

Nov. 28, 1967

E. I. DOUCETTE ET AL

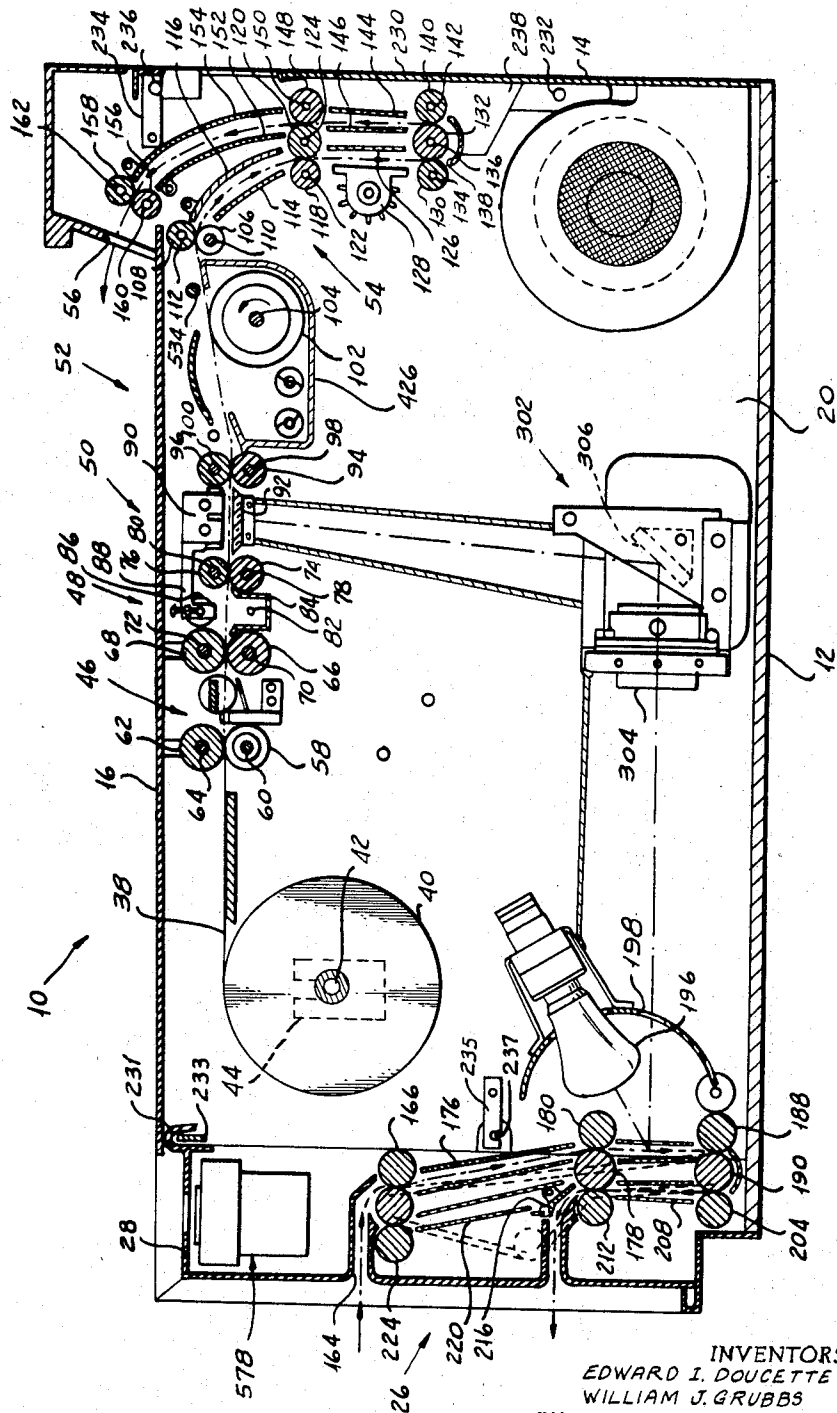
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TONER MONITORING SYSTEM FOR ELECTROSTATIC COPIER

Filed July 22, 1964

11 Sheets-Sheet 1

Fig 1



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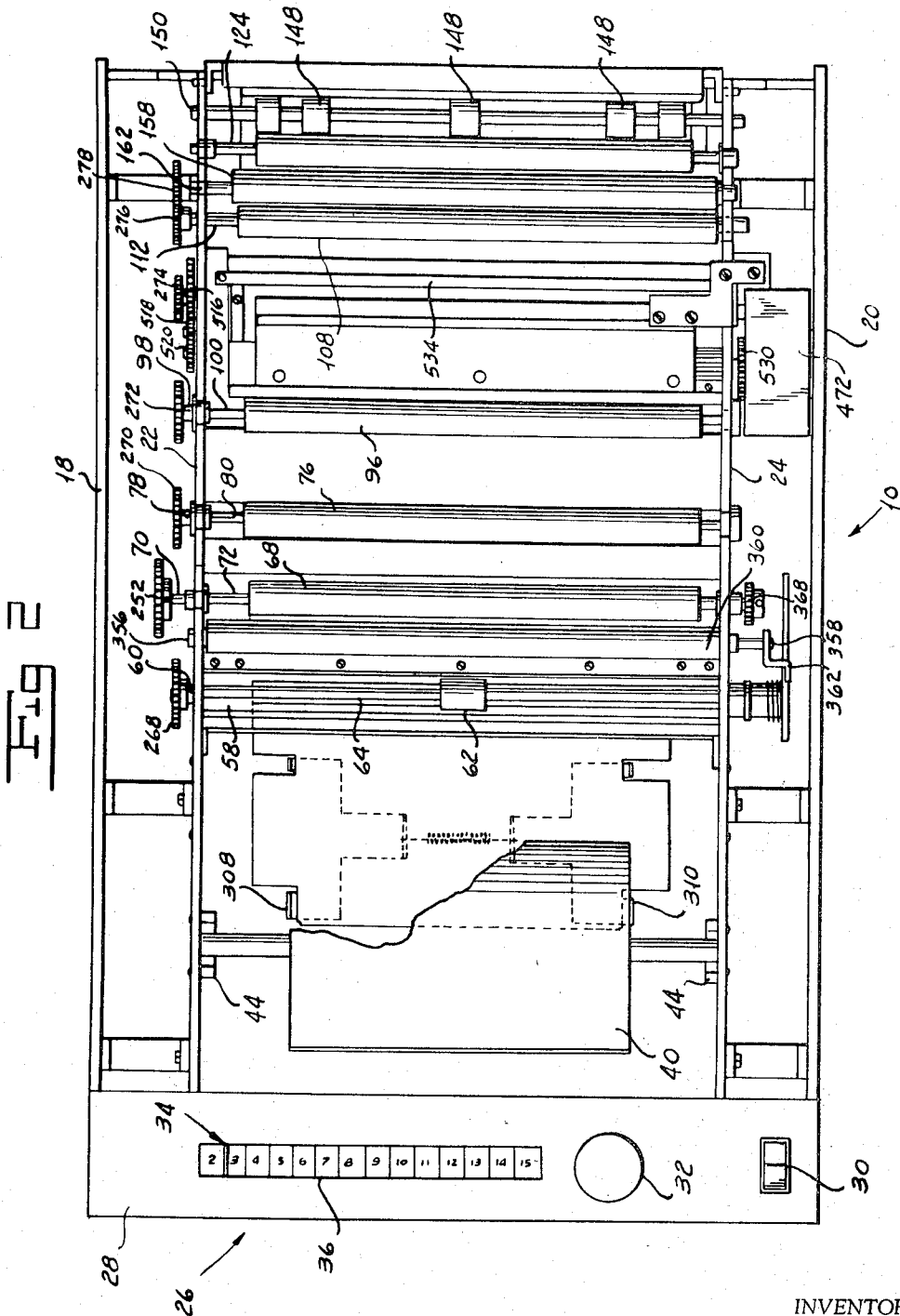
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11 Sheets-Sheet 2



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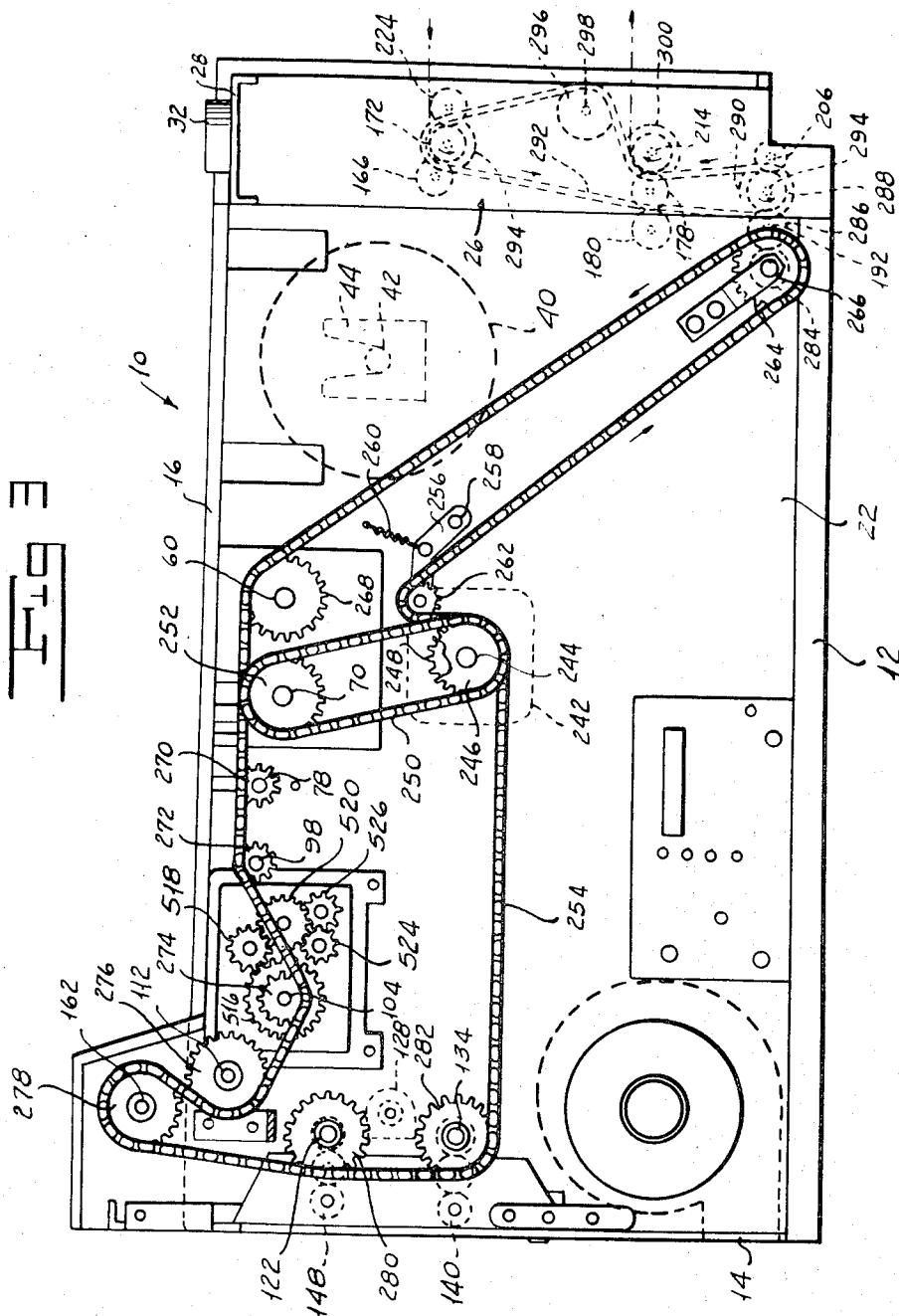
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11 Sheets-Sheet 3



