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[54] **ELECTROSTATOGRAPHIC OFFICE COPIER**
5 Claims, 15 Drawing Figs.

[52] U.S. Cl. **118/637,**
 95/89, 117/37, 118/410

[51] Int. Cl. **B05b 5/02,**
 B05c 3/02

[50] Field of Search **118/637,**
 203, 262, 212, 204, 410; 117/37 LX; 95/89, 94;
 15/256.52

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ABSTRACT: Apparatus for electrostatographically copying, particularly with the use of copy sheets coated with a photoconductor wherein the photoconductive surface is charged, exposed to form a latent electrostatic image and developed. In the development zone, a copious supply of developer liquid is engaged against the image-bearing surface in close adjacency to an electrode surface. This is accomplished by applying liquid to the peripheral surface of an electrode in the form of a roller, or by the use of an electrode taking the form of a wick having capillary passages formed therein, or by a stationary electrode member having an action surface intersected by plural capillary passages. Liquid developer material is thus applied to only the image-bearing surface to render the latent image visible and utilitarian.

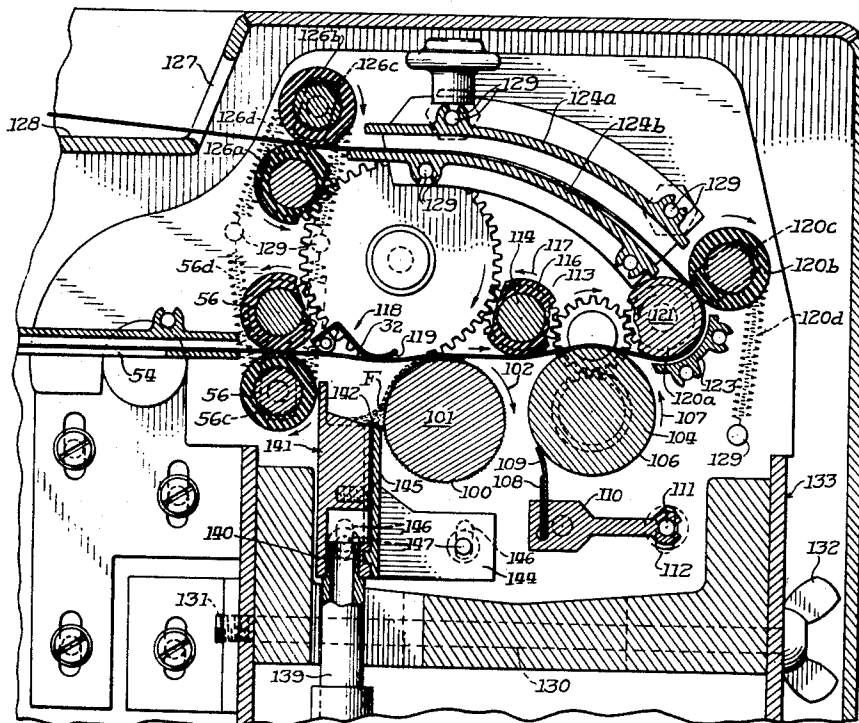


Fig. 1.

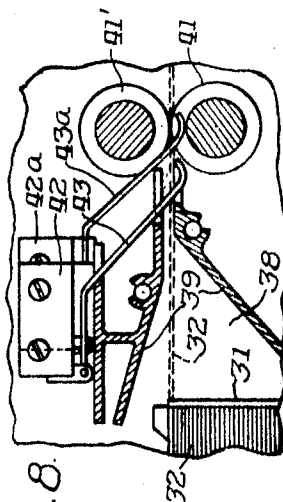
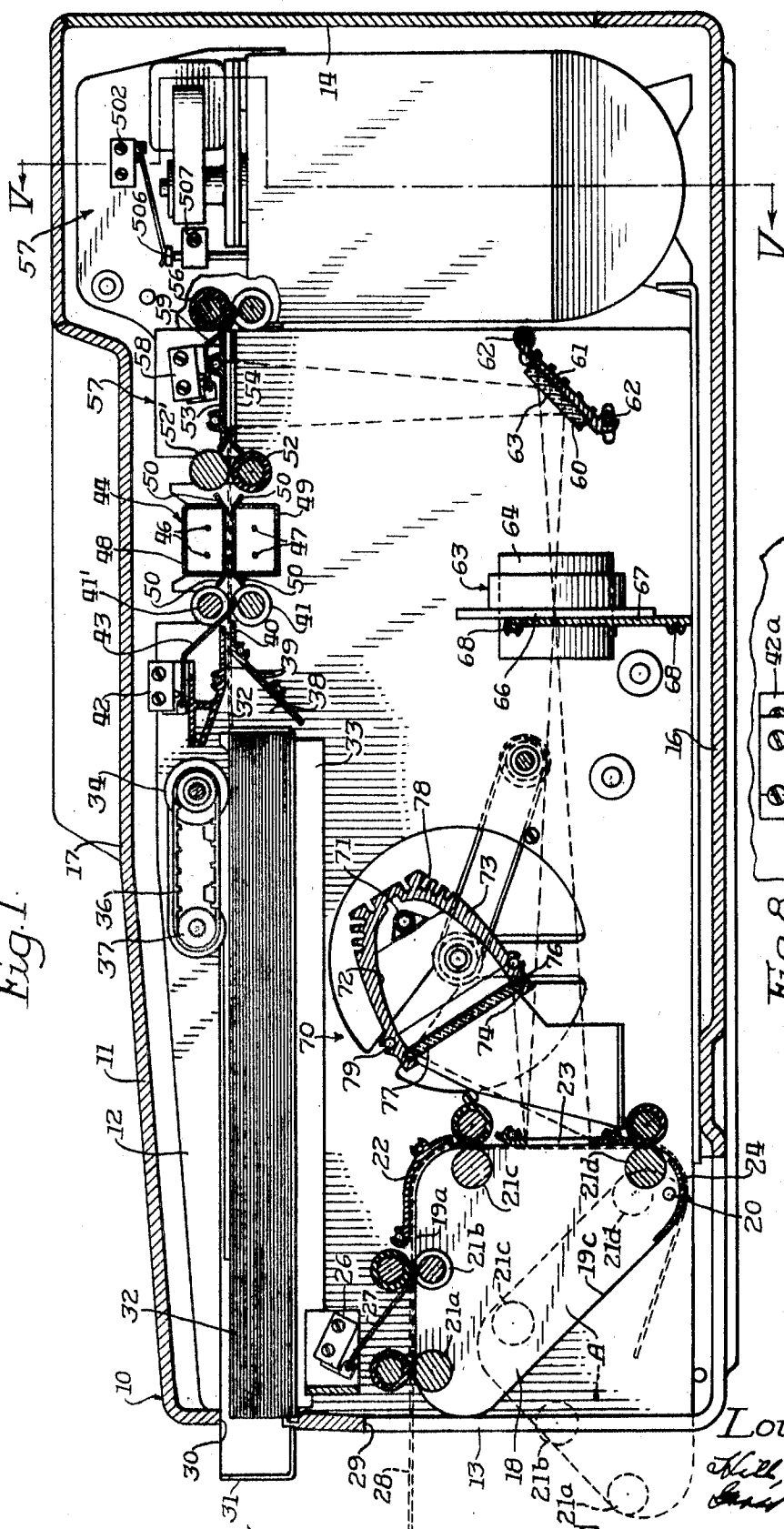


Fig. 8.

