Sept. 15, 1959 J. L. FISHER ET AL 2,904,000

MAGNETIC-BRUSH DEVELOPER

Filed May 15, 1957 2 Sheets-Sheet 1

FIG. 1

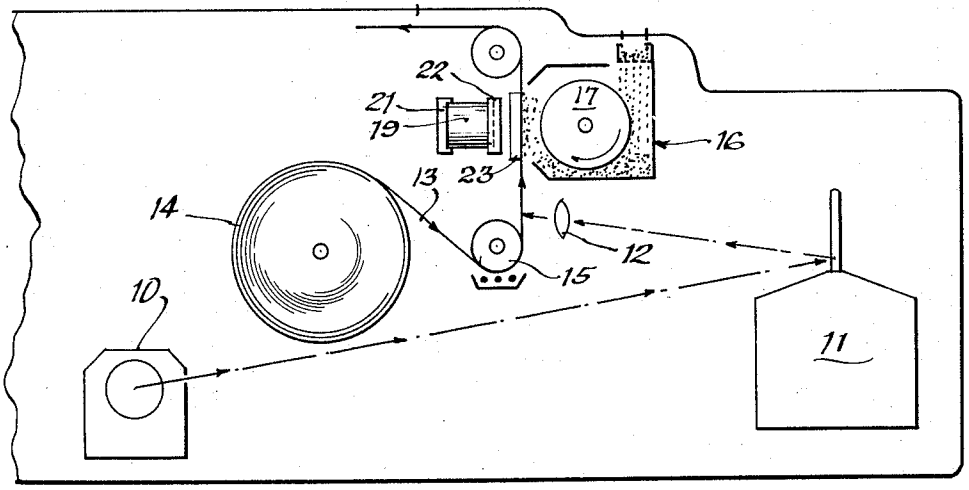


FIG. 2

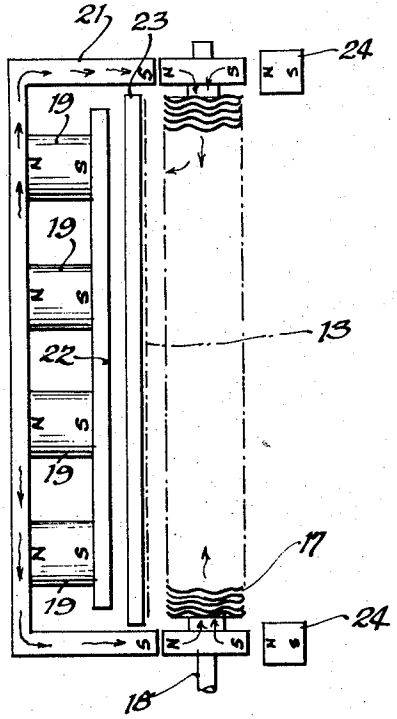
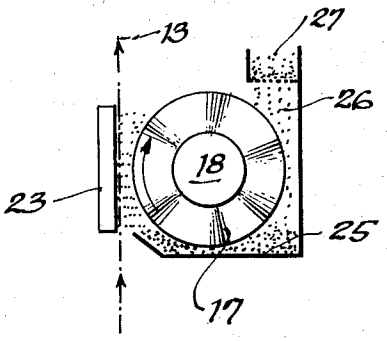


FIG. 3



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Filed May 15, 1957 2 Sheets-Sheet 2

