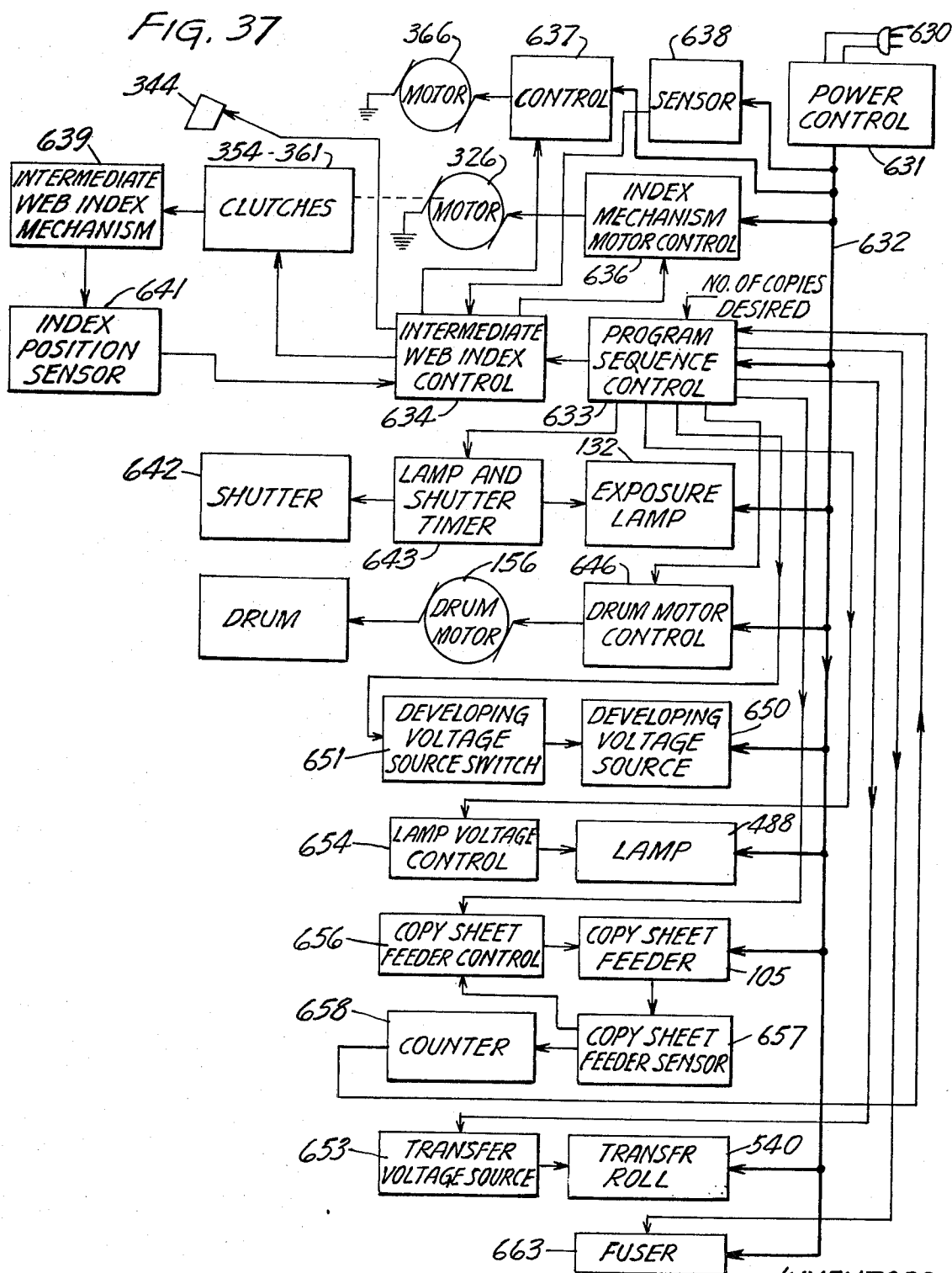


FIG. 36



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COPYING AND DUPLICATING APPARATUS

This application is a continuation of application Ser. No. 640,547 filed May 23, 1967, now abandoned.

This invention relates to a new and improved apparatus and to a process for electrographically producing a copy of graphic intelligence using an appropriate electronically conductive pigmented powder and an appropriate photoconductive web.

More particularly, in one aspect this invention relates to an electrophotographic duplicating machine adapted to reproduce on plain paper one or more copies of a graphic original from an image of such graphic original formed on a photoconductive web carried by a pod assembly which has relative movement to developing and transfer stations to produce the copy or copies.

In another aspect, this invention relates to electrophotographic methods for copying graphic originals and to an apparatus for making multiple copies of a given graphic original from a single image thereof formed on a photoconductive web.

Heretofore, in prior art electrophotographic copying machines and associated methods, in order to make a copy it was necessary to form first an electrostatic latent image of the graphic original on a photoconductive surface, usually on the surface of a revolving drum, by uniformly electrostatically charging the surface followed by exposure of the charged surface to the light image to be copied. The electrostatic latent surface image is developed by attracting an electroscopic making powder imagewise to the remaining charged areas of the photoconductive surface of the drum. The electroscopic powder image on the drum was then transferred to a copy sheet and later fixed. The drum surface served as an intermediate and if more than one copy is to be made the latent image must be reformed each time on the drum.

Before the drum surface could be reused for forming the next electrostatic latent image, an elaborate clean-up operation is necessary. This clean-up operation involves (a) removing from such surface substantially all electroscopic powder remaining thereon, (b) neutralizing all charges remaining on the surface, and (c) conditioning the photoconductive surface to a substantially uniform state of photoconductivity (e.g. dark adapting).

Moreover, in such prior art apparatus and methods, it is necessary to replace periodically the photoconductive material. Since the photoconductive material is physically attached to the drum, such replacement involves replacing the entire drum, necessitating considerable associated expense and inconvenience.

Furthermore, in such prior art apparatus, in order to form an image of a graphic original upon the cylindrically curved photoconductive surface, a scanning type optical system is necessary and the drum must be revolving. In a given apparatus, such an optical system has fixed parameters so that only predetermined types of graphic originals can be copied without completely redesigning the optical system.

By the present invention there are provided apparatus and associated methods which overcome the shortcomings of the prior art and which provide new and improved techniques for electrographically copying graphic originals. Thus, the present invention is suitable for practicing the electropowder process, which is described in French Pat. No. 1,456,993, issued

Sept. 19, 1966. By the electropowder process, a photoresponsive sheet, for example, a photoconductive surface, is exposed to a light image without preliminary electrostatic charging to form a differentially conductive pattern corresponding to the light image and is then contacted with an electrically conductive developer powder while simultaneously a suitable electric potential is applied between a conductive support or backing for such imaged sheet and the powder applicator so that the imaged sheet is differentially coated with the powder corresponding to the conductive pattern thereon. The resulting powder coated photoresponsive sheet is then contacted with a receptor sheet while simultaneously being placed in a suitable electric field. The result is that a powder image of the graphic original is transferred from the photoresponsive sheet to the receptor sheet so that a copy of a graphic original is thereby formed. When the apparatus and methods of this invention are practiced using the electropowder process, more than one copy of a graphic original can be made from a single imaging operation simply by repeating all the steps except the image exposure step.

The present invention provides in one machine not only the capacity to make single copies of graphic originals but also the capacity to make multiple copies of such graphic originals at relatively high speeds. The machine is simple to operate, has minimum make-ready time, and has no clean-up operation following a single or multiple copying run.

Furthermore, the present invention provides a means for projecting an image of a graphic original on a planar surface built into the drum so that conventional optical projection techniques can be employed.

Accordingly, it is the object of this invention to provide a new improved copying and duplicating apparatus.

Another object is to provide a copying apparatus wherein the photoconductive material is disposed within a pod assembly, which in the illustrated embodiment is a drum means, supporting a web of the photoresponsive material and affording movement of the web relative to a developing and transfer station. The web may be moved about the outer surface of the drum in a sequence to place unused portions in a copying position and rewind used portions. In the embodiment illustrated herein the pod assembly is movable and carries with it the supply and rewound roll of the web during the copying operation.

Another object is to provide automated apparatus and method useful for practicing electrophotographic copying of graphic originals and which is especially useful for practicing the electropowder reproduction process.

Another object is to provide apparatus and associated methods suitable for making multiple copies of a graphic original in good quality and at high speeds.

Another object is to provide apparatus and methods whereby one can, once a photoconductive surface has been imaged by a graphic original using light exposure, prepare multiple copies of such graphic original from such imaged photoconductive surface in a predetermined sequence of operations without re-exposing such photoconductive surface.

Other and further objects of the present invention will become apparent to those skilled in the art from the following specification taken together with the attached drawing wherein:

FIG. 1 is a representation of the device of the present invention showing the spatial positions of the various subassemblies relative to one another;

FIG. 2 is an enlarged end elevational view of the pod assembly showing spindle drive means and web path;

FIG. 3 is a side elevational view taken from the line 3—3 of FIG. 2;

FIG. 4 is a vertical sectional view taken along the line 4—4 of FIG. 3;

FIG. 5 is an enlarged detailed sectional view taken along the line 5—5 of FIG. 3;

FIG. 6 is a cross-sectional view taken along line 6—6 of FIG. 4;

FIG. 7 is an enlarged detailed sectional view taken along the line 7—7 of FIG. 3;

FIG. 8 is an enlarged detailed partially sectional and perspective view taken along the line 8—8 of FIG. 4;

FIG. 9 is an enlarged detailed sectional perspective view taken along the line 9—9 of FIG. 4;

FIG. 10 is an enlarged detailed sectional view taken along the line 10—10 of FIG. 3;

FIG. 11 is an enlarged detailed sectional view taken along the line 11—11 of FIG. 3;

FIG. 12 is an enlarged detailed sectional view taken along the line 12—12 of FIG. 3;

FIG. 13 is an enlarged detail view taken through the region 13—13 of FIG. 3 and also as indicated in FIG. 14;

FIG. 14 is a vertical sectional view taken along the line 14—14 of FIG. 13;

FIG. 15 is a horizontal sectional view taken along the line 15—15 of FIG. 13;

FIG. 16 is an enlarged detailed sectional view taken along the line 16—16 of FIG. 2;

FIG. 17 is an enlarged detailed sectional view taken through the region 17—17 of FIG. 3;

FIG. 18 is a side elevational view of the web advance mechanism shown in FIG. 17;

FIG. 19 is a vertical sectional view of the web advance mechanism;

FIG. 20 is an enlarged fragmentary detail view of the web brake;

FIG. 21 is an enlarged fragmentary detail view showing a web metering means and grounding roll;

FIG. 22 is a detail view of the web metering means illustrated in FIG. 22;

FIG. 23 is a diagrammatic representation showing one interrelationship between a first microswitch and a first cam used in the web metering means shown in FIGS. 21 and 22;

FIG. 24 is a view similar to FIG. 23 but showing another relationship between a second microswitch and a second cam used in the web metering means shown in FIGS. 21 and 22;

FIG. 25 is a fragmentary detail view of the grounding roll and drum;

FIG. 26 is a partially sectionalized and elevational view of a drum brake;

FIG. 27 is an elevational and partially sectional view of the developing assembly;

FIG. 28 is a fragmentary plan view of the rollers in the developing assembly;

FIG. 29 is an enlarged vertical sectional view of the magnetic roller of the developing assembly taken along the line 29—29 of FIG. 28;

FIG. 30 is a vertical sectional view of the light-exposing means;

FIG. 31 is a plan view of the transfer assembly;

FIG. 32 is a sectional view taken approximately along the line 32—32 of FIG. 31;

FIG. 33 is a vertical sectional view of the transfer roll;

FIG. 34 is an elevational view of the transfer assembly shown in FIGS. 31 and 32;

FIG. 35 is a view illustrating an operation of the copy sheet clamping mechanism employed in the transfer assembly of FIGS. 31—34;

FIG. 36 is a view similar to FIG. 35 but illustrating mechanism in a different location as the transfer roll revolves clockwise; and

FIG. 37 is a block diagram of an electrical control and programming circuit for the device of the present invention.