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Fig. 2

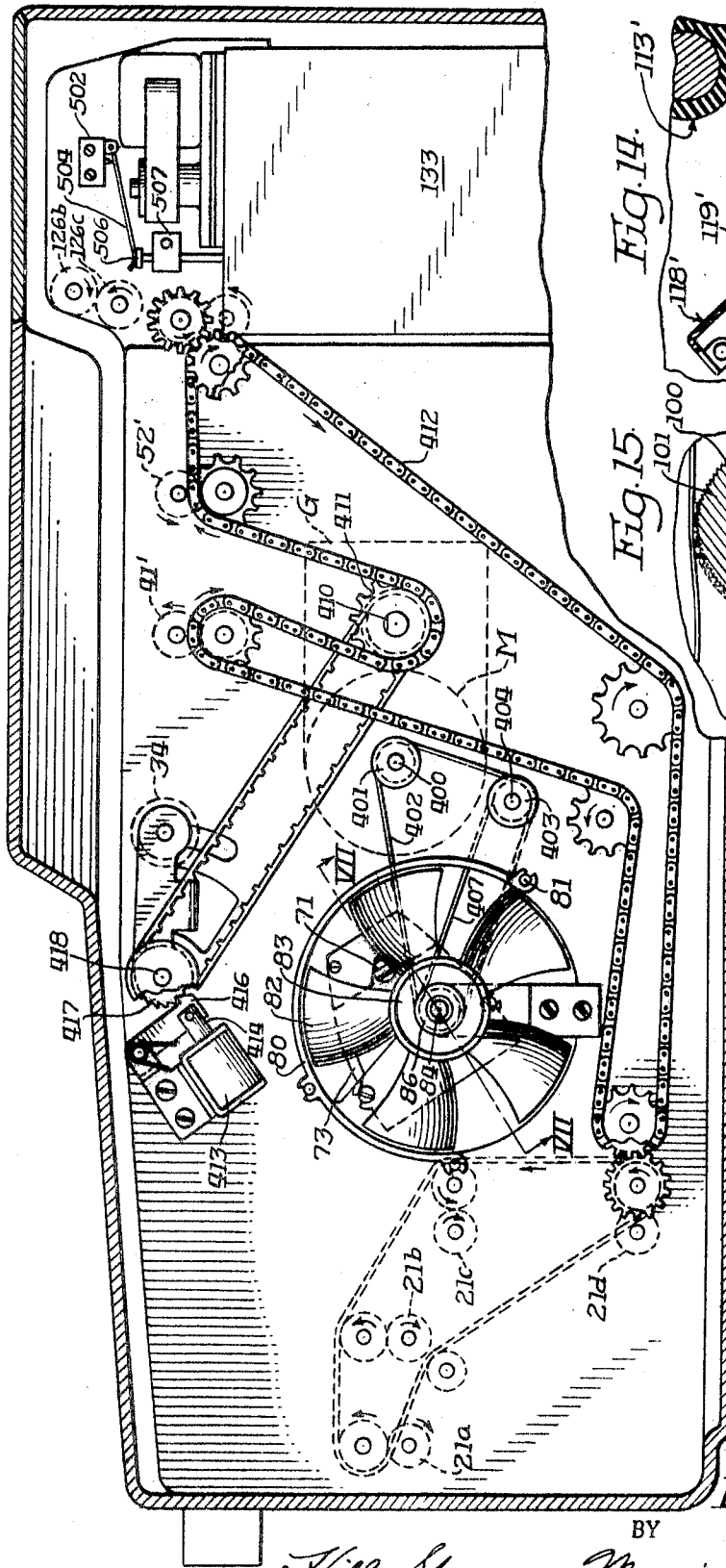


Fig. 14.

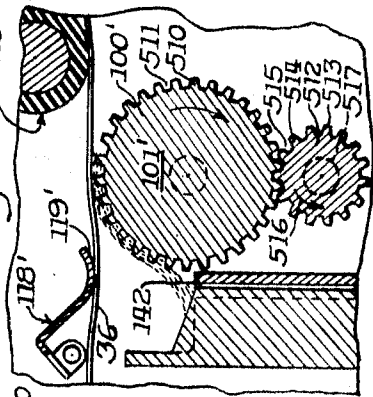
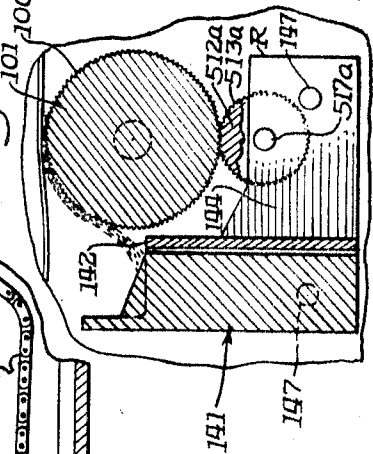


Fig. 15.

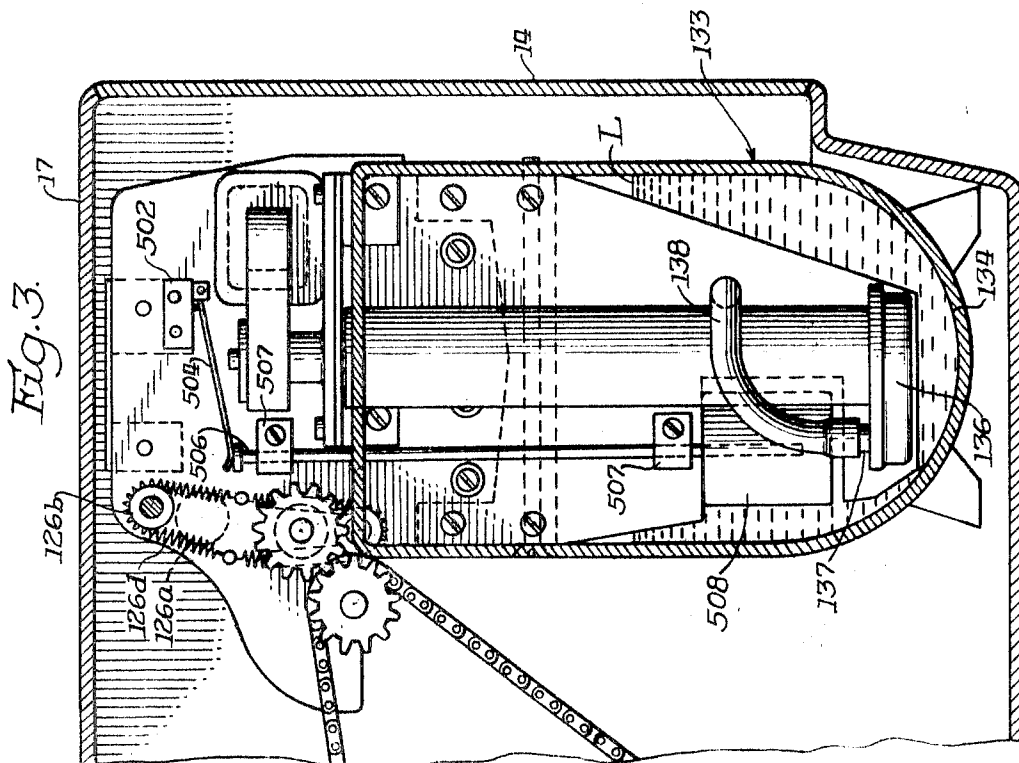
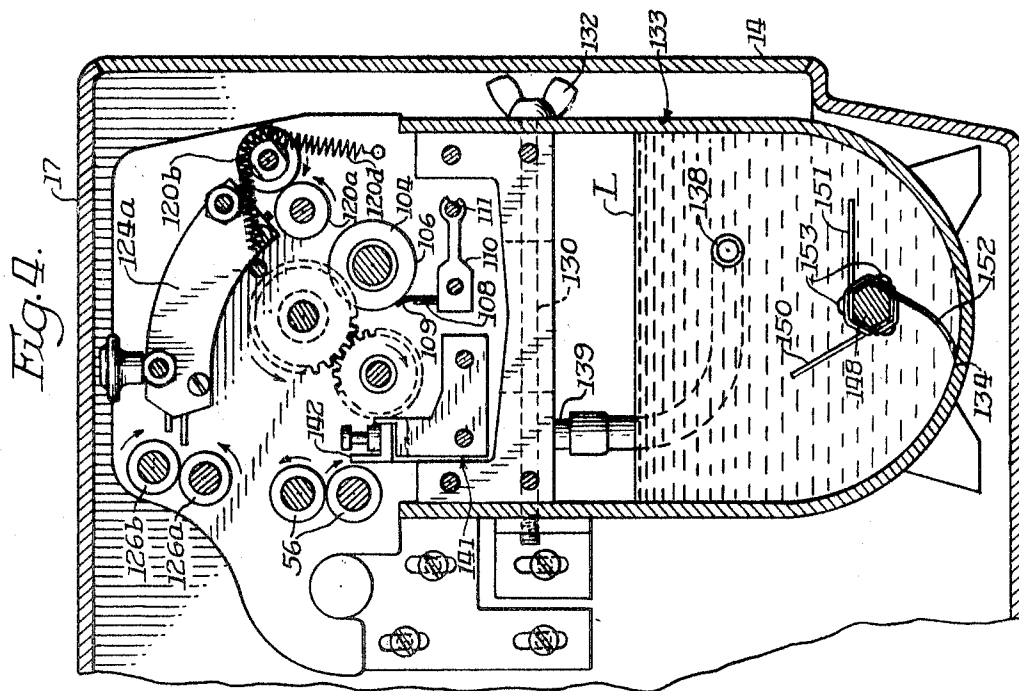


