April 7, 1970 G. MATKOVICH ET AL 3,504,968

TONER DISPENSING APPARATUS FOR ELECTROSTATIC COPYING MACHINES

Filed May 31, 1966 2 Sheets-Sheet 1

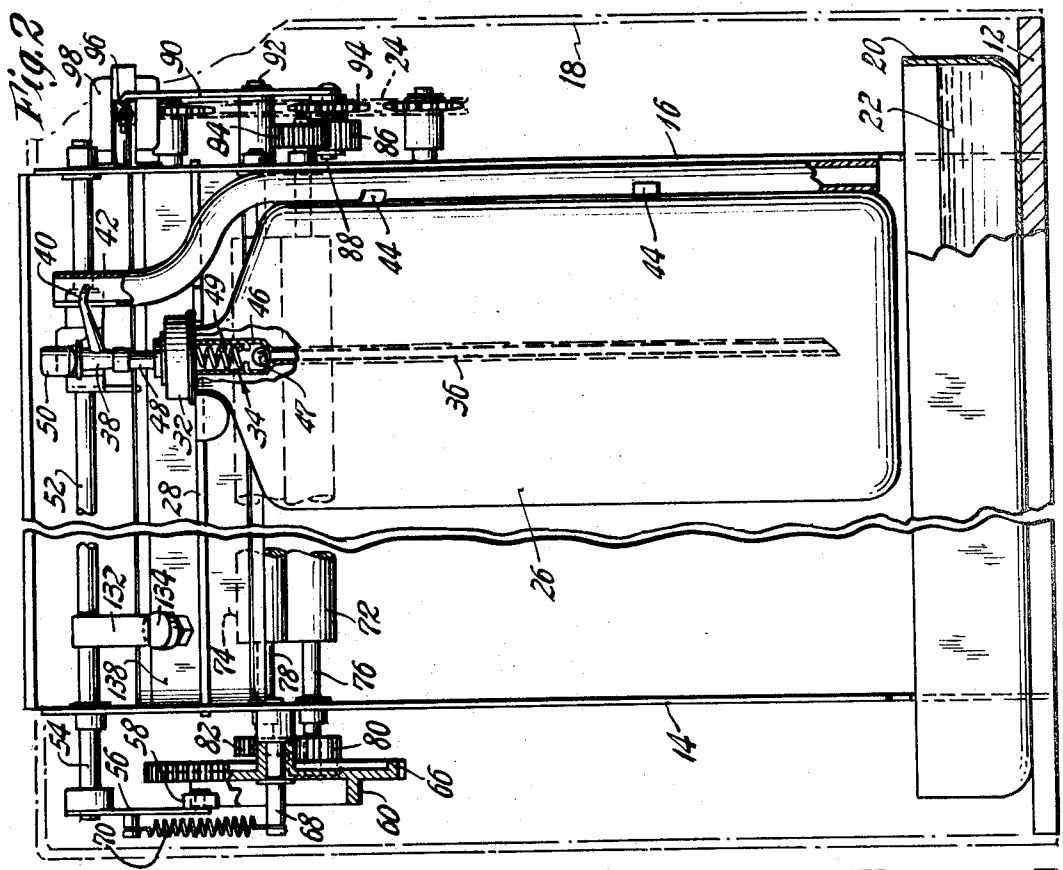


Fig. 2

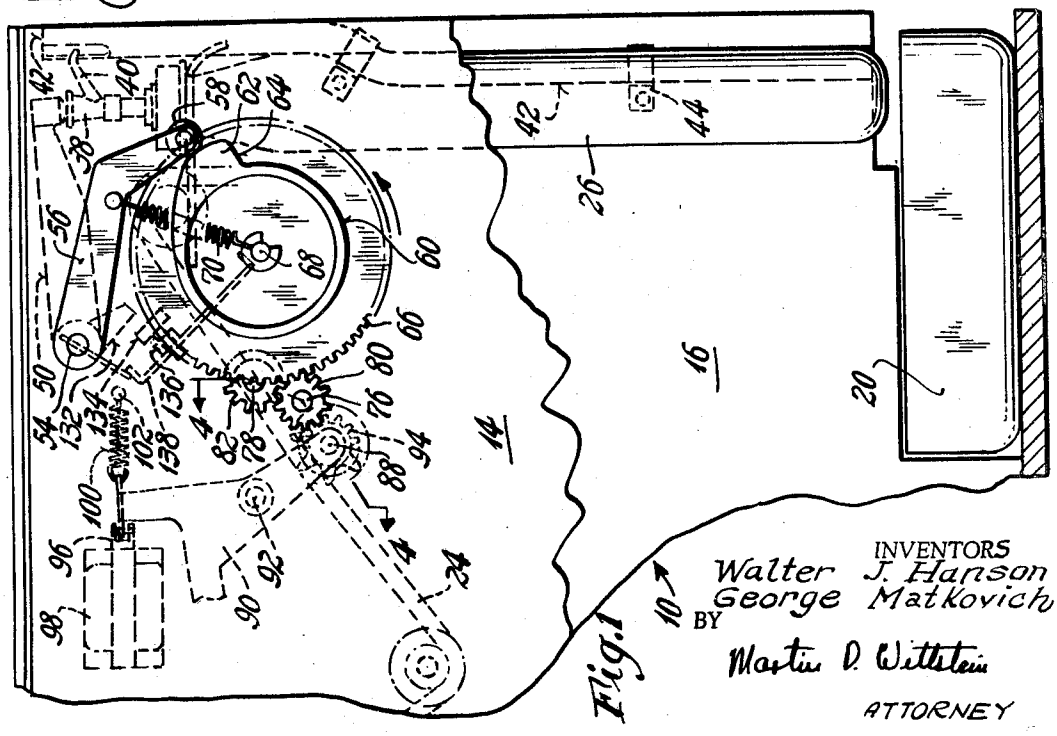


Fig. 1

INVENTORS
Walter J. Hanson