The operational principles of this invention will be understood by reference to FIG. 1 where there is shown a schematic side-elevational view of an apparatus constructed in accordance with the present invention. This embodiment of the apparatus is designated in its entirety by the numeral 101 and comprises several cooperating subassemblies designated in their respective entireties as a pod assembly or drum means 102, a web imaging or image projecting means 103, an image developing means 104, sheet feeding means 105, image transfer means 106, and fusing means 107. In a duplicating apparatus or one designed to make multiple copies a source of columnated light or light-exposing means 108 and a grounding means 109 are provided as will be hereinafter explained. These subassemblies are independently supported and positioned within a cabinet or frame 135.

The pod assembly or drum means 102 includes a generally cylindrically-shaped casing or drum which has mounted therein a supply roll 110 of a photoconductive web 111, and a take-up roll 112 for the same. The outer peripheral surface of the drum is formed by an imaging plate 114 which has a substantially flat exterior surface positioned within the (projected) circumferential periphery of the drum and at least one electrically isolated, electrically conductive semicylindrical pad means 115. Pad means 115 is preferably adjacent the imaging plate 114. Means (illustrated hereinafter) is provided to advance and position a portion of web 111 from roll 110 first upon plate 114 and then on the pad means 115, and means (illustrated hereinafter) is provided for rotating the drum means 102 about its axis.

The image-projecting means 103 is illustrated herein as an optical projecting system for directing a light image of a graphic original 130 onto the section of web 111 positioned over imaging plate 114.

Image developing means 104 is a system (discussed hereinafter) for applying a fusible magnetically responsive pigmented powder 120 onto the image-bearing portion of web 111 in the presence of a simultaneously applied electrical field, after said imaged portion is indexed from plate 114 to a position over pad means 115, and the drum is advanced to carry pad means 115 past said developing means. The powder

120 is at least semiconductive in the electrical field applied at the developing means. In the illustrated device pad means 115 comprises a pair of similar circumferentially spaced pad assemblies 169 and 170 each having electrically conductive surfaces.

Sheet feeding means 105 may be any suitable receptor feeding mechanism for feeding a copy sheet 126 from a supply thereof into the image-transfer means 106.

Image-transfer means 106 is a system (illustrated hereinafter) affording the transfer of a developed powder image from web 111 to a receptor or copy sheet 126.

Fusing means 107 receives copy sheet 126 from image-transfer means 106 and fuses the powder 120, transferred or deposited in an imagewise pattern onto sheet 126 as by heating.

The light-exposing means 108 includes a source of light mounted within a housing formed to permit exposure of the developed web to light, essentially all rays emitted being parallel and directed to impinge on the pad means 115 across at least the full width of the web 111. At this light-exposing means or station 108 the previously light exposed areas of the web 111 which have no developer powder retained thereon are re-exposed making such areas of optimum conductivity when web 111 is photosensitive.

The grounding means 109 includes a roller engageable with the web 111 as it is carried past the transfer means 106, which roller serves to bleed off any charges which have built up on web 111 or on the conductive surface of pad means 115. In making multiple copies this grounding means 109 reduces the state of charge so that the web will be presented to the developing means 104 at the same electrical condition on each cycle.

For use with a photoconductive material as the intermediate web the operation of apparatus 101 is as follows. A predetermined section or length of photoconductive web 111 is placed on imaging plate 114 as a result of it being advanced (e.g. translated or indexed) from supply roll 110 through a slot in the cylindrical drum surface onto said imaging plate 114. A light image of a graphic original 130 is projected by image projecting means 103 onto the web at the imaging plate 114, thereby producing on the so-exposed section of web 111 a differentially conductive pattern corresponding to the projected image. The resulting exposed section of web 111 is then moved from imaging plate 114 onto pad means 115 of the drum means 102 by advancing web material from the supply roll and re-winding a portion of the web on the take-up roll. Next, the drum means 102 is rotated (counterclockwise as viewed in the drawing) so that the image section of web 111 and pad means 115 are moved together past the development means 104 where the powder 120 is applied in a series electrical circuit arrangement with an appropriate electrical potential to the non-light struck or image-forming areas on the section of web 111 disposed on the pad means. The powder will adhere to the web 111 corresponding to the pattern of the visible graphic original 130. Continued rotation of the drum carries the developed image past the exposing means 108 which re-exposes the areas of the image having no developer powder thereon.

As the resulting powder-developed pattern on web 111 advances upon rotation of the entire drum means 102 to the image-transfer means 106, a copy sheet 126 is fed from sheet-feeding means 105 into image-transfer means 106 to be aligned, registered, and placed in face-to-face contact with the image section of the web. During continued rotation and while the web section is progressively placed in contact with the copy sheet the powder developed image on web 111 is transferred, in the presence of a second electrical potential to the surface of copy sheet 126 in an imagewise pattern corresponding to that of the graphic original 130. As the copy sheet leaves the image-transfer means 106 it is picked up by the fusing means 107 where the powder is fused to the copy sheet 126, thereby completing the production of a first copy from the graphic original 130. The drum, upon continuing its rotation passes grounding means 109 to "short out" or remove any charges built up on the surface of web 111.

If more than a single copy is desired, drum means 102 continues to rotate without being reimaged at the image-projecting means 103, so that the image area of web 111 again passes, sequentially the development means 104, exposing means 108 and moves to transfer means 106, whereupon an additional copy sheet is fed in timed relationship from sheet feeding means 105 to transfer means 106 and through the fusing means 107. The operation is repeated until the desired number of copies have been made. At the completion of a duplicating operation, the drum means 102 returns to a home or base position (e.g. a position such as illustrated in FIG. 1) where another copying operation can be undertaken as desired.

This embodiment will now be described in detail.

Image Projecting Means

The imaging means 103 comprises a transparent supporting stage 131 upon which the original 130 may be placed, illuminating means for the stage and original in the form of suitable lamp and reflector assemblies 132, a pair of first surface reflectors 133 and 134 and projection lens means 136 positioned between said reflectors. The reflectors 133 and 134 and the lens means 136 project and direct a light image of the original to a particular area on the surface of drum means 102, which area is on the imaging plate 114. A shutter is disposed relative to the projection lens means 136 to control exposure. The shutter is controlled from a timer to afford the proper exposure and the imaging system projects an image of the entire original onto the web when the shutter is open.

Drum Means: Frame and Drive

FIGS. 2 through 16 show one embodiment of a drum means 102. In this embodiment the drum means is defined by the combination of a pair of circular, spaced, parallel, axially aligned end walls 141 and 142 (see FIG. 3), which are maintained in fixed spatial relationship to one another by three spanner members 146, 147 and 148 (see FIG. 4), each of which is duly secured to an adjoining end wall 141 and 142 by appropriate means, such as screws 149 or the like. Each end wall 141 and 142 and each spanner member 146, 147 and 148 is formed of a nonconductive plastic, such as phenolic resin, or the like. Observe that the exterior

surface portions of spanner members 146, 147 and 148 are each formed so as to have curvatures corresponding to the radius of curvature of the spaced end walls 141 and 142.

Affixed one on each end wall 141 and 142 so as to lie on the axis 139 of the drum are a pair of aligned, outwardly oppositely extending stub shafts 153 and 154, respectively (see FIG. 4). Stub shafts 153 and 154 are journaled in appropriate bearing members (not shown) supported by side plates of the frame 135 for embodiment 101. A pulley 155 is axially mounted on stub shaft 154 and the entire drum means 102 is driven by means of an electric motor 156, through the image transfer means 106 by an interconnecting timing belt 157, in timed relation with said image transfer means.

Mounted in and between end walls 141 and 142, and circumferentially spaced from one another are two similar guide roller assemblies 161 and 162 and a third guide roller assembly 165. Each of the assemblies 161 and 162 is located such that its respective roller surface portion is parallel to the axis of the side walls and substantially flush with the adjacent peripheral edges of end walls 141 and 142. Construction details of the guide roller assemblies 161 and 162 are described below.

Circumferentially spaced from guide roller assemblies 161 and 162 is capstan assembly 163 which is mounted between end walls 141 and 142. Capstan assembly 163 is located both so as to have its axis parallel to the axis of the drum means, and so as to have its circumferential surface portions generally aligned with the adjacent peripheries of respective end walls 141 and 142. Constructional details of capstan assembly 163 are described below.

Positioned within the interior of drum means 102 and mounted between end walls 141 and 142 are a pair of spindle assemblies, one being designated as supply spindle assembly 144, and the other being designated as take-up spindle assembly 145. These spindle assemblies 144 and 145 are each positioned so as to have their respective axes parallel to the axis of the drum means 102. The spindle assemblies 144 and 145 are so spaced from one another that a supply roll 110 of the web 111 can be mounted on spindle assembly 144 and be transferred to spindle assembly 145 without interfering with the operation of each other. Constructional details of each spindle assembly 144 and 145 are described below.

Referring to FIG. 6, there is seen a vertical cross sectional view of guide roller assembly 161. Assembly 161 is shown to have a dead shaft 188, which is mounted between end walls 141 and 142, respectively, by a pair of shoulder bolts 189. Centrally journaled on dead shaft 188 by means of a pair of bearing members 191 is roller 192 conveniently formed of steel or the like. Adjacent each opposite end of roller 192, and spaced therefrom by a thrust washer, is journaled one end of a pair of angle members 196 and 197 respectively (which together provide a pivotal or hinge support for the imaging platform or plate 114 as below described). Retainer clips maintain the roller 192 centered on dead shaft 188. Guide roller assembly 162 in this embodiment is similar to guide roller assembly 161 except, of course, the angle members 196 and 197 are absent.

The web guide roller assembly 165 (see FIG. 16) comprises a dead shaft 198, mounted between axially spaced projections 180 by bolts 199, the heads of which are accommodated in grooves formed in the end walls 141 and 142, and a roller 200 journaled on the shaft 198 by suitable bearings as best shown in FIG. 20. The roller 200 is formed of steel and covered with a layer of resilient material having a high friction coefficient like natural rubber.

