Feb. 13, 1968 L. D. SACRE 3,368,525

LIQUID DEVELOPER SYSTEM FOR PHOTOCOPY MACHINE

Filed Oct. 4, 1965 2 Sheets-Sheet 1

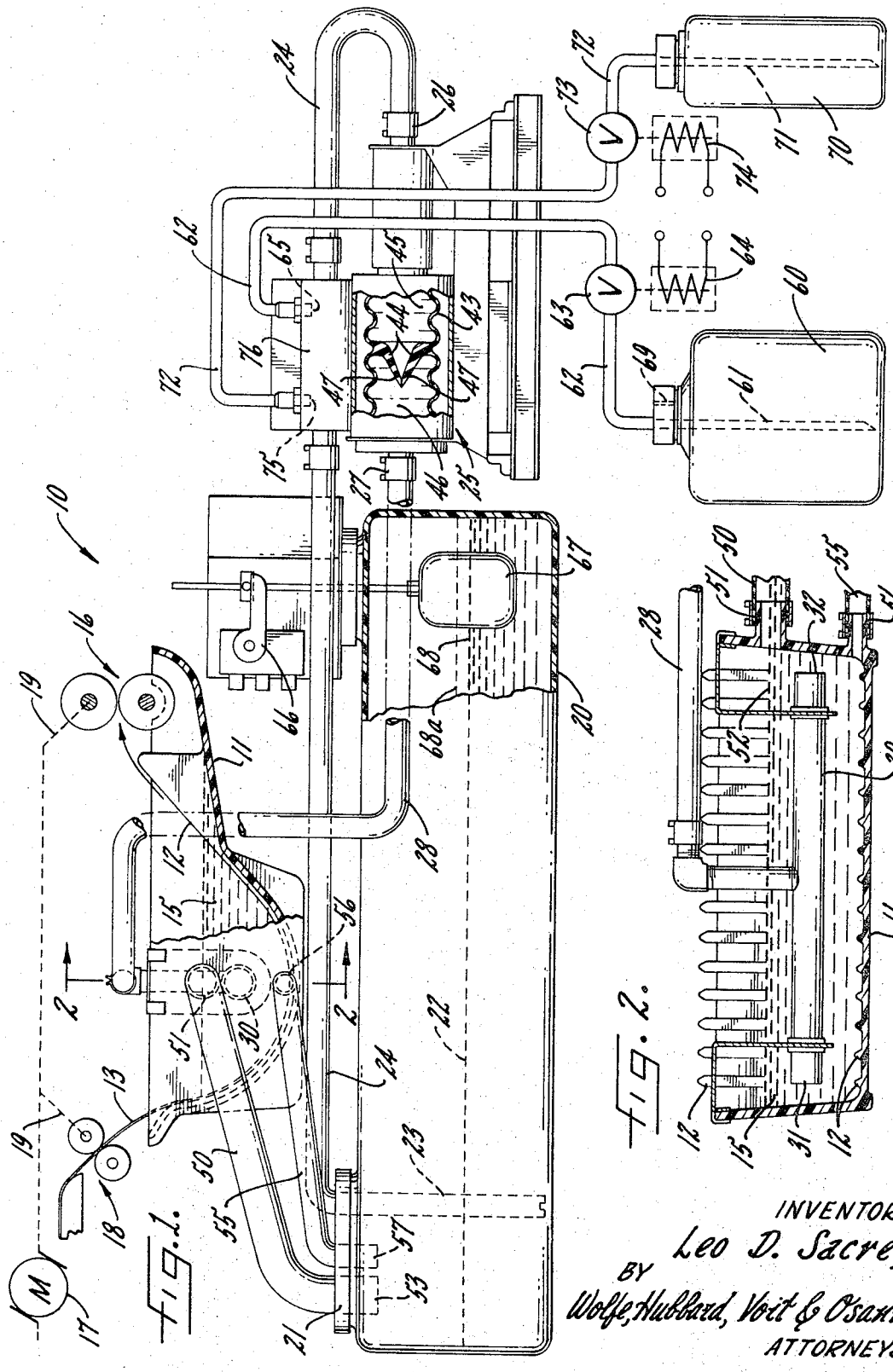

FIG. 1.