George Matkovich

BY
Martin D. Wittstein
ATTORNEY

April 7, 1970 G. MATKOVICH ET AL 3,504,968

TONER DISPENSING APPARATUS FOR ELECTROSTATIC COPYING MACHINES

Filed May 31, 1966 2 Sheets-Sheet 2

Fig. 3

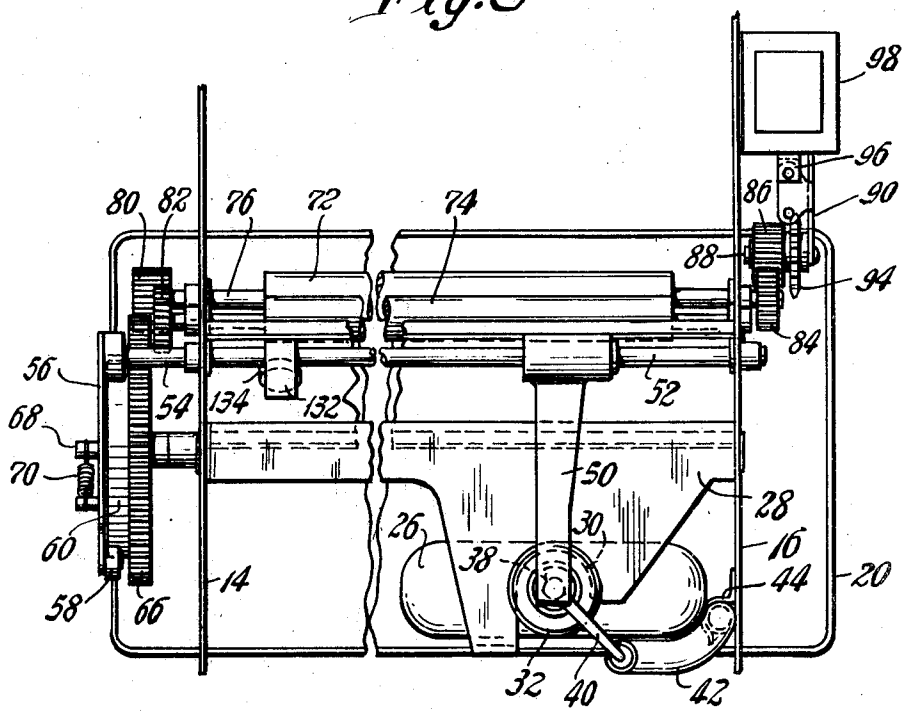
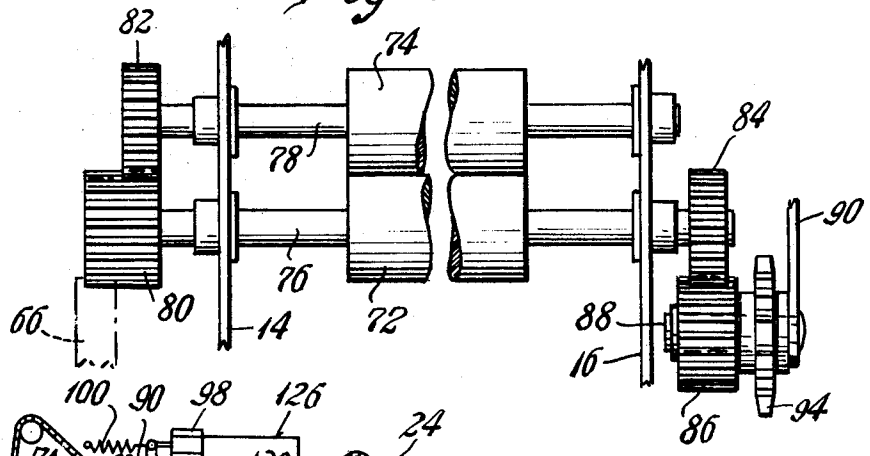