Drum Means: Imaging Platform

In drum means 102 (see FIGS. 3, 4, and 6), located between guide roller assembly 161 and capstan assembly 163, and between and entirely within the periphery of both end walls 141 and 142, is the planar imaging plate 114 which has a planar base member 201 with a pair of rigidizing channels having upright portions 202 and 203 disposed along opposite sides thereof. Upright portions 202 and 203 are formed so as to fit within the periphery of the end walls 141 and 142 in the assembled drum means 102. On one end of base member 201, and secured to one end of each upright portion 202 and 203, is a hinge formed by the angle members 196 and 197, (FIGS. 3 and 4) which are, themselves journaled at one end for pivotal swinging movements on opposite end portions of the dead shaft 188 of the guide roller assembly 161. The hinge mounting for the imaging plate 114 affords access to the interior of the drum means 102 and is retained in its normally closed position (as shown in FIGS. 3 and 4, for example) by means of a pair of screws 208 and 209 (FIG. 6) which project inwardly in opposed relationship through appropriate threaded bores in end walls 141 and 142 into aligned sockets formed in each respective adjoining upright portion 202 and 203.

DRUM MEANS: PAD ASSEMBLIES

Between guide roller assemblies 161 and 162, and also between guide roller assembly 162 and capstan assembly 163 are the pad assemblies 169 and 170, respectively. The pad assemblies 169 and 170 form circumferentially spaced portions of a circumferentially extending surface of the drum between end walls 141 and 142. Each pad assembly 169 and 170 comprises a circumferentially extending member 210 (see FIGS. 4, 8 and 9) formed of an electrically conductive material, and has a raised central surface area which supports the web material 111. A layer 211 of a low friction electrically conductive material is suitably secured to and covers the raised area of the conductive member 210 to allow easy movement and smooth operation of the photoconductive web 111 over its surface. When web 111 has an electrically conductive backing to serve as the field electrode, layer 211 may be thin paper.

In the case of pad assembly 169, an angle or rib member 175, of metal or the like, is fastened along its opposite side edges to member 210 to secure the member to the end walls 141 and 142 (FIG. 8) by convenient fasteners such as bolt and nut assemblies 214 and cap screws 216, respectively. Axially extending end members 217 and 218 join the ribs 175 at the ends of the pads (FIG. 4). The pad assemblies 169 and 170 are substantially similar except that the assembly 170 is hinged to the side walls and therefore the ribs 175 extend beyond member 210 at each end to form a hinge

or pivot at one end, in conjunction with opposed pins 179 as illustrated in FIG. 4, and to support the guide roller assembly 165 at the opposite end. A pair of opposed pins 181 (FIG. 4) extend towards one another through the end walls 141 and 142 and the ribs 175 of pad 170 to secure the pivotal pad assembly 170 in operating position. These pins 181 may be similar to pins 208 and 209 and may easily be withdrawn from the ribs 175 affording pivotal movement of the entire pad assembly 170 and the guide roller assembly 165, thereby providing access to the interior of drum means 102. Circumferentially extending slots are formed at each end of spanner member 146 so that swinging movements of the pad assembly 170 are not impeded.

Electrical contact can conveniently be made with the members 210 of pad assemblies 169 and 170 by means of a wire lead (not shown) secured to a screw. Electrical contact is made with the drum by conventional slip rings (not shown).

Drum Means: Supply and Take-Up Spindles

Referring to FIG. 10, there is seen a vertical cross-sectional view of supply spindle assembly 144. Assembly 144 employs a driven shaft 226, one end 227 of which has a shoulder formed thereon for axially supporting a center bored circular end cap or core supporting collar 228. A nut 229 is threadably received on shaft 226 adjacent end 227 to releasably retain the collar 228 on the shaft 226. Shaft 226 is reduced adjacent its other end 231 to provide two shoulders 233 and 234 to snugly fit in the bore of a collar 235 which is pressed against shoulder 233 and to be received in a suitable bearing 236. Bearing 236 is mounted within a threadably mounted bearing support 237 which support is mounted in a threaded cap 238 fixed on end wall 141. The support 237 is manually adjustable by an exterior flange 239 having circumferential knurled edge portions. In aligned opposed relationship with the axis of bearing support 237 and mounted through an aperture in end wall 142 is a second bearing support 241. The bearing support 241 supports a pair of aligned bearings journaling one end of a stub shaft 243, the other end of which is shouldered and formed with a keyway to fixedly support a pulley 245 thereon. The pulley 245 is formed with an axially extending tapered hub portion which mates an interior chamfer formed on the collar 228 as shown. The resulting relationship between stub shaft 243 and driven shaft 226 is such that, when the entire spindle assembly 144 is duly mounted between end walls 141 and 142, shafts 243 and 226 are coaxial with one another and pulley 245 frictionally drives collar 228 and a supply roll core 247.

The core 247 is conventionally formed of cardboard and has an axially extending slot formed in one end to ensure driving engagement with the collar, such as 228 which may have an axial rib engageable with said slot. To remove a core 247 and a roll 110 of the web 111 from the assembly 144, bearing support 237 is threadably moved in cap 238 outwardly until the bearing 236 and shaft 226 are axially separable. Then collar 228 can be separated from pulley 245 and shaft 226, core 247 and collars 228 and 235 are removed from the drum means 102. When they are removed, the nut 229 can be removed and collar 228 slipped off the shaft 226. The core and web may then be slipped off the

shaft. To mount a fresh supply roll 110 of web material 111 on the assembly 144 a reverse procedure is followed but care is used to align the slotted core with the rib on the collar 228.

As will be appreciated from the subsequent description herein, in accordance with the teachings of this invention, a supply roll 110 (not shown in FIG. 10) comprises a wound web of photoconductive material 111 on a core 247. Thus, when pulley 245 is rotated, core 247 rotates advancing photoconductive web 111 therefrom or rewinding photoconductive web thereon, depending upon the direction of rotation.

Referring to FIG. 11, there is seen a vertical cross-sectional view of take-up spindle assembly 145. Assembly 145 has a shaft 251 supporting a take-up drum 252 having axially spaced end caps 253 and 254 press fitted on the shaft 251. A pulley 255 is keyed to shaft 251 adjacent the cap 254 to drive the drum 252. The opposite ends of the shaft 251 extend beyond the ends of the drum 252 and pulley 255 and are suitably supported by bearings and bearing supports in the end walls 141 and 142. This take-up spindle assembly 145 winds the web 111 after it has been advanced around the outer peripheral surface portion of drum means 102.

Drum Means: Web Drive

A capstan and guide roller combination provide means for advancing the web 111 from the supply roll assembly to the outer surface of the drum means 102.

Referring now to FIG. 12 there is seen a vertical cross-sectional view of capstan assembly 163. Assembly 163 comprises a roller 261 formed by a rigid core 262 which has a uniform coating 263 of resilient material, such as a neoprene synthetic rubber, or the like. Mounted within each end of core 262 is an end cap 264, which caps are fixed on a shaft 265. A pair of bearing supports 266 and 267 are mounted in aligned axial relationship to one another through end walls 141 and 142, respectively, and each bearing support is suitably fixed to its respective end wall. The shaft 265 extends through bearing support 267 and the extended portion has a pulley 268 axially mounted thereon by suitable means, for example, a wedge tightener 269 and a key (not shown). The pulley 268 thus affords a drive means for the capstan or roller 261.

Guide roller means are provided adjacent the surface of the roller 261 to maintain web 111 in driving engagement with a substantial portion of the driven roller 261. In the present embodiment the guide roller means is a roller 270 (see FIGS. 3, 4, 13, 14 and 15), which is rotatably mounted on a dead shaft 272. The dead shaft 272 supported by independently adjustable brackets 273 is mounted on the end walls 141 and 142. The roller 270 has a rigid core coated on the outer circumferential surface with a resilient elastomeric material, such as natural or synthetic rubber, giving the roller a dense high coefficient of friction surface.

The brackets 273 each comprise a base plate 276 secured to the associated drum end wall by means of screws 277. One end of each base plate 276 is located so as to be adjacent the roller 261 of the capstan assembly 163, each such end being characterized by an upturned ear 278 (see FIGS. 13 and 14). The base plate 276 is also formed with opposed flanges 279 and 281

which define a channel in which is slidably received a support block 282 to which is connected an end of the dead shaft 272, secured thereto by a cap screw 283. Movement of the block 282 is restricted and its position is adjustable. A helical compression spring 284 is disposed between the ear 278 and the block 282. Block 282 is adjustable within the channel by a set screw 292 threadably received in a block 293 secured to the flanges 279 and 281 in a position above the block 282. The screw 292 thus affords adjustment of the block 282 and roller 270 moving it toward or away from the capstan roller 261. Spring 284 aids in maintaining the position of the block 282.

Mounted on the exterior face of end wall 142, and adjacent the imaging plate 114 is a bearing support 302 (FIGS. 2 and 27) which is adapted to journal three stub shafts 304, 306 and 307. The exterior end of each shaft is connected to a cup-like member formed with splines and forming a female drive coupling on said exterior ends. Bearing support 302 journals shafts 305 and 307 intermediate their ends and journals the interior end of shaft 306. Intermediate the ends of shaft 306 a timing belt pulley 309 is secured by means of a key and keyway assembly. Belt pulleys 311 and 312 are secured to the interior ends of stub shafts 305 and 307, respectively. Pulley 311 is interconnected with pulley 245 on supply spindle assembly 144 by means of an appropriate timing belt 313 (FIG. 2). Similarly, pulley 312 is interconnected with pulley 255 on take-up spindle assembly 145 by means of a timing belt 314, and, similarly pulley 309 is interconnected with pulley 268 of capstan drive assembly 163 by means of an appropriate timing belt 315. Thus, when stub shaft 305 is driven, supply spindle 144 is rotated; when shaft 307 is driven, take-up spindle 145 is rotated; and when stub shaft 306 is driven, capstan assembly 163 is rotated.

Brake means for each stub shaft 305, 306 and 307 is provided between the shaft and the bearing support 302. The brakes illustrated are provided by a plate 317 which is secured to the bearing support 302 and provided with three similar chamfered openings each of which is adapted to receive, in contact frictional engagement, truncated conoidal disks 319, 320 and 321 which are secured to stub shafts 305, 306 and 307, respectively. It will be noted in FIG. 17 that the stub shafts 305, 306 and 307 are axially slidable in the bearing support 302 affording a release of the brake disks 319, 320, and 321 from engagement with plate 317. Compression springs 322 fit on the shafts 305, 306 and 307 between the disks and the bearing support 302 to urge the disks into locking engagement with the plate 317. Suitable washers permit relative rotation between the springs and the bearing support.

When a supply roll 110 of photoconductive web 111 is mounted upon supply spindle 144 (as shown, for example, by dotted lines in FIG. 2), such web is threaded in the assembled drum means 102 by extending same around guide roller 270 and capstan roller 261, and out of the interior of drum means 102 through a slotted opening. From this location the web is passed across impinging plate 114 and then first over guide roller assembly 161, over pad assembly 169 past guide roller assembly 162, over pad assembly 170 and finally around guide roller assembly 165 and into the drum through the slotted opening and onto take-up drum 252 of take-up spindle 145.