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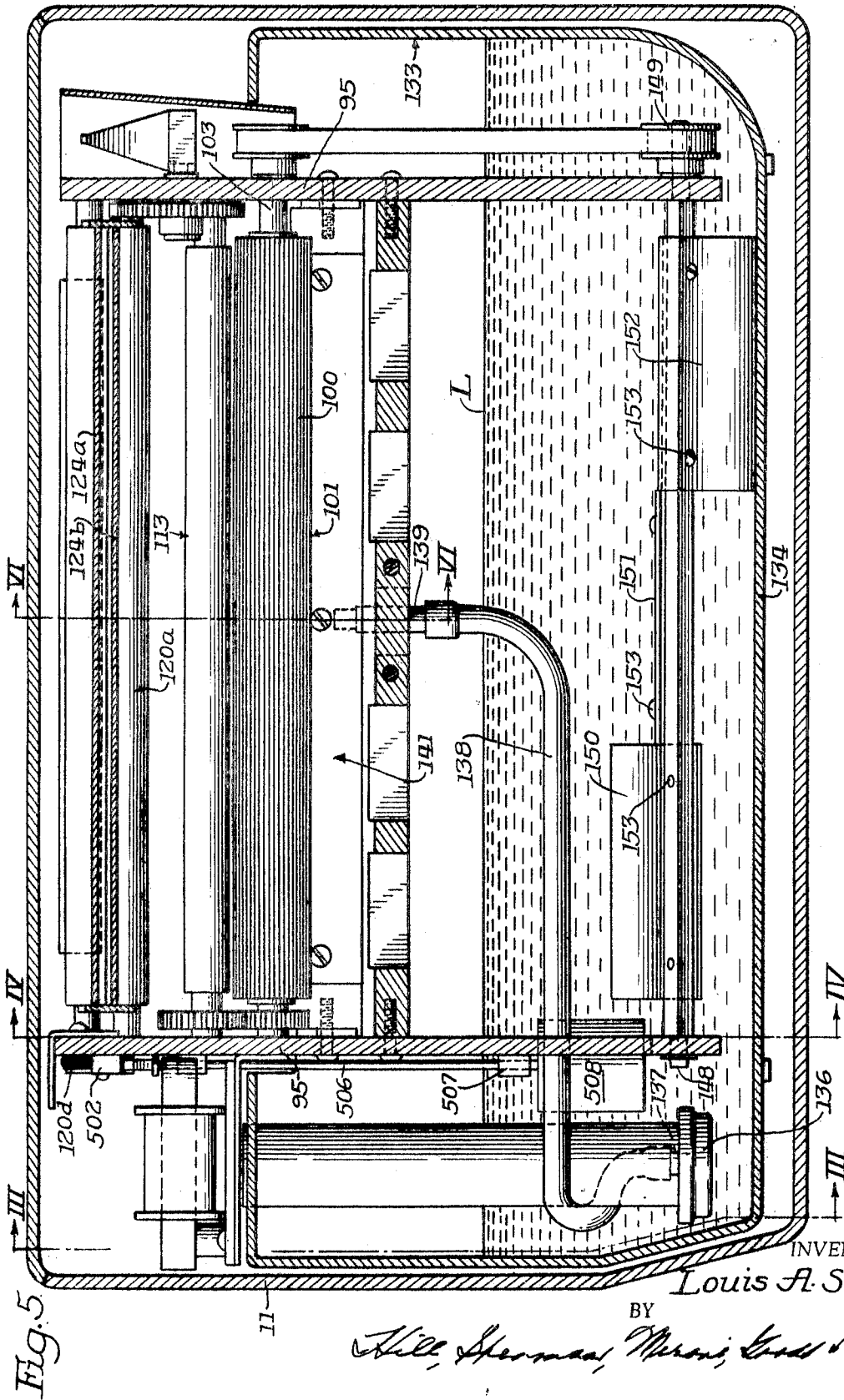
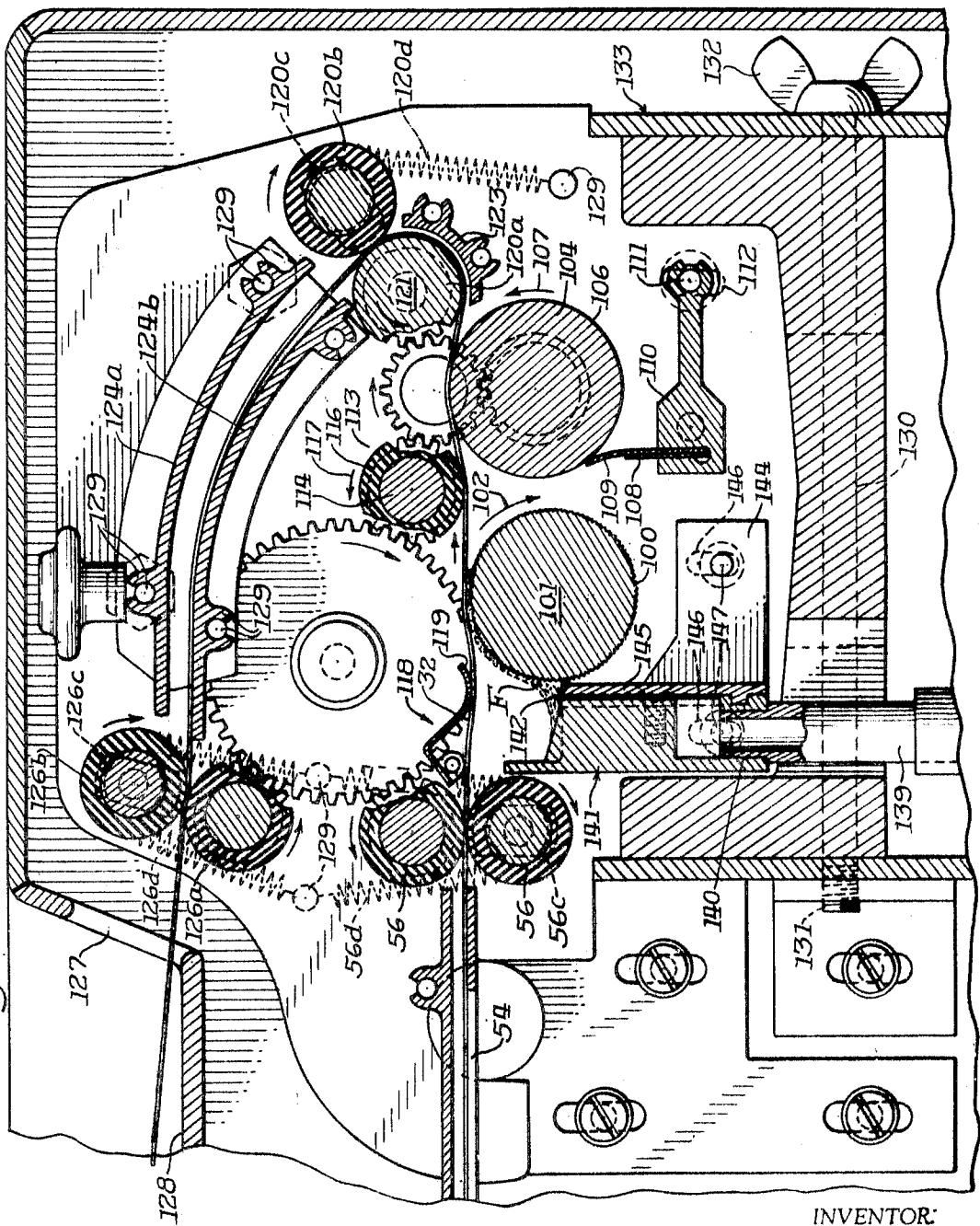


Fig. 6.



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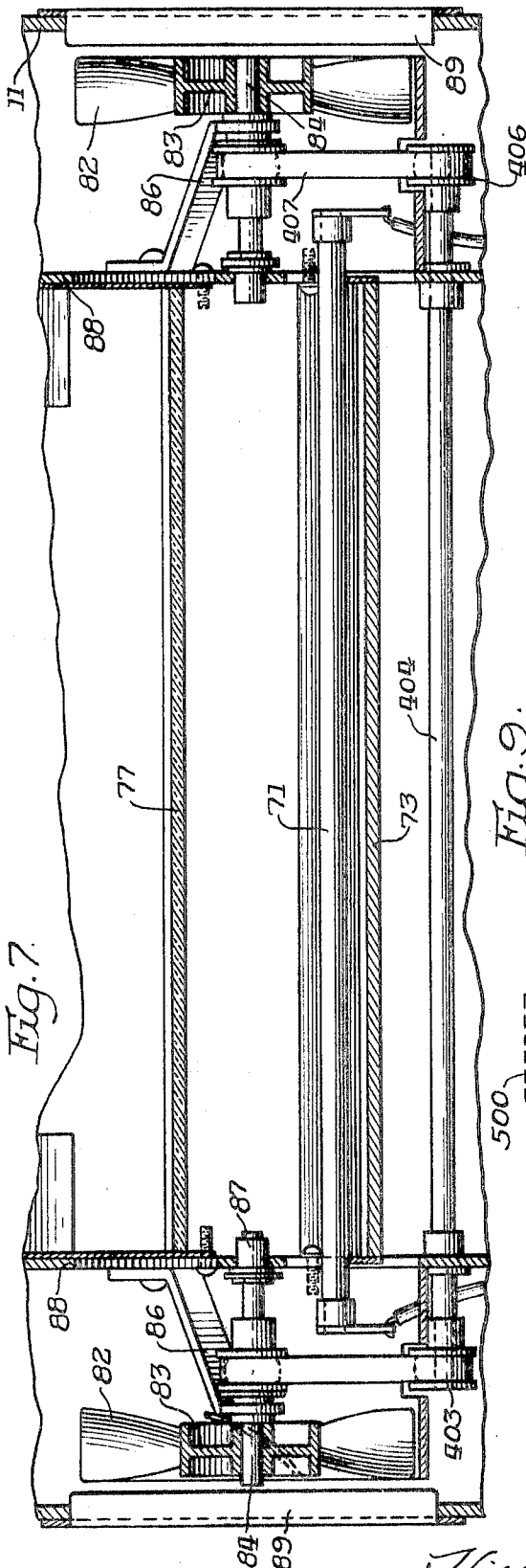
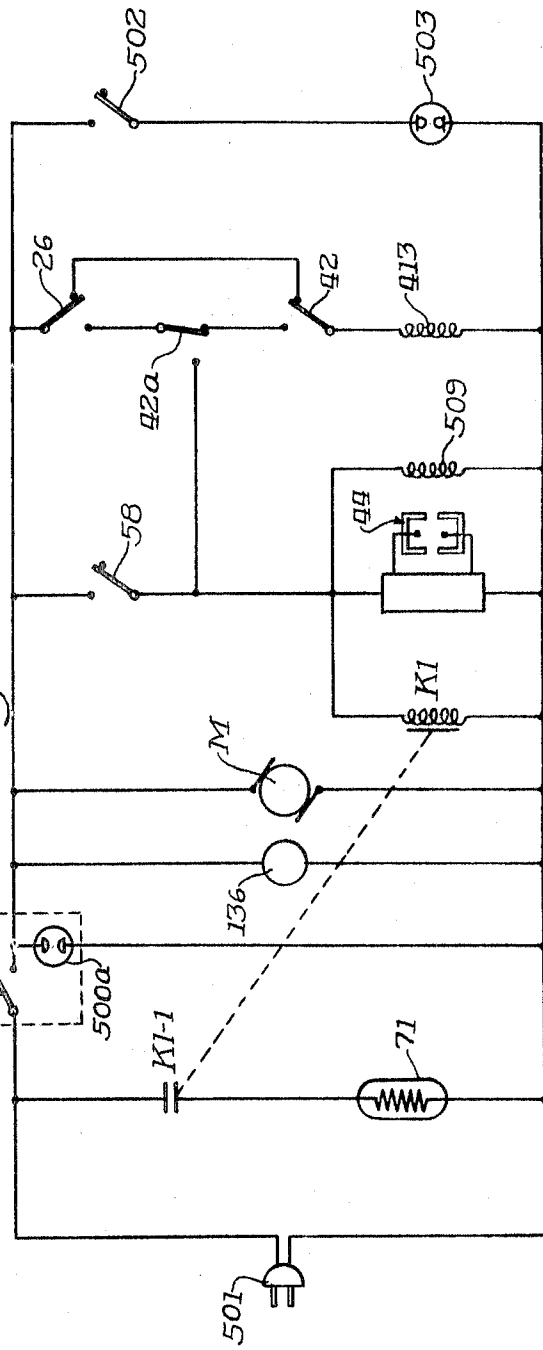