Fig. 4



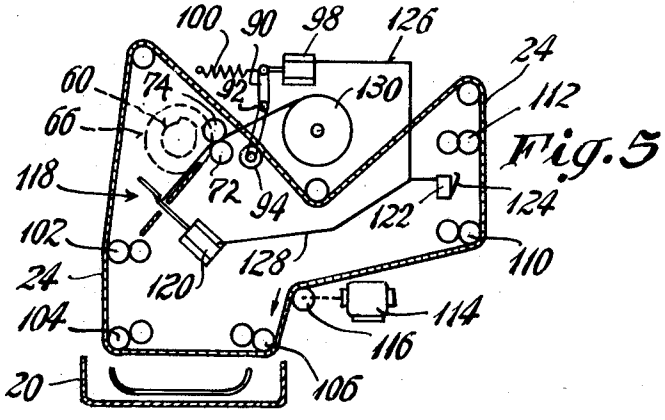


Fig. 5

INVENTORS
Walter J. Hanson
George Matkovich
BY
Martin D. Wittstein
ATTORNEY

United States Patent Office 3,504,968
Patented Apr. 7, 1970

3,504,968

TONER DISPENSING APPARATUS FOR ELECTROSTATIC COPYING MACHINES

George Matkovich, Stamford, and Walter J. Hanson, Old Greenwich, Conn., assignors to Pitney-Bowes, Inc., Stamford, Conn., a corporation of Delaware

Filed May 31, 1966, Ser. No. 553,822
Int. Cl. G03g 9/04, 15/00, 13/00
U.S. Cl. 355—10 4 Claims

ABSTRACT OF THE DISCLOSURE

In combination with an electrostatic photocopy machine having a copy paper feeding means and a liquid toner developing means through which copy paper passes, a device for replenishing toner at a rate correlated with the rate at which toner is withdrawn from the developing solution. A cyclically operable means actuates a dispensing mechanism periodically while copy paper is being fed to dispense a metered quantity of toner into the developing means.

This invention relates generally to electrophotographic copying machines. More particularly it relates to an apparatus for automatically replacing toner material which is applied to exposed copy paper during the developing process so as to produce a visible image which is a reproduction of the original sheet.

The present invention is based upon the theory of replacing expended toner material at a rate very closely approximating or sustantially equal to the rate at which the toner material is removed from a developing medium, by exposed copy paper passing therethrough. This is accomplished, in its broader aspects by correlating the rate of toner replenishment with the length of copy paper which is fed through the developing medium, which length may vary from copy to copy, to the end that the quality of copies produced remains constant over a large number of copies regardless of the amount of toner material which may be removed from the developing medium by any individual copy, this amount depending upon the length of copy paper being fed through the developing medium for such individual copy and the extent of indicia to be reproduced thereon.

In electrophotographic copying machines of the type to which the present invention relates, an original sheet having indicia thereon is inserted into the copying machine and is illuminated. An image of the indicia on the original is transferred by means of an optical system to copy paper which has previously been uniformly electrostatically charged. The intensity of the light reflected from the original, in accordance with the indicia thereon, produces a latent image of the indicia on the copy paper by dissipating the electrostatic charge on the copy paper in those areas which are exposed to the reflected light. Thereafter, the copy paper is passed through a developing medium which typically is a liquid bath containing pigmented toner particles held in suspension which adhere to the remaining electrostatically charged areas of the copy paper to produce a visible image.

Since the quality of the copy, that is the sharpness and clarity of detail and the character of shading, is largely dependent upon the extent to which particles of toner material adhere to the charged areas of the copy paper, it is important to maintain a proper balance of toner material in suspension in the developing bath at all times as to obtain consistently high quality copies. Should the amount of toner material in suspension become too high or too low, the copies becomes too dark or too light re-

spectively, in either of which events sharpness and clarity of detail is lost, shading may become distorted, and generally copies are produced which, in varying degrees, are unacceptable for the purposes intended.

It is apparent that the need for additional toner material in the developing bath may be ascertained by observation of copies as they emerge from the copying machine, and that it may be left to the discretion of the user as to whether it is necessary to add toner material and in what quantity. The obvious guess-work inherent in such a procedure will inevitably result in a lack of uniformity in the quality of copies over an extended period of time.

It has therefore been proposed to add toner material automatically to the developing bath to maintain the proper balance of toner particles in suspension within permissible limits. One such proposal has been to observe the concentration of toner particles in suspension by photo-electric means, and to thereby actuate a dispensing mechanism when the concentration of toner material reaches a predetermined minimum level to replace toner material until a predetermined maximum concentration is obtained. While this procedure has been found to accomplish satisfactory results, the equipment required to carry it out is relatively complicated and expensive and therefore not commercially attractive, and it is not suitable for maintenance or adjustment by unskilled persons.

