May 26, 1970 A. S. ZERFAHS 3,514,203

AUTOMATIC TONER REPLENISHER

Original Filed May 11, 1964 3 Sheets-Sheet 1

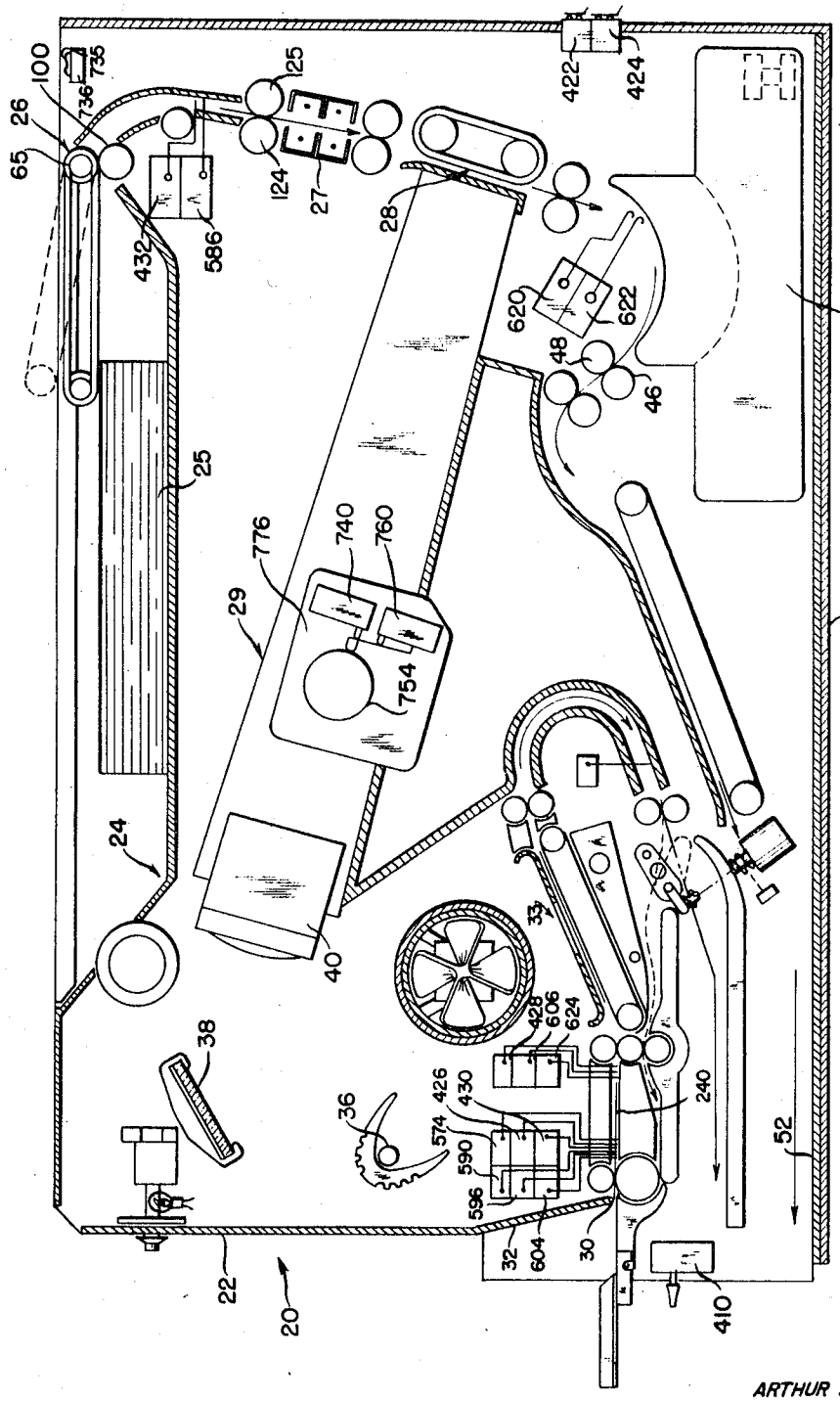


FIG. 1

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AUTOMATIC TONER REPLENISHER

Original Filed May 11, 1964 3 Sheets-Sheet 2

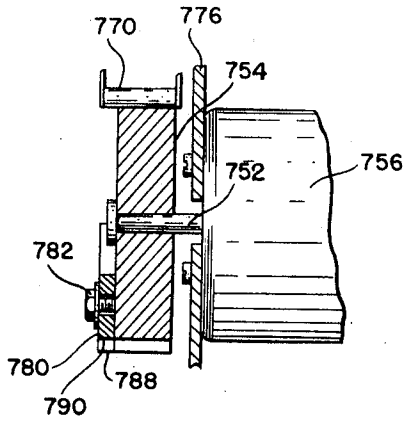


FIG. 3

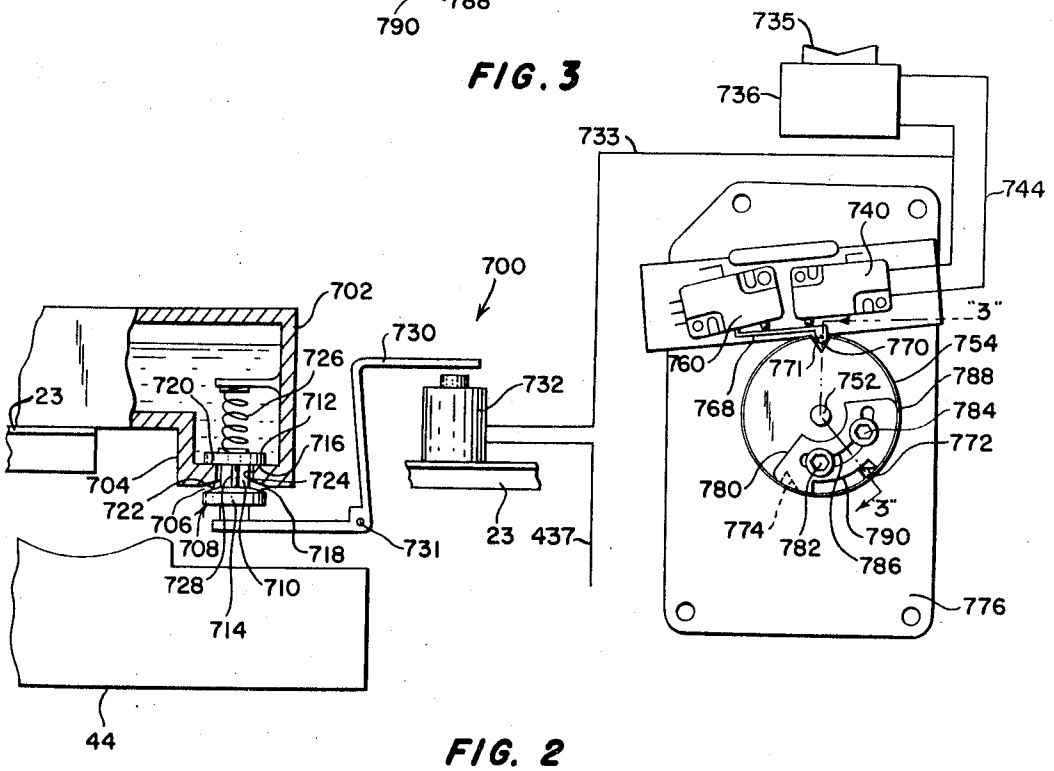


FIG. 2

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AUTOMATIC TONER REPLENISHER

Original Filed May 11, 1964 3 Sheets-Sheet 3

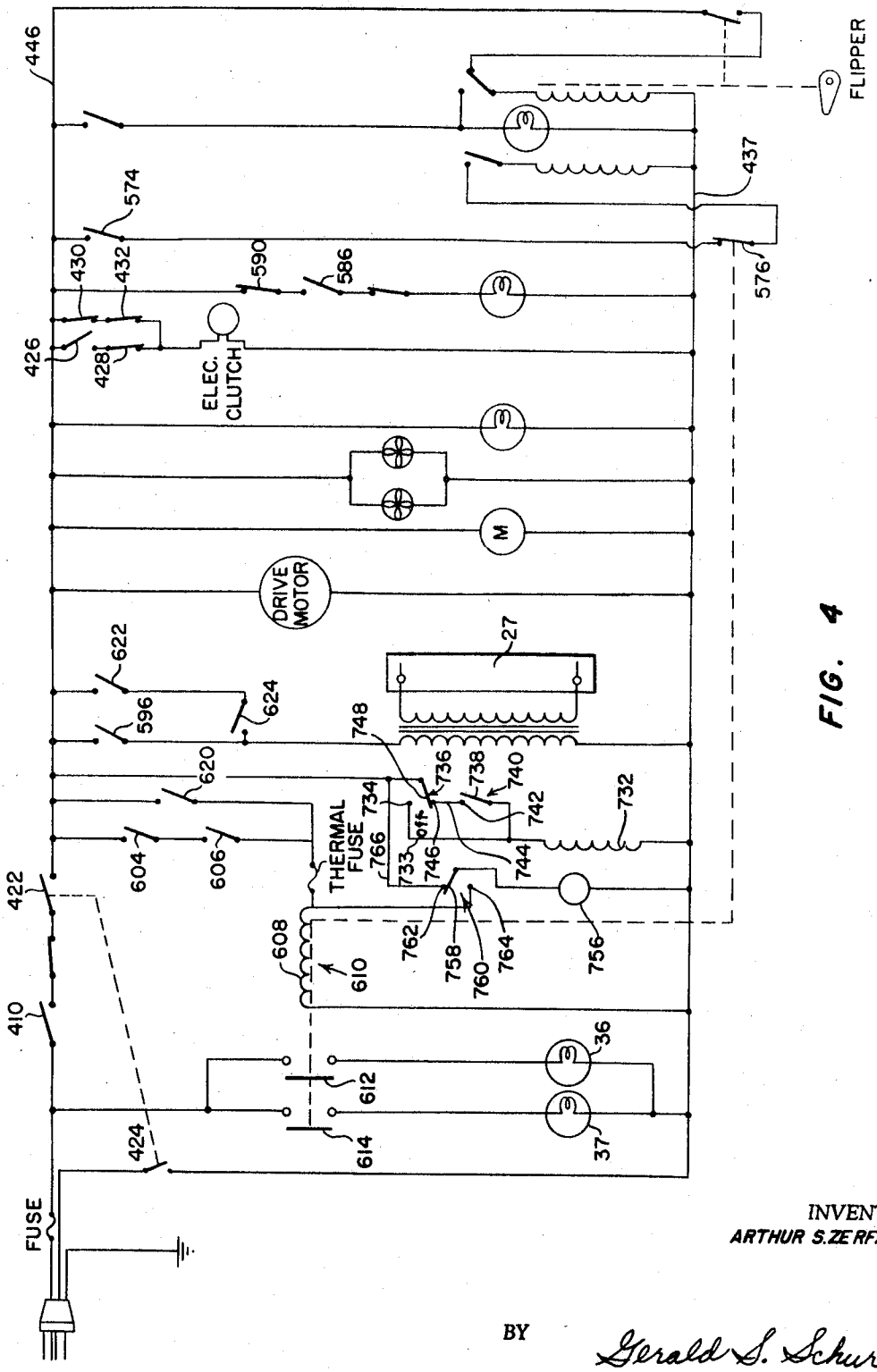


FIG. 4

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3,514,203

AUTOMATIC TONER REPLENISHER

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Original application May 11, 1964, Ser. No. 366,268, now Patent No. 3,330,179, dated July 11, 1967. Divided and this application May 17, 1967, Ser. No. 639,115

Int. Cl. G03g 15/10

U.S. Cl. 355—10 12 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus having a valve operated by the movement of copy paper through a photocopying machine for automatically replenishing pigment materials in the liquid developer or toner solution which is contained in a tank for developing the final image on the copy paper. A solenoid mechanism operated by the moving copy paper actuates the valve to deliver a solution of the pigment material from a storage container in amounts controlled by the length of the copy paper passing through the developer in the tank.

This application is a division of copending United States application Ser. No. 366,268 filed May 11, 1964, for Automatic Photocopying Apparatus now Pat. No. 3,330,179.

The present invention relates to duplicating machines such as electrostatic printers which use a liquid toner solution for making copies of original documents. The liquid toner solutions or liquid developers used in duplicating machines which make multiple copies of an original document basically comprise a dispersion of pigment particles in a high resistivity liquid carrier. The pigment particles may be coated with a fixer or charge control agent or other various additives. As the duplicating machine is used, the proportion of pigment particles in the solution diminishes since these particles are removed from solution on the image regions of the copy sheets. After several copies have been developed, the density of pigment particles on successive copy sheets may decrease thereby undesirably reducing the uniformity of the copies produced.