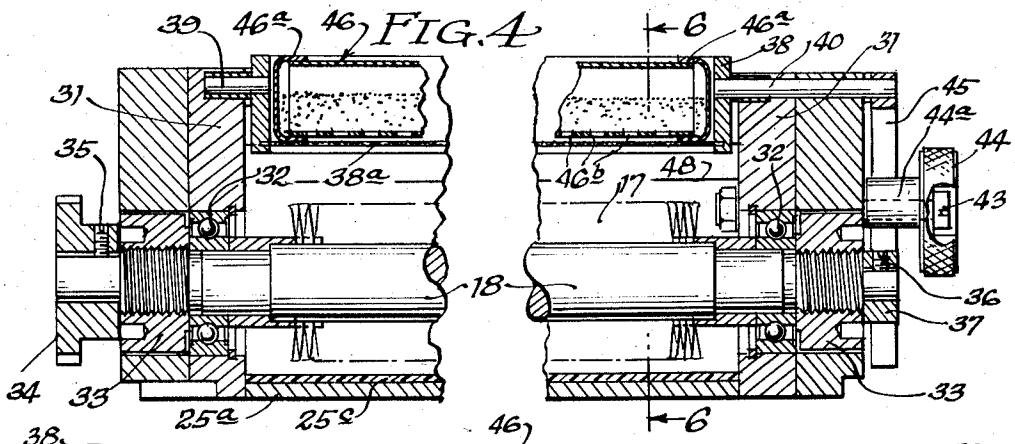

FIG. 4

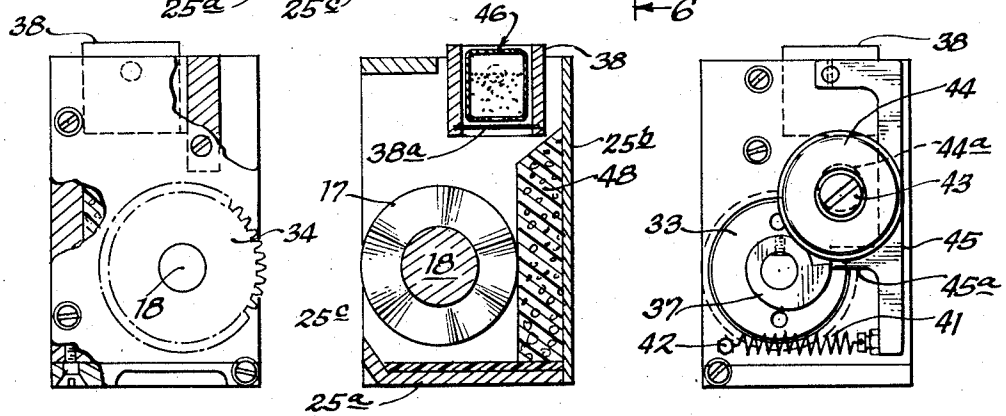

FIG. 5 FIG. 6 FIG. 7

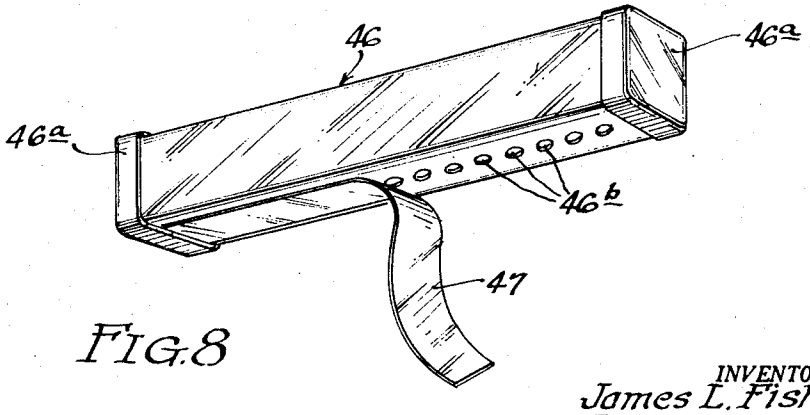

FIG. 8

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MAGNETIC-BRUSH DEVELOPER

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Application May 15, 1957, Serial No. 659,291

9 Claims. (Cl. 118—637)

This invention relates to the field of electrostatic photography and is in particular directed to an improved magnetic-brush developer for use therein.

While not restricted in its utility to any particular type of application, our invention is of special value in applications wherein a continuous photographic image or series of successive photographic images is formed on an elongated strip of sensitized material, the latent image or images on such sensitized material being then progressively developed by being continuously passed through a developer mechanism. A typical application of this sort is electrophotographic oscillography.

A widely used technique for developing latent images in the electrophotographic art is the so-called "magnetic brush." In this technique, a magnetized brush, usually consisting of a large number of iron discs or washers carried coaxially on a shaft, is charged with a mixture of powdered iron and finely divided pigmented thermoplastic material commonly called "toner." The sensitized sheet containing electrostatic latent images is then passed alongside the brush, and the brush is rotated at a speed such that its peripheral speed is several times the rate of advance of the sensitized sheet. The toner powder, while normally adhering to the iron particles, will be drawn away from the iron and deposited on the sensitized sheet in the charged areas thereof, with the result that a faithful monochrome visual image is formed on the sensitized sheet in a pattern corresponding to the areas of electric charge thereon. The iron, which simply acts as a carrier for the toner powder, is not attracted to the image-carrying sheet, since the force of magnetic attraction tending to hold it on the brush is greater than the electric forces tending to draw it to the sheet.