A simpler and less costly proposal has been to automatically dispense a predetermined quantity of toner material into the developing bath each time the copying machine is cycled for operation to produce a copy. A distinct disadvantage of this procedure is that it does not correlate the rate of toner material replenishment with the rate at which it is withdrawn from the developing bath. Thus, more or less toner material may be withdrawn on each copy in accordance with the extent of indicia on the original, yet a fixed predetermined quantity of toner material is replaced with each machine operation producing a copy. It is therefore possible, and in fact probable, that the rate of toner material replacement will be out of synchronism with the rate at which it is withdrawn, resulting in an eventual imbalance of toner particles in suspension to the extent that unacceptable copies are produced.

The above disadvantage is apparent in copying machines which utilize cut sheets of a predetermined length on which copies are produced. This disadvantage becomes more critical, however, in those machines in which copy paper is supplied as a web in roll form, the length of an original sheet is measured as it passes through the machine and a length of copy paper is severed from the web which corresponds to the length of the original sheet. In such a machine, it would be completely undesirable to dispense a predetermined quantity of toner material each time that the copying machine is cycled for operation since it would be necessary to adjust the dispensing mechanism to operate in accordance with the length of the original sheet each time such length changes. Thus a series of short copies would withdraw less toner material with each machine cycle than would a corresponding series of long copies, yet the same quantity of toner material would be dispensed with each copy produced.

It is, therefore, a principal object of the present invention to provide a toner dispensing apparatus for use in an electrophotographic copying machine which automatically maintains a proper balance in the concentration of toner particles in suspension over an extended period of time and yet avoids the disadvantages of prior art devices.

Another object of the present invention is to provide a toner dispensing apparatus for an electrophotographic copying machine which dispenses additional toner ma-

terial into the developing bath at a rate which is correlated with the rate at which the toner material is withdrawn from the developing bath by copy paper passing therethrough.

Still another object of the present invention is to provide a toner dispensing apparatus for an electrophotographic copying machine which dispenses a metered quantity of toner material spaced in accordance with the feeding of successive predetermined unit lengths of copy paper to and through the developing solution.

It is yet another object of the present invention to provide a toner dispensing apparatus for an electrophotographic copying machine which operates either in response to the feeding of cut sheets of variable predetermined length, or in response to feeding of variable lengths as determined by the length of an original sheet passing through the copying machine which is measured and according to which a corresponding length of copy paper is automatically severed from a web thereof.

Yet another object of the present invention is to provide a toner dispensing apparatus for an electrophotographic copying machine in which the amount of toner material dispensed per unit length of copy paper delivered to the developing bath may be varied so as to maintain the rate of toner material replenishment correlated with the rate at which it is withdrawn from the developing bath regardless of the density of indicia on a given length of original which is to be reproduced on a predetermined or correspondingly measured length of copy paper.

A still further object of the present invention is to provide a toner dispensing apparatus for an electrostatic copying machine which is relatively simple in construction, economical to manufacture, and is easily maintained by unskilled persons.

In its broader aspects, the principles of the invention are presently embodied in a toner dispensing apparatus for use in combination with all electrophotographic copying machine having means for feeding copy paper of varying lengths along a copy paper path, means for producing a visible image on the copy paper from an original sheet and including developing means in the copy paper path having toner material therein, the toner dispensing apparatus comprising a source of concentrated toner material, dispensing means having communication with the source of toner material and with the developing means and operable when actuated to dispense toner material, and means operable only when the copy paper is being fed past a given point in the copy path for actuating the dispensing means to dispense a quantity of toner material metered in accordance with the feeding of each predetermined unit length of copy paper past the given point in the copy paper path.

The foregoing and other objects and features of the present invention will be more readily apparent from an understanding of the following detailed description when considered in conjunction with the accompanying drawings in which:

FIGURE 1 is a side view of a toner dispensing apparatus made in accordance with the principles of this invention, and shown in operative association with a fragmentary portion of an electrostatic copying machine.

FIGURE 2 is an end view, partly in section, of the structure illustrated in FIG. 1,

FIGURE 3 is a plan view of the structure illustrated in FIGS. 1 and 2,

FIGURE 4 is a view, on an enlarged scale, of a portion of the drive means, taken on the line 4—4 of FIG. 1, and

FIGURE 5 is a schematic view of certain operative details of a copying machine with which the present invention is concerned.

Referring to the drawings, and particularly to FIGS. 1 and 2 thereof, the toner dispensing apparatus of this invention is illustrated as associated with an electrostatic copying machine, only so much of the structure of the copying machine being shown as is necessary to an understanding of the principles of the invention.