Accordingly a principal object of this invention is to provide a novel apparatus for automatically replenishing pigment materials in the liquid developer or toner solution used for developing the final image on a copy sheet.

A yet further object is to provide a novel means for automatically replenishing the developer that is responsive to the length of the copy paper that passes through the printer.

Further objects of the inveniotn will presently appear as the description proceeds in connection with the appended claims and the annexed drawings wherein:

FIG. 1 is a sectional view of an electrostatic printer embodying the automatic toner replenisher of the invention;

FIG. 2 is an enlarged partially schematic view of the automatic replenishing system;

FIG. 3 is a section taken substantially along lines 3—3 of FIG. 2; and

FIG. 4 is a schematic diagram of the sequencing and control circuit for the printer shown in FIG. 1;

Referring now to the drawings, and more particularly to FIG. 1, the reference numeral **20** generally designates an electrostatic printing machine comprising a casing **22** removably mounted on a rigid frame **23**. Reference may be made to parent patent application Ser. No. 366,268 in which the printer **20** is disclosed in greater detail.

Arranged within casing **22** is a copy paper supply compartment **24** comprising a shallow sheet metal tray into which photoconductive paper may be loaded in a stack **25**. A paper feed mechanism generally indicated at **26** removes sheets of the copy paper from stack **25** in compartment **24** and transports them one at a time through a corona charging unit **27** where a uniform charge of approximately —400 volts is applied to the surface of the copy paper. From charging unit **27**, each sheet of copy paper is fed through an imaging station **28** located adjacent the lower end of an imaging projector **29**.

The original document to be copied may be manually inserted through a horizontal slot **30** provided in a panel **32** which forms the front wall of casing **22**. The document fed through slot **30** is conveyed through an imaging station **33**. The copy paper is advanced through its imaging station **28** synchronously and in timed relation to the movement of the document through station **33**.

Imaging station **33** is located below the forward end of imaging projector **29**. Light is focused on imaging station **33** as by a pair of projection lamps **36** and **37**, shown in FIG. 4, and an image is reflected from the surface of the original document into an objective lens **40** of projector **29** by a mirror **38**. Lens **40** projects the reflected image onto the surface of the sheet of copy paper passing through its imaging station **28**. As the image strikes the copy paper, the charge on the paper is reduced by an amount determined by the intensity of the reflected light. The black portions of the original will reflect such a relatively small light intensity as to affect the charge very little, while the light portions of the original will reflect sufficient light intensity as to almost completely release the latent electrostatic charge on the copy paper as is well known in the art.

With continued reference to FIG. 1, the exposed copy sheet containing the latent charge pattern is developed to provide a visible image as by being passed through a developing tank **44**. A liquid developer contained in tank **44** and having charged particles is applied to the latent image bearing surface of the copy paper. These charged particles, which may have a positive polarity, are attracted to negatively charged areas on the copy sheet to a degree determined by the charge at each region on the surface on the copy paper, thereby producing a graphic image. The copy paper feed mechanism then moves the developed copy paper between squeegee rollers **46** and **48** which remove the excess developer from the copy paper and which, if desired, may provide a direct voltage of relatively low magnitude to control the density of the image and/or the cleanliness of the background of the developed copy paper.

The sheets of copy paper deposited on surface **52** may be removed by an operator through an opening in panel **32**.

Referring to FIGS. 1 and 4, the leading edge of the advancing document to be copied trips an actuator to close a further normally open switch **604** at the same time that it trips switch **596**. Actuation of switch **604** to its closed position closes a circuit to another normally open switch **606** which is tripped to its closed position by the leading edge of the advancing document at the same time that switch **428** is opened. Switches **428** and **606** are tripped by the advancing document considerably before the trailing edge of the document clears the actuators of switches **426**, **430**, **574**, **590**, **596**, and **604** with the result that switches **426**, **430**, **574**, **590**, **596** and **604** are held in their tripped positions when the document trips switches **428** and **606**.

By closing switches **604** and **606** a circuit is completed to energize a winding **608** of a relay **610** in an energizing network for projection lamps **36** and **37**, shown in FIG.

4. Energization of relay **610** closes two sets of normally open relay contacts **612** and **614** and opens switch **576**. Contacts **612** and **614** are respectively connected in series with projection lamps **36** and **37** are illuminated by advancement of the document to be copied to the position along guide path **240** where it trips switch **606** after tripping switch **604**.