In the course of operation of a magnetic-brush developer, the iron powder is not depleted appreciably, but the toner is of course continuously carried away as the latent images are developed on the sheet, and hence it must be replaced.

A major object of the present invention is to provide, in a magnetic-brush developer, a greatly improved means of maintaining the proper supply of toner powder on the brush.

Another object of the invention is to provide a means for supplying toner powder to a magnetic-brush developer which permits periodic re-charging of the apparatus with toner powder without the necessity for handling or working with the toner powder in bulk form.

A further object of the present invention is to provide, in a magnetic-brush developer, apparatus including a toner magazine from which the toner powder is systematically released under controlled conditions into the brushing zone.

Achievement of this last-mentioned object carries with it the further object and advantage that the supply of toner powder in the brushing zone is maintained at the optimum level for image development for the particular speed at which the sensitized sheet is being passed through the developer. This speed may vary over a wide

range, according to the particular application, and hence the rate of consumption of toner powder will vary correspondingly. With the apparatus of our invention, the rate at which toner powder is supplied to the brushing zone is directly responsive to the rate of advance of the sensitized sheet.

Other objects and advantages of the invention will appear from the following detailed description of a typical embodiment thereof.

In the appended drawing, we have shown, in Figure 1, a diagrammatic view of a typical electrophotographic oscillograph in which our invention might normally be used. The oscillograph shown therein does not broadly constitute our invention and is shown merely to illustrate the typical environment in which our invention might be employed. Fig. 2 is a diagrammatic plan view of the magnetic-brush developer, showing generally the manner in which a permanent magnetic flux is passed through the brush proper during its operation. Fig. 3 is a diagrammatic sectional view through the developer, bringing out the manner in which the rotating magnetic brush picks up from the tray below it a mass of toner-coated iron particles and brushes them against the sensitized paper as it passes by, leaving on the charged portions thereof a thin deposit of toner powder. Fig. 4 is a transverse view, mostly in section, of our magnetic-brush developer, bringing out certain of its structural features and showing its over-all assembly. Fig. 5 is an end elevation view of the Fig. 4 structure; Fig. 6 is a sectional view of the Fig. 4 structure along the line **6—6** of Fig. 4; and Fig. 7 is an end elevation view of the Fig. 4 structure, showing the opposite end of the apparatus from that portrayed in Fig. 5. Fig. 8 is a perspective view showing the toner container which forms a part of our invention, as it appears before insertion into the toner magazine illustrated in Figs. 4–7.

A typical environment in which our magnetic-brush developer might be used is shown diagrammatically in Fig. 1. Therein, we have shown the general assembly of an electrophotographic oscillograph. A light source **10** throws a beam of light onto a mirror galvanometer assembly **11**, which, in practice, may include a number of mirror elements rotatable responsively to the currents passing through the galvanometer coils with which the respective mirrors are associated. Light beams from the galvanometer mirrors of unit **11** are reflected through a suitable optical system, indicated diagrammatically by the lens **12**, onto the surface of an elongated sensitized sheet **13**, which is unrolled from a stock roll **14**, passed through a charging unit **15**, and thence moved to the position at which the light beams from galvanometer unit **11** strike it. The beams produce on the sensitized sheet a plurality of latent images in the form of oscillograph traces, the lateral positions of which are respectively indicative of the currents passing through the galvanometer coils.

After exposure, the sheet **13** moves upward through the developer assembly **16** which is the subject matter of the present invention. Thereafter, the sheet **13**, now carrying developed images produced by deposit of toner powder thereon, passes to a suitable "fixer" and thence to storage.

It will be understood that the oscillograph just described is in its general aspects a prior-art instrument. The present invention is concerned solely with the developer apparatus designated generally by the reference numeral **16**.

Figs. 2 and 3 are diagrammatic figures which illustrate generally the mode of operation of the developer.