Fig. 7.

Fig. 9.

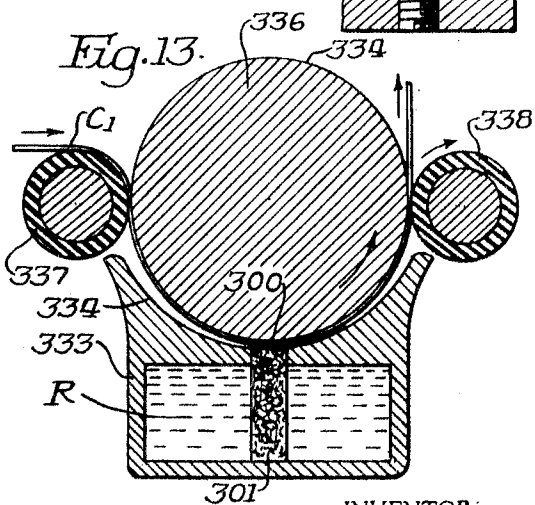
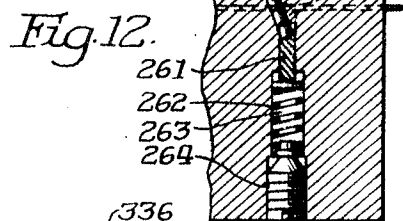
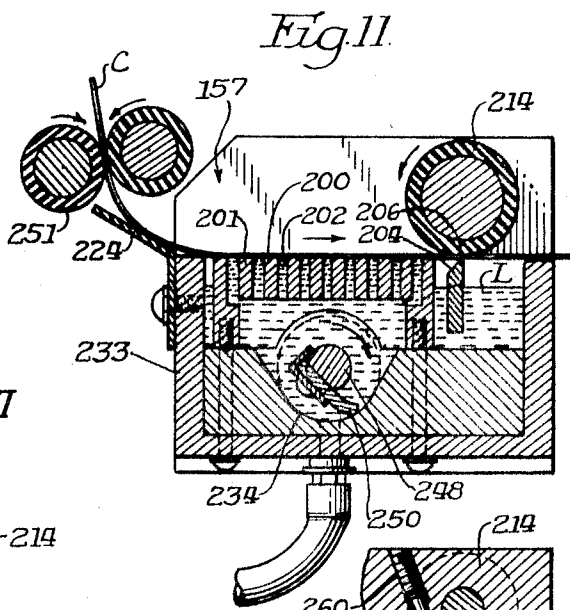
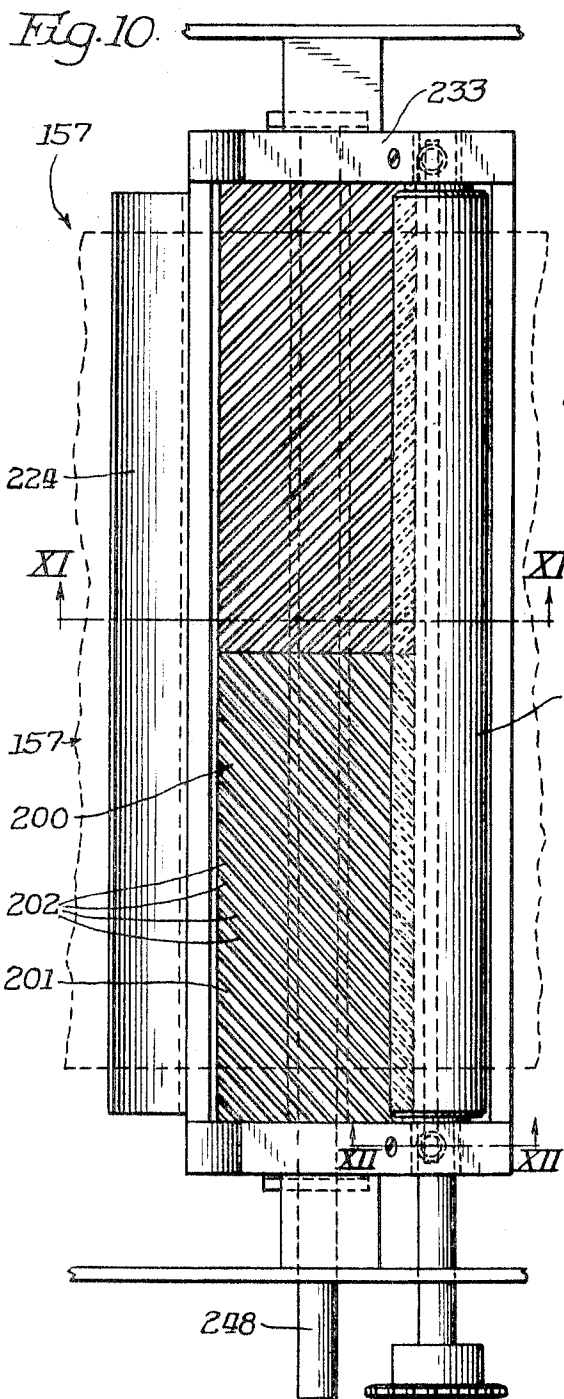


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ELECTROSTATOGRAPHIC OFFICE COPIER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention herein disclosed relates to the field of art pertaining to electric photography and specifically to developing apparatus, as well as apparatus pertaining to electric photography generally.

2. Description of the Prior Art

The early expired patents of Carlson 2,221,776 and 2,297,691 teach the basic steps of electrostatography whereby the surface of a photoconductive layer is initially charged, then exposed photographically, whereupon the latent electrostatic image is developed by dusting the charged surface with an electrostatically attractable finely divided material. In Greig 3,052,540 and 3,052,539, zinc oxide coated paper is used as the copy sheet, thereby contemplating the use of expendable copy sheets instead of reusable photoconductive plates. Subsequent developments have also contemplated the utilization of liquid development material, however, in most instances the coated copy sheet is either totally immersed in the development material or is so bathed with developing material as to produce a severe wetting problem of the paper carrier. A set carrier, of course, necessitates drying means and interposes additional delays in time sequences which drastically extend the length of the copying procedure.