As the copy paper emerges from imaging station **28** as shown in FIG. 1, it simultaneously trips two normally open switches **620** and **622** before entering tank **44**. By closing switch **620**, a further circuit, as shown in FIG. 4, is provided in parallel with the circuit through switches **604** and **606** for maintaining relay **610** energized. Shortly after switch **620** is tripped, the trailing edge of the original document clears the actuators of switches **426, 430, 574, 590, 596**, and **604** where the original document and the sheet of copy paper are about the same length. As a result, switches **426, 574, 596**, and **604** will open, and switches **430** and **590** will close. Although switch **604** opens at this time, projection lamps **36** and **37** remain illuminated as a result of the relay energizing circuit being completed by closing switch **620**.

If the sheet of copy paper and the document are the same length, the trailing edge of the copy paper will clear the actuators of switches **432** and **586** at the same time that the trailing edge of the document clears the actuators of switches **426, 430, 574, 590, 596** and **604** with the result that switches **432** and **586** will respectively open and close at the same time that switches **426, 574, 596**, and **604** open. Closing of switches **430** and **432** completes a circuit for energizing clutch for advancing the next sheet of copy paper in stack **25** to rollers **65** and **100**.

After the trailing edge of the original document clears the actuator of switch **596**, corona unit **27** remains energized through switch **622** and a normally open switch **624**. Switch **624** is connected in series with switch **622** and winding **598** and has an actuator which is positioned in document feed path **240** to be tripped to its closed position simultaneously with the actuation of switches **428** and **606**. Corona unit **27** will remain energized as a result of the closing of switch **622** by the copy paper and the closing of switch **624** by the original document.

When the trailing edge of the original document clears the actuators for switches **428, 606**, and **624**, switch **624** will open to de-energize corona unit **27**. Although switch **606** opens at this stage of the operation, relay **610** and, consequently, projection lamps **36** and **37**, shown in FIG. 4 remain energized through switch **620**.

As the copy paper which was advanced through corona unit **27** and imaging station **28** passes through tank **44**, its trailing edge clears the actuator for switch **620**, permitting this switch to open with the result that projection lamps **36** and **37** will turn off. The processed copy paper is advanced from tank **44** to surface **52** where it may be removed from the printer as previously explained.

Referring now to FIG. 2, a mechanism **700** for automatically replenishing the toner pigment applied to the copy paper in tank **44** is shown to comprise a container **702** in which a liquid pigment particle solution is stored. Container **702** is suitably mounted on frame **23** and is formed with a cylindrical section **104** providing a liquid outlet port **706** for supplying the stored solution to tank **44**.

With continued reference to FIG. 2, a valve member **708** is mounted in cylindrical section **704** for controlling flow of the solution through outlet port **706**. Valve member comprises a cylindrical section **710** axially extending between radial flange portians **712** and **714** which respectively define opposed annular seating surfaces **716** and **718**. Surfaces **716** and **718** are respectively adapted to seat against oppositely facing annular surfaces **720** and **722** formed in cylindrical section **704** at opposite ends of a straight through bore **724** which coaxially receives section **720** of valve member **708** and which establishes fluid communication between the interior of the container **702** and outlet port **706**.

Valve member **708**, as shown in FIG. 2, is biased by a spring **726** to a position where surface **716** seats on surface **720** to block passage of the solution in container **702** through bore **724**. The dimensions of bore **724** and valve member **708** are such that when surface **716** seats on surface **720**, surface **718** is axially spaced below seating surface **722**. When valve member **708** is lifted from the position shown in FIG. 4 against the bias of spring **726**, the solution in container **702** will flow through bore **724** along longitudinal grooves **728** formed in section **710** until valve member **708** is raised to a position where surface **718** seats against surface **722**. Thus in either its fully raised or fully lowered position, valve member **708** serves to block supply of solution to tank **44**. As valve member **708** is rased from its position shown in FIG. 2 to its fully raised position, a metered predetermined amount of solution in container **702** is permitted to flow into tank **44** to replenish the tank solution with pigment.

To automatically operate valve member **708**, an actuating arm **730**, also shown in FIG. 2 is pivotally mounted on frame **23** by a pin **731** and has one end adapted to engage the lower end of member **708**. By pivoting arm **730** in a clockwise direction, valve member **708** is lifted against the bias of spring **726**. To pivot arm **730** for lifting valve member **708**, a solenoid **732** (FIGS. 2 and 4) is suitably mounted on frame **23** and has one terminal connected to conductor **437**.