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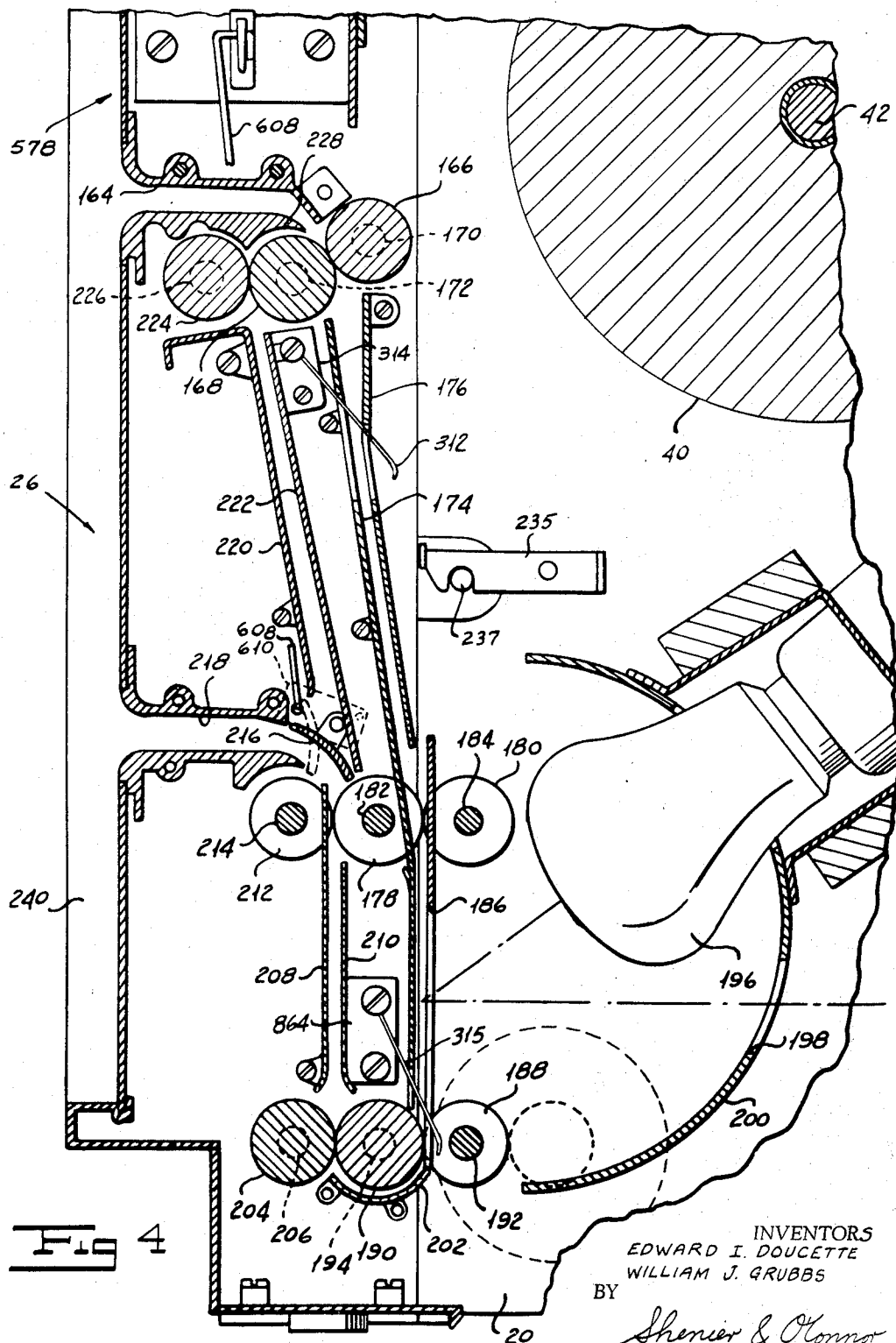
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11 Sheets-Sheet 4



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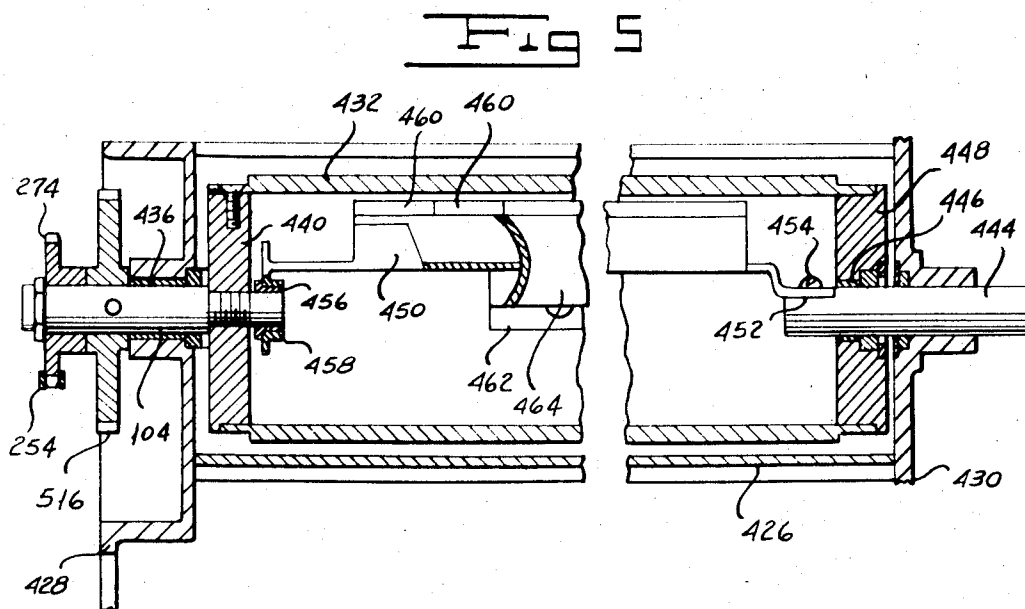
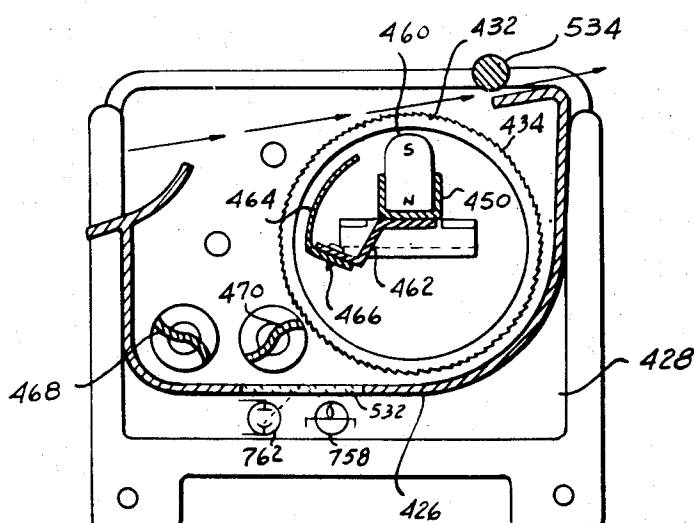
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11 Sheets-Sheet 5



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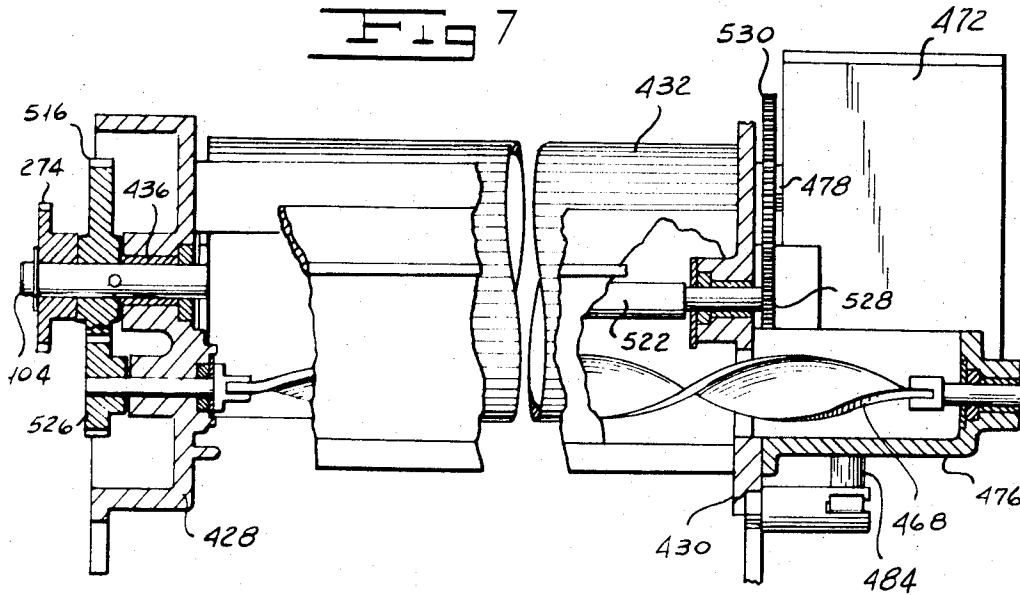
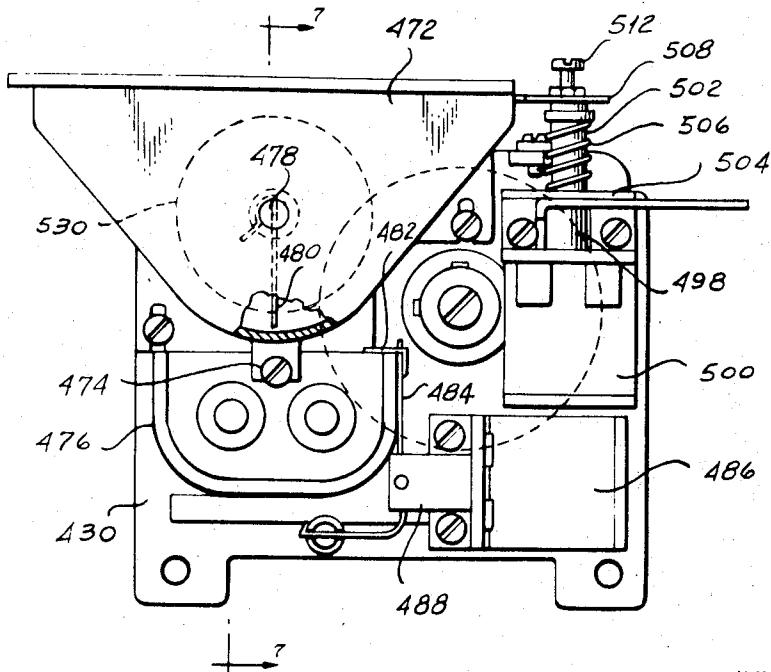
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11 Sheets-Sheet 6