SUMMARY

The present invention is particularly characterized by apparatus for applying liquid electrostatographic developing material to only the image bearing surface of a carrier and without wetting the carrier so that the requirement of additional fusing mechanism or squeegeeing rolls and drying mechanism is completely eliminated without loss of function. It is contemplated that a film of developer liquid will be engaged against only one side of the sheet at one point along a transport path extending through a developing zone. Engagement of a simple reverse roller with the image-bearing surface removes any superfluous liquid developing material with such efficacy that no additional squeegeeing, drying or fusing equipment is required. Thus, the copy sheet is substantially dry when it leaves the machine and copies can be produced with greater speed and convenience and with satisfactory characteristics of readability.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view with parts shown in elevation and parts shown somewhat schematically showing an electrostatographic office copier provided in accordance with the principles of the present invention;

FIG. 2 is a view generally similar to FIG. 1 but illustrating components of the drive means for synchronously operating various parts of the transport system and other rotatable members utilized in the apparatus of the present invention;

FIG. 3 is a fragmentary cross-sectional view taken generally on line III-III of FIG. 5;

FIG. 4 is a fragmentary cross-sectional view taken generally on line IV-IV of FIG. 5;

FIG. 5 is a cross-sectional view taken generally on line V-V of FIG. 1;

FIG. 6 is a fragmentary cross-sectional view taken on line VI-VI of FIG. 5 and illustrates additional details of the developing mechanism provided in accordance with the principles of the present invention;

FIG. 7 is a cross-sectional view taken on line VII-VII of FIG. 2;

FIG. 8 is an enlarged fragmentary view showing additional details of the feeler switches used in connection with the transport of copy sheets;

FIG. 9 is a schematic wiring diagram showing the electrical circuitry associated with the machine of the present invention;

FIG. 10 is an alternative form of developing mechanism provided in accordance with the principles of the present invention shown in plan elevation and with parts removed for the sake of clarity;

FIG. 11 is a fragmentary cross-sectional view taken on line XI-XI of FIG. 10;

FIG. 12 is a fragmentary cross-sectional view taken on line XII-XII of FIG. 10;

FIG. 13 is a fragmentary cross-sectional view showing yet another embodiment of a developer arrangement contemplated by the present invention;

FIG. 14 illustrates an alternative embodiment of a liquid applying roller having special purging means; and

FIG. 15 shows a purging roller arrangement provided for the form of the invention of FIGS. 1-9.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

While the inventive developments herein disclosed are of general utility, a particularly useful application is found in an electrostatographic office copier of desk-type size. A machine embodying the principles of the present invention and operable in accordance with the apparatus of the present invention is shown generally at 10. A casing 11 forms a housing for the machine or apparatus and has a hollow interior forming a compartment or enclosure 12 having a front wall 13, a rear wall 14, a bottom wall 16 and a top wall 17.

Disposed adjacent the lower portion of the front wall 13 is a feeding and transport mechanism for original document material shown generally at 18. More specifically, the feeding and transport mechanism utilizes a frame member 19 which is pivotally mounted on a pivot pin 20 to the casing 11. The frame member 19 rotatably mounts one of each set of a plurality of transport rollers consisting of matched pairs of rollers shown at 21a, 21b, 21c and 21d. The frame 19 is movable from a full line position to a second dotted line position, as shown in FIG. 1. The mating rollers of each of the transport rollers are rotatably mounted in stationary position in the casing 11 so that the full line position corresponds to a nip-forming position with each set of rollers 21a, 21b, 21c, 21d prescribing a transport path. In the second position shown in dotted lines, the frame is positioned in an open clearing position so that the rollers are separated from one another to facilitate removal of paper jams in the event a document becomes jammed in the transport path. In this position, it is further possible to completely remove this frame assembly if a slot is cut in each frame member leading from the hole in which the pivot pin 20 is mounted, as shown in dotted lines in FIG. 1.

There is additionally provided along the boundary of the transport path a curved direction-changing baffle 22 and an exposure window shown at 23, as well as a second direction-changing baffle 24.

A sensor switch is shown at 26 and has a sensing finger 27 extending into the transport path between the rollers 21a and 21b for engagement with the edge of an original document shown at 28.

In addition to carrying the rollers, the frame 19 has an upper leg 19a and a vertical leg 19b which provides a guide surface and cooperates with the confronting adjacent surfaces of the baffles 22 and the window 23 in prescribing a transport path. A third leg 19c is also provided so that the legs 19b and 19c cooperate with the baffle 24 as well. Accordingly, an original document to be copied is fed into the machine face up and the edge is inserted into the nip of the first set of rollers 21a. The document is then advanced by the rollers 21a along the transport path prescribed by the wall 19a of the frame 19 and the leading edge of the document engages the feeler arm 27 of the control switch 26. The document is picked up by the rollers 21b and is further advanced against the baffle 22, thereby changing the direction of the document into the nip of the rollers 21c and along the path prescribed by the leg 19b of the frame 19. The document then passes through the exposure station formed by the window 23, whereupon the document is

picked by the nip of the rollers 21d and is guided by the baffle 24, thereby changing direction and guiding the document towards the front wall 13. It will be noted that the front wall 13 has an opening 29 formed therein to facilitate access to the feeding and transport mechanism.

The front wall 13 has a second opening 30 formed therein through which a tray 31 containing a supply of pre-cut copy sheets is contained which sheets are shown at 32. The tray 31 is supported on suitable guide means 33 and it will be appreciated that different size trays for accommodating different size sheets can be selectively inserted into the machine.

A sheet selector and feeder is provided in the form of a pickup roller 34 which is free to move up and down as the supply of sheets 32 is depleted and the roller is rotatably driven by a belt 36 threaded over a suitable driver 37 rotatably mounted in the casing 11 superjacent the tray 31. A single sheet is thus fed by the pickup roller 34 into the throat 38 of a copy sheet feed and transport system. The throat 38 is formed by appropriately diverging baffle members 39 having a constricted outlet 40 which lies in feeding registry with the nip formed by a pair of transport rollers 41, 41'. A control switch is shown at 42 and has a feeler arm 43 extending into the transport path, thereby to be engaged by a single copy sheet 32 shown in dotted lines advanced into the copy sheet transport system.

The copy sheet may constitute any well-known photographic carrier such as a zinc oxide coated paper, thereby providing a uniform photoconductive surface suitable for receiving an electrostatic image thereon. In the orientation of the arrangement herein shown, the photoconductive surface is positioned face down. As the copy sheet is transported in the direction of its length by the rollers 41, 41', it is first driven through a charging station shown generally at 44 and comprising more specifically a double corona charging unit including a pair of separate opposed corona charging units each having fine longitudinally extending corona wires shown at 46 and 47, respectively, positioned interiorly of a trough-shaped reflector shield respectively indicated at 48 and 49. The reflective shields are U-shaped in configuration, each including a bight portion and perpendicularly disposed parallel leg portions each terminating in an outwardly flared flange 50 so that the flanges 50, 50 on each side of the double corona charging unit 44 form ingress and egress pilot portions facilitating passage of the copy sheet 32 therethrough. The corona wires 46 and 47 operate as electrodes and a uniform charge is thus placed upon the photoconductive surface. The casing 11 provides a light-tight enclosure for the copy sheets and, accordingly, the photoconductive surface is thus conditioned by the charging station 44 for the reception of an image in an exposure station shown generally at 51.

Adjacent the exit portion of the charging unit 44 and also adjacent the inlet portion of the exposure station 51 is a pair of transport rollers 52, 52' forming a nip for receiving the charged copy sheet and directing the same through the exposure station 51. A backing plate 53 is provided spaced parallel to a window 54 and a second pair of transport rollers 56 provide a nip at the outlet of the exposure station 51 thereby to receive the exposed copy sheet and direct the same through a developing station shown generally at 57.

A control switch 58 is provided having a feeler arm 59 projecting into the transport path adjacent the exit portion of the exposure station.

It is contemplated by the present invention that the upper roller 52' just past the corona charging unit 44 is preferably conductive. The utilization of a conductive roller at the location of the roller 52 eliminates the adverse effects attributable to apparent "lateral conductivity" of the paper base of the copy sheet 32. In this regard, the roller 52 provides an alternate low resistance path for current bleedoff which might otherwise occur through lateral conductivity and thereby prevents such bleedoff through the developer unit of the machine since it is possible that with a long enough sheet of copy paper 32, part of the sheet could be in the corona charging unit 44 and in the developer unit 57 simultaneously.

It is also contemplated by the present invention that the upper roller 41' before the corona unit is preferably conductive. Unless static charge buildup in the paper supply stack, presumably caused by the above-mentioned "lateral conductivity" effects, is prevented, double and triple feed of zinc oxide-coated paper 32 may result because of the tendency of the sheets to adhere to each other. The conductive upper roller 41', therefore, provides a low-resistance path to drain off current from the uncoated side of the copy sheet before it reaches the stack.

In accordance with the principles of the present invention, the image to be reproduced is directed along an optical track extending from the window 23 to the window 54, thereby to project the image on the original document 28 onto the copy sheet 32. Accordingly, the optical track includes a mirror 60 which is carried on a mirror support 61 engaged on suitable mounting supports 62 carried by the casing 11. The mirror 60 has a reflective surface 63 disposed at approximately a 45° intercepting angle between the window 23 and the window 54. The mirror 60 is adjustably mounted to permit selected compensation for lens position.

Additionally, there is provided a lens assembly shown generally at 63 and including a lens housing 64 carried in a frame 66 attached to a suitable lens mounting 67 also supported by suitable mounting means 68 in the casing 11. The lens housing 64 is arranged between the window 23 and the mirror reflective surface 63 so that the image appearing on the original document 28 will be focused at the reflective surface 63 and projected to a focal plane corresponding to the photoconductive surface presented by the copy sheet 32 at the window 54.