As shown in FIG. 4, the other terminal of solenoid **732** is connected by a conductor **733** to a contact **734** of a two position manually operated, spring loaded pushbutton switch **736** and also to a switch blade **738** of a normally open switch **740**. Switch blade **738** is adapted to engage a contact **742** which is connected by a conductor **744** to a further contact **746** of switch **736**.

To manually operate the valve member **708** and with continued reference to FIG. 4, switch **736** has a leaf **748** normally engaging contact **746** to establish a circuit for energizing a solenoid **732** when switch **740** is closed. A pushbutton **735** suitably mounted on the switch **736** is depressible to actuate leaf **748** to engage contact **734** to thus complete a circuit for selectively energizing solenoid **732** through conductor **733**. Energization of solenoid **732** attracts arm **730**, causing it to pivot in a clockwise direction as viewed in FIG. 2 for lifting valve member **708** against the bias of spring **726**.

With reference to FIGS. 2 and 4, switch **740** is actuated by a mechanism comprising a cam **754** nonrotatably mounted on a drive shaft **752** of a conventional timer motor **756**. One motor winding terminal of motor **756** is, as shown in FIG. 4, connected to conductor **437**. The other terminal of motor **756** is connected to a blade **758** of a two-position switch **760** having contacts **762** and **764**.

Blade **758** normally engages contact **762** which is connected by a conductor **766** to a conductor **446** to energize motor **756** when switches **410, 422**, and **424** are closed throught a current path that is in parallel with solenoid **732**.

With continued reference to FIG. 4, contact **764** is connected to conductor **446** through switches **604** and **606** and also through switch **620**. Thus, when switch blade **758** engages contact **764**, motor **756** is energized to rotate cam **754** whenever relay **610** including winding **608** is energized to illuminate lamps **36** and **37**.

As shown in FIG. 2, switch **760** is actuated by a spring leaf **768**. A roller **770** mounted on leaf **768** is biased into engagement with the periphery of cam **754** which is formed with three circumferentially spaced apart notches **771, 772**, and **774**. When roller **770** is unseated from cam notches **771, 772**, or **774** and rides high on the periphery of cam **754** switch blade **758** is urged into engagement with contact **764** to complete a circuit for energizing motor **756** whenever relay **610** is energized.

When cam 754 is rotated to a position where roller 770 seats in any one of the notches 771, 772, or 774, switch blade 758 is moved into engagement with contact 762 to keep motor 756 energized through conductor 766. As a result, motor 756 cannot be de-energized when roller 770 is in any of the notches 771, 772, and 774 for a purpose to be explained shortly.

With continued reference to FIG. 2, switch 740 is actuated by leaf 768 and is closed to complete a circuit for energizing solenoid 732 whenever roller 770 seats in any of the cam notches 771, 772, and 774. Actuation of switch 740 is so adjusted that it closes after switch blade 758 engages contact 764 and opens before blade 758 disengages from contact 764. This insures that solenoid 732 is not held energized for objectionable, long periods of time. Owing to the previously described circuitry for energizing motor 756, it will be appreciated that cam 754 cannot be stopped in a position where roller 770 is seated in any one of the notches 771, 772, or 774 with the result that solenoid 732 cannot be continuously energized to permit an excessive amount of pigment to be supplied to tank 44.

As shown in FIG. 2, switches 760 and 740 are suitably mounted on a support plate 776 which is secured in place on frame 23. Motor 756 is mounted on plate 776 by any suitable means.

In operation of the printer 20, the switches 410, 422, and 424 must be closed before the document to be copied is fed into the printer 20. When switches 604 and 606 are closed by the advancing document, relay 610 is energized to illuminate exposure lamps 36 and 27. Closing of switches 604 and 606 also completes a circuit for energizing motor 756 through switch 760 with the result that cam 754 will be rotated. When roller 770 enters any one of the cam notches 771, 772, or 774, switch 740 closes to energize solenoid 732 through switch 736. Since an energizing circuit for motor 756 is maintained through engagement of switch blade 758 with contact 762 when roller 770 is seated in any of the cam notches 771, 772, or 774 cam 754 will continue to rotate, causing roller 770 to ride out of the cam notch to open switch 740. As a result, solenoid 732 will be pulsed each time roller 770 rides into one of the cam notches 771, 772 or 774.