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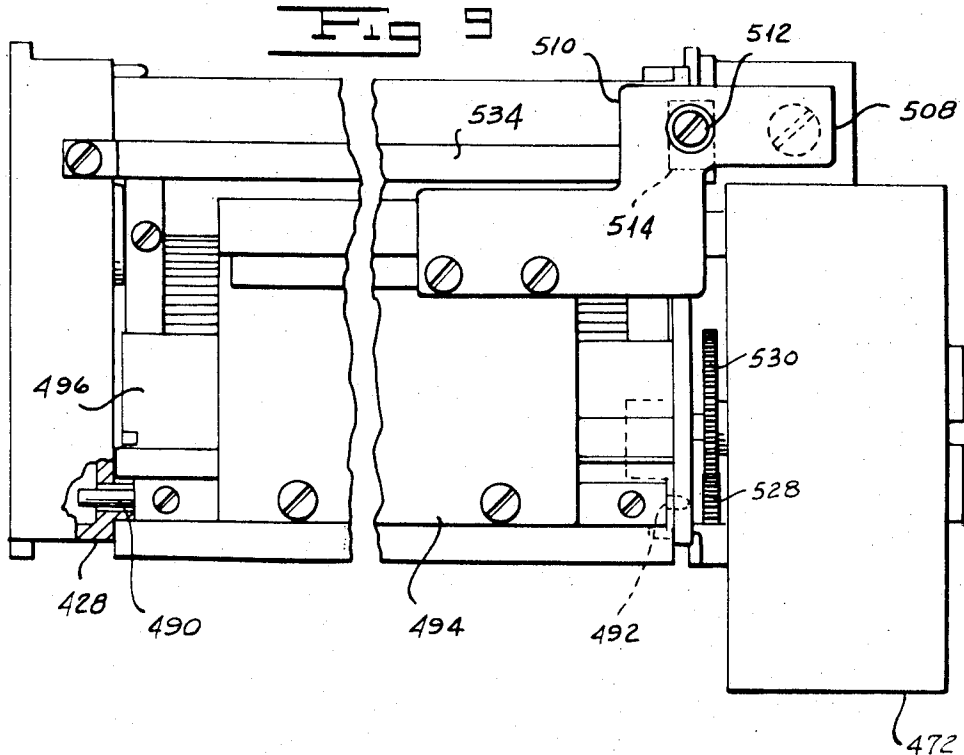
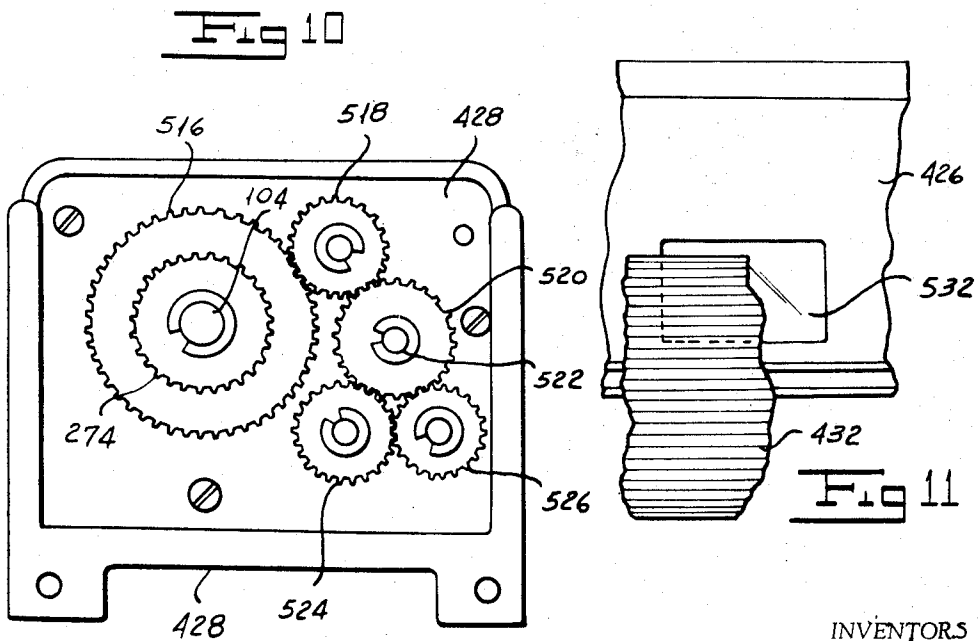
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11 Sheets-Sheet 7



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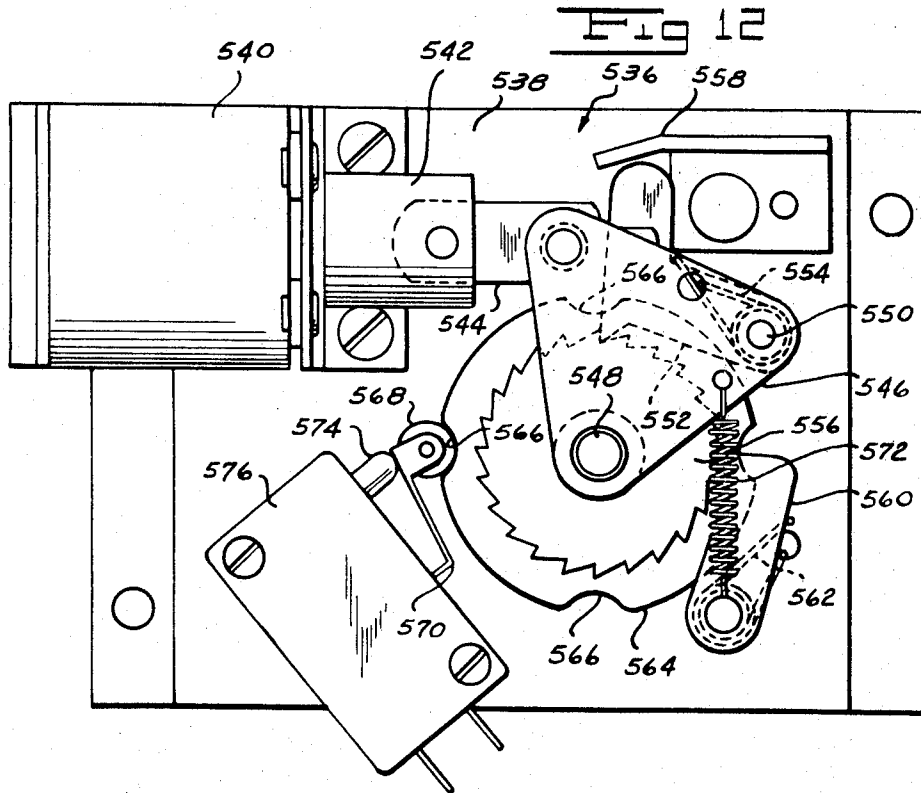
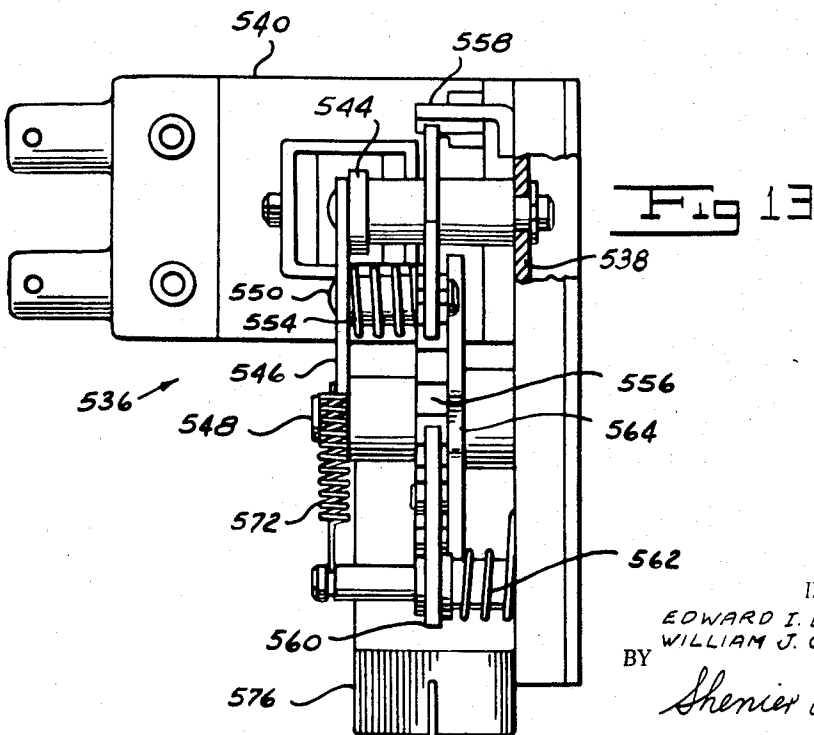
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11 Sheets-Sheet 8