To advance the web 111 during a copying sequence, it is necessary to employ a drive system which accurately advances the intermediate web 111 a fixed distance around the circumferential portions of drum means 102. The drive system illustrated herein affords the desired accuracy and is unique in that after operation to effect the web advance it may be disengaged from the drum means 102 to allow the drum means 102 to be rotated free of such drive system. Those skilled in the art will readily appreciate that other types of drive systems instead of one wherein the power source is maintained externally of a drum, as in the present embodiment, can be employed without departing from the spirit and scope of the present invention.

For example, one could drive a supply spindle, a take-up spindle and a capstan assembly by means of a plurality of concentric shafts mounted axially relative to the drum assembly whereby the spindles and capstan assembly are suitably connected to selected ones of the concentric shafts by means of gears, belts, etc. Alternatively, one could locate within a drum assembly motors and associated drive means so that by an appropriate mechanical assembly one could interconnect these motors and energize them independently whether the drum is revolving or stationary.

To advance a photoconductive web from a supply roll 164 to a take-up drum 252 around the circumferential portions of drum means 102, as indicated above, and in addition to provide the capability of rewinding web 111 from the take-up roll 112 back to the supply spindle 144, as when the supply roll 110 has been used up, the following novel drive system is employed in the copying machine of this invention. Each time the intermediate web is indexed or advanced, the web advances around capstan assembly 163 and a portion is wound on the take-up roll 112 to place an unexposed portion onto imaging plate 114 and advance an exposed portion onto a pad assembly. Such an indexing cycle is accomplished each time it is required in the machine operation by an automatic control hereinafter described. When the intermediate web is almost completely reeled off the supply roll 164 and onto the take-up roll, the drive system is signaled and reverses the direction of movement of the intermediate web and continuously operates until the intermediate web is almost completely rewound back onto the supply roll. When the web material used is of a type which can be reused, the machine is then again ready for cycling advance.

This drive system, as shown and illustrated in FIGS. 17, 18 and 19, is powered by a DC electric motor 326 which incorporates a combined electrodynamic brake and electrically actuated mechanical brake assembly 327 (for example, one available from General Electric Company under the trade designation of Statetrol). The brake assembly 327 is employed to accomplish slow starting and stopping of the drive system in order to prevent damaging a web. The mechanical brake assembly 327 stops the motor 326 at a precise determined position after the brake assembly 327 has slowed rotation of the drive shaft of motor 326 down to almost a complete stop.

The drive shaft of motor 326 drives a gear system 328 by means of a timing belt 329, or the like. Gear system 328 employs a rotatable housing 330 (with certain associated components) and a frame member 331

(with certain associated components). The timing belt 329 directly connects, through a pulley 332, the motor 326 with a central drive shaft 333 of the gear system 328. The center shaft 333 has a male splined sleeve 334 secured thereto at one end which fits slidably within and is driven from the pulley 332. A male spline member 335 is fitted and secured to the opposite end of shaft 333 for mating driving engagement with the female cup-like member on stub shaft 306 to drive the capstan assembly 163.

This drive coupling is effected by axial movement of the shaft 333 which movement is accomplished by axial movement of a bearing member 340 which is slidably mounted in the frame 331 and journals shaft 333 and a bearing 341 journaling housing 330. The bearing member 340 is joined by a lug 342 to a pivotal lever 343 which under the force of a solenoid assembly 344 pivots about a pin 346 against the bias of compression spring 347.

Axial movement of pulley 332 is restricted by a guide bracket 348 which is secured to frame 331 and fits on axially opposite sides of a disk 349 secured to said pulley 332.

Rotation of shaft 333 and its axial movement affords drive means for the several shafts which are associated with the housing 330 and coupling of the shafts with the drum means 102, respectively. A drive gear 351 is keyed to shaft 333 internally of the housing 330, see FIG. 17, and has a first pinion 352 which drives a gear wheel 353 which in turn, through a suitable commercially available clutch assembly 354, such as a Hilliard L2-1-313A slip clutch, drives a stub shaft 355. The shaft 355, on its exposed end supports a male spline member 356 which affords mating torque transmitting engagement with the cup-like member on stub shaft 305 as shown in FIG. 17.

A second gear face 358 on the gear 351 drives a pinion 359 which, through a slip clutch assembly 361 drives a stub shaft 362. The stub shaft 362 is journaled in the housing 330 and has a male spline member 363 on its exposed end for mating torque transmitting engagement with the cup-like member on shaft 307, as shown in FIG. 17.

Thus actuation of solenoid 344 shifts the bearing member 340, shaft 333 and housing 330 toward the drum means 102. This causes a mating of the opposed torque transmitting couplings and axial movement of stub shafts 305, 306 and 307 to release their brake means. Energization of motor 326 thus affords rotation of the shafts 333, 355 and 362 to drive stub shafts 306, 305 and 307, respectively, and the ultimate rotation of the capstan assembly 163, supply spindle 144 and take-up spindle 145.

The drive gears 352, 353 and 358, 359 for stub shafts 355 and 362, respectively, are so sized that shaft 362 rotates at a faster number of revolutions per unit of time than does shaft 355. Thus, for example, shaft 355 can be driven at a fixed rate which is about 15 times slower than shaft 362. Shaft 355 is driven at a speed slower than shaft 333 by meshing gears 352 and 353. Shaft 362 is driven at a speed faster than shaft 333 by meshing gears 358 and 359. Thus, the supply spindle 144 is being driven at a slower rpm than the capstan assembly 163 so that in effect the intermediate web is being pulled from the supply spindle 144 by the capstan

assembly 163, thus causing the clutch assembly 354 to continually slip during an indexing cycle. This feature maintains tension in the web between the capstan assembly 163 and the supply spindle 144. Shaft 362 is driven faster than the capstan assembly 163, thus causing the clutch assembly 361 on shaft 362 to continually slip during an indexing cycle to maintain tension in the web 111 between the capstan assembly 163 and the take-up spindle 145. After each indexing cycle, which advances the web 111 about the drum means 102, the solenoid 344 is de-energized releasing engagement of drive couplings between the various stub shafts under pressure of spring 347.

For a rewinding cycle, the supply spindle 144 must be driven in a direction opposite that associated with the indexing cycle and at a speed faster than the take-up spindle 145. Therefore the shafts 355 and 362 are orbited around the center shaft 333, 180° so that their positions relative to shafts 305 and 307 are interchanged. Such orbiting is accomplished by revolving the housing 330, 180° around the axis of shaft 333 and bearing support 340. This rotation is accomplished by energizing a small motor 366, which through a gear box 367 drives a pinion 368. The pinion 368 meshes with a gear 369 formed on the outer periphery of the housing 330. A cam 371 associated with a switch 372 and driven from the motor 366 stops rotation of said housing upon completion of the desired rotation.

The three shafts 333, 355 and 362 may then be engaged respectively, with shafts 306, 307 and 305 on the drum means 102 and by then reversing the direction of rotation of the drive motor 326 the rewinding cycle may be accomplished.

Drum Means: Web Brake

To maintain the web 111 in a tensioned configuration about exterior surface portions of the drum, a web brake mechanism, herein designated in its entirety by the numeral 375 is located near the guide roll assembly 165 and is actuated by a portion thereof on the frame of embodiment 101 adjacent wall 141 of the drum means 102.

FIGS. 16 and 20 show details of the guide roll assembly 165 and of the web brake mechanism 375 which comprises a brake shoe 377 having a curved plate upon which is fixed a polyurethane foam pad or the like, positioned along and adapted to engage a circumferential surface portion of the guide roller 200. The shoe 377 is fastened by welding or the like to a shaft 378 which is positioned parallel with the axis of the roller 200. The opposite end portions of the shaft 378 are journaled in respective end walls 141 and 142 of the drum means 102 thereby adapting shaft 378 for rotational movement about its axis. Attached to the brake shoe 377 is means defining a lever arm 379 which provides a moment arm for controlling pressure of the brake shoe 377 against the cylindrical surface portions of the guide roller 200. A leaf spring 381 is mounted so as to have one end fixed to a pin 382, which is itself mounted in end wall 141. The other end of spring 381 is adapted to exert a biasing force against the lever arm 379 so as to maintain the brake shoe 377 in engagement with roller 200. Leaf spring 381 acts to urge the lever arm 379 downwards (referring to FIG. 20). The brake shoe pad normally engages the web 111 and clamps it against the surface of roller 200.

When it is desired to advance the web 111 in an indexing operation, the shoe 377 is disengaged from the web 111 by pivoting it about shaft 378 by exerting pressure against the lever arm 379 in a direction and in an amount sufficient to offset the biasing force of the leaf spring 381. Such pressure is exerted from outside the drum means 102 when drum means 102 is in a "home" position by a lever 384, one end of which is formed with a projection 385 adapted to engage the lever arm 379. This lever 384 is pivoted or fulcrumed about a pin 386 by a solenoid 387 connected to the opposite end of said lever. A spring 388 is connected to the lever 384 to withdraw the projection 385 from engagement with the lever arm 379.

During rotational movements of the drum means 102, the lever 384 is positioned outside the circumferential region of drum means 102 by means of the bias exerted by coil spring 388 and so does not interfere with rotational movements of the drum means 102. When the drum means 102 is in a "home" position, and it is desired to advance the web 111, the lever 384 is pivoted about pin 386 by the solenoid 387 to move the brake shoe 377 away from the surface of roller 184, thereby releasing the web 111 for indexing or translation movements. When the web 111 has been translated a predetermined distance (as controlled by a web metering means 390), further indexing movement of the web 111 ceases and, simultaneously, the solenoid 387 is de-energized.

Drum Means: Web Meter

In order to control web movement about the drum means 102 and ultimately to obtain accurate registration of imaged portions of web 111 with the pad assemblies 169 and 170 and consequently with a copy sheet 126, means are provided to accurately measure the linear movement or length of web 111 fed onto the drum means 102 when web 111 is advanced. Such measurement is conveniently accomplished by the use of the web metering means 390 as shown in FIGS. 21, 22, 23, and 24.

Referring to FIGS. 21 and 22, web metering assembly 390 is seen to employ a L-shaped frame member 391, the foot of which is journaled for pivotal movements upon a pin 392, which itself is rigidly mounted to the main frame 135. The elbow of frame member 391 is secured to an armature of a solenoid assembly 393, the inner-relationship between solenoid assembly 393, frame member 391 and pin 392 being such that actuation of the solenoid assembly pivots frame member 391 about pin 392 against the bias of a tension spring 394, and away from the capstan assembly 163 or clockwise as viewed in FIG. 21. When solenoid 393 is deactuated, frame member 391 is in the position shown in FIG. 21.

Journaled through the upper end of the upstanding arm of frame member 391 on suitable bearings is a drive shaft 396 carrying in fixed relationship thereon an elastomeric (rubber)-tired drive disk 397. Coaxially mounted on and keyed to the drive shaft 396 adjacent the disk 397 is a drive pinion 398.

In the midportion of the same arm of frame member 391 and journaled therein is a driven shaft 401 which supports a driven gear wheel 402 matingly engaged with the pinion 398. On the other end of the driven shaft 401 is a pair of axially spaced driven disk cams

403 and 404. Thus when solenoid 393 is not energized the disk 397 bears against the outer surface of capstan roller 261.

The respective sizes of gears 398 and 402, and of disk 397 are so chosen that the web 111 will advance a desired predetermined distance over the capstan roller 261 and rotate shaft 401 through one revolution.