By pulsing solenoid 732, arm 730 is momentarily attracted to lift valve member 708. When solenoid 732 is deenergized, spring 726 returns valve member 708 to the position shown in FIG. 2. As a result of displacing valve member 708 in this manner, a small predetermined amount of solution in container 702 is supplied to tank 44.

Motor 756, it will be noted, remains energized to continuously rotate cam 754 until the trailing edge of the document clears the actuator for switch 604 and the trailing edge of the copy paper clears the actuator for switch 620. Since switch 606 is closed at the time the copy paper is picked up by rollers 124 and 125, cam 754 will be continuously rotated for the period of time that the leading edge of the copy paper travels from rollers 124 and 125 to the actuator of switch 620. Thereafter, cam 754 continues to be rotated depending essentially upon the length of the copy paper since the leading edge of the copy paper trips switch 620 to closed position and holds switch 620 in closed position until its trailing edge clears the actuator for switch 620. Thus, the amount of pigment supplied to tank 44 is made dependent on the length of copy. The length of copy paper, it will be appreciated, constitutes an approximate measure of the amount of pigment picked up by the copy paper in tank 44 and thus the amount of pigment that is required to be replaced.

The number of shots of solution supplied to tank 44 from container 702 may be adjusted by varying the speed of motor 756 or by changing the number of notches in cam 754. If an additional amount of pigment is needed to replace that which is removed by the copy paper, pushbutton 736 is manually depressed to swing leaf 748 into engagement with contact 734 for energizing solenoid 732 through conductor 733. When pushbutton 736 is released, this energizing circuit for solenoid 732 is interrupted by the return movement of leaf 748 into engagement with contact 746 where solenoid 732 is energized only when switch 740 is closed.

To effectively vary the number of notches in cam 754 in which roller 770 will seat, a plate 780, as shown in FIGS. 2 and 3, is mounted on the forward side of cam 754 by a pair of screws 782 and 784. Screws 782 and 784 extend through an arcuate slot 786 in plate 780 and are threadedly received in tapped bores (not shown) formed in cam 754. By loosening screws 782 and 784, plate 780 is adjustably swingable about the rotational axis of cam 754.

With continued reference to FIGS. 2 and 3, plate 780 is formed with an outer peripheral surface 788 which is flush with the periphery of cam 754 and which has an elongated, circumferentially extending, outwardly opening recess 790. In the position of plate 780 shown in FIG. 7, recess 790 aligns with notch 772. The dimensions of plate 780 and of cam 754 are such that recess 790 will be disposed circumferentially between notches 772 and 774 when plate 780 is in its extreme counterclockwise adjusted position.

As best shown in FIG. 3, roller 770 projects beyond the forward side face of cam 754 so that its left-hand end portion rides along surface 788 of plate 780. By adjusting plate 780 to the position shown in FIG. 3 where recess 790 aligns with notch 772, roller 770 will ride into notches 771 and 772 but will not ride into notch 774. When plate 780 is swung to an extreme counterclockwise position where recess 790 is between notches 772 and 774, roller 770 only rides into notch 771 as cam 754 is rotated. By removing plate 780, roller 770 is permitted to ride into all three of the cam notches 771, 772 and 774. Thus it is clear from the foregoing that by adjusting or removing plate 780, the number of times solenoid 732 is pulsed and, consequently, the number of shots of solution supplied to tank 44 for each revolution of cam 752 may be selectively varied.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by Letters Patent is:

1. In a duplicating machine the combination comprising means for producing an image on a sheet of copy paper including means providing for a supply of toner having developer particles adapted to produce a visible image on the sheet of copy paper and means for contacting the sheet of copy paper with the toner to apply the developer particles to at least one surface of the said sheet of copy paper, and replenishing means for replenishing the supply of developer particles in said toner, said replenishing means being operable in response to a unidirectional actuating movement, and actuating means for actuating said replenishing means, said actuating means being operable in response to the movement of the sheet of copy paper through said machine for producing said unidirectional actuating movement for automatically actuating the replenishing means in accordance with the length of copy paper moving through said machine.