FIG. 2.

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Fig. 3.

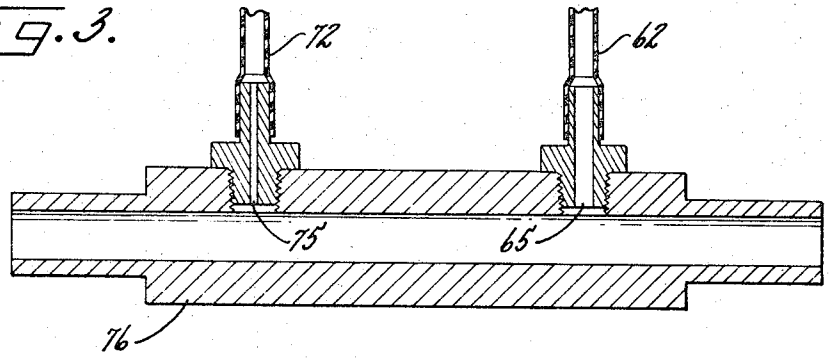


Fig. 4.

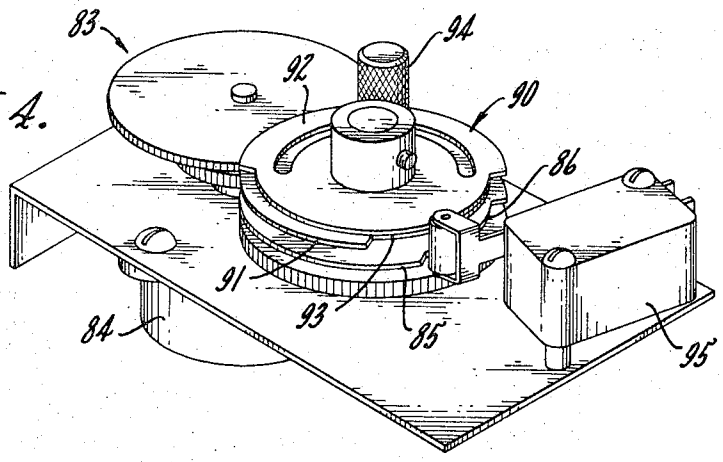
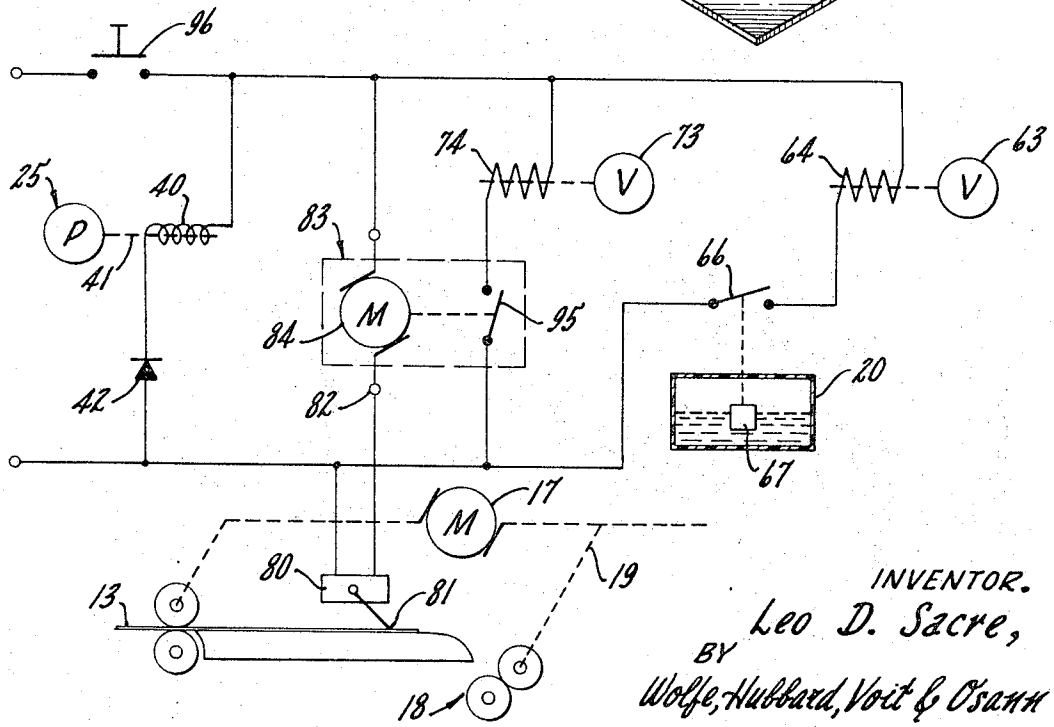