Disk cam 403 has positioned on a portion of its circumference a cam lobe 406 while disk cam 404 has circumferentially positioned on it a cam lobe 407. Each disk cam 403 and 404 actuates respectively, a normally open switch 408 and 409 by the lobes 406 and 407. The switches are mounted on the frame member 391 and are interconnected with the electrical circuitry of the embodiment 101.

At the beginning of a web advance cycle, the switches 408 and 409 are bypassed. After a short delay period and after the lobes 406 and 407 are rotated beyond switches 408 and 409 the same open and the bypass line is opened. As the web 111 advances, the cam 403 rotates in the direction shown by the arrow 411 (FIG. 23) and eventually lobe 406 actuates switch 408 to close the contacts thereof to reduce the speed of the drive motor 326. This will decrease momentum and will ensure a more accurate indexing of the intermediate web 111 about the drum means 102. The capstan shaft 261 continues to rotate and eventually lobe 407 comes into contact with switch 409 (FIG. 25) causing the same to close, at which point the drive motor 326 is completely de-energized and the brake assembly 375 is energized by deactuation of the solenoid 387 thereby ending further translation of web 111. Thereafter, the solenoid 393 is actuated and the frame member 391 is pivoted about pin 392 so that the disk 397 is removed from engagement with the web 111 and capstan roller 261. This completes a cycle of the intermediate web indexing. An override switch exists to bypass closed switches 408 and 409 upon initiation of a subsequent cycle until they are again returned to their normally open position upon movement of lobes 406 and 407, respectively, out of engagement therewith.

An alternative metering system may use different switching techniques such as photoelectric cells to control web advance and register the web on the pad assemblies 169 and 170 after exposure.

After indexing the web on the drum means 102 the drum is rotated about its axis 139 transporting the web past the processing stations as above-described.

Drum Means: Drum Latch

In order to stop the drum means 102 in a precise determined "home" or reference position at the end of a rotational movement thereof it is necessary to employ a drum stop means or drum brake, designated in its entirety in FIG. 26 by the numeral 415, which is mounted on frame 135.

In FIG. 26, there is seen a plate 416 which is secured to the frame 135 by any suitable means, in this instance, bolts 417. Attached to plate 416 are the following subassemblies: a pivotable brake assembly 418, a solenoid assembly 419, and a compression spring assembly 421.

The brake subassembly 418 employs a frame member 422 which is pivoted on its rear end portion about a pin 423, the pin 423 being rigidly mounted in

the plate 416. The brake assembly 418 includes a pawl 424 which is pivoted on pin 426 mounted rigidly in the frame member 422 so as to have its axis substantially parallel with the axis of drum means 102. The pawl 424 is urged toward the axis of drum means 102 by a compression spring assembly 427 including a slide 428, sleeve 429 and compression spring 430 which maintains the slide 428 against the upper surface of pawl 424.

An armature 432 of solenoid assembly 419 is attached to an ear 433, which is rigidly mounted on the midportion of frame member 422, by means of a link 434. When a solenoid 436 is de-energized as illustrated in FIG. 26, the frame member 422 is maintained in the position there illustrated by the spring assembly 421, which comprises a slide, sleeve and spring structure like assembly 427 but slightly larger. A stop member 438 locates frame member 422 relative to the drum means 102 and plate 416 in its raised and lowered position. When the drum means 102 is rotating, the solenoid assembly 419 is actuated, so that the brake assembly 418 is pulled away from the circumferential portions of the drum means 102 against the bias of the spring assembly 421 and is clear of the latching dog 440 which is secured to the exterior surface of drum end wall 142.

When it is desired to stop rotational movement of the drum means 102 in its reference or "home" position, the solenoid assembly 419 is de-energized allowing the brake subassembly 418 to pivot about pin 423, thereby bringing the pawl 424 into proximity with the circumferential surface portions of drum means 102 and into the path of the dog 440. Then as the drum means 102 rotates toward a "home" position, the dog 440 engages a lower cam surface 441 of pawl 424 urging the pawl upward against the bias of spring assembly 427 to an out-of-the-way position. The dog 440 is thus allowed to pass the pawl 424, after which the pawl 424 returns under spring bias into the position shown generally in FIG. 26.

The ultimate braking of the drum means 102 is accomplished by dog 440 contacting the head 442 of the shock absorber assembly 443 forming part of the brake assembly 418. The head 442 is connected to a piston 444 which piston is slidable in a sleeve 446 and telescopes with a hollow cylindrical barrel 447. Barrel 447 is fixedly held by a stop 448 and supports a compression spring 449 which urges the head 442 and piston 444 toward the pawl 424. As the dog 440 strikes the head 442 it is rapidly decelerated by the force of spring 449 until it stops. The spring 449 then moves the piston 444, head 442 and dog 440 to the fixed reference or "home" position shown in FIG. 26 with the dog 440 pressed against a face 451 of the pawl 424.

Mounted at one end on the head 442, so as to have its axis substantially parallel to that of piston 444, is a rod 452 which is slidable in a frame 453 upon movements of piston 444. The other end of rod 452 has a ramp 454 formed thereon which affords a cam surface for actuating a normally open switch 456 upon the piston moving into sleeve 446 under rotational force of dog 440. As soon as switch 456 is closed, the drum drive motor 156 is de-energized so that the drum means 102 is no longer rotated by power.

Means may be provided in advance of the latch assembly 415 to decelerate the drum by braking the motor 156 mechanically or electrodynamically when the drum has previously been operating at high speeds. The drum brake 415 however is sufficient to finally stop and precisely reposition the drum at the end of a copying cycle.

Development Means

After an image is projected onto the web overlying the imaging platform and the imaged portion of the web 111 is indexed as described, the drum latch is released and the drum means 102 begins to rotate to complete a copy cycle. The next station or step in this cycle is the development of the differentially conductive pattern by development means 104 which uses a powder 120.

The function of this development means 104 is to deposit pigmented powder in an imagewise pattern (corresponding to the graphic original being copied) on the photoconductive web. While there is hereinafter illustrated one technique for carrying out such deposition, other methods can be readily employed without departing from the spirit and scope of this invention.

The development means 104 illustrated in FIGS. 27-29 includes a hopper 460 for storing the supply of free-flowing ferromagnetic pigmented powder 120. A vibrator 461 is mounted beneath one inclined wall of the hopper 460 to insure the flow of powder from the hopper to a trough 462 disposed below the discharge slot of the hopper. The trough 462 has a raised lip on its front edge which acts as a doctor blade. Adjustably supported above the lip of the trough 462, by the frame of the developing subassembly including side walls 463 and 464, preferably formed of nonconductive material, is a magnetic roll assembly 466. The pigmented powder 120 will adhere to the roll 466 and when carried by the roll into proximity with the surface of the web 111, will be transferred imagewise to the web by establishing a series electrical circuit arrangement with an appropriate electric field.

A portion of the roll assembly 466 is continuously rotated during operation of the apparatus. A motor and reduction gear assembly 467 drives, by a belt 468 and suitable pulleys, an adjustably mounted drive shaft 469. The drive shaft 469 has a pair of transversely spaced drive rollers 471 and 472 secured thereto. The drive rollers 471 and 472 frictionally engage drive rings 473 and 474, respectively, on the roll assembly 466.

The magnetic roll assembly 466 is shown in detail in FIGS. 28 and 29. The roll assembly 466 comprises a rotatable electrically conductive nonmagnetic hollow cylindrical sleeve 475, formed for example of aluminum with a diameter of about 1 inch, having end caps on each end which retain the drive rings 473 and 474 and which support roller bearing assemblies 476 to rotatably mount the sleeve 475 on a dead shaft 477. The shaft 477 is fixedly supported at each end by brackets adjustably supported on the side walls 463 and 464. One external end of shaft 477 has a flat surface 478 to which is mounted an electrical connector 479. Within the sleeve 475 and adjacent one end cap is an electrical contact spring 481 which is secured to the shaft 477 and bears against the inner wall of sleeve 475 to carry an electrical current from connector 479 to sleeve 475.

Extending axially within the sleeve 475 and positioned circumferentially around shaft 477 are a plurality of elongate magnets 482, preferably eight as illustrated, disposed to form a substantially continuous ring about the shaft. The magnets 482 are formed of an oriented ferromagnetic material, such as barium ferrite embedded in a matrix, which is for example rubber based and heat set to produce a magnet having substantially uniform field density along its full length. The magnets 482 are alternately and oppositely polarized along their radially opposite edges and are disposed in an alternate array to form a strong magnetic field at the interstices. Alternatively, the bar magnets may be oppositely polarized along their axially extending circumferentially-spaced edges, although the first form is preferred. The magnets are held in fixed position on the shaft 477 by suitable retaining collars and springs. The end caps are also retained by collars and washers to accurately position the roll 466 on the shaft in axially aligned relation with the pad assemblies on the drum.

The sleeve 475 is rotated counterclockwise as seen in the drawing and is preferably spaced from the surface of the web by about 0.010 to 0.030 inch. The continuous rotation of the sleeve 475 draws powder 120 from the trough 462 across the doctor blade, which is spaced between about 0.010 and 0.050 inch from the surface of the sleeve 475, to move with the sleeve into the nip area between the sleeve and the web on the cylindrical drum surface. The gap between the doctor blade and the sleeve should be larger than the space between the sleeve and drum to insure that the powder 120 forms a continuous conductive path between the sleeve and web.

When an electrical field is applied to the series electrical circuit comprised of the electrically conductive sleeve 475, the semiconducting powder in the nip region, the photoconductive surface of web 111, and the pad assembly carrying the web, an electrical current flows which is seen as a real current in the conducting and semiconducting portions of the above series circuit, and as a displacement current in the insulating layers as they charge (similar to a capacitor in a series circuit). The powder may stick to the web in regions where an insulating or more resistive barrier exists at the powder-photoconductive layer interface (dark regions) since a field builds up across this interface as a result of the above-mentioned current flow. In other regions where the photoconductive layer is more conductive (light struck), a much smaller field (or none at all) will develop across this interface as a result of the current flow, and the powder will not stick to the photoconductive web because a charge is not built up which overcomes the attractive force of the magnetic developing roll assembly. The potential is supplied from a suitable source of direct current and the roll assembly 466 may be at a high positive potential and the pad assembly may be at ground potential.

After the powder 120 has been deposited on the web 111 the rotation of the drum carries the developed image pattern past the light-exposing assembly 108.

The Light-Exposing Means

The purpose of the light exposing means 108 is to direct columnated light toward the developed image on the web to re-expose the photoconductive surface thereof and increase the life of the differentially con-

ductive image pattern. This is particularly advantageous when more than a single copy of an original is desired after making the original exposure onto the web at the imaging plate.

Referring now to FIG. 30, a vertical cross-section of the light-exposing assembly 108 is illustrated and comprises a housing 486 which is generally rectangular in cross-section and extends transversely of the machine a distance at least slightly greater than the width of the raised surface on the pad assemblies 169 and 170. In the back of the housing 486 is mounted a reflector 487 and a light source 488, which may be a fluorescent tube, for long life, or a tungsten lamp. Extending across the front of the housing 486 is a block 489 formed with a slot 491 which extends substantially the full length of the block, at least across the width of the raised portion of the pad assemblies, and through the full width of the block, which width is about five times the height of the slot. The slot 491 is symmetrical but varies in height across the length of the block, being narrower in the center as indicated by dotted lines in FIG. 30, since the amount of illumination on the web, at this distance from the lamp, tends to fall off toward each edge.