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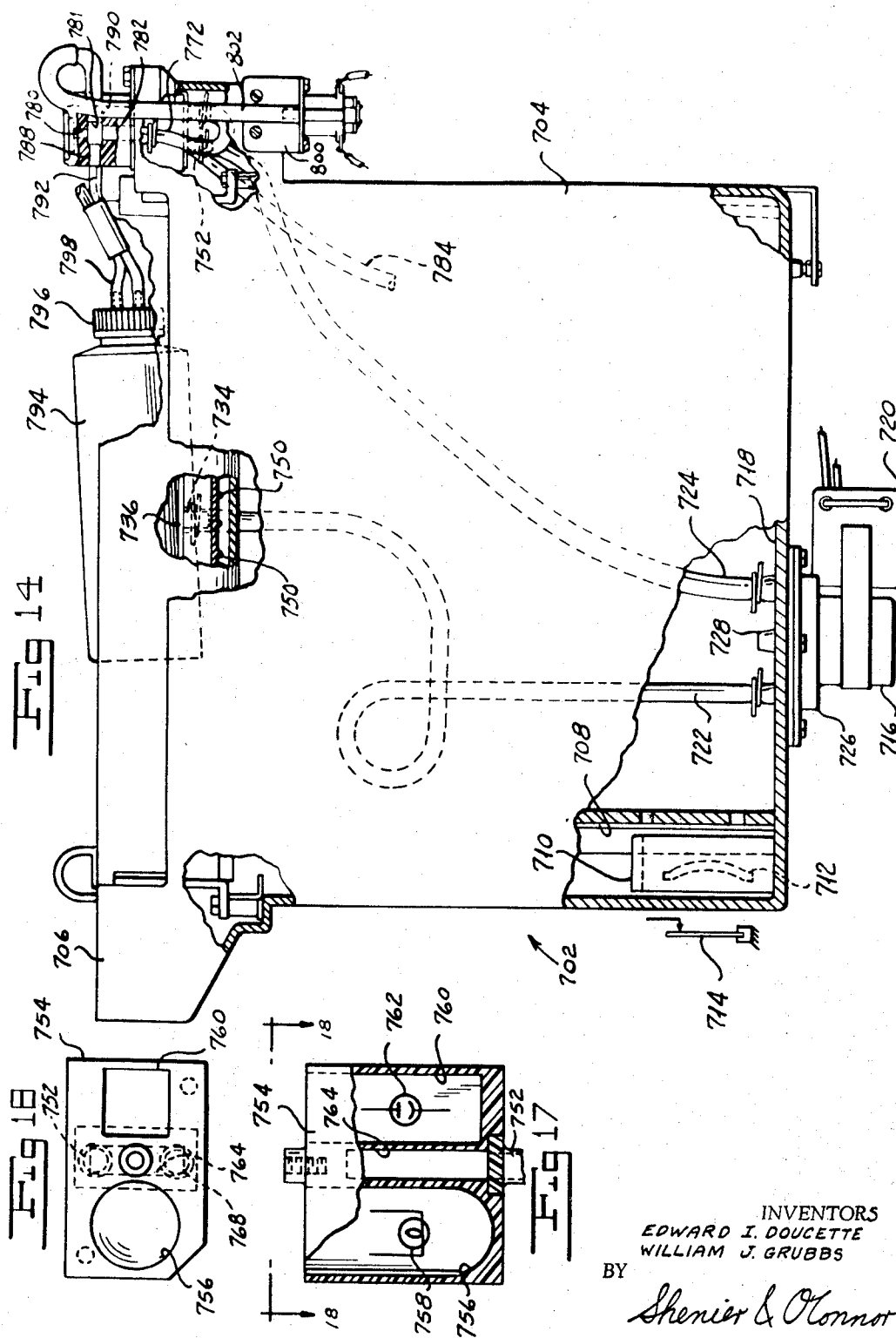
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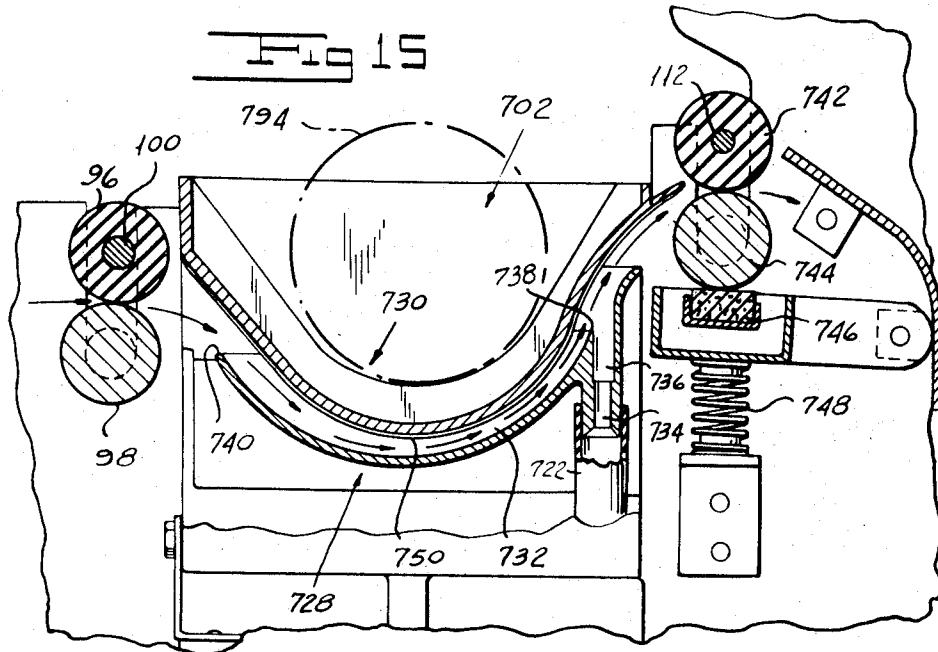
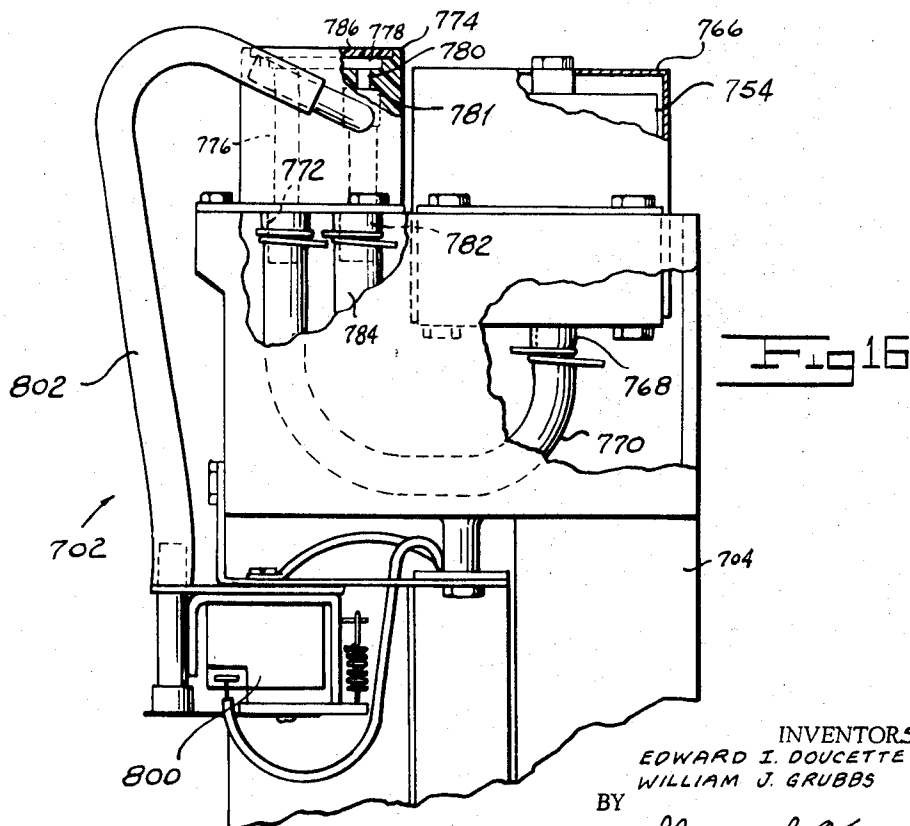
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11 Sheets-Sheet 10



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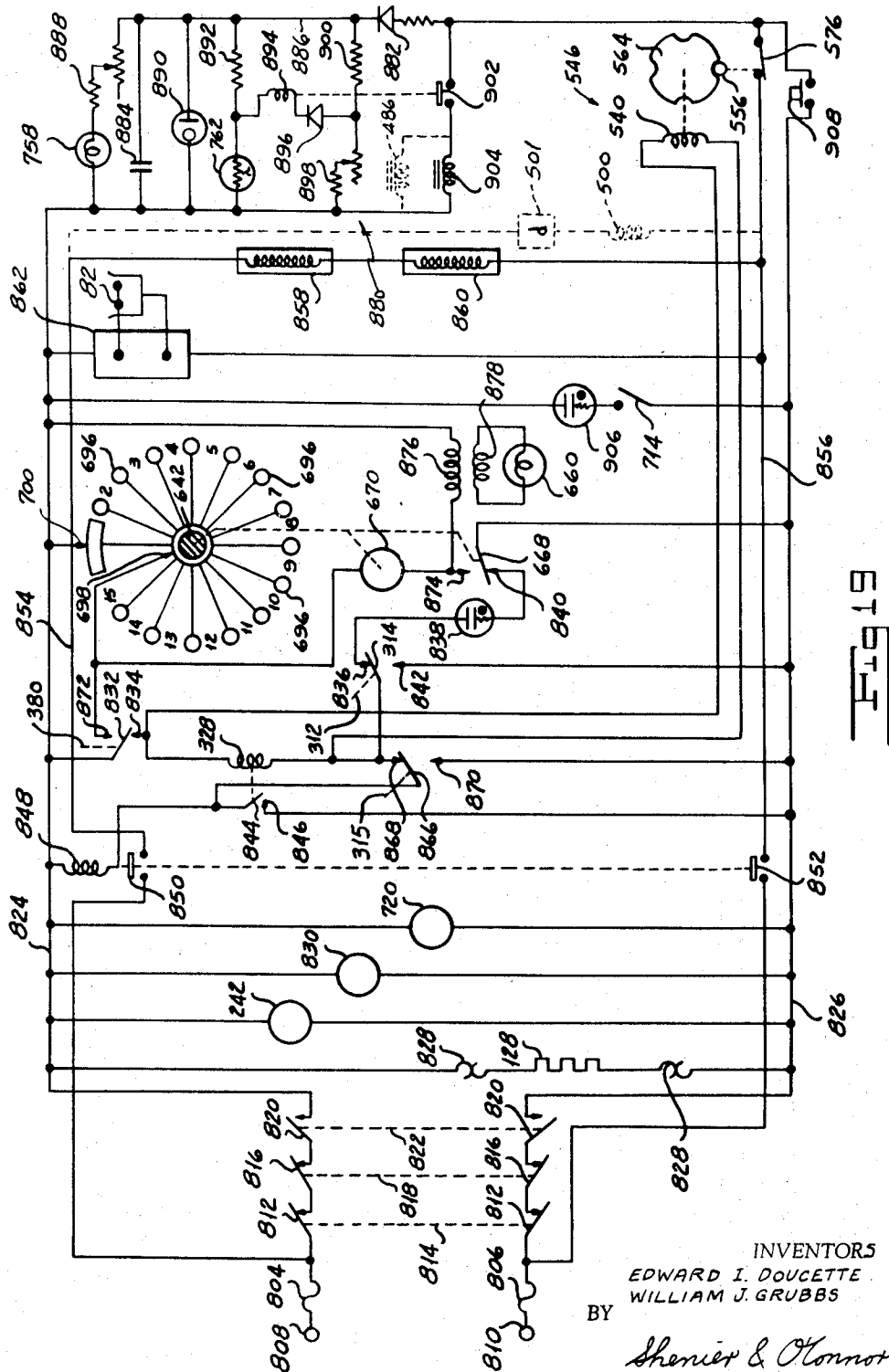
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11 Sheets-Sheet 11



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TONER MONITORING SYSTEM FOR ELECTROSTATIC COPIER

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14 Claims. (Cl. 95—1.7)

Our invention relates to an electrostatic copier and more particularly to a system for monitoring the toner content of the developer of the copier.

One of the many types of copying machines known in the prior art is the electrostatic copier in which copy material successively is fed through a charging zone wherein it receives an electrostatic charge, through an exposure zone in which an image of the original to be copied is focused on the charged copy material to produce a latent electrostatic image thereon, through a developing system in which the material carrying the latent electrostatic image is subjected to the action of a developer to cause particles of toner to adhere to the material over the uncharged areas thereof to develop the image, and thence through a fixing system which sets the image on the material.

Some of the electrostatic copiers employ a dry developer system in which the developer consists of carrier particles and particles of toner having a relationship in the triboelectric scale such that when the particles are mixed they become oppositely charged whereby the toner particles are picked up by the charged copy material and the carrier particles are repelled. Other machines employ a liquid developer which is a suspension of toner particles in a liquid carrier such, for example, as a suitable hydrocarbon. In each case as the electrostatic image is developed, toner particles are removed from the developer so that ultimately the toner is depleted to such an extent that only very faint copies can be made. It will readily be apparent that when this occurs more toner must be added to the developer if satisfactory copies are to be made.