In order to illuminate the original image at the window 23, an illumination means is provided in accordance with the principles of the present invention as shown generally at 70.

The illumination means includes an elongated halogen quartz light source 71 positioned at the focal point of an elliptically configured reflective surface 72 formed by a generally trough-shaped reflector member 73. The trough-shaped member 73 is open-ended and also has a trough opening 74 characterized by the formation in opposite legs thereof of a recess 76 receiving a flat lens 77 constituting an infrared filter, thereby to prevent excessive thermal energy from reaching the exposure station at the window 23 which might cause excessive heating of the original document 28.

The reflector member 73 also has thickened walls longitudinally grooved as at 78, thereby to provide radiator fins for additional dissipation of thermal energy. The walls are provided with mounting receptors cooperating with suitable mounting means 79 thereby to carry the reflector member 73 in the casing 11.

As shown in FIG. 2, an arcuate shield 80 extends through more than 180° of circumferential length and is carried by mounting means 81 in the casing in radially outwardly spaced relation to the reflector member 73, thereby preventing transmission of thermal energy from the light source into the remainder of the machine. The arcuate shield 80 extends coextensively with the reflector member 73 and there is positioned at opposite ends thereof air translation means taking the form of fan blades 82 mounted on a hub 83 rotatably carried on a shaft 84 having a driving pulley 86. The inboard end of each shaft 84 is journaled in an appropriate bearing 87 carried by framing members 88 forming part of the casing structure. Upon rotation of the fan blades 82, air is translated through the confined zone prescribed by the arcuate shield 80 and is directed through the open end of the reflector member 73. The sidewalls of the casing 11 are provided with vents 89 (FIG. 7) in register with the fan blades 82 so that the excess thermal energy may be readily dissipated outside of the enclosure of the casing 11.

After the copy sheet 32 has been exposed and an electrostatic latent image placed on the photoconductive surface, the copy sheet is directed by the rollers 56 through the developing station shown generally at 57. The details of the developing station provided in accordance with the principles of the

present invention may be noted upon referring to FIG. 1 in conjunction with FIGS. 3, 4, 5 and 6. Generally, it is contemplated that the flexible sheet represented by the copy sheet 32 will be transported through the developing zone 57 to facilitate application of developer liquid only to a single side of the sheet. An electrode or applicator, or as used herein, an applicator electrode is provided so that a copious fresh supply of developer material may be applied to the photoconductive image bearing surface of the sheet 32 in close adjacency to the electrode surface.

Since surface tension of a smooth-faced roller tends to reduce the effective working area of the electrode surface, it is contemplated that an action surface be provided which is roughened or otherwise treated to increase the effective working area thereof. In the form of the invention shown in FIGS. 3, 4, 5 and 6, such an action surface is formed as an outer peripheral surface 100 on an applicator electrode taking the form of a developer roller 101 mounted for rotation in the direction of the arrow 102, i.e., the same direction as the direction of movement of the copy sheet 32. To endow the surface 100 with increased area as well as capillarity and to improve the ability of the surface to retain a film of liquid, the surface of the developer roller 101 is knurled or otherwise serrated to enhance its liquid retention properties.

In knurling the surface of the roller 101, it is preferable to provide longitudinal grooves or serrations, thereby affording a surface which moves relative to the image surface of the copy sheet 32 in such a manner as to present to the image surface alternate peaks and recesses of a development electrode. In order to eliminate any tendency of the electrode development component in producing a line pattern on the image surface, the peaks may be widened and the alternate root or recess sections operate as reservoirs in which a quantity of development liquid is contained. It will be appreciated that the individual reservoirs will be successively depleted upon transferring developer material to the image bearing surface, however, the surface is constantly conditioned and reconditioned to take on a fresh supply of developer for maximizing the efficiency of the development process. As shown in FIG. 5 the roller 101 is mounted on a shaft 103 and the opposite ends of the shaft 103 are suitably journaled in appropriate bearings carried by the framing 95 of the developer unit.

If desired, it is contemplated by the present invention that means be provided for purging the liquid material returning to the reservoir. Thus, if a developer roller is provided having a grooved surface configuration, after the liquid in the grooves of the developer roller has reached the point of contact with the sheet being developed, the liquid remaining may be depleted of toner particles. Then, because of the surface tension the diluted liquid may remain in the grooves and may not be replaced by concentrated toner solution unless it is physically removed or purged in some manner.

In accordance with the principles of the present invention, purging takes place by mounting a roller with a configuration complementary to that of the serrated developer roller, thereby squeezing out any diluted liquid and conditioning the grooves to take on a new supply of concentrated toner.

Referring specifically to FIG. 14, it will be noted there is provided a developer roller 101' having a working surface 100' which is characterized by the formation therein of circumferentially spaced gear teeth 510 alternating with root recesses 511.

A purging roller is shown at 512 and is provided with a peripheral action surface 513 characterized by the formation therein of meshing gear teeth shown at 514 and alternating with root recesses 515.

The purging roller 512 rotates in the direction of the arrow 516 so that the gear teeth 514 mesh with the gear teeth 510. Thus, the root recesses 511 of the developer roller 101' are substantially completely filled by the gear teeth 514 and any diluted toner solution remaining in the root recesses 511 because the surface tension will be physically displaced and the working surface 100' of the developer roller 101' will thus

be conditioned to take on a fresh supply of concentrated developer material.

The purge roller 512 is mounted on a bearing journaled shaft 517 and will be rotatably driven by virtue of the meshing relationship with the developer roller 101.

It will be appreciated that other purging means may be provided within the scope of the present disclosure. For example, in FIG. 15 there is shown an arrangement whereby the structure of FIGS. 1-9 may be provided with a purging roller 512a having an action surface 513 for engaging the knurled surface 100 of the developer roller 101. Since a knurled surface may have a knurling pattern in many different configurations including a herring bone pattern or a longitudinal grooved pattern or a circumferentially grooved pattern or a crisscross pattern, it will be understood that the working surface 513a of the purging roller 512a advantageously comprise an elastic or resilient material which will operate to squeeze any dilute developer material from the working surface 100, thereby conditioning the surface 100 to take on a fresh supply of developer material. Also, as shown in FIG. 15, it will be noted that the purging roller 512a is carried on a shaft 517a disposed to locate the purging roller 512a in a reservoir R.

From the purging arrangement shown in FIGS. 14 and 15, it will be evident that any two mating surfaces may be effectively provided between the developer roller and the purging roller. It is contemplated by the present invention that other purging means could also be provided as alternatives. For example, a fluid jet might be directed at the working surface of the developer roller thereby to impinge a jet of either air or liquid against the surface of the developer roller to remove diluted developer liquid and condition the surface to take on a fresh supply of developer material.

Spaced longitudinally from the developer roller, there is provided a drying roller 104 having an outer peripheral surface 106 disposed to engage the image-bearing surface of the copy sheet 32 after a film of developer liquid has been applied thereto. The drying roller 104 is carried on a separate shaft journaled in the framing means so that it can be operated in the direction of the arrow 107 in a direction reverse to that of the copy sheet 32. Thus, any superfluous liquid appearing on the photoconductive surface will be wiped therefrom. The peripheral surface 106 of the dryer roller 104 is, in turn, scraped by a doctor blade 108 having a flexible lip 109 engaged against the peripheral surface of the roller 104 at the lower left quadrant as shown in FIG. 6. The doctor blade 108 is carried by a bracket 110 which is supported by a mounting member 111 which can be adjusted within the confines of an elongated slot 112 and locked in selected adjusted position in order vary the tension with which the flexible blade 109 engages the surface 106 of the roller 104, thereby to keep the surface 106 of the roller 104 dry within optimum limits. It will be noted that the developer roller 101 and the drying roller 104 are spaced sufficiently far apart from one another as to leave a considerable spacing dimension therebetween, thereby avoiding any possible contact between the two peripheral surfaces 100 and 106 and avoiding any possibility of any liquid split or intercommunicating capillarity therebetween.

In accordance with the principles of the present invention, a transport roller is provided on the opposite side of the copy sheet 32 which transport roller is shown at 113. The roller 113 has rigid core 114 and a rubber peripheral sleeve 116 and is mounted for rotation in the direction of the arrow 117, i.e., the same direction as the movement of the copy sheet 32. The transport roller 113 is specifically spaced in relation to both the developer roller 101 and the drying roller 104 so that it is disposed therebetween but without forming a contact nip with either roller. Moreover, the spacing relationship is sufficiently large between the respective rollers 101, 104 and 113 so that there is no possibility of a liquid split occurring therebetween or any intercommunicating capillarity when a copy sheet 32 is not present. Thus, wetting of the nonimage side of the copy sheet 32 is effectively precluded.

To insure proper guidance of the copy sheet 32 through the developer station 57, there is provided an appropriate baffle means which baffle means is shown at 118 and can comprise either a roller or some other suitable guiding surface 119 arranged to direct the leading edge of an entering copy sheet 32 into proper engagement with the film of liquid on the peripheral surface 100 of the developer roller 101.