As shown in Fig. 2, the developer comprises a magnetic brush **17** consisting of a shaft **18** on which are secured a plurality of spaced corrugated washers of mag-

netizable material. This brush, per se, is not a part of our invention, and may be of the type disclosed in the copending application of John D. Schroeder, Serial No. 611,693, filed September 24, 1956, and now Patent No. 2,822,779, or of any other suitable type known to the art. Means for passing a continuous magnetic flux through the brush **17** are provided in the form of a plurality of permanent magnets **19**, in conjunction with iron pole pieces **21** and **22**, which define a magnetic circuit including the brush **17** and passing through the air gap between the brush and the pole piece **22**. Disposed within this air gap is a nonmagnetic plate **23** to which a high-voltage static electric charge is impressed during developer operation. The sensitized sheet **13** passes upward through the aforementioned air gap, in contact with the front face of back plate **23**. If desired, additional permanent magnets **24** may be provided on the opposite side of brush **17** as supplemental sources of magnetic flux for the brush.

As may be seen from the diagrammatical sectional view of Fig. 3, a tray **25** is disposed behind and beneath the brush **17**. Tray **25** is filled with a suitable quantity of powdered iron particles mixed with toner powder, the mixture being generally denoted by the reference numeral **26**. A toner magazine **27** is disposed above tray **25**, and means to be described later are employed for replenishing the supply of toner in the tray **25** from the magazine **27** as it is consumed by being deposited on the progressively advancing sheet **13**.

The toner particles tend to adhere to the iron particles, and the mixed mass of iron particles and toner is continually brushed against the image-carrying surface of sheet **13** by rotation of the brush **17**. The details of this operation will be discussed in a later paragraph in connection with the Figs. 4–7.

As previously mentioned, the magnetic attractive force of the magnetized brush **17** is sufficiently great to keep the iron particles from depositing on the sheet **13**, but the particles of toner, being unaffected by the magnetic flux, are drawn to the sheet **13** by the electric charge thereon and are deposited in a pattern corresponding to the latent electrostatic charge, thus producing a developed image.

Turning now to Figs. 4–7, we shall describe in some detail the specific structure of the developer unit **16**.

The shaft **18**, carrying the brush **17**, is mounted in a rigid frame **31** by means of suitable anti-friction bearings **32**. The ends of the shaft outboard of the bearings **32** are threaded to receive nuts **33** which hold the shaft in the desired position within the frame **31** while leaving it free to rotate.

At one end of the shaft **18**, a gear **34** is keyed, being held rigidly in place by means of a set screw **35**. Gear **34** is coupled by means of a suitable gear train (not shown) to provide rotation of the brush **17** at a predetermined rate of speed governed by the rate of advance of the sensitized sheet to be developed. Preferably this can be best achieved by using a single driving motor to rotate the shaft **18** and to advance the sensitized sheet **13**, the desired relative speeds being achieved by design of the gear train.

The peripheral speed of brush **17** should preferably be from about three times to five times the rate of advance of the sheet **13**, although this optimum speed will vary from application to application.

Keyed to the other end of shaft **18**, by means of a set screw **36**, is a cam **37**, the shape of which may best be seen in Fig. 7. Preferably it is of the type having a gradually increasing radius around its circumference, culminating in a single abrupt step back to the minimum radius. The particular shape employed for cam **37** may be varied according to the needs of the application, however, and we do not desire to be limited to the particular shape of cam shown. The cam **37** cooperates with a follower arm **45** to control the rate of flow of toner powder into the brushing zone, in a manner to be described in a later paragraph.

Suitably supported on the frame in any desired manner is the tray **25** heretofore mentioned, comprising a base pan **25***a* and a back plate **25***b*. If desired, the upper surface of the base pan **25***a* may be covered with a non-metallic pad **25***c*.

Supported above and somewhat to the rear of the brush **17** is an elongated, generally rectangular toner magazine **38**, of length approximately equal to that of brush **17**. The toner magazine **38** is open at the top, has solid side and end walls, and is provided with a screen-mesh bottom **38***a*, the mesh being so chosen that it will retain toner powder within it in the absence of agitation but will permit the toner powder to sift through when briskly agitated.

Brush scraper **48** is a soft pad of foam plastic cemented to the back plate **25***b*. Its function is to wipe the back surface of brush **17** and thereby to promote mixing of the iron powder and toner.

The magazine **38** is rockably mounted in the frame by means of a pair of coaxially disposed end shafts **39** and **40**, each of which is received within a suitable bearing provided in the frame members. Shaft **39**, at the end of the magazine nearest the gear **34**, terminates in the frame bearing which receives it, but shaft **40**, on the opposite end of magazine