It has been suggested in the prior art that electrostatic copying machines be provided with a system for adding toner as necessary. These systems of the prior art are generally inefficient and are not accurately controlled. As the copies being produced by the machine become too light to be satisfactory the operator adds toner as, for example, by pushing a button provided for this purpose. It will be appreciated that when and how much toner is added is under the control of the operator of the machine.

It has further been proposed that copiers be provided with automatic toner replenishing systems. In the normal course of operation of a copier, it will not ordinarily be necessary to add toner after each copying operation. As a matter of fact, where originals containing very little dark area thereon are to be copied, toner need not be added for a relatively long period of time. On the other hand, where originals having a relatively high proportion of dark area are being copied, while it is not necessary to add toner after each copying operation, it will become necessary to add toner after a relatively small number of copies have been made. Owing to these considerations, monitoring systems which operate continuously are relatively inefficient since they do much unnecessary work.

We have invented a monitoring system for electrostatic copiers which overcomes the disadvantages of toner adding systems of the prior art. Our system automatically adds toner as needed to produce satisfactory copies. It is rendered operative only after a predetermined number of copies have been made. It is more efficient than are systems of the prior art. Our arrangement may operate with

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either a dry developer or a wet developer system. It is simple and efficient for the result achieved thereby.

One object of our invention is to provide a toner monitoring system for an electrostatic copier which is energized each time a predetermined number of copies have been made.

Another object of our invention is to provide a toner monitoring system for an electrostatic copier which automatically adds toner to the developer as needed.

A further object of our invention is to provide a toner monitoring system for an electrostatic copier which is more efficient than are toner adders of the prior art.

A still further object of our invention is to provide a toner monitoring system for an electrostatic copier which is simple and certain in operation.

Other and further objects of our invention will appear from the following description.

In general our invention contemplates the provision of a toner monitoring system in which a replenisher responsive to the lightness of the dry or wet developer is conditioned to operate each time a predetermined number of copies have been made to add toner to the developer as required. In the wet developer system a unique Venturi arrangement adds toner to the developer in response to a demand.

In the accompanying drawings which form part of the instant specification and which are to be read in conjunction therewith and in which like reference numerals are used to indicate like parts in the various views:

FIGURE 1 is a sectional view illustrating a form of our improved electrostatic copier having a dry developer system.

FIGURE 2 is a top plan view of the form of our electrostatic copier illustrated in FIGURE 1.

FIGURE 3 is a side elevation of our electrostatic copy machine with a side panel removed illustrating the drive system of the machine.

FIGURE 4 is a fragmentary sectional view of our improved electrostatic copier illustrating the original transport mechanism thereof.

FIGURE 5 is a fragmentary sectional view of a portion of the dry developer system of the form of our copier shown in FIGURE 1.

FIGURE 6 is a side elevation of the dry developer system of the form of our copier shown in FIGURE 1.

FIGURE 7 is an elevational view of the dry toner system with parts broken away and with other parts shown in section of the form of our improved copier shown in FIGURE 1.

FIGURE 8 is an end elevation of the dry developer system illustrated in FIGURE 7.

FIGURE 9 is a top plan view of the dry developer system shown in FIGURE 7 with parts broken away and with other parts shown in section.

FIGURE 10 is an end elevation of the dry developer system shown in FIGURE 9.

FIGURE 11 is a fragmentary plan view of the dry developer system shown in FIGURE 7.

FIGURE 12 is a side elevation of a counter mechanism employed in our improved electrostatic copier.

FIGURE 13 is a plan view of the counter shown in FIGURE 12.

FIGURE 14 is a side elevation of a wet developer system which can be employed in our improved electrostatic copier with parts broken away and with other parts shown in section.

FIGURE 15 is a fragmentary sectional view of the wet developer system shown in FIGURE 14.

FIGURE 16 is a side elevation of the toner replenishing system of the wet developer system shown in FIGURE 14 with parts broken away and with other parts shown in section.

FIGURE 17 is a side elevation of a monitoring element of the toner replenishing system shown in FIGURE 16 with a part broken away.

FIGURE 18 is a top plan view of the monitoring element shown in FIGURE 17 taken along the line 18—18 of FIGURE 17.

FIGURE 19 is a schematic view of one form of electrical control circuit which can be used on our improved electrostatic copier.

Referring now to FIGURES 1 to 3, one specific form of our electrostatic copier indicated generally by the reference character 10 has a base 12, a back 14, a top 16, and removable side panels 18 and 20. Within the machine is the main machine frame including respective bearing support plates 22 and 24 held in spaced relationship by any suitable means known to the art.

We detachably mount an original transport system indicated generally by the reference character 26 at the front of the machine 10. The top 28 of the unit 26 carries a push button 30 for turning the machine on and off, as well as a knob 32 which can be actuated to set the machine to make a plurality of copies. Knob 32 moves a pointer 34 to a position with relation to a scale 36 at which the pointer indicates the number of copies the machine is set to make.

In a manner to be described hereinafter, as an original moves through the original transport system 26, copy material such as copy paper 38 is drawn from a roll 40 carried by a shaft 42 supported in brackets 44 carried by the plates 22 and 24. The copy material being drawn from the roll 40 successively passes through a cutting station indicated generally by the reference character 46, a corona system indicated generally by the reference character 48, a copy paper exposure station 50, a developing station 52 and a fixing system indicated generally by the reference character 54. Ultimately the developed copy passes outwardly through an opening 56 onto the upper surface of the top 16 to a position at which it is accessible to the operator of the machine.

More specifically, when a copy is being made, a copy paper lower feed roll 58 is clutched to a shaft 60 to cause the paper to be drawn through the nip between the roll 58 and an upper feed roll 62 carried by a shaft 64. After passing through the cutter station 46, the copy material passes through the nip between a pair of feed rolls 66 and 68 carried by shafts 70 and 72. A pair of guide rolls 74 and 76 supported on shafts 78 and 80 carry the copy paper from the corona station 48 to the exposure station 50. As is known in the art, the copy material 38 carries a coating of photoconductive material such, for example, as zinc oxide or the like. As the length passes through the station 48, it is subjected to a potential between a corona discharge wire 82 disposed in a housing 84 and a ground roller 86 carried by a bracket 88. Having thus received a charge, the paper passes between a guide 90 on bracket 88 and a window 92 through which an image of the original to be copied is focused on the paper in a manner to be described.

Respective feed rolls 94 and 96 carried by shafts 98 and 100 carry the copy paper from the exposure station 50 to the developer station 52. It will readily be understood by those skilled in the art that as the copy material carrying an electrostatic charge is exposed to the image to be copied, the charge leaks off in the relatively lighter area of the image and is retained over the relatively darker areas of the image. After having passed through the nip between rollers 94 and 96, the copy paper rides over a toner roller 102 carried by a shaft 104. As will be described in detail hereinafter, as the copy paper passes by the toner roller 102 it is brushed with particles of toner which are attracted to the charged areas of the material so as to be adhered thereto to develop a latent image on the copy material. As is known in the art, the toner may, for example, be powdered resinous material having a color which contrasts with that of the copy material 38.

As the copy material 38 leaves the developer station 52, it passes through the nip between rollers 106 and 108 carried by shafts 110 and 112. The rolls 106 and 108 feed the copy material to the space between a pair of guides 114 and 116 which lead to a pair of feed rolls 118 and 120 carried by shafts 122 and 124. The copy material 38 then passes through the space between a guide 126 and a heater 128 which applies sufficient heat to the particles of toner carried by the sheet to fuse them to the sheet without at the same time scorching the sheet.

Guide rolls 130 and 132 carried by shafts 134 and 136 feed the copy material to an arcuate guide 138 which directs the leading edge of the sheet up into the nip between the roll 132 and a roll 140 carried by a shaft 142. The sheet is then fed upwardly between guides 144 and 146 to the nip between the roll 120 and a roll 148 carried by a shaft 150. As will be described in detail hereinafter, when the original has passed through the original transport system 26, the length of material 38 being fed from the roll 40 has been cut to the length of the original. The cut sheet is fed by rolls 120 and 148 to guides 152 and 154 which direct the sheet to the nip between rolls 156 and 158 carried by shafts 160 and 162. These terminal rollers 156 and 158 direct the sheet through opening 56 onto the upper surface of the top 16 where it is accessible to the operator.

Referring now to FIGURES 1 and 4, an original to be copied is fed to the system 26 by passing it into an opening 164 to the nip between feed rolls 166 and 168 carried by shafts 170 and 172. Guides 174 and 176 direct the original from rolls 166 and 168 to the nip between rolls 178 and 180 carried by shafts 182 and 184. Rolls 178 and 180 guide the original toward an exposure window 186 to the nip between rolls 188 and 190 carried by shafts 192 and 194. As the original passes by the window, light from a source 196 is directed onto its surface to reflect an image from the sheet through an opening 198 in a light reflector 200 along a path indicated by the dot-dash line in FIGURE 4.

As the leading edge of the original emerges from between rolls 188 and 190, it engages a guide 202 which directs the original to the nip between roll 190 and a roll 204 carried by a shaft 206. The sheet is then directed upwardly as viewed in the figures and is guided by guides 208 and 210 to the nip between roll 178 and a roll 212 carried by shaft 214.

Our original transport system comprises a baffle 216 adapted to be moved in a manner to be described between the full line position shown in FIGURE 4 and the broken line position. In the full line position of the baffle 216, it directs the original out through an opening 218 through which it is returned to the user. In the broken line position of the baffle, the leading edge of the original moves upwardly past the baffle to guides 220 and 222 which carry the original upwardly to a nip formed by roll 168 and a roll 224 carried by a shaft 226. When this occurs, a guide 228 on one of the walls of the opening 164 directs the original back to the nip between rolls 166 and 168 to cause the original to be recycled through the system 26. It will readily be apparent from the structure just described that the broken line position of the baffle 216 is that position it occupies when multiple copies of a single original are to be made.

From the structure described thus far, it will be apparent that shafts 60, 64, 70, 72, 78, 80, 98, 100, 104, 122, 134, 184 and 192 are supported on the main frame plates 22 and 24 or on subassembly support plates carried by these members. We mount the shafts 124, 136, 142 and 150 on a backdoor assembly comprising a door 230 which is secured to the back 14 of the machine by hinge pins 232. Any suitable means, such as a releasable catch 234 on the main frame, may engage a pin 236 on the door 230 to retain the door in its closed position. Inwardly extending flanges 238 support the shafts 124, 136, 142 and 150, as well as the guides 126, 144 and 146.

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The side walls 240 of the original transport unit 26 carry shafts 170, 172, 182, 184, 192, 194, 206, 214 and 226, as well as the guides of the original transport mechanism. We removably mount the unit 26 on the machine in any convenient manner. For example, hangers 231 on the assembly 26 may engage a bracket 233 on the main machine body. Latches 235 engage pins 237 on the assembly 26 to hold it in position.