Fig. 5.



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LIQUID DEVELOPER SYSTEM FOR PHOTOCOPY MACHINE

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1 Claim. (Cl. 118—637)

ABSTRACT OF THE DISCLOSURE

A liquid developer system for a photocopy machine including a developer tray having means for guiding copy sheets therethrough, an enclosed reservoir bottle below the level of the tray, a liquid pump connected between the bottle and the tray for pumping developer liquid from the bottle into the tray, an overflow line connected from a working level at the top of the tray to the reservoir bottle, and a drain line connected from the bottom of the tray to the reservoir bottle. The overflow line is relatively free of restriction while the drain line is restricted so that the body of developer liquid is maintained at the working level while the pump is running, but permitting total draining of the tray when the pump is shut off. Replenisher bottles of liquid vehicle and toner are connected through replenisher lines to the developer system for replacing consumed developer liquid. Control valves are provided in the two replenisher lines, with the vehicle replenisher valve being controlled by a float switch mounted in the reservoir bottle at a position designed to maintain a level of developer liquid well below the top of the reservoir bottle to provide space for the developer liquid drained from the tray.

The present invention relates to photocopy machines and more particularly to means for handling and replenishing the developer liquid.

It is an object of the present invention to provide a liquid developer system for a photocopy machine which automatically maintains the developer liquid at full strength and efficiency and which prevents loss of the volatile component by evaporation during the time that the machine is not being used. It is a more specific object of the present invention to provide a novel liquid developer system for a photocopy machine in which the developer liquid is constantly re-circulated between a developer tray and an enclosed reservoir as long as the machine is in use and automatically drained into the reservoir when the machine is turned off.

It is another object of the present invention to provide a novel means for adding toner in the form of a liquid concentrate to the developer liquid from time to time and in accordance with the total length of the copy sheets passing through the machine. In this connection, it is an object to provide means for adding toner concentrate which is accurate, which insures prompt mixing between the concentrate and the body of liquid, and which permits the amount of concentrate per unit length of copy sheet to be easily and quickly varied.

Other objects and advantages of the invention will become apparent upon reading the attached detailed description and upon reference to the drawings in which:

FIGURE 1 shows a liquid developer system constructed in accordance with the present invention with the components as viewed in elevation;

FIG. 2 is a section through the developer tray taken along the line 2—2 in FIG. 1;

FIG. 3 is an enlarged section taken through the replenisher fitting;

FIG. 4 is a perspective view of a timer for controlling the flow of toner concentrate;

FIG. 5 is a schematic electrical diagram of the control circuit used in the system of FIG. 1.

While the invention has been described in connection with a preferred embodiment, it will be understood that the invention is not limited to the illustrated embodiment but that I intend to cover the various modifications and alternative constructions included within the spirit and scope of the appended claim.