Positioned in transversely spaced relation across the length of the housing 486, and immediately behind the block 489 are a plurality of parallel, vertically extending nonreflective baffle plates 492. The plates 492 and slot 491 block stray rays of light from the source and only the rays directed from the source and reflector directly toward the drum surface pass out through the slot 491.

The light source 488 preferably is energized from full dark to full light within 35 milliseconds and likewise the "off" time of the light should be within 35 milliseconds. Alternatively, a shutter may be provided to block the slot 491 which may be a rotatable shutter operated by a rotary solenoid.

The bias light assembly 108 thus affords means for re-exposing the conductive areas or previously light-exposed areas of the web 111 having no developer powder 120 thereon, making such areas of optimum conductivity.

Transfer Means

On continued rotation of drum means 102, the developed image area is moved to the image transfer means 106 for the transfer of the powder from the web 111 to the copy sheet 126. To achieve maximum sharpness of the transferred image, the copy sheet is brought into intimate contact with the developed image area on the web. The copy sheet is brought into contact and separated from the web 111, and after achieving contact, an electric transfer field is applied. This transfer field may be established by applying a high negative potential to the transfer roll 540. A transfer of the powder image from the web 111 to a copy sheet 126 is accomplished by passing web 111 in face-to-face contact with copy sheet 126 in the nip region between the surface of a pad assembly on the drum means 102 and the transfer roll 540 while the high voltage field is applied therebetween. The positively charged particles are moved toward the transfer roll 540 during this phase of operation of the embodiment 101 and are received on the copy sheet.

Referring to FIGS. 31 through 36, there is seen the transfer roll 540 which is entirely suspended on a shaft 541. A pair of spaced parallel hubs 542 and 543 are keyed to the shaft 541 near opposite end portions thereof. To the circumferential portions of each hub 542 and 543 is secured a pair of disks 546 and 547 respectively, which are formed of an electrically non-conductive material such as phenolic resin or the like. Secured to the disks 546 and 547 by means of suitable fasteners such as bolts 548 is a generally cylindrical member 550 conveniently formed of an electrically conductive non-magnetic material such as aluminum or the like and which has a thickened lip or internal flange portion 551 at opposite ends for convenience in securing the member 550 to the disks 546 and 547 in a manner to define an axially extending slot in the peripheral wall.

Just as the drum means 102 is given a circumference which is an integral multiple of the number of imaged regions desired, so is the circumference of the cylindrical member 550 chosen to be in excess of the maximum length of a single copy sheet 126. In general, it is desirable to make the diameter of the drum means 102 an integral multiple of the diameter of the transfer roll assembly 540 because of timing considerations in machine operation.

A major portion of the exposed circumferential surface of the cylindrical member 550 is covered with a pad member 552 adhered thereto by means of an adhesive or the like. The pad member 552 is conveniently formed so as to be both resilient and capable of conducting electrical current. The pad member 552 has a width somewhat larger than the width of a copy sheet 126 and a length somewhat in excess of the length of a copy sheet 126.

In the axially extending slot of cylinder 550 is mounted a clamp assembly 553. The clamp assembly 553 employs a base member 554, conveniently formed of metal, plastic, or the like, which has a circumferentially curved upper surface mating with that of pad member 552 and has an axially extending, outwardly opening channel or slot 556. In the slot 556 is suspended a bar 557 which is journaled on its opposite ends for rotary movement in the opposite flange portions 551 of the cylinder 550. To bar 557 is secured a plurality of regularly spaced circumferentially extending (as respects member 550) metal fingers 558, each of which is provided so as to overlie an appropriately formed recessed, circumferentially extending depression in base member 554 permitting each finger to lie substantially flush with the surface of pad member 552 when the bar 557 is in a position of rest. The metal fingers 558 are conveniently formed of sheet metal or the like and are each formed adjacent their free ends with a generally radially inwardly extending portion, which is bent and formed with a knee 562.

The fingers 558, when in a closed position flush with the surface of pad 552, are adapted to secure the lead edge of a copy sheet 126 against the surface of the transfer roll 540. The operation of fingers 558 is as follows. After the bar 557 is pivoted in a direction so as to raise the fingers from a position flush with the surface of pad 552, the lead edge of a copy sheet 126 is moved against the fingers 558 (FIG. 34) where such lead edge of sheet 126 contacts and is registered and positioned

by the radial portion 561 of finger 558. The bar 557 is then pivoted in a direction so as to clamp the copy sheet 126 between the fingers 558 and the outer surface of member 554 (FIG. 35). The circumferential portion of each finger 558 functions as a clamp for copy sheet 126. At the completion of a transfer operation (e.g., after the finger 558 has passed the nip region of drum means 102 and pad 552) the bar 557 is again rotated in a direction so as to move the fingers 558 away from flush engagement with the surface of cylinder 550. At this time the knee 562 of each finger 558 (FIG. 36) functions to eject or lift off the lead edge of copy sheet 126 from member 552 of clamp assembly 553. Thus, as cylinder 550 rotates, each finger 558 has three sequential functions: to register the lead edge of a copy sheet 126, to clamp the lead edge of such a copy sheet 126, and to eject the lead edge of such a copy sheet 126.

The entire transfer roll assembly 540 is suspended within a U-shaped frame member 565. This frame member 565 is, in turn, attached through its base to the main frame assembly 135 of the embodiment 101. Journaled in the opposite wall portions of the frame 565 is a drive shaft 566 which is driven by the motor 156 through a suitable drive chain or timing belt and a readily releasable drive coupling (not shown), which are positioned at the right end of the shaft 566 as shown in FIG. 31.

This drive shaft 566 serves as the pivot axis for axially spaced bell crank members 569 and 570. Bell crank 569, as best shown in FIG. 34 has a horizontally extending leg 572 and a depending leg 573. The bell crank member 570 (see FIG. 32) comprises a cast gear housing 574 which forms the horizontally extending leg and a depending leg 576 corresponding to depending leg 573 of bell crank 569. The shaft 541 supporting transfer roll 540 is supported in the legs 572 and 574 of the bell crank members and within the housing 574 one end of the shaft 541 is keyed to a drive gear 577 which meshes with and is driven from a gear 578 fixed on drive shaft 566 (see FIG. 31). The gears 577 and 578 are similar, giving them a ratio of 1:1 so the roll 540 makes one revolution for each revolution of the drive shaft 566.

The left end of drive shaft 566 as shown in FIG. 31 supports a pulley 581 which drives, through the timing belt 157, the pulley 155 mounted on a stub shaft extending axially of the drum wall 142 of drum means 102. In the illustrated embodiment 101 the relationship of pulley 581 to the pulley 155 is such that drive shaft 566 makes three turns or complete revolutions about its axis for each complete revolution of the drum means 102. Pulley 581 is similar in size to gear 578 thus a three to one ratio between the drum and the transfer roll 540 is maintained.

Attached to bell crank 569 and having its center positioned at the axis of shaft 541 is a cam disk 582. Cam disk 582 includes an electrically nonconductive spacer disk 583 which is formed of a phenolic resin or the like and which is rigidly secured to the horizontally extending leg 572 of the bell crank 569. The cam disk 582, formed of wear resistant material, metal or the like, has the periphery formed with an appropriate cam surface including lobes and depressions. Riding the periphery of the cam 582 is a cam follower roller 585.

The cam follower roller 585 is secured to one end of a lever 586 which is secured to the disk 546 at the other end. The lever 586 is biased to place roller 585 in continuous engagement with cam 582 and the end of the lever 586 carrying roller 585 is connected to a link 587 which joins the lever 586 to a radially extending lever arm 588. Lever arm 588 is secured to a crank arm 589 joined rigidly to the bar 557 to rotate the same and swing the fingers 558. Thus, as transfer roll 540 rotates, the cam follower roller 585 follows the periphery of cam ring 582 causing periodic oscillatory movements to occur in bar 557. These oscillatory movements, as explained above, cause the opening and closing of fingers 558 in the clamp assembly 553.

Due to the outer contour of the drum means 102, the configuration of the transfer roll, the desirability of grasping the copy sheets and pulling them to the nip area between the drums, the required pressure contact between the copy sheet 126 and web 111, the need to index the web on the drum when the same is stationary, and other considerations, the transfer roll 540 is moved sequentially toward and away from the periphery of the drum casing 108. This movement is programmed during operation of the apparatus for copying and duplicating by a pair of cam disks 591 and 592 mounted in axially spaced relation on a driven cam shaft 593 journaled in wall portions of the frame 565. The cam shaft 593 is driven from the main drive shaft 566 by a belt 594 entrained about two pulleys 595 and 596 secured to the shafts 593 and 566 respectively, and an idler pulley 597. The disks 591 and 592 are identical and a cam follower roller 598 is carried by each depending leg of the bell crank members 569 and 570. The cam followers 598 are maintained in engagement with the cam surface of the disks 591 and 592 by tension springs 599 and 601 which extend between the depending legs 573 and 576 and a frame wall member 579. The configuration of the disks 591 and 592 are shown most clearly in FIG. 34 and have a generally circular shape interrupted by two lobes (one long lobe 602 and one small lobe 603) which are located to pivot the crank arm 569 (as seen in FIG. 34) clockwise moving the transfer roll 540 away from the drum when regions on the circumference of the drum means 102 between pad assemblies 169 and 170 are moving past the nip area (which regions may be termed non-pad regions). The transfer roll 540 is moved by the cam disks, and the supporting bell crank members, only a distance to completely disengage the same from the circumferential portions of the drum and web 111 when non-pad regions are adjacent the transfer roll assembly.

In the machine embodiment herein described when the drum means 102 is in a "home" position, the transfer roll assembly 540 is located over pad assembly 170 as illustrated in the diagrammatic sequence shown in FIG. 1. Since the cam disks 591 and 592 as explained, have their lobes so positioned that the transfer roll 540 is engaged with the pad assemblies of drum means 102, it is necessary to have the transfer roll assembly 540 disengaged from drum means 102 during periods when drum means 102 is at rest or in its "home" position. This is necessary to permit the web 111 to be freely advanced over the circumferential surface of drum means 102 as explained elsewhere. This is accomplished by an electrically actuated latch which

acts against the depending legs 573 and 576 of the bell crank members while the drum is making an extra revolution after completion of a copying cycle. This latch mechanism (see FIGS. 1, 32 and 34) comprises a transversely extending rotatable rod 604, positioned parallel to and below cam shaft 593, upon which are secured radial arms 606 and 607 associated with depending legs 573 and 576, respectively. As the rod 604 is rotated about its axis, one radial arm is positioned to engage the lower end of each associated depending leg to lock bell crank members 569 and 570. The rod 604 is caused to rotate by means of an additional radial arm 608 which is keyed to said rod 604 near the midportion thereof and which is circumferentially spaced from arms 606 and 607. The free end of arm 608 is pivotally secured to the ends of a pair of links each of which are joined to the plunger of a solenoid 611 and 612 (see FIG. 34) which solenoids are positioned in a longitudinally aligned opposed relationship such that when solenoid 611 is energized, arm 608 pivots the rod 604 to cause arms 606 to 607 to engage depending legs 573 and 576, as a consequence of which the transfer roll 540 is held against the bias of springs 599 and 601 out of contact with the drum means 102. Actuation of solenoid 612 swings arms 606 and 607 from an over center camming position back to a position whereby springs 599 and 601 urge the cam rollers 598 against cam disks 591 and 592, and the transfer roll 540 into contact with drum means 102.