Referring now to FIGURES 1 to 3, the drive system of our machine includes a drive motor 242 supported on the plate 22 for example. Motor 242 is adapted to be energized in a manner to be described to drive a shaft 244 carrying a pair of sprocket wheels 246 and 248. Wheel 246 drives a pitch chain 250 in engagement with a sprocket wheel 252 on the shaft 70. When energized, motor 242 drives shaft 244 in a counterclockwise direction as viewed in FIGURE 3 to drive shaft 70 in a counterclockwise direction. Sprocket wheel 248 drives a pitch chain 254 which provides the main drive for the machine. A bracket 256 swingably supported on a pin 258 on plate 18 is normally urged by a spring 260 to swing in a clockwise direction as viewed in FIGURE 3. Bracket 256 carries a sprocket wheel 262 which engages the chain 254 to take up the slack in the chain.

Chain 254 extends from sprocket wheel 262 around a wheel 264 on shaft 266 carried by a bracket on plate 22 and thence upwardly to sprocket wheels 268 and 270 carried by shafts 60 and 78. From wheel 270, chain 254 extends over a sprocket wheel 272 on shaft 98, under a wheel 274 on shaft 104, under a sprocket wheel 276 on shaft 112 and over a wheel 278 on shaft 162. From the wheel 278, chain 254 passes downwardly and into driving engagement with a sprocket wheel 280 on shaft 122 and under a wheel 282 on shaft 134 and back to wheel 248.

From the structure just described, it will be seen that when motor 242 is energized, shafts 60, 78, 98, 162, 122, 134 and 266 all are driven in a counterclockwise direction as viewed in FIGURE 3. Shafts 104 and 112 are driven in a clockwise direction. Shaft 266 carries for rotation therewith a gear 284 which engages a gear 286 on shaft 192. Gear 286 drives a gear 288 on shaft 194 to drive a sprocket wheel 290. Wheel 290 drives a pitch chain 292 which extends upwardly from the sprocket wheel 290 to a wheel 294 on shaft 172 and then downwardly around an idling, chain-tensioning sprocket wheel 296 on a shaft 298 carried by the unit 26. From wheel 296 the chain 292 extends over and drives a sprocket wheel 300 on shaft 214. It will be appreciated that with the unit 26 assembled on the machine, gear 288 is brought into driving engagement with gear 286. When motor 242 is energized to drive shaft 266 in a counterclockwise direction, shaft 192 is driven in a clockwise direction to drive shaft 172 in a counterclockwise direction and to drive shaft 214 in a clockwise direction through the medium of chain 292.

Referring to FIGURE 2, the main frame of the machine carries a pair of adjustable copy material guides 308 and 310 between which the copy paper passes in its travel toward the feed rolls 58 and 62. The distance between the guides 308 and 310 can be adjusted to accommodate copy material of varying widths.

Referring again to FIGURES 1 and 4, as has been explained hereinabove, as the original is carried past window 186, light from a source 196 impinges on the surface of the original and an image thereof is reflected back through opening 198 in the reflector 200. The base 12 carries an optical system indicated generally by the reference character 302 comprising a lens 304 through which the reflected image passes to a mirror 306 which directs the image upwardly through the window 92 over which the copy material is passing.

As has been explained hereinabove, when the push button 30 is actuated to turn the machine on, the chains 254 and 292 drive the various rollers in the manner set forth hereinabove. When the machine is to make a copy,

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the original is inserted into the opening 164 and is advanced by rolls 166 and 168 through the space between guides 174 and 176 until it engages a feeler 312 adapted to operate a microswitch 314. One of the operations to be performed in response to operation of the switch 314 is the initiation of the copy paper feeding operation. As has been explained, this operation is achieved by clutching roll 58 to the shaft 60. As it continues its travel through the original transport system, the original engages a lower feeler 315 to actuate a switch 864. While we have shown switches 314 and 864 as being mounted on the removable unit 26, they may more conveniently be carried by the main machine body to facilitate the making of the necessary electrical connections.

At the cutting station 46 we dispose a cutting mechanism which, since it per se forms no part of our invention, we will not describe in detail. A suitable mechanism is shown and described in detail in the copending application of Charlap et al., Ser. No. 379,232, filed June 30, 1964 for an electrostatic copier. As is pointed out more fully in that application, in response to actuation of the feeler 312 by the leading edge of an original, roll 58 is driven to advance copy material from the roll 40 through the cutting station 46. Then when the trailing edge of the original leaves the feeler 312, roll 58 is no longer driven and the cutter mechanism operates to cut the copy material.

Referring now to FIGURES 1 to 3 and 5 to 11, as the copy material leaves the rollers 66 and 68, it passes through the space between corona wire 82 and ground roller 88 and receives an electrostatic charge. It then advances through rollers 74 and 76 and over window 92 through which an image of the original is projected onto the copy paper. It loses its charge over the relatively lighter areas of the image and retains the charge over the relatively darker areas before it is fed by rollers 96 and 98 into the developer zone 52 of the machine.

In one form of our copy machine we employ a dry developer system comprising a tray 426 supported between developer assembly side plates 428 and 430 carried by the main side plates 22 and 24 of the frame. We dispose a developer roller 432 having a serrated surface 434 for rotary movement in the tray 426. A bushing 436 supported in the plate 428 rotatably carries the shaft 104. We secure an end plate 440 of the toner roller 432 to shaft 104 for rotation therewith so that when the shaft 104 is driven in a manner to be described, the toner roller 432 is driven. A stationary shaft 444 mounted in the side plate 430 carries a bushing 446 which rotatably supports the other end plate 448 of the roller 432.

One end of a magnet support bracket 450 carries a lug 452 which we secure to the shaft 444 by any suitable means, such as by a screw 454. A bushing 456 on a portion of the shaft 104 extending inwardly beyond the plate 440 receives a boss 458 on the bracket 450. We dispose a plurality of magnets 460 along the length of the bracket 450. The bracket 450 carries a pair of spaced shield mounting brackets 462 to which we secure a shield 464 by any suitable means, such as screws 466.

From the structure just described, it will be apparent that the magnet and shield assembly is stationary while the developer roller 432 will rotate in response to rotation of the shaft 104.

As will be described in detail hereinafter, in the dry developer form of our machine, tray 426 normally holds a supply of a mixture of a magnetic material such, for example, as iron filings and a toner which may, for example, be a suitably colored resin adapted to be attracted to the charged areas on the copy material and thereafter fused to the copy material by the application of heat. In order to ensure that the mixture of the carrier particles and the toner particles is as uniform as is possible, we rotatably mount a pair of agitators 468 and 470 in the side plates 428 and 430. These agitators are constantly driven to mix the toner particles with the particles of

carrier material. We mount a toner supply housing 472 outboard of the side plate 430 by any suitable means such, for example, as by a screw 474 secured to an extension 476 of the tray 426 into which both of the agitators 468 and 470 extend. Housing 472 carries a shaft 478 which supports an agitator 480 which, in response to rotation of shaft 478, stirs the toner particles within the container 472. We provide the toner adder assembly with a gate 482 normally urged closed by a spring 484 secured to the side plate 430. When in a manner to be described hereinafter, the supply of toner in the dry developer has become depleted, a signal is fed to a solenoid 486 to energize the solenoid to draw its armature 488 to the right as viewed in FIGURE 8 to permit toner to drop through the bottom of housing 472 into the extension 476 from which it is moved by the agitators 468 and 470 into the tray 426 adjacent the toner roller 432.

A pair of pivot shafts 490 and 492 pivotally support a clapper 494 on the side plates 428 and 430. We dispose a paper guide 496 below the clapper 494 ahead of the toner roller 432 in the direction of movement of the copy paper. The armature 498 of a solenoid 500 carries a screw 502 which extends upwardly through a bracket 504. A spring 506 on the screw bears between the bracket 504 and the head of the screw normally to urge the armature 498 to its uppermost limit position as shown in FIGURE 8. In this position of the screw, a lateral extension 508 on an arm 510 carried by the clapper 494 rests on the head of the screw 502. When a sheet of copy material is fed into the space between the guide 496 and clapper 494, solenoid 500 is energized to move the screw 502 downwardly to permit clapper 494 to fall under the influence of gravity toward the paper being fed to ensure contact between the paper and the material carried by the roller 432. An adjustable screw 512 on arm 510 is adapted to engage a strike plate 514 to limit the downward movement of the clapper.

As has been explained hereinabove, the drive mechanism of our machine comprises the chain 254 which drives a sprocket wheel 274 on shaft 104. Shaft 104 carries a toner roller drive gear 516 which drives an idler gear 518 carried by side wall 428. Gear 518 drives a gear 520 carried by the toner adder drive shaft 522 which is rotatably supported in the plates 428 and 430. Gear 520 engages respective gears 524 and 526 to rotate the agitators 468 and 470.

The end of shaft 522 outboard of plate 430 carries a gear 528 which meshes with the gear 530 carried by the shaft 478 of the toner supply. Thus, as the gear 516 rotates, agitator 480 is driven to stir the toner particles within the housing 472. It is to be noted that we provide a window 532 in the underside of the tray 426 to permit the dry developer to be monitored to determine when toner should be added in a manner to be described hereinafter.

We provide our assembly with an iron rod 534 disposed just over the adder as it moves onto the toner roller. This rod is in the fringe of the magnetic field produced by the toner magnets. It collects any stray particles to prevent them from falling onto the copy material as it moves through the developer system.

We provide our machine with a counter mechanism for producing an output pulse after a predetermined number of copies have been made. As will be explained hereinafter, this counter mechanism pulse is a demand pulse for enabling the toner adder system each time a certain number of copies has been made.

Referring now to FIGURES 12 and 13, our counter mechanism indicated generally by the reference character 536 comprises a plate 538 mounted at any suitable location on the machine such, for example, as on the plate 24. In a manner to be described hereinafter, a solenoid 540 receives an electrical impulse each time a copy is made on the machine. Solenoid 540 has an armature 542 connected by a link 544 to a bell crank 546 loosely sup-

ported on a shaft 548 carried by plate 538. In response to energization of the solenoid 540, plate 546 is oscillated once for each copy. A pin 550 on crank plate 546 supports a first pawl 552 which is normally urged by a spring 554 into engagement with a ratchet wheel 556 carried by shaft 548 for rotation therewith. A stop plate 558 on the support 538 ensures that the pawl 552 engages the wheel 556 to step the wheel as the solenoid actuates the crank 546. We provide our counter assembly with a locating pawl 560 normally urged by a spring 562 into engagement with the wheel 556.

Shaft 548 also carries for rotation therewith a cam plate 564 having recesses 566 into which a follower roller 568 supported by a spring 570 is adapted to ride. A spring 572 normally tends to urge the plate 546 to rotate in a clockwise direction to return armature 542 to its normal position following actuation.

We so construct our counter mechanism that there are a predetermined number such, for example, as six ratchet wheel teeth over the arcuate distance between a pair of successive recesses 566 on the plate 564. In response to the first energization of the solenoid 540, plate 564 is moved through one step in a counterclockwise direction to drive the follower 568 out of a recess against the action of spring 570. As it moves out of the recess, the follower 568 operates the actuating element 574 of a normally closed switch 576. The follower 568 remains out of a recess 566 until the sixth energization of solenoid 540 at which time it drops back into the recess. It will thus be apparent that our counter mechanism produces a pulse each sixth copy in the particular form of the counter shown in the drawings.