As the copy sheet 32 progresses, therefore, the upper surface thereof is engaged by the rubber sleeve 116 of the transport roller 113 and the sheet is guided over the dryer roller 104 and into engagement with one roller of a pair of transport rollers shown at 120a and 120b. The transport roller 120a also has a rigid core 121, the peripheral portion being metallic or rubber. Metal is preferred, however, to overcome the effect of the leading edge of the sheet hitting the roller as the sheet emerges from the developer section. A roller of high frictional characteristics momentarily slows the travel of the sheet at the developer roller, resulting in a transverse line on the copy sheet due to overdevelopment along this line. A curved baffle guide 123 is spaced immediately outwardly adjacent the peripheral surface of the transport roller 120a, thereby insuring that the copy sheet 32 which is now developed and dry will be directed into the nip of the rollers 120a and 120b. A curved return guide having upper and lower members 124a and 124b receives the copy sheet 32 and directs the same through a final pair of transport rollers shown at 126a and 126b, whereupon the copy sheet 32 is discharged through an opening 127 onto a surface 128 formed in the top of the enclosure 11.

It will be noted that in providing the various transport rollers 56, 120a, 120b and 126a, 126b one of the rollers (the lowermost roller 56, the roller 120b and the roller 126b) is mounted in a bearing arrangement allowing movement of the bearing in a corresponding slot shown at 56c, 120c and 126c. A continuous biasing force is exerted by a spring 56d, 120d and 126d suitably anchored at opposite ends to the framing or casing 11 as at 129 and operatively engaged with the slidable mount so that the transport rollers are resiliently biased into a good nip-forming relationship, thereby to obtain a good resilient purchase on the copy sheet 32 passing along the transport path.

Further, it will be noted that the upper and lower guide members 124a and 124b are snap-fit by means of snap fastener mounts 129, thereby to facilitate removal for inspection or cleaning.

In order to supply a film of liquid to the action surface 100, it is contemplated that a unit be provided which can be inserted or removed from the machine through the manipulation of only a single screw 130. Thus, the screw 130 is shown having an engagement with a correspondingly threaded recess 131 formed in a mounting bracket within the casing 11 and a wing nut is shown at 132 which can be readily manipulated by an operator. The unit retained by the screw 130 contemplates a tank made of a suitable plastic material such as polyethylene or the like which extends across the width of the casing enclosure 11 and is particularly characterized by a curved lower wall, the tank being indicated at 133 and the curved lower wall being shown at 134.

The tank 133 is adapted to contain a supply of liquid developer and in FIGS. 3 and 4 of the tank 133 is shown filled with a liquid developer material up to a level shown at L.

A pump 136 is immersed in the tank 133 at one end thereof and has an inlet formed therein near the bottom of the tank below the level L of liquid developer so that upon operation of the pump a supply of liquid developer will be discharged by the pump 136 through an outlet 137 and into a discharge conduit 138 which extends upwardly to a discharge nipple fitting 139 connected as at 140 to a weir shown generally at 141. The weir 141 has a hollow interior and is specifically characterized by a weir notch or bulkhead 142 formed by one wall thereof 143 immediately adjacent the action surface 100 of the developer roller 101. Thus, whenever the pump 136 is operated to discharge developer liquid into the weir 141, the liquid developer will flow over the notch or bulkhead 142 and

a film a liquid developer, as shown at F in FIG. 6, will be formed on the action surface 100. The weir 141 is mounted on the framing 88 by means of a bracket 144 and appropriate adjustment slots are shown at 146 so that the actual mounting pins 147 may be selectively positioned relative to the slots 146 and the weir locked in adjusted assembly, thereby to selectively position the notch or bulkhead 142 in proper adjacency to the action surface 100. It will be noted that the weir 141 is mounted in the upper portion of the tank so that excess developer liquid flowing over the notch or bulkhead 142 is gravitationally drained and returned directly to the body of liquid in the lower portions of the tank 133. Likewise, superfluous developer liquid removed by the doctor blade 108 from the surface 106 of the dryer roll 104 will also be gravitationally returned to the body of liquid L in the bottom of the tank 133.

In order to prevent the formation of sludge in the tank 133, suitable agitation means are provided in the bottom of the tank which in the present invention takes the form of a rotatable shaft 148 journaled in the framing parts 95 of the developing unit and having a driving pulley 149 on the end thereof. The shaft 148 carries a plurality of flexible panels 150, 151 and 152 (FIG. 5) which are connected to the shaft by means of fasteners 153 and which extend radially therefrom. The flexible panels 150, 151 and 152 are spaced circumferentially and are spaced axially so that they are out of phase with respect to one another and extend sufficiently radially so that they sweep the arcuate lower wall 134 of the tank 133, thereby keeping the reservoir provided by the tank free of sludge.

The structure of the present invention is well suited to use as or adaptation for a "shoot-through" arrangement or system which is so characterized because it resembles a contact printing technique.

In the so-called "shoot-through" technique, a sheetform original image carrying support member containing document content on one face thereof is positioned in contact with a sheet form copy member having a photoconductive surface on one face thereof and with both of said faces facing in the same direction.

While so contacted with one another, the two sheet form members are moved in the direction of their length through an ion field, for example, through the corona charging unit 44 to produce a uniform charge pattern on the photoconductive surface.

Thereafter, and while still so contacted together, the two sheets are moved through a bath of light, for example, at the exposure station 54, thereby to leave a charge pattern on the photoconductive surface corresponding to the document content on the original image carrying support member.

At this point, both members may be passed through the developing station 57 without necessitating separation, since visible image forming material can be applied directly on the photoconductive surface without wetting or otherwise adversely affecting the original to develop a right reading image.

If desired, the original may be peeled off or removed from the copy before development.

In FIGS. 10-13, alternative developer structures are shown which operate in accordance with the principles of the present invention. Thus, as shown in FIGS. 10 and 11, a developer mechanism 157 is shown having an action surface 200 provided as the top wall of a flat rigid applicator electrode member 201 and made of material such as conductive metal or the like. The action surface 200 is intersected by plural passages 202 thereby endowing the surface 200 with capillarity. The member 201 is mounted in a reservoir shown generally at 233 and contains a supply of liquid developer filled to a level shown at L. Agitation means subjacent the member 201 comprise a rotatable shaft 248 carrying flexible blades 250 which sweep an arcuate wall 234 formed in the reservoir 233, thereby to prevent the formation of sludge in the reservoir. The agitation means also insures that liquid is constantly engaged against the lower end of the capillary passages 202. By

virtue of the small size of the passages 202, a meniscus will be erected within the capillary passages 202 and thus a film of liquid developer will appear at the surface 200 so that a copy sheet, shown at C, driven across the action surface 200 by a pair of transport rolls 251 will have developer liquid applied only to the image-bearing surface thereof.

Superfluous liquid is removed from the image-bearing surface of the copy sheet C by a drying means such as a doctor blade 204 having a portion 206 engaging the image-bearing surface. Disposed opposite the doctor blade 204 is a transport roller 214. A baffle guide 224 is arranged on the inlet side of the developer unit 157, thereby to assist in guiding the copy sheet C over the action surface 200.

To control the degree of tension between the doctor blade 204 and the copy sheet C, shown in FIG. 12, there is provided an adjustment set screw 260 which engages a stop member 261 bottomed against one end of a coil spring 262 received in a recess and operating to load the doctor blade upwardly towards the image-bearing surface of the copy sheet C. The spring 262 is received in a recess 263 and the recess 263 is closed by a plug 264 bottoming the other end of the coil spring 262.

In the form of the invention shown in FIG. 13, an action surface is shown at 300 formed by a development electrode which takes the form of a wick 301 having the requisite qualities of capillarity by virtue of the capillary passages inherently formed in the material of the wick itself. Thus, the wick 301 would be made of a suitable porous material such as porous metal and substantial portions of the wick would be immersed within a reservoir R of developer liquid contained within a tank 333. In the form of the invention illustrated in FIG. 13, the action surface 300 of the wick 301 projects just beyond a curved baffle surface 334 spaced adjacent the peripheral surface 334 of a roller 336. A pair of transport rollers 337 and 338 are shown disposed on opposite sides of the roller 336 and in nip-forming engagement therewith so that a copy sheet C₁ may be directed between the roller 336 and the curved surface 334 with the image-bearing surface engaged against the action surface 300 of the wick 301.

It is contemplated by the present invention that all of the rotating components of the transport system may be rotatably driven from a common driving motor shown generally in FIG. 2 at M. The motor M has a takeoff shaft 400 to which is connected a driving pulley 401 over which is trained a pulley belt 402. The belt 402 engages a first pulley wheel 86 on one side of the machine and thereby drives one of the air translation means 82, 83 rotatably. The belt 402 also engages a driving pulley 403 connected to the end of a shaft 404, which shaft 404 extends to the other side of the machine and has a driving pulley 406 connected thereto which is interconnected with the other driving pulley 86 of the other air translation means 82, 83 by means of a pulley belt 407. Thus, both air translation means are driven in unison with one another.