The operational sequence in transfer roll 540 is as follows. A copy sheet 126 from a paper feed mechanism 105 enters a paper guide chute formed by an upper guide 614 and a lower guide 616. As the clamp assembly 553 moves with the revolving surface of cylinder 550, it comes to a position which is adjacent or opposite the edge of the guides 614 and 616. At this point, the metal fingers 558 are wide open (see FIG. 34), and the copy sheet 126 is moved against the respective radial portions 561 thereof. As the transfer roll continues to rotate, the cam follower roller 585 causes the bar 557 to pivot, with the result that the fingers 558 close onto the lead edge of the copy sheet 126. This is illustrated in FIG. 35.

While so clamped, the copy sheet 126 is moved into face-to-face engagement with the intermediate web 111 at the nip formed between the drum means 102 and the transfer roll 540. As will be hereinafter explained, simultaneously and continuously with such contacting of copy sheet 126 with intermediate web 111, and only during the time when a pad assembly 169 or 170 passes through the nip area, a high voltage potential is applied between these members.

After the leading edge of copy sheet 126 has passed beyond the nip area, the cam follower roller 585 causes the bar 557 to pivot again in a direction so as to open the fingers 558. This opening movement is so regulated by the position of the lobes on cam ring 582 that the knee 562 causes the lead edge of copy sheet 126 to move away from the surface of member 554 and onto a set of stationary fingers 618 leading to the fusing means 107. As the transfer roll 540 continues to revolve, the entire copy sheet 126 is moved through the nip area, thereby completing transfer of one complete image from the intermediate web 111 onto the copy sheet 126.

The high voltage potential is connected to the cylindrical member 550 by means of a slip ring 621 (FIG. 32) which is secured to the flange portion 551 adjacent the nonconductive disk 546, a wiper or brush is biased into engagement with the ring 621, which brush is suitably supported in a cylindrical support secured to the cam 582, and a suitable electrical lead is connected to the wiper. Placing a potential on the ring 621 thus places the pad 552 in a position of a conductive surface when pressed into contact with the copy sheet 126.

Grounding Means

When making multiple copies after the initial exposure to the original, the grounding means 109 affords means for "shorting out" the photoconductive surface and insulating backing of the web 111 between the end of one copying cycle and before the start of another cycle. The grounding means 109, see FIGS. 21 and 25, comprises a conductive roller 622, formed of a conductive resilient gelatin (or suitable substitute such as conductive rubber), which is supported on a rotatable shaft 623 intermediate a pair of drive rollers 624. Drive rollers 624 are slightly larger in diameter than the roller 622 and are positioned to engage the end walls 141 and 142 of the drum to drive the roller 622. When a pad assembly 169 or 170 moves a web section to the grounding means the roller 622 is rotating to prevent any scuffing action when roller 622 engages the web. When roller 622 contacts the pad area or the web, the drive rollers 624 are raised off the peripheral edge of the end walls and roller 622 is driven by direct contact with the web 111.

The shaft 623 is rotatably supported at each end by pivoted arms 625, which are pivoted by pins 626 connected to fixed brackets 627 supported from a frame member 628. A pair of adjustable compression spring assemblies 629 are positioned, one adjacent each arm 625, to bias the roller 622 and drive rollers 624 from the frame member 628 toward the periphery of the drum and drum end walls, respectively.

Electrical Circuit

FIG. 37 is a block diagram of an electrical control circuit suitable for programming and controlling operation of the apparatus of FIG. 1 and the several views.

This schematic circuit is adapted to be energized by means of plug member 630. Plug member 630 is adapted for connection to a source of electricity such as a normal outlet from a 230 volt, 60 cycle source. A main power control 631, connected to member 630, functions to provide suitable power for each circuit component. Appropriate electrical power is distributed to each circuit component by means of various conductors which are generally and collectively designated as 632.

The entire machine operation is under control of a program sequence control 633. Program sequence control 633 may be, for example, either a multicam and multiswitch sequencing device, a plurality of relays connected in a predetermined manner or a transistorized, fixed program device which a person skilled in the art could adapt for programming, in the proper operating sequences, the embodiment of FIG. 1.

The program sequence control 633 is a fixed programmed device and an operator initiates machine

operation by entering the number of copies desired into the control 633, placing the graphic original 130 on the stage 131, and starting the control 633. The machine is preferably programmed to have a slightly different sequence, depending upon the number of copies to be produced. When the number of reproductions of an original is less than 10, one sequence is followed, and if the number is 10 or more, a second sequence is followed.

As explained above, a photoconductive intermediate web 111 is used which is sequentially advanced, by a drive motor 326. The indexing of the web is controlled by a web index control unit 634 which, in predetermined manner, controls a motor control 636 for motor 326, clutches 354 and 361, solenoid 344, and motor control 637 for motor 366 and is in turn sensitive to signals from a rewind sensor 638, an index mechanism 639 for image position, and web advance and position sensor 641, which includes switches 408 and 409.

The index control unit 634 affords two operations as described hereinbefore, when the copying machine is selectively programmed to produce less than 10 reproductions of an original only a single latent image is produced on the intermediate web. After the intermediate web has been imaged, the web is indexed to a developing position with the image over pad assembly 169. This image position is conveniently identified as position I. When the copying machine is selectively programmed to produce more than 10 reproductions of an original graphic image, two separate exposures are made on separate areas of the intermediate web. A first exposed or imaged area is indexed to image position I in the manner for making less than 10 reproductions. Then a second exposure is made on the web and again the entire web is indexed or advanced and the first exposed area is advanced to an image position which may be conveniently referred to as image position II over pad assembly 170 while the second exposed area is advanced to image position I over pad assembly 169. The selected positions of the exposed or imaged sections is monitored by the web advance and position sensor 641 which includes the web metering means 390.

After the original is properly placed, the number of copies is determined and the copying cycle begins. The first exposure is produced on the intermediate web 111 by the control 633 energizing the exposure lamp assemblies 132 and a shutter 642 through a timer 643 which causes an image to be projected onto the web 111. Prior to imaging, exposure lamp assemblies 132 may be either off or in a low intensity standby condition. When the image is projected onto the intermediate web, a differentially conductive pattern corresponding to light on dark areas of the projected image is produced on the web 111. The index control 634 is then conditioned to advance the exposed section of the web into image position I. If 10 or more reproductions are to be made, control 634 effects a second exposure sequence by operation of the timer 643, lamp assemblies 132 and shutter 642, after which the first image is advanced to image position II and the second image is advanced to image position I. The index control 634 is disabled terminating the imaging sequence. The program sequence control 633 then begins the sequential steps of developing, re-exposing, transferring, and fusing.

As discussed hereinbefore, the imaged intermediate web is disposed on the pad assemblies 169 and 170 located on the exterior periphery of the drum means 102. The program sequence control 633 initiates the drum rotation by actuating a drum motor control 646. The drum motor control 646 controls operation of a drum motor 156 and regulates the rate of rotation. The drum motor control 646 also controls operation of the drum latch or brake 415 including the solenoid assembly 419 and switch 456.

The drum rotation from its "home" position advances the intermediate web containing the exposed areas or images past the development means 104, light-exposing means 108, and image transfer means 106. It is also the function of this control circuit to control the sheet feeding means 105 and fusing means 107.

The drum may make one or more revolutions before operation of the several stations is initiated by the program sequence control 633. As an imaged section reaches the development means 104 the program sequence control 633 causes a developing voltage source 650 to apply a developing voltage between the magnetic roller 466 and the conductive member 210 of the drum pad assembly adjacent the development means 104 at that time. The developing voltage from voltage source 650 is applied to the roller 466 as the pad assemblies 169 and 170 reach selected positions. The voltage source 650 is controlled by a switch 651 controlled by program sequence control 633.

A visible image is developed on the exposed web sections by the developer powder at the development means 104 which powder is transferred to the web 111 in the presence of an electrical potential between the magnetic roller 466 of the development means and the conductive surface of the pad assemblies whereby the charge carriers movement through the powder to the insulative image areas on the surface of the web 111 causes the developer powder to transfer to and adhere to said web at the insulative image areas forming a visible image pattern. The positive electrical potential for the development means 104 is supplied through a developing voltage source switch 651 leading to the connector 479 on shaft 477. Continued rotation of the drum advances the developed image past the light exposing means 108 which has been energized by the program sequence control 633 through a lamp voltage control 654. The light emitted from the slot 491 of the exposing means 108 increases the conductivity of the background areas to compensate for the finite loss of conductivity due to the previous field application when the image being formed is a positive image. The drum then carries the developed image to the transfer means 106 whereupon the powder forming the image on the web 111 is transferred to a receptor or copy sheet.

Operation of a copy sheet feeding means 105 is regulated by a copy sheet feeder control 656. The feeder control 656, in response to being conditioned by the program sequence control 633, enables the copy sheet feeding means 105 to advance a copy sheet into movable contact with the drum and in register with the image position or with the pad assembly bearing the developed image. The powder image developed on the web is then transferred to the copy sheet. As the copy sheet feeding means 105 feeds each copy sheet into movable contact with a pad assembly, a copy sheet

feeder sensor 657 enables the copy sheet feeder control 656 to continually deliver copy sheets in sequence. A counter 658, responsive to the copy sheet feeder sensor 657, keeps an accumulated count of the number of copy sheets fed by the copy sheet feeding means 105 to the transfer means 106. The counter 658 supplies the accumulated count to the program sequence control 633 whereby the control 633 can compare the number of copies desired with the number of copies printed and terminate machine operation when the numbers are equal.

The copy sheet upon contacting the developed image and the intermediate sheet has the developed image transferred thereto in the presence of a transfer voltage. The transfer voltage is produced from a transfer voltage source 653, and is of an opposite polarity to the developing voltage produced from the developing voltage source 650.

The copy sheet, having the developed image thereon in the form of loose powder particles, is passed through a fusing means.

The fusing means 107 may conveniently include fusing lamps 663. The fusing lamps 663 are started by the program sequence control 633 when copies are to be made, but are otherwise off when the machine is in stand-by condition. The fusing lamps 663, when energized cause the developing powder, which forms the visible developed image, to be permanently fused to the copy sheet. The copy sheet having the reproduced graphic image thereon is deposited into a collector 664 on the copying machine adjacent the discharge end of the fuser.

A typical operation for making a single copy is initiated by an operator placing the original 130 of the graphic image on the stage 131, entering "one" into the program sequence control 633, and starting the program sequence control 633. The program sequence control 633 then initiates the timer 643, which timer causes the exposure lamp assemblies 132, in cooperation with shutter 642 to impart a light image of the graphic original on the photoconductive web 111.