The numeral **10** designates generally an electrostatic copying machine comprising a base **12**, a pair of upright parallel side frame members **14** and **16**, and a suitable housing **18** enclosing the copying machine as a whole. A developing tank **20** containing a suitable quantity of liquid developing solution **22** is mounted within the copying machine **10**, and is illustratively shown as resting on the base **12**. The developing solution **22** contains toner particles in suspension which are withdrawn from the solution by exposed copy paper passing therethrough. The exposed copy paper is guided through the developing bath **22** by suitable guides and feed rollers, hereinafter more fully described, the rollers being driven by an endless chain **24** disposed outside of the frame member **16**.

It will be apparent to those skilled in the art that the specific construction of the copying machine forms no part of the present invention and is, therefore, not disclosed in detail, with the exception of the hereinafter described structure thereof with which the toner dispensing apparatus cooperates to control operation of the latter in response to operation of the former.

The dispensing apparatus comprises a container **26** suitably mounted in the copying machine, such as by being suspended from a plate **28** having a slot **30** therein which receives the neck of the container **26** (see FIG. 3). The mouth of the container is closed by a cap **32** which has a pump **34** mounted therein, the pump **34** having communication with the container contents by means of the dip tube **36**. The pump **34** is provided with an actuating stem **38** projecting upwardly thereform and a discharge spout **40** projecting laterally from the stem **38**. The spout **40** is in communication with a tube **42** secured to the frame member **16** by suitable clamps **44**, the tube **42** extending downwardly and terminating in position to discharge into the developing solution tank **20**.

The pump **34** is preferably though not necessarily a positive displacement type reciprocating pump in which a pump chamber **46** communicates with the dip tube **36** through a one-way ball valve **47**, and the stem **38** is integrally formed with a hollow piston **48** having another one-way ball valve therein (not shown) which reciprocates telescopically within the pump chamber **46** and carries the other ball valve therewith, the piston being normally urged upwardly by a spring **49** within the pump chamber. Once the pump is initially primed, a downward movement of the piston **48** and stem **38** forces a metered quantity of fluid in the pump chamber **34** to flow into the hollow piston through the ball valve not shown which, in turn, forces liquid in the piston to be discharged through the spout **40**. On the return stroke of the piston, additional liquid is drawn up the dip tube past the ball valve **47** to replace the quantity discharged.

The pump **34** is actuated by an actuating mechanism comprising a lever **50** fixedly mounted on a shaft **52** which is journaled for rotation in the side frame members **14** and **16**. An extension **54** of the shaft **52** projects outwardly of the side frame member **14** and fixedly carries a second lever **56** on the free end of which is mounted a cam follower or roller **58**. A cam **60** having a lobed portion **62** and a sharp declining face **64** is secured to, or formed integrally with, a gear **66** which is mounted for rotation on the frame member **14** as by the stub shaft **68**. The roller **58** is continuously urged into contact with the cam **60** by a spring **70** connected between the stub shaft **68** and the lever **56**. The spring **70** has sufficient strength to overcome the compression spring **49** located in the pump **34** so that during the major portion of rotation of the cam **60**, the pump stem **38** and associated parts are maintained in a depressed position, i.e., the position occupied by the parts at the end of a dispensing stroke.

It will thus be seen that the actuating mechanism constitutes a cylindrically operable means for periodically actuating the pump **34** to dispense a metered quantity

of toner material each time the cam **60** makes one complete revolution.

While it would be entirely feasible to provide an independent drive means for the gear **66** which would be operable only when copy paper is being fed past a given point in the copy paper path, it has been found to be more expedient to drive the gear **66** directly from a feeding mechanism which is operable only to feed and while feeding a variable length of copy paper. Thus, the copying machine includes a means for feeding copy paper of variable lengths along a copy paper path whether manually settable to feed a selected predetermined length cut sheets, or automatically operated to feed a variably length of copy paper severed from a web thereof in accordance with a measured length of the original sheet. This means includes the above mentioned feeding mechanism to which the gear **66** is directly connected.

More particularly, a pair of feed rollers **72** and **74** are carried by shafts **76** and **78** respectively, which are journaled for rotation in the side frame members **14** and **16**. Roller **72** is driven by means hereinafter described, and by means of gears **80** and **82** mounted on shafts **76** and **78** respectively outside of the frame member **14**, the roller **72** drives the roller **74**. As best seen in FIGS. 3 and 4, the gear **80** meshes with both the upper roller gear **82** and with the cam gear **66** whereby both of the latter are simultaneously driven in response to rotation of the roller **72**.

The latter is driven by means of a gear **84** mounted on the shaft **76** outside of the opposite side frame member **16**. This gear in turn is driven by a gear **86** connected to a shaft **88** rotatably mounted on one end of a lever **90**, the lever **90** being pivotably supported on the frame member **16** by a stud **92**. The shaft **88** also carries a sprocket wheel **94** continuously engaged by the drive chain **24** so that both the sprocket **94** and gear **86** rotate in response to movement of the chain **24** when the gears **84** and **86** aare engaged.