2. The duplicating machine defined in claim 1 wherein said supply of toner is in liquid form and is confined in a receptacle, and wherein said replenishing means for replenishing said supply of developer particles comprises a container for storing developer particles in liquid form, said container having an outlet port, and valve means con-

trolling the flow of developer particles through said outlet port, said valve means being operable in response to said unidirectional actuating movement, and said actuating means being adapted for operating said valve means in accordance with the length of copy paper moving through said machine.

3. The duplicating machine defined in claim 2 comprising means for selectively adjusting the amount of the stored pigment particles in liquid form delivered to said receptacle in response to a predetermined length of copy paper passing into contact with said toner.

4. The duplicating machine defined in claim 1 wherein said replenishing means for replenishing said supply of developer particles comprises a container for storing developer particles in liquid form, said container having an outlet port for supplying said particles to said receptacle, and valve means controlling the flow of said developer particles from said container to said receptacle, said valve means being operable in response to said unidirectional actuating movement, and said actuating means being adapted for cyclically actuating said valve means between opened and closed positions a predetermined number of times in response to the movement of said copy paper dependent upon the length of the copy paper coming into contact with said toner.

5. The duplicating machine defined in claim 4 comprising means for adjusting the number of times said valve means is opened by said actuating means for a given length of copy paper.

6. In a duplicating machine, means for developing an image on a sheet of copy paper including means providing for a supply of toner having developer particles, said supply of toner being in liquid form and confined in a receptacle, and means for passing said copy paper into contact with said toner to apply the developer particles at least to one surface of said copy paper for producing a visible image thereon, and means controlled by the sheet of copy paper moving through said machine for automatically replenishing the supply of developer particles in said toner comprising a container for storing developer particles in liquid form and having an outlet port, valve means controlling the flow of developer particles through said outlet port and being operable in response to a unidirectional actuating movement, and means responsive to the movement of said copy paper through said machine for operating said valve means in accordance with the length of the said sheet of copy paper comprising switch means having an actuator so disposed in the path of the moving copy paper that said switch means is tripped by the leading edge of said sheet of copy paper and held in the tripped position until the trailing edge of said sheet of copy paper clears said actuator, and means for producing said unidirectional actuating movement in response to the tripping of said switch means for actuating said valve means to an opened position.

7. The duplicating machine defined in claim 6 comprising means including a lamp for providing at least one source of projection radiation for projecting the image of a document to be copied onto said copy paper before it contacts said toner, and means for energizing said lamp whenever said switch means is tripped by said copy paper.

8. In a duplicating machine, a duplicating station, guide means defining a path for routing a document to be copied through an exposure zone in said duplicating station, means for advancing said document along said path and for feeding copy paper through said duplicating station in timed relation with the movement of the document therethrough to enable the transfer of an image from said document to said copy paper as they pass through said duplicating station, and means for developing the image on said copy paper comprising a receptacle for confining a body of liquid toner having pigment particles adapted to make a visible image on the copy paper and means for passing the copy paper into contact with the toner after it passes through said duplicating station to apply the pigment particles to at least one surface of said copy paper, and means controlled by movement of said document and said copy paper for replenishing the supply of pigment particles in said toner.

9. The duplicating machine defined in claim 8 wherein said pigment particle replenishing means comprises a container for storing pigment particles in liquid form and having an outlet for supplying said solution to said receptacle, a normally closed valve for controlling flow of said pigment particles from said container to said receptacle, and means including first and second actuator means for operating said valve, said first actuator means being engaged by said document as it is advanced towards said exposure zone to open said valve, and said second actuator means being engaged by said copy paper as it moves away from said station to open said valve after said document disengages from said first actuator means.

10. The duplicating machine defined in claim 9 wherein said means for operating said valve further comprises means for cyclically opening and closing said valve as long as the document and copy paper respectively remain engaged with said first and second actuator means.

11. The duplicating machine defined in claim 10 wherein said second actuator means comprises a switch actuated by movement of said copy paper and wherein said means for cyclically operating said valve comprises a motor energized by actuation of said switch and means controlled by energization of said motor for effecting operation of said valve.

12. The duplicating machine defined in claim 1 wherein said toner is in liquid form and wherein the developer particles which are provided for replenishing the supply of particles in said toner are in liquid form.

References Cited

UNITED STATES PATENTS

3,195,430	7/1965	Young	355—10
3,282,177	11/1966	Stanton	355—10
3,352,218	11/1967	Ostensen	355—3

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U.S. Cl. X.R.

117—37