Turning now to the drawings there is shown a liquid developer system **10** including a developer tray **11** having a series of ribs **12** for guiding a sensitized copy sheet **13**. For the sake of simplicity the other components of a typical photocopy machine have been omitted, cross reference being made to copending Leo D. Sacre application Ser. No. 487,496 filed Sept. 15, 1965. The copy sheet **13** may be of the general type described in Sugarman et al. Patent 3,051,569 issued Aug. 28, 1962. It will suffice to say that the copy sheet is of paper having a coating consisting of finely divided photosensitive material, for example zinc oxide, dispersed in a dielectric binder for example, isobutyl methacrylate or melamine formaldehyde. The sheet is given an allover electrostatic charge, immediately following which the optical image of the original is cast upon the sheet tending to dissipate the charge from the light-struck areas. Following exposure the sheet **13** is transported, as shown, into the developer tray where it is guided, face up, under a body of developer liquid **15**. Such developer liquid is in the form of a colloidal suspension of toner particles, i.e. finely divided particles of pigment, dispersed in a liquid vehicle having good dielectric properties, preferably aliphatic or other slightly volatile hydrocarbon. As the sensitized sheet enters the liquid, the suspended toner particles are attracted to the charged areas in accordance with the intensity of the charge, thereby pigmenting or developing the image. The developed sheet is discharged from the tray in the direction of the arrow and between a pair of "squeegee" or expeller rollers **16** where the excess liquid is removed and runs back into the tray. Following this the copy may be passed through a blast of warm air to complete the drying prior to being discharged from the machine. A single drive motor **17** is employed to drive pairs of transport rollers, a typical pair being indicated at **18**, as well as the final expeller rollers **16** via suitable drive connections diagrammatically indicated at **19**.

In carrying out the present invention means are provided for constantly circulating developer liquid between the tray **11** and a reservoir. In the present instance the reservoir is in the form of a reservoir bottle **20** which is formed of plastic or the like having a header **21** for the making of fluid connections and containing a body of developer liquid **22**. For the purpose of withdrawing liquid from the reservoir bottle, a dip tube **23** is used which is connected via a suction line **24** to a fluid pump **25** having a suction or inlet connection **26** and a pressure outlet connection **27**. The outlet of the pump feeds a pressure line **28** which is connected to a T-shaped distributor **30** having outlets **31**, **32** at the respective ends of the tray. The pump **25** is of simple construction providing a flow on the order of 15 cubic centimeters per second at a differential pressure, between the suction side **26** and pressure side **27** which is just sufficient to overcome the friction in the fluid lines. Experience has shown that a pump having a bellows impeller driven by an integral vibrator motor is well suited to this application. A preferred pump for this purpose is manufactured by Gorman-Rupp of Bellville, Ohio identified as their model M12115. It will suffice to say that such a motor has a

coil 40 vibrating an armature 41 which is supplied with half waves of A-C through a rectifier 42. The armature is connected to a bellows 43 having integral valve flaps 44 defining an inlet chamber 45 and an outlet chamber 46. Movement of the central portion of the bellows to the right compresses the fluid in the chamber 45 causing the tips 47 of the flaps to open slightly forcing a small amount of the liquid into the outlet chamber 46. On the return stroke the tips are sealed by fluid pressure and the liquid in the outlet chamber is partly expelled. The result in successive cycles is to produce a steady flow of liquid from inlet to outlet. The developer liquid which is discharged at the ends of the distributor 30 sets up a current in the developer tray which maintains the toner in an evenly distributed suspension.

In accordance with the invention the reservoir bottle is located below the level of the tray and interconnected with the tray by an overflow line which is connected at a working level at the top of the tray and a restricted drain line which is connected to the bottom of the tray so that developer liquid is maintained at the working level during the time that the pump is turned on and completely drained, by gravity, from the tray to the reservoir when the pump is turned off. Thus referring to FIG. 1 I provide an overflow line 50 having an inlet connection 51 positioned at the desired working level 52 of the developer liquid and having an opposite end 53 which terminates within the enclosed reservoir. Similarly a drain line 55 is provided having an inlet 56 at the bottom of the tray and an outlet 57 which extends into the reservoir. The drain line is preferably made of tubing having a smaller gauge than the overflow line so that the gravity draining rate is substantially less than the rate of output of the pump, with the result that the developer is kept at the working level 52 with constant overflow which is accommodated through the overflow line 50.