In order to start and stop the feed rollers **72** and **74** as well as the cam gear **66** for the dispensing mechanism in synchronism with the determinate length of copy paper to be fed to the developing bath, the lever **90**, which is pivotably mounted on the stud **92**, is connected at its opposite end to the armature **96** of a solenoid **98**. As best seen in FIG. 1, a spring **100** is connected between the upper end of the lever **90** and a pin **102** mounted on the side frame member **16** to normally urge the lever **90** to a position in which the gear **86** is out of contact with the gear **84** so that the feed rollers **72** and **74** and the cam gear are stationary. Upon energization of the solenoid **98**, the armature **96** is moved toward the left as viewed in FIG. 1, whereupon the lever **90** is rocked in a counterclockwise direction to engage the gear **86** with the gear **84** to establish a driving relationship between the chain **24** tand the feed rollers **72** and **74** and the cam gear **66**. The lever **90** and gears **86** and **84** thus constitute a clutch actuated by the solenoid **98** and the spring **100**. Thus it is seen that the cam gear **66** and associated parts driven thereby constitute a means which is operable or driven only when copy paper is being fed past a given point in the copy paper path for periodically actuating the dispensing means to dispense a metered quantity of toner material spaced in accordance with the feeding of each predetermined unit length of copy paper past the given point.

As briefly indicated above, the means for feeding a varying length of copy paper, of which the rollers **72** and **74** are a part, further includes either manually settable means for feeding a selected predetermined length cut sheet, or automatic sensing and severing means for feeding a variable length of copy paper severed from a web in accordance with a measured length of original sheet from which the copy is made. The toner dispensing apparatus of the present invention is at present preferably utilized in connection with a copying machine of the latter type, and is diagrammatically illustrated in FIG. 5 in operative association with only so much of such a copying machine as is necessary to understand the invention.

Accordingly, referring to FIG. 5, the endless chain **24** is disclosed as continuously engaging several pairs of feed roller pairs **102**, **104** and **106** constituting, with suitable guides, a copy paper path and transfer means for conveying determinate lengths of copy paper to and through the developing tank **20** and to a suitable receiver for finished copies. Additional roller pairs **110** and **112** constitute, also with suitable guides, an original sheet transfer means for conveying the original sheet to and through an illuminating station (not shown). The chain **24** is driven by a motor **114** and a sprocket **116** thereby driving the copy paper roller pairs and original sheet roller pairs in unison.

A severing mechanism generally indicated by the numeral **118** is disposed between the roller pair **102** and the feed rollers **72** and **74**, the severing mechanism including a solenoid **120** or other suitable power means for actuating the severing mechanism at an appropriate instant.

A sensing element, such as the micro-switch **122** is mounted so as to have a contact finger **124** disposed in the path of an original sheet as the latter is fed through the original sheet path by the roller pairs **110** and **112**. The switch **122** is suitably connected to the clutch solenoid **98** by a lead **126** and to the severing mechanism solenoid **120** by a lead **128**, so that these solenoids are energized when the switch **124** is closed during the time that an original sheet is moving past the switch **122**. During this time the feed rollers **72** and **74** are feeding a determinate length of copy paper in accordance with the measured length of the original sheet as determined by the sensing switch **122**, and the cam gear **66** is being rotated by the gear **80** attached to the lower feed roller **76**.

In operation of the apparatus described above, a suitable master control switch energizes the motor **114** to drive the chain **24** in the direction indicated by the arrow. Simultaneously, all of the feed roller pairs in both the original sheet path and the copy paper path are rotated in synchronism, with exception of the initial feed rollers **72** and **74**.

If, now, an original sheet is introduced into the copying machine through the feed roller pair **110**, the leading edge of the sheet deflects the finger **124** to close the switch **122**, thereby energizing the clutch solenoid **98** and the severing mechanism solenoid **120**. The blade of the severing mechanism is thereby retracted out of the path of the copy sheet web, and simultaneously the copy paper feed clutch is engaged by rocking the lever **90** to engage the gear **86** carried thereby with the gear **84** carried by the shaft **76** of the feed roller **72**, thereby causing rotation of the roller **72**. The drive from the roller **72** is transferred to the upper roller **74** through the gears **80** and **82**, thereby feeding copy paper from the supply roll **130**, suitably mounted in the copying machine, to the copy paper transfer mechanism whereby the copy paper is conveyed through the copying machine to be subjected to the various steps of the copying process. One of these steps is that the copy paper is conveyed through the developing tank **20** in which the toner material adheres to the electrostatically charged areas of the copy sheet as described above.

When the trailing edge of the original sheet passes the finger **124**, the switch **122** opens to cause disengagement of the feed clutch as well as actuation of the severing mechanism, whereby a length of copy sheet will have been severed from the web which corresponds to the length of the original sheet. Thus, it will now be understood that the switch **122**, the clutch elements and feed rollers **72** and **74** and the severing mechanism **118** all constitute the means for feeding copy paper of varying lengths to the copy paper transfer means.