We provide our machine with a repeat copy mechanism which has not been shown in detail since it per se does not form a part of our invention. Suitable mechanism for producing repeat copies is shown and described in detail in the copending Charlap et al. application referred to hereinabove. As is pointed out in that application, knob 32 is adapted to be actuated to set the gate or baffle 216 to the broken line position shown in FIGURE 4 to recycle the original through the original transport mechanism 26. As is also pointed out in the copending application, the baffle 216 is automatically reset to return the original when the desired number of repeat copies have been made.

Referring now to FIGURES 14 to 18, we have shown a form of our machine in which a wet developing system, indicated generally by the reference character 702, is used in place of the dry developer system, indicated generally by the reference character 52 in FIGURE 1. As will be apparent from the description hereinafter, the wet developer system 702 may readily be interchanged with the dry developer system 52. The liquid developer system includes a tank 704 adapted to contain a supply of a suitable liquid developer comprising a carrier having particles of toner material suspended therein. An inlet passage 706 at the top of the tank permits additional carrier to be poured into the tank in the event that the supply of carrier is depleted through evaporation or the like. A chamber 708 at one side of the tank to which fluid is admitted receives a float 710 carrying a magnet 712 adapted to influence a reed switch 714 outside the tank. It will readily be apparent that when the float 710 reaches a predetermined low level within the chamber 708, thus indicating that the supply of developer is at a predetermined low level, then the magnet 712 actuates switch 714 to light a lamp in a manner to be described hereinafter to indicate that the supply of developer is too low.

We mount a pump 716 on the base 718 of the tank 704. The motor 720 is adapted to be energized to drive the pump to supply liquid developer to respective lines 722 and 724 connected to fittings leading to the impeller chamber 726 of the pump. A fitting 728' extending above

the base 718 of the tank permits liquid to flow into the pump.

We provide our liquid developer system with a trough, indicated generally by the reference character 728, adapted to be mounted on the top of the tank 704. This trough 728 receives an upper guide, indicated generally by the reference character 730, to provide a space 732 between the guide and the trough through which copy paper carrying a latent electrostatic image can pass and be subjected to the action of the liquid developer.

We connect the tubing or pipe 722 to a fitting 734 leading into a distribution channel 736 extending from side-to-side of the trough. When pump 716 is being driven, developer supplied to the line 722 is fed up into the distribution channel and flows over an edge 738 of the channel into the space 732. It fills up this space 732 between the upper guide 730 and the trough 728 until the excess flows over an edge 740 at the front of the trough and returns to the tank 704. It will thus be apparent that the space 732 is supplied with developer liquid to a predetermined level.

A length of copy material passing through the machine is fed by rolls 98 and 96 into the space 732 and travels through the space and upwardly to squeeze rolls 742 and 744, the upper roll 742 of which is formed from rubber or the like and the lower roll of which is formed from metal. A wiper 746 is normally urged by a spring 748 into engagement with the roll 744 to remove moisture therefrom. From the rolls 742 and 744 the sheet of copy material passes to the section 54 which, in the liquid developer form of our machine serves to dry the copy. It will readily be apparent that roller 742 may be carried by the driven shaft 112. It will be noted that we provide the upper guide with a plurality of ribs 750 on the underside thereof to facilitate passage of the copy material through the space 732.

We provide both forms of our machine with means for monitoring the developer to ensure that the correct proportion of toner to developer exists and with means for replenishing the toner automatically as it is depleted in the course of making copies. In the liquid form of the machine, we connect the tube or pipe 724, which supplies liquid developer from the tank so long as pump 716 is driven, to one inlet 752 of a monitoring block 754 formed, for example, from a clear plastic resin. We form block 754 with a recess 756 for receiving a lamp 758 and with a recess 760 which receives a photocell 762. Passage 752 leads into a chamber 764 provided in the block between the chambers 756 and 760. It will readily be apparent that light from the lamp 758 passes through the walls defining the chamber 764 to the photocell 762. In so doing, it also passes through the liquid developer within the chamber 764. Consequently, if the liquid developer is too light or in other words has too little toner therein, photocell 762 will develop an output signal at a predetermined level, which as will be described hereinafter actuates the replenishing assembly.

We provide the block 754 with a cover 766 to shield the block from extraneous light. Block 754 has an outlet passage 768 which we connect by a hose 770 to one inlet 772 of an injector or jet pump body 774. The inlet 772 leads to a passage 776 entering into a recess 778. A flow restricting passage 780 leads to a space 781. An outlet passage 782 is connected back to the tank by a tube 784. Cover plate 786 closes the recess 778 so that liquid coming in through fitting 772 travels through passage 776, through the space 778 and outwardly through passage 780, space 781 and outlet 782 back to the tank.

We form the body 774 with respective passages 788 and 790 leading into space 781 from opposite sides thereof. A tube 792 connects the passage 788 to the interior of the toner bottle 794 through the bottle cap 796. Conveniently, the bottle 794 may rest within the upper guide 730 with the level of toner in the bottle below passage 780. Another tube 798 connects the interior of the bottle

794 to the atmosphere through the cap. We connect the passage 790 to a normally open air valve assembly 800 by a tube 802. Valve 800 is adapted to be actuated in response to an electrical signal in a manner known to the art to close valve 800.

From the structure just described, it will readily be apparent that under normal conditions when the liquid within tank 704 contains sufficient toner, photocell 762 produces no effective output signal. At the same time valve 800 is open and the liquid passing through the injector body 774 merely is returned to the tank. If, however, the liquid developer becomes too light indicating that toner should be added, then photocell 762 produces an output signal, which in a manner to be described hereinafter is fed to the valve 800 to actuate the valve to close passage 790. When this occurs, a Venturi effect causes toner to be drawn from the bottle 794 into the passage 788 and thence to the space 781 wherein it mixes with the developer until the system has sufficient toner. It is to be understood, of course, that the operation just described can take place only if a signal has been produced by the counter mechanism to actuate switch 576 to indicate that the developer should be checked for quantity of toner.

Referring now to FIGURE 19, we have shown one form of electrical control circuit which can be used to control the operation of our copier. The particular circuit illustrated in FIGURE 19 is for use with the liquid toner form of our machine discussed above. Respective fuses 804 and 806 connect our circuit to the terminals 808 and 810 of a suitable source of electrical power such, for example, as the usual 110 volt 60 cycle alternating current. Respective rear interlock switches 812 ganged by a connection 814 and lid interlock switches 816 ganged by a connection 818 connect the fuses 804 and 806 to on-off power switches 820 ganged by a connection 822. Thus, the fuses 804 and 806 together with the switches 812, 816 and 820 connect terminals 808 and 810 to main control circuit conductors 824 and 826. It will readily be appreciated that in the normal condition of our circuit before the machine is set for operation, the rear door and lid are closed so that switches 812 and 816 are closed but the power switches 820 are open.

In order to condition our machine for operation, we close switches 820 to apply power to lines 824 and 826. We connect the heater 128 across lines 824 and 826 by thermostats 828. We connect the main drive motor 242, the pump motor 720 and a blower motor 830 in parallel across the lines 824 and 826 so that when the switches 820 close, the heater is energized and all the motors 242, 720 and 830 are energized.

A switch 832 is normally held in engagement with a contact 834 by an arm 380 of the cutter mechanism shown in the copending Charlap et al. application. We connect the solenoid winding 328 and the counter mechanism solenoid 540 in parallel between contact 834 and the arm 314 of the upper switch responsive to the feeler 312 first engaged by an original inserted in the machine. Before the original is inserted, arm 314 engages a contact 836. We connect a glow lamp 838 indicating "insert" between contact 836 and a contact 840 engaged by the arm 668 of the switch which indicates that no repeat copies are to be made. Arm 668 is connected to line 826. From the structure just described, it will be apparent that when the power switches 820 have been closed the circuit of lamp 838 is complete from line 824 through arm 832 and contact 834, through winding 328, through arm 314 and contact 836, through the lamp 838 and through contact 840 and arm 668 to conductor 826. Thus lamp 838 indicates that the machine is ready to receive an original.

With the machine in the condition just described, when a copy is to be made the original is inserted into the original transport mechanism to engage feeler 312 to move arm 314 out of engagement with contact 836 and into engagement with a contact 842. It will be understood

that with lamp 838 in the circuit, winding 328 does not carry sufficient current to actuate the solenoid. When, however, arm 314 moves into engagement with contact 842, the winding is energized to pivot lever 334 to permit a switch arm 844 to engage a contact 846. The engagement of arm 844 with contact 846 energizes a relay winding 848 to close switches 850 and 852 to connect power from the fuses 804 and 806 to secondary control lines 854 and 856. In response to this operation, power is applied across the exposure lamps 858 and 860. At the same time, the high voltage power supply 862 is connected between line 824 and line 856 to apply power to the corona wires 82.

Engagement of the arm 314 with contact 842 also applies power to solenoid winding 540 of the counter mechanism 546 to step cam 564 through one step.

As the original travels through the original transport mechanism, it engages a second feeler 315 to operate a switch 864 having an arm 866 to move the arm out of engagement with a contact 868 and into engagement with a contact 870. This operation completes a circuit to winding 848 bypassing arm 844. Ultimately, the trailing edge of the original leaves the feeler 312 and arm 314 moves from contact 842 back to contact 836. Now, the solenoid 328 and the solenoid 540 are de-energized and arm 380 is permitted to operate the cutter mechanism in the manner described in the copending Charlap et al. application. When this happens, arm 832 moves out of engagement with contact 834 and into engagement with a contact 872. As will be explained hereinafter, this operation steps the multiple copy mechanism when the latter has been set to make more than one copy. Ultimately, the trailing edge of the original leaves the feeler 315 and arm 866 moves back into engagement with contact 868. Winding 848 is de-energized and the machine is set for the next copying operation.

As is pointed out in detail in the copending Charlap et al. application where more than a single copy is to be made, a shaft 642 is rotated to move a brush 700 to an intersegmental space between conductive segments 696 with the space corresponding to the number of copies which are to be made. When such a setting is made, an arm 668 of a switch positioned by shaft 642 moves into engagement with a contact 872 connected to one terminal of the resetting motor 670 of the repeat copy mechanism and to a terminal of a primary winding 876 connected to conductor 824. An indicating numeral illuminating lamp 660 is connected across the secondary winding 878 associated with winding 876. When multiple copies are to be made, lamp 660 illuminates a numeral corresponding to the number of copies.

With the machine set for multiple copies when the knife arm 380 moves it permits arm 832 to engage contact 872 to pulse motor 670 to initiate a movement thereof to bring the brush 700 into engagement with a segment 696 to provide a holding circuit for the motor so long as the brush 700 is in engagement with that segment. When the brush leaves the segment the motor circuit is broken. The repeat operation continues until shaft 642 returns to its initial position wherein arm 668 is moved out of engagement with contact 874 and back into engagement with contact 840 in the manner described in the copending application.