In order to maintain the amount of developer liquid in the system constant and to make up for the loss of the vehicle absorbed in the porous copy sheets, an enclosed vehicle replenisher is provided which is connected to the suction side of the pump with the flow being controlled by a solenoid valve which is turned on and off by a float switch in the reservoir. Thus I provide an enclosed replenisher bottle 60 having a dip tube 61 connected to a vehicle replenisher line 62 having a valve 63 controlling the flow, the valve being operated by a solenoid 64. The vehicle replenisher line terminates at an orifice 65 in the line 24 at the suction side of the pump. For energizing the solenoid 64 a normally open switch 66 is provided under the control of a float 67. In the event that the level drops below the line 68, the contacts in the switch 66 are closed thereby energizing the solenoid 64 and opening the valve 63 so that vehicle is drawn from the replenisher bottle and discharged at the orifice 65 into the suction stream of the recirculating developer liquid. When the level of the liquid in the reservoir rises to the level 68*a*, the switch 66 is opened, turning off the solenoid and stopping the flow. A small vent 69 is provided in the cap of the bottle to admit a small amount of air to take the place of the liquid which is withdrawn.

The level 68, for which the float switch is adjusted. allows sufficient head room in the reservoir to accommodate the entire contents of the tray.

In accordance with one of the aspects of the invention novel means are provided for replenishing the toner which is removed from the developer liquid as the copies are developed. Thus I provide a toner concentrate bottle 70 containing toner concentrate in the form of toner particles packed in a small amount of vehicle and sufficiently concentrated to form a liquid having a viscosity which is substantially greater than the developer liquid. Extending down into the body of toner concentrate is a dip tube 71 which is connected by a toner concentrate line 72 to a concentrate valve 73 having an associated

solenoid 74. The concentrate line terminates in an orifice 75. As shown in detail in FIG. 3, the orifice 75 is made of small diameter, for example, 0.014", supplied by a line in the form of flexible tubing having an inside diameter of 1/16 inch. The restricted orifice thus performs a metering function so that under the suction which exists in the suction line 24 only a small amount of concentrate will be fed to the stream of recirculating developer liquid during each unit of time that the valve 73 is open.

It is one of the features of the present invention that the vehicle orifice and the concentrate orifice are both located at the suction side of the pump, preferably close together and occupying the same fitting indicated at 76. It is a further feature of the present invention than an orifice of relatively small diamteer is employed with the relatively viscous toner concentrate closely adjacent the suction side of a pump of the vibratory, rapidly pulsating type, with the vibrations of the fluid column serving to keep the concentrate in the immediate vicinity of the orifice in constant motion thereby to avoid any tendency toward blockage or constriction.

In accordance with the present invention a timing motor is provided having an input line which is energized only as long as copy sheets are flowing through the machine and which controls a pair of output contacts for opening the valve in the concentrate line when the integrated length of the processed copy sheets reaches a predetermined total, and with the valve being kept open a sufficient length of time to meter out an amount of concentrate approximately equal to that which has been consumed by the sheets. For the purpose of detecting the presence of a copy sheet in the machine, a copy sheet detector switch 80 (see FIG. 5) is used having a detector arm 81 and feeding the input terminal 82 of an integrating timer 83 having a motor 84. As shown in FIG. 4, the motor 84, via a suitable gear train, drives a pair of cams at different speed, the cams acting jointly to control a switch which energizes the solenoid which controls the flow of toner concentrate. Thus in the present instance I provide a first cam 85 having a notch 86 and which rotates at 1/4 r.p.m. and a second, composite, cam 90 which is formed of a pair of cam elements 91, 92 to provide a notch 93 of adjustable width. The composite cam operates at a higher speed than the cam 85, for example at the rate of 1 r.p.m. For the purpose of clamping the cam elements 91, 92 in an adjusted position to set the width of the notch 93, the upper one of the two cam elements is slotted and engaged by a thumb nut 94.