At the end of the imaging sequence, the program sequence control 633 actuates the index control 634. The index control 634 activates the motor 326 via motor control 636 to index the intermediate web from the imaging position on plate 115 to image position I on pad assembly 169. The indexing is monitored by web metering means 390. The advance of the imaged section of web 111 also advances an unexposed section onto the imaging plate 114.

The program sequence control 633 then enables motor control 646 and energizes motor 156 to rotate the drum means 102, drive the developing roll 466, together with the transfer roll drive shaft 566. As the exposed image area, at image position I, is advanced by the drum to the development means 104, a developing voltage from source 650 between the conductive member 210 of the pad assembly 169 and the developer roll 466 applies powder 120 evenly over the web 111 in the nip area between the pad 169 and the roller 466, and the presence of the electrical field causes the powder to adhere to the nonconductive areas of the image pattern to develop the same. The drum continues to advance the developed image, and copy sheet feeding means 105 advances a copy sheet

126 from the stack into the opened fingers 558 on the transfer roll assembly 540 and its rotation and operation under the direction of cam 582 and disks 591 and 592 place the copy sheet in registry with the developed image on the web. Transfer voltage source 653 establishes an electric field between the pad assembly and the pad 552 on the transfer roll 540 of opposite polarity relative to the developing voltage across the copy sheet and web. The image formed by the powder on the web 111 is thus transferred due to the charge carriers movement from the web to the copy sheet 126. The copy sheet is directed from the nip between the pad assembly and transfer roll to the fusing means 107 whereupon the fusing lamps 663 cause the powder on the copy sheet 126 to be permanently fused thereto producing a copy of the original.

If less than nine copies are programmed, for example, the drum means 102 under control of program sequence control 633 continues to rotate the same imaged section on the intermediate web through the developing and transferring sequences to make each copy. Similarly if more than nine copies are programmed, the two imaged areas, at image positions I and II, will produce two copies for each rotation of the drum means 102. Each image would be developed, transferred and fused sequentially.

Having thus described the present invention in terms of the process to be performed and the apparatus, it is to be understood that certain changes and modifications can be made without departing from the scope or spirit of the invention.

What is claimed is:

1. An electrographic copying machine adapted to produce a copy of graphic intelligence on a photoconductive web material, said copying machine comprising
 - a. a pod assembly including internal means for storing a supply of web material, an external peripheral imaging section and an external peripheral electrically conductive developing section spaced from said imaging section, and means for moving said web material from said storing means over said imaging section and from said imaging section to said electrically conductive developing section of said assembly.
 - b. imaging means for registering graphic intelligence on a said web material when disposed on said imaging section,
 - c. developing means including a conductive distributor means for applying conductive powder to the web material on said developing section, and means connected to said distributor means and to said developing section for applying an electric field between said conductive distributor means and said developing section to carry said powder to said web, and
 - d. means for moving said pod assembly to move said external electrically conductive developing section containing said web material thereon from an initial position past said developing means whereby a visible pattern of such graphic intelligence is produced on said web material and to return said developing section to said initial position.
2. An electrographic copying machine adapted to produce a copy of graphic intelligence on a radiation responsive web material utilizing the electropowder process, said copying machine comprising

- a. a generally cylindrical pod assembly mounted for rotative movement about its axis, including
 1. internal means for storing a supply of said web material,
 2. support means defining an external surface over which a said web material is moved from said internal means, said external surface including an imaging section and a developing section,
 3. internal restoring means for said web material after movement thereof over said support means, and
 4. driven means for moving the web to position successive sections of said web on said imaging section and for advancing said sections of said web onto said developing section of said pod assembly,
 - b. imaging means for projecting an image bearing graphic intelligence onto a said section of web material when disposed on the imaging section of said pod assembly,
 - c. developing means including
 1. conductor means connected to a voltage source and to said developing section,
 2. distributor means for carrying pigmented conductive material to a said section of web material on said developing section in conductive contact with said web, and
 3. conductor means connected to said distributor means for establishing an electric field between said distributor means and a said web section to form a visible pattern of such graphic intelligence on said section of web material by depositing some of said conductive material on insulative areas of said web material as the same is advanced on said developing section of said pod assembly to said developing means,
 - d. driving means for said driven means to move said web material about said imaging and developing sections of said pod assembly, and
 - e. means for rotating said pod assembly to move said developing section from an initial position to said developing means to produce a visible pattern of the graphic intelligence on a said section of web material and returning said developing section to said initial position.
3. An electrographic copying machine according to claim 2 wherein
 - a transfer station is disposed adjacent the periphery of said pod assembly, said transfer station comprising means for bringing a receptor into intimate contact with a said section of said web material disposed on said developing section, and means for imparting an electrical field between said developing section and said transfer station when a said receptor is placed in contact with said web material to transfer the image formed by said conductive material to said receptor.
 4. An electrographic copying machine according to claim 2 wherein said imaging section of said support means is a planar surface.
 5. An electrographic copying machine according to claim 2 wherein said external surface of said support means includes a planar imaging surface and two circumferentially spaced semi-cylindrical developing surfaces defining said developing section, each said semi-cylindrical surface having an area to receive an imaged

section of web material and each said semi-cylindrical surface being conductive and electrically isolated.

6. An electrographic copying machine according to claim 2 wherein said internal means comprises a rotatable spindle assembly, said internal restoring means comprises a driven take-up spindle assembly, and said driven means comprises a driven capstan for drawing a said web material from a roll supported on said rotatable spindle assembly and drive means for said internal restoring means, said capstan being disposed in adjacent relation to said imaging section of said support means, said spindle assemblies and said capstan being disposed parallel to the axis of said pod assembly and being mounted at their ends in end walls of said pod assembly.

7. An electrographic copying machine according to claim 6 wherein said means for driving said driven means comprises a drive system supported adjacent an end wall of said pod assembly, said drive system comprising drive shafts supported by said pod assembly and connected to said capstan and driven take-up spindle assembly,

coupling means affording releasable driving engagement with said drive shafts when said pod assembly is in its initial position,

motor means for driving said coupling means, and

means for moving said coupling means into and out of driving engagement with said drive shafts as desired to advance a said web material.

8. An electrographic duplicating machine adapted to reproduce one or more copies of a graphic original from a photoresponsive web onto a receptor, said duplicating machine comprising

a. a pod assembly including a planar imaging surface and a part cylindrical surface, internal means for storing said photoresponsive web, means mounting said assembly for rotation about an axis coaxial with said cylindrical surface, and means for indexing a section of said web from said internal means over said imaging surface and said cylindrical surface of said pod assembly,

b. imaging means for projecting a light image of a said graphic original on a said web overlying said imaging surface to form a differentially conductive image pattern on said web when said pod assembly is in an initial position,

c. developing means including conductive roller means for applying a pigmented conductive developer powder against said web in conductive contact with said roller means and said web during movement of the cylindrical surface past said developing means,

d. means for concurrently applying an electrical field in the region between said roller means and said cylindrical surface to develop a visible image of such graphic original on said web,

e. transfer means including an electrically conductive member affording intimate contact between the resulting imaged web and a said receptor,

f. means for establishing a second electrical field between said cylindrical surface and said conductive member for transferring said developer powder forming said visible image on said web to a said receptor when in said intimate contact, and

g. means for producing relative sequential movement of said pod assembly from said initial position past said developing means and said transfer means whereby an image of such graphic original is reproduced on a said receptor.

9. An electrographic copying machine adapted to produce a copy of a graphic original on a receptor, said copying machine comprising

a. a pod assembly comprising

1. a supply roll of said photoconductive web material,

2. means extending parallel to the axis of said pod assembly rotatably supporting said supply roll,

3. means defining an external peripheral surface for said pod assembly including a planar surface and a semi-cylindrical surface defining a path of movement for said web material about said pod assembly, and

4. means supporting said pod assembly for rotation about the axis of said semi-cylindrical surface,

b. means for advancing a predetermined length of said web from said supply roll and advancing the web over said peripheral surface of said pod assembly,

c. imaging means for projecting an image bearing graphic intelligence onto said web material when said pod assembly is at rest with said planar surface disposed at a reference position,

d. developing means including

1. an applicating roller disposed adjacent the peripheral surface of said pod assembly for applying pigmented conductive material upon said web in the region and in conductive contact with and between said roller and said web material disposed on said semi-cylindrical surface, and

2. electrical field producing means for concurrently establishing an electrical field between said roller and said semi-cylindrical surface of said pod assembly to deposit conductive material onto said web material, and

e. means for rotating said pod assembly from said reference position to said developing means for developing said image pattern imparted to said photoconductive web material.

10. An electrographic copying machine according to claim 9 wherein

f. transfer means are provided including

1. means for bringing a receptor into intimate contact with said web material surface after development thereof, and

2. a second electrical field producing means for subsequently establishing an electrical field between said means for bringing a receptor into contact with said web material and said semi-cylindrical surface for transferring the conductive material from said web material to said receptor.

11. An electrographic copying machine according to claim 10 wherein said semi-cylindrical surface is electrically conductive to define a field electrode for said developing means and said transfer means.

12. An electrographic copying machine according to claim 10 wherein said web material has a conductive backing forming a field electrode cooperating with said applicating roller and means for bringing a receptor

into contact with said web material to form said electrical fields.

13. An electrographic copying machine according to claim 10 including

fusing means for fusing said conductive material to said receptor, and
means for directing said receptor to said fusing means from said transfer means.

14. An electrographic copying machine according to claim 5 including

control means for operating said imaging means, said driving means and said means for rotating said pod assembly to afford exposure of a section of a said web material on said imaging section, advance said section to one said semi-cylindrical developing surface, exposing the subsequent section of web material on said imaging section, advancing said web material to move the first section to the other semi-cylindrical developing surface and said subsequent section to said one semi-cylindrical developing surface, and then rotate said pod assembly to move said developing surfaces and web sections past said developing means and said transfer station to produce the desired copies of said graphic intelligence.

15. An electrographic duplicating machine adapted to produce a plurality of copies of a graphic original, said copying machine comprising

a generally cylindrical rotatable pod assembly, said assembly comprising
means for supporting a supply of web material comprising a coating of photoconductive material on a nonconductive support layer, rotatable means for rewinding used portions of

said web material,

said means supporting said supply and said rewinding means being positioned within the peripheral extent of said assembly, the periphery of said assembly being defined by a planar member disposed within the periphery of axially spaced circular end walls and by a pair of spaced semi-cylindrical electrically conductive pads about which said web material may be moved from a supply and said rewinding means,

means for maintaining said assembly in a fixed position,

imaging means for projecting an image onto said planar portion of the periphery of said assembly while said assembly is in said fixed position,

means for advancing said web material to move the exposed section of said material disposed on said planar member to a position in register with one of said arcuate pads,

control means for again exposing a new section of said web material disposed on said planar member and for again advancing said second exposed section to registry with one of said pads,

means for rotating said assembly,

means adjacent the rotational path of said pads for first depositing a pigmented powder material on said web material and then transferring said powder to a copy sheet, said means for depositing and transferring said powder material including means for establishing an electrical field during said depositing and transferring, and

means for feeding copy sheets into register with the imaged sections of said web material disposed on said pads.

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