While the feed rollers **72** and **74** are operating to feed copy paper, the gear **80** drives the cam gear **66** to rotate the cam **60** in the direction of the arrow in FIG. 1. When

the cam follower **58** drops off the lobed portion **62** of the cam, the spring **70** causes the lever **56** to rock in a clockwise direction, thereby rotating shaft **52** and rocking the pump actuator **50** in the same direction to depress the pump actuating stem **38**, the latter causing a predetermined quantity of concentrated toner material to be discharged from the spout **40** into the tube **42** and then to the tank **20**. Continued rotation of the cam **60** allows the spring **70** to maintain the above parts in the just described position until the lobed portion **62** again raises the cam follower **58**, the lever **56**, and the pump actuator **50**, whereupon the spring in the pump, as is well known in the art, raises the pump actuating stem **38** and reprimes the pump preparatory to another dispensing stroke of the actuating stem **38**.

Preferably, but not necessarily, the size of the cam **60** is correlated with an average unit length of copy paper utilized over an extended period of time. Thus, the cam **60** is preferably constructed to cause an actuation of the pump **34** each time 11 inches of copy paper is fed by the rollers **72** and **74**. It is apparent that this unit length may be varied to suit particular circumstances, particularly where material to be copied is of such a nature that the demand for toner replacement either exceeds or is less than the maximum and minimum limits of a pump adjustment mechanism now to be described.

Referring to FIGS. 1 and 2, the shaft **52** carries an abutment member **132** which is adapted to engage an adjustable stop **134** in the form of a thumb screw threadedly engaged in a collar **136** secured to a cross-member **138** of the copying machine. Adjustment of the thumb screw **134** limits the rotation of the shaft **52** by the spring **70** and hence the downward movement of the pump actuating stem **38** on its dispensing stroke. In this manner the quantity of toner material dispensed with each actuation of the pump can be varied from the maximum capacity of the pump to any lesser quantity desired in accordance with the extent of the indicia to be copied per unit length of copy paper. The arrangement of the cam **60** and cam follower **58** and the spring **70** thus constitute a lost motion connection between the cam and the lever **50** for permitting variations of the toner quantity dispensed with each cycle.

While, for purposes of illustration, and as the embodiment at present preferred, the dispensing apparatus of the present invention has been disclosed in combination with a copying machine of the type which feeds a variable length of copy paper from a web, the invention has equal applicability in a copying machine which utilizes copy paper in sheets pre-cut to a predetermined length. Thus the variable length of copy paper fed for each copy is determined by the length of cut sheets provided in the machine, which of course, may vary from sheet to sheet.

In the above connection, the feed rollers **72** and **74** are controlled by suitable means to operate for a period of time necessary to feed a cut sheet of known length. Such control may be either automatic by sensing a change of position of the copy sheet or by manually selectable means for a plurality of different lengths of copy sheet. In any event, the duration of operation of the feed rollers, corresponding to the length of time necessary to feed a sheet of predetermined length, controls the duration of operation of the pump actuating means, including the cam **60**, so that the pump will still be actuated to dispense a metered quantity of toner material in response to the feeding of each predetermined unit length of copy paper to and through the developing bath, notwithstanding that the length of copy paper fed with each cycle of operation is now predetermined for any individual copy.

It will be apparent from the foregoing that there is disclosed a toner dispensing apparatus for an electrophotographic copying machine which achieves the foregoing objects. It is to be understood that the invention is not to be limited to the specific embodiment described above and shown in the accompanying drawings, which embodiment is merely the best mode presently contemplated for carrying out the principles of the invention and is susceptible to change in form, size, location and arrangement of parts, but rather the invention is intended to cover all such variations, modifications and equivalents thereof as may be deemed to be within the spirit and scope of the invention as defined in the appended claims.

We claim:

1. In combination with an electrophotographic copying machine having means for feeding copy paper of varying lengths along a copy paper path and including a feeding mechanism operable only when feeding one of said varying lengths of copy paper, and means for producing a visible image on the copy paper from an original sheet, said means including developing means disposed in said path and having toner material therein, apparatus for automatically replacing an equivalent amount of toner material as that withdrawn from the developing means each of said lengths of copy paper passing therethrough, said apparatus comprising

(A) supply means mounted in said copying machine providing a source of concentrated toner material,

(B) dispensing means having communication with said source of toner material and with said developing means and operable when actuated to dispense a metered quantity of toner material into said developing means,

(C) cyclically operable means for periodically actuating said dispensing means to dispense said metered quantity of toner material spaced in accordance with the feeding of each predetermined unit length of the copy paper by said feeding mechanism,