As has been explained hereinabove, each time a paper feeding operation begins, winding 540 is energized to move cam 564 through one step. After a predetermined number of steps of the cam, switch 576 closes to connect the toner replenishing circuit indicated generally by the reference character 880 across lines 824 and 856. Circuit 880 comprises a diode 882 and a capacitor 884 forming a rectifier to provide a direct current potential on a conductor 886. A current limiting resistor 888 provides a suitable potential for illuminating the lamp 758 of the toner monitoring mechanism. A voltage regulating tube 890 regulates the voltage on conductor 886. As has

also been explained hereinabove, light from the lamp 758 passes through the liquid developer toward the photocell 762 which we connect in series with a resistor 892 between line 824 and conductor 886. When the photocell 762 receives sufficient light, it conducts enough current to energize a relay winding 894 polarized by a diode 896 connected to the common terminal of voltage dividing resistors 898 and 900 connected between line 824 and line 886. When the winding 894 is energized, it closes a normally open switch 902 to energize the winding 904 of the valve assembly 800 to add toner to the liquid developer.

We connect switch 714 in series with a glow tube 906 between lines 824 and 826 so that when the supply of liquid developer reaches a predetermined low level, lamp 906 is illuminated to indicate that the supply of liquid developer must be replenished. A manually operable push button switch 908 permits relay 894 to be energized to add toner manually if desired.

In order to adapt the circuit of FIGURE 19 for use with the form of our machine using the dry developer, we may of course eliminate the pump motor 720. In order to energize the clapper solenoid 500, as the sheet of copy paper enters the space between the roll 192 and the clapper, we may connect the solenoid 500 in parallel with the illumination lamps 858 and 860 so that the solenoid will be energized in response to the closing of switches 850 and 852. If desirable, we may connect a delay network 501 in series with the winding 500 to prevent premature operation of the clapper. We replace the solenoid 904 of the liquid developer replenishing system with the winding 486 of the dry system. For purposes of simplicity, we have indicated the connections for the dry developer system in phantom in FIGURE 19. It will be appreciated further that, as is indicated in FIGURE 6, where the dry developer system is employed, the sensor monitoring arrangement operates on reflected light rather than on transmitted light. The circuit parameters can readily be adjusted for this operation.

In operation of a machine provided with our toner monitoring system with the lid closed and the machine plugged in, switches 820 are closed, for example, by operating push button 32 to set the machine in operation. Heater 128, motors 242, 720 and 839 are energized and the "insert" lamp 838 indicates that the machine is ready to receive an original. The original is then inserted into the system 26 and where only a single copy is made is returned through an opening 218. If the machine is set to make multiple copies with baffle 216 in the broken line position in FIGURE 4, lamp 660 rather than lamp 838 is lighted and the original recycles through the system 26 until the number of copies for which the machine has been set have been made. Each time the original passes through the system 26, the machine makes a copy of precisely the length of the original. The operation of the machine in producing copies is described in more detail in the copending Charlap et al. application.

Each time an original moves arm 314 into engagement with contact 842, winding 540 receives a pulse which steps cam 564 through one step. In the particular embodiment of our monitoring system shown and described, on each sixth step of cam 564 follower 556 falls into a cam recess to permit switch 576 to close to energize the toner monitoring system. Upon the occurrence of this event if the toner content of the developer, liquid or dry, is too low, photocell 762 is energized to operate relay 894 to close switch 902 to energize either the winding 904 of the liquid system or the winding 486 in the dry system. If the dry system is being used, winding 486 opens the gate 482 to permit toner to drop from the container 472 into the trough extension 476. If the liquid system is being employed, energization of winding 904 closes valve 800 to cause toner to flow from the bottle 794 into the passage 758 and thence down through hose 784 into the tank 704.

When sufficient toner has been added, cell 762 is de-energized and valve 800 opens.

If the supply of developer is below a predetermined low level, magnet 712 closes switch 714 to light lamp 906 to indicate that liquid carrier should be added. If for any reason it is desired to test toner content at some other time than after making a sixth copy, push button 908 is operated to condition the monitoring system.

It will be seen that we have accomplished the objects of our invention. We have provided a toner monitoring system which automatically adds toner to the developer as needed to make satisfactory copies. Our system is conditioned for operation each time a predetermined number of copies have been made. It is simple and efficient for the result achieved thereby.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of our claims. It is further obvious that various changes may be made in details within the scope of our claims without departing from the spirit of our invention. It is, therefore, to be understood that our invention is not to be limited to the specific details shown and described.

Having thus described our invention, what we claim is:

1. In a copying machine for subjecting copy material to the action of a liquid developer made up of toner and carrier from a supply of developer, a light source, a photosensitive element, means mounting said element and said light source in spaced relationship, means for flowing developer from said supply through the space between said element and said light source, means forming a first passage with a restriction therein, means for flowing developer from said developer supply through said first passage and back to said supply, a supply of liquid toner, means providing communication between said toner supply and said first passage adjacent said restriction, a second passage providing communication between the atmosphere and said first passage, means adapted to be actuated to close said second passage, an electrical circuit comprising said light source and said photosensitive element adapted to actuate said second passage closing means in response to a predetermined low toner content of said developer, a source of electrical energy, an original transport system for carrying an original along a predetermined path through said machine, a sensor disposed along said path to be actuated by an original moving along said path and means responsive to a predetermined number of actuations of said sensor for coupling said circuit to said source.

2. In a copying machine for subjecting copy material to the action of a liquid developer made up of toner and carrier from a supply of developer, a light source, a photosensitive element, means mounting said element and said light source in spaced relationship, means for flowing developer from said supply through the space between said element and said light source, means forming a first passage with a restriction therein, means for flowing developer from said developer supply through said first passage and back to said supply, a supply of liquid toner, means providing communication between said toner supply and said first passage adjacent said restriction, a second passage providing communication between the atmosphere and said first passage, means adapted to be actuated to close said second passage, an electrical circuit comprising said light source and said photosensitive element adapted to actuate said second passage closing means in response to a predetermined low toner content of said developer, a source of electrical energy and means responsive to a predetermined number of operations of said machine for coupling said circuit to said source.

3. In a copying machine, a system for replenishing the toner in a supply of liquid developer comprising means for producing a demand signal indicating that the proportion of toner in said developer is below a certain proportion, means forming a first passage with a restriction

therein, means for flowing developer from said supply through said first passage and back to said supply, a supply of liquid toner having a level below said restriction, means providing communication between said toner supply and said first passage adjacent said restriction, a second passage providing communication between the atmosphere and said first passage adjacent said restriction and means responsive to said demand signal for closing said second passage to draw toner from said supply into said developer flowing through said first passage.

4. In a copying machine, a system for replenishing the toner in a supply of liquid developer comprising means for producing a demand signal indicating that the proportion of toner in said developer is below a certain proportion, means forming a first passage with a Venturi restriction therein, means for continuously flowing developer from said supply through said first passage and back to said supply during operation of said machine, a supply of toner, means providing communication between said toner supply and said first passage adjacent said restriction, a second normally open passage providing communication between the atmosphere and said first passage adjacent said restriction, and means responsive to said demand signal for closing said second passage to draw toner from said supply into said developer flowing through said first passage.

5. A system as in claim 4 in which said signal responsive means comprises a normally open valve and means responsive to said signal for closing said valve.

6. In a copying machine for subjecting material to the action of a developer made up of toner and carrier, electrical developer monitoring means adapted to produce a signal in response to a predetermined low proportion of toner to carrier in said developer upon the application of electrical energy to said monitoring means, a source of electrical energy, a switch adapted to be operated to connect said monitoring means to said source, an original transport system for carrying an original along a path through said machine, a second switch adapted to be actuated by an original moving along said path and means responsive to a predetermined number of actuations of said second switch for operating said first switch.

7. In a copying machine for subjecting material to the action of a developer made up of toner and carrier, electrical developer monitoring means adapted to produce a signal in response to a predetermined low proportion of toner to carrier in said developer upon the application of electrical energy to said monitoring means, a source of electrical energy, a switch adapted to be operated to connect said monitoring means to said source, a cam, a follower associated with said cam, an operative connection between said follower and said switch, a ratchet wheel, a pawl associated with said wheel, means responsive to actuation of said ratchet wheel by said pawl for stepping said cam, a solenoid adapted to be energized to operate said pawl to step said ratchet wheel and means responsive to operation of said machine for energizing said solenoid.

8. In a copying machine for subjecting material to the action of a developer made up of toner and carrier, electrical developer monitoring means adapted to produce a signal in response to a predetermined low proportion of toner to carrier in said developer upon the application of electrical energy to said monitoring means, a source of electrical energy, a switch adapted to be operated to connect said monitoring means to said source, said switch being a normally closed switch, a cam having a recess therein, a follower associated with said cam, an operative connection between said follower and said switch for holding said switch open when said cam is out of said recess and means responsive to operation of said machine for stepping said cam.

9. In a copying machine for subjecting material to the action of a developer made up of toner and carrier, electrical developer monitoring means adapted to produce a

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signal in response to a predetermined low proportion of toner to carrier in said developer upon the application of electrical energy to said monitoring means, a source of electrical energy, a switch adapted to be operated to connect said monitoring means to said source, a cam, a follower associated with said cam, an operative connection between said follower and said switch and means responsive to operation of said machine for stepping said cam.

10. In a copying machine for subjecting material to the action of a developer made up of toner and carrier, electrical developer monitoring means adapted to produce a signal in response to a predetermined low proportion of toner to carrier in said developer upon the application of electrical energy to said monitoring means, a source of electrical energy, a switch adapted to be operated to connect said monitoring means to said source and means responsive to a predetermined plurality of operations of said machine for operating said switch.

11. In a copying machine for subjecting material carrying a latent electrostatic image to the action of a developer comprising toner and carrier, means adapted to be actuated in response to a predetermined number of operations of said machine, means adapted to be actuated in response to a predetermined low proportion of toner to carrier in said developer and means responsive to concomitant actuation of said machine operation responsive means and said toner content means for adding toner to said developer.

12. In a copying machine for subjecting material carrying a latent electrostatic image to the action of a developer made up of toner and carrier, means responsive to the operation of said machine for producing a signal each time a predetermined number of copies have been made, means for monitoring said developer to produce a signal when the toner content thereof is below a predetermined percentage of toner to carrier and means

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responsive to concomitant occurrence of said signals for adding toner to said developer.

13. In a copying machine for subjecting material carrying a latent electrostatic image to the action of a developer made up of a mixture of toner and carrier, means for counting copies made by said machine to provide a first signal when a predetermined number of copies are counted, means for monitoring said developer to provide a second signal when the toner-to-carrier content of said developer is below a predetermined level and means responsive to the concurrence of said first and second signals for adding toner to said developer when the toner content of said developer is below said predetermined low level.

14. In a copying machine for subjecting material carrying a latent electrostatic image to the action of a developer made up of toner and carrier, means responsive to a predetermined use of said material by said machine for producing a first signal, means for monitoring said developer to produce a second signal when the toner content of said developer is below a predetermined percentage of toner to carrier and means responsive to concomitant occurrence of said first and second signals for adding toner to said developer.

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