As a result of the use of the dual speed, adjustable cams, the switch, indicated at 95, may be set to operate, with a high degree of accuracy, at the end of a predetermined, integrated time period. In a practical case, the integrated time interval may be 240 seconds. Since the timer motor 84 is turned on only during the time of passage of the copy sheets, and since the copy sheets may, in a practical machine, be transported at the rate of 3 inches per second, 720 inches of copy sheet, corresponding to 66 sheets of letterhead size, will be processed prior to closure of the switch 95. The time that the concentrate is allowed to flow depends upon a number of factors including the viscosity of the concentrate, the size of the orifice through which it must pass and the amount of suction. With such parameters established, it is a simple matter to position the cam elements 91, 92 to provide a notch 93 of appropriate length so that the average amount of toner in the system is maintained at a sufficiently high level so as to produce copies of high density as the machine is operated over an external period of time.

While the operation of the system as a whole will be readily understood from the foregoing description, it may be helpful to summarize it briefly. Under standby conditions, with the pump turned off, the developer liquid is totally drained from the tray via the drain line 55 into the reservoir. Since the reservoir and the two replenishing bottles are enclosed, very little of the volatile vehicle is

lost through evaporation. When the photocopy machine is turned on, the main switch, indicated at **96**, causes the pump **25** to be energized by half waves of current through the rectifier, reciprocating the pumping element and causing the flow of the developer liquid from the reservoir through the line **24** and out of the pump through the line **28** into the distributor **30** in the developer tray. As the liquid level rises in the developer tray some of the liquid flows through the drain line **55** back into the reservoir bottle, but since the drain line is relatively restricted, the liquid level will continue to rise to establish a working level **52**. Any tendency for the liquid to rise above the level **52** is thwarted by drainage through the unrestricted overflow line **50**. Thus the combined flow through the overflow and drain lines **50**, **55** equals the rate of output of the pump, and constant recirculation of the developer liquid takes place all the time that the machine is in use.

Each time that a copy sheet passes through the machine the timing motor **84** is energized, and, after 240 seconds of such energization, the notches **86**, **93** on the two cams come into register with the switch arm thereby causing the switch **95** to turn on closing the circuit to the solenoid **74** which opens the valve **73** in the toner concentrate line. Because of the slight negative pressure which exists on the suction side of the pump, toner concentrate flows from the concentrate bottle **70** through the concentrate line **72** to the orifice **75** where the flow is metered. Because of the constant flow and vibration which exists in the recirculation path, the toner concentrate is promptly and evenly dispersed in the body of developer liquid.

When the float switch **66** calls for additional liquid, energizing the solenoid **64** and opening the valve **63**, the liquid vehicle, too, is intimately mixed with the flowing stream of developer liquid. In short, the stream, although augmented by added toner and vehicle, is completely homogeneous by the time it is discharged into the developer tray. When the arm of the switch **95** is engaged by the end of the notch **93**, the switch **95** is again turned off, closing the concentrate valve **73** so that no further concentrate is added, with the process being repeated at the end of an additional 240 seconds or following the processing of an additional 66 copies of letter size. Where copy paper of legal size is used, replenishment of the toner will take place automatically upon processing a proportionately reduced number of copies.

In the following claim the term "suction side" of the pump shall be understood to mean any region of reduced

pressure resulting from the presence of the pump or from the flow of the pumped liquid. The term "float switch" shall be understood to mean any switch which automatically senses a drop in the level of the liquid in the reservoir bottle for energization of the valve which controls the flow of the added vehicle.

I claim as my invention:

1. In a liquid developer system for a photocopy machine using a developer liquid formed of a colloidal suspension of toner dispersed in a liquid vehicle, a developer tray having a body of developer liquid and means for guiding a sensitized copy sheet therethrough, an enclosed reservoir bottle, a liquid pump connected between the reservoir bottle and the tray for pumping developer liquid into the tray, an overflow line connected from a working level at the top of the tray to the bottle, a drain line connected from the bottom of the tray to the bottle, said overflow line being relatively free of restriction and said drain line being restricted so that liquid developer is maintained at the working level during the time that the pump is running but is totally drained from the tray when the pump is shut off, an enclosed vehicle replenisher bottle, a replenisher line including a valve connected to the replenisher bottle and the suction side of the pump, and a float switch in the reservoir bottle for controlling the valve to replenish the vehicle consumed in the developer system, said float switch being positioned to maintain a level of liquid developer well below the top of the reservoir bottle to provide space for the developer liquid drained from the tray.

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