(D) means mechanically coupling said cyclically operable means to said feeding mechanism for operation therewith whereby the toner material is replaced in said developing means at a rate which is correlated with the rate at which the toner material is withdrawn from the developing means by the varying lengths of copy paper passing therethrough,

(E) said dispensing means including a movable discharge element and said cyclically operable means comprising a movable actuator for moving said discharge element and cam and cam follower means mechanically connected to said actuator for moving the latter to cause operation of said discharge element, said coupling means driving said cam in response to operation of said copy paper feeding mechanism, and

(F) said dispensing means comprises a positive displacement pump having a reciprocating discharge element movable over a dispensing stroke and a priming stroke and resilient means normally urging said discharge element toward a terminal position of said priming stroke, and said cyclically operable means comprises a movable actuator for moving said discharge element toward the terminal position of said dispensing stroke with sufficient force to overcome the force of said first named resilient means, and cam and cam follower means connected to said actuator for moving the latter in a direction against the force of said second named resilient means to permit said first named resilient means and said discharge element to prime said pump before said second named resilient means causes a dispensing stroke of said discharge element, and means for driving said cam in response to operation of said copy paper feeding means.

2. Apparatus according to claim **1** further including adjustable stop means interposed in the path of movement of said actuator in the direction of movement caused by said second named resilient means whereby the extent of movement of said discharge element on said dispensing stroke may be adjusted to vary the quantity of toner material dispensed by said pump.

3. In combination with an electrophotographic copying machine having means for feeding an original sheet through the copying machine, means for feeding copy paper along a copy paper path and including a feeding mechanism operable only when feeding one of said varying lengths of copy paper, and means for producing a visible image on the copy paper from the original sheet, said means including developing means disposed in said path and having toner material therein, apparatus for automatically replacing an equivalent amount of toner material as that withdrawn from the developing means by each of said lengths of copy paper passing therethrough, said apparatus comprising

(A) supply means mounted in said copying machine providing a source of concentrated toner material,

(B) dispensing means having communication with said source of toner material and with said developing means and operable when actuated to dispense a metered quantity of toner material into said developing means,

(C) cyclically operable means for periodically actuating said dispensing means to dispense said metered quantity of toner material spaced in accordance with the feeding of each predetermined unit length of copy paper by said feeding mechanism.

(D) means mechanically coupling said cyclically operable means to said feeding mechanism for operation therewith, and

(E) control means for determining the length of time said feeding mechanism is operative to feed copy paper and to cause operation of said cyclically operable means whereby toner material is replaced in said developing means at a rate which is correlated with the rate at which the toner material is withdrawn from the developing means by the varying lengths of copy paper passing therethrough, said control means including sensing means for detecting the passage of an original sheet through the copying machine, and means responsive to operation of said sensing means for respectively enabling and disabling said copy paper feeding mechanism in accordance with the movement of the original sheet past said sensing means whereby said feeding mechanism and said cyclically operable means are simultaneously operated in accordance with the measured length of the original sheet.

4. In combination with an electrophotographic copying machine having means for feeding copy paper of varying lengths along a copy paper path and including a feeding mechanism operable only when feeding one of said varying lengths of copy paper, and means for producing a visible image on the copy paper from an original sheet, said means including developing means disposed in said path and having toner material therein, apparatus for automatically replacing an equivalent amount of toner material as that withdrawn from the developing means each of said lengths of copy paper passing therethrough, said apparatus comprising

(A) supply means mounted in said copying machine providing a source of concentrated toner material,

(B) dispensing means having communication with said source of toner material and with said developing means and operable when actuated to dispense a metered quantity of toner material into said developing means,

(C) cyclically operable means for periodically actuating said dispensing means to dispense said metered quantity of toner material spaced in accordance with the feeding of each predetermined unit length of the copy paper by said feeding mechanism,

(D) means mechanically coupling said cyclically operable means to said feeding mechanism for operation therewith whereby the toner material is replaced in said developing means at a rate which is correlated with the rate at which the toner material is withdrawn from the developing means by the varying lengths of copy paper passing therethrough,

(E) said dispensing means including a movable discharge element and said cyclically operable means comprising a movable actuator for moving said discharge element and cam and cam follower means mechanically connected to said actuator for moving the latter to cause operation of said discharge element, said coupling means driving said cam in response to operation of said copy paper feeding mechanism, and

(F) said cyclically operable means includes lost motion connection means between said cyclically operable means and said dispensing means for varying the actuating effect of said cyclically operable means on said dispensing means whereby said metered quantity of toner material dispensed with each actuation of said dispensing means may be varied.

References Cited

UNITED STATES PATENTS

3,195,430	7/1965	Young	95—1.7
3,333,566	8/1967	Kent	95—1.7 X
3,354,802	11/1967	Doucette	95—1.7

JOHN M. HORAN, Primary Examiner

U.S. Cl. X.R.

118—637