The motor M also has a gear box G with a power takeoff shaft 410 to which is connected a sprocket 411. Suitable sprockets are connected to the various drive members of the transport rolls and a timing belt 412 is threaded over all of the various sprockets including the drive sprocket 411 to drive all of the transport rollers in unison with one another. A solenoid motor is shown in FIG. 2 at 413 and has its movable core 414 connected to a stop member 416 engageable with a ratchet 417 connected on the end of a shaft 418 on which the roller 37 is connected. The ratchet wheel 417 is part of an overrunning clutch drive so that the feel roller 34 will be rotatably actuated only when the solenoid motor 413 unlatches the ratchet wheel 417 by actuation of the plunger 414 and the stop member 416.

It will be further noted upon referring to FIGS. 5 and 6 that appropriate intermeshing gears are provided between the various rollers so that all of the rollers will operate in unison. It is not believed necessary to trace through all of the gear train members for a proper understanding of the present invention, however, it may be noted that the gears may be provided in an appropriate size relation so that in the form of the invention

shown in FIGS. 3-6, the developer roller 101 will move at a different speed than the advancing copy sheet 32, thereby minimizing the effect of developing high spots on the image surface corresponding to the pattern on the surface of the developer roller. It is contemplated by the present invention that such speed will be selected to be in the range of from about 0 to 50 percent faster or slower which, measured in terms of feet per minute, would be in the order of from about 10 to 30 feet per minute. The speed selected may depend on the spacing of the serrations on the developer roller 101.

It is also contemplated by the present invention that rotation of the developer roll could be started and stopped selectively by means of an appropriate clutch, if desired, thereby to further minimize wetting the nonimage sides of the paper by depleting the meniscus upon keeping the roll stationary to avoid tail edge overflow onto the nonimage side of the copy paper 32. That action can be controlled by an appropriate sensor switch of the type shown and described.

Referring to the wiring diagram of FIG. 9, a plug 501 is provided for plugging into an AC outlet, thereby connecting the machine across a line receiving power from a usual domestic source of supply.

The exposure lamp 71 is controlled by a contact identified at K1-1 located ahead of an on-off switch 500 and which contact K1-1 is controlled by a lamp relay indicated at K1.

An indicator lamp 500a is located in circuit with the on-off switch 500 and will be illuminated whenever the on-off switch is actuated into its "on" position. Thus, actuation of the switch 500 will result in the energization of the pump 136 and the main drive motor M will also be energized.

Upon closing of the on-off switch 500, the solenoid motor 413 is also energized thereby permitting the feed roller 34 to advance a copy sheet 32 up into the ready position. At the ready position, the leading edge of the copy sheet will engage the feeler arm 43 of the switch 42, thereby breaking the circuit to the solenoid 413 and the copy sheet will be held in the ready position. Thus, the switch 42 will be moved to its second position away from the position shown in full lines in FIG. 9.

When an original document is fed into the machine, the switch 26 is actuated and the paper feed solenoid 413 is again energized, thereby feeding the copy sheet 32 into the nip of the first feed rolls 41. The copy sheet engages the feeler finger 43a and will actuate the switch 42a, thereby operating as a feeder cutout switch and again deenergizing the paper feed solenoid 413. That action further operates to simultaneously energize the lamp relay K1 as well as the corona power supply for the corona charging unit 44 and the developer roll solenoid shown in FIG. 9 at 509.

When the relay K1 is energized, the contact K1-1 are closed thereby energizing the exposure lamp 71.

The copy sheet 32 will complete a holding circuit by actuating the switch 58 upon engaging the feeler arm 59. The effect of the holding circuit is set by the minimal length of the copy sheet 32. Thus, when the original document leaves the switch 26, i.e., engagement with the feeler arm 27, or the trailing edge of the copy sheet leaves the feeder cutout switch 42a as controlled by the feeler arm 43a, the circuitry is under the control of the holding circuit as shown in FIG. 9. When the trailing edge of the copy sheet 32 leaves the feeler arm 59 and opens the switch 58, the corona power supply is deenergized as is the lamp relay K1, thereby deenergizing the light source 71 and the developer roll solenoid 509 is also deenergized.

With the advantageous arrangement of the present invention, an original document can be fed through the machine at a rapid rate and successive documents can be fed through the machine less than 1 inch apart. As soon as the original document opens the switch 26, it cooperates with the register switch 42 so that a new copy sheet 32 moves up to the ready position. Thus, the control circuit of the present invention affords a high productivity rate in terms of copies per minute while actually running the total machine with all of the components, at speeds which are relatively slower than have been heretofore prevalent in the prior art.

As shown in FIGS. 1, 2 and 9, an additional switch is provided at 502 in control of the energization of a signal light 503. The switch 502 has a feeler arm 504 which engages the actuator rod 506 guided for reciprocation by a pair of brackets 507, 507 and having connected at the end thereof a float 508 (FIG. 3). Thus, the float indicates the proper liquid level within the tank 133 and if the liquid level becomes depleted to adversely affect the operability or operation of the machine, the switch 502 will be conditioned to energize the signal light 503, thereby serving as a visible warning to the operator that the tank 133 should be replenished with developer liquid.

Although minor modifications might be suggested by those versed in the art, it should be understood that we wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of our contribution to the art.

We claim as our invention:

1. A liquid electrostatographic developer apparatus comprising:

two pair of transport rollers each forming a nip at spaced ingress and egress points along a path extending through a developing zone for driving a copy sheet through the zone in the direction of its length,

means forming said developing zone between said nips and including a roller having peripheral gear teeth that comprise an electrode action surface for projecting into said path and for engaging only one side of the copy sheet,

a purging roller having peripheral gear teeth that intermesh with said action surface,

a drive roll for engaging the opposite side of the sheet, but spaced longitudinally from said applicator electrode a sufficient distance so that no portion of the action surface will engage the drive roll regardless of the presence of a copy sheet,

and means for supplying developer liquid to only the action surface of said applicator,

whereby the application of liquid developer will be confined to only one side of the copy sheet closely adjacent the electrode action surface.

2. In a liquid developer station for applying developer material to a photographic carrier having an electrostatic latent image on one surface thereof;

a rotatable developer roller for engaging the image-bearing surface of the carrier;

means for applying a film of liquid developer material to the peripheral surface of the developer roller including a tank forming a reservoir for holding a supply of liquid developer, and a weir spaced adjacent said developer roller over which liquid developer flows, a pump having an inlet connected to said reservoir and an outlet discharging to said weir, whereby the liquid flowing over the weir engages the peripheral surface of the developer roller and excess liquid returns gravitationally to the reservoir;

means for removing superfluous liquid from the image-bearing surface of the carrier after engagement of said development roller with said image-bearing surface;

a transport roller for engaging the opposite side of said carrier and spaced from said developer roller sufficiently to prevent the formation of a liquid split therebetween; and

carrier transport means including drive means for driving a carrier between said rollers in the direction of the length of said image-bearing surface.

3. In a liquid developer station for applying developer liquid to one surface of a sheetform member,

a rotatable developer roller having peripheral gear teeth for engaging the said one surface of said sheetform member, means for applying a film of liquid developer material to the peripheral surface of said developer roller before engagement thereof with said sheetform member, and

a purging roller having peripheral gear teeth interengaging said gear teeth on said developer roller for purging the surface of said developer roller after engagement thereof with said sheet form member and conditioning said surface to take on a fresh supply of developer liquid.

4. In a liquid developer station for applying developer material to a photographic carrier having an electrostatic latent image on one surface thereof,

a rotatable developer roller for engaging the image-bearing surface of the carrier,

means for applying a film of liquid developer material to the peripheral surface of the developer roller,

means removing superfluous liquid from the image-bearing surface of the carrier after engagement of said development roller with said image-bearing surface,

a transport roller for engaging the opposite side of said carrier and spaced from said developer roller sufficiently to prevent the formation of a liquid split therebetween, and

drive means for driving a carrier between said rollers in the direction of the length of said image-bearing surface and including means for regulating said developer roller for selectively starting and stopping said developer roller and for coordinating rotation of said roller relative to movement of said copy sheet.

5. In a liquid developer station for applying developer material to a photographic carrier having an electrostatic latent image on one surface thereof;

a rotatable developer roller for engaging the image-bearing surface of the carrier;

means for applying a film of liquid developer material to the peripheral surface of the developer roller including a tank forming a reservoir for holding a supply of liquid developer, and a weir spaced adjacent said developer roller over which liquid developer flows, a pump having an inlet connected to said reservoir and an outlet discharging to said weir, whereby the liquid flowing over the weir engages the peripheral surface of the developer roller and excess liquid returns gravitationally to the reservoir;

means for adjusting the spacing dimension between the weir and the adjoining surface of said developer roller;

means for removing superfluous liquid from the image-bearing surface of the carrier after engagement of said development roller with said image-bearing surface;

a transport roller for engaging the opposite side of said carrier and spaced from said developer roller sufficiently to prevent the formation of a liquid split therebetween; and

carrier transport means including drive means for driving a carrier between said rollers in the direction of the length of said image-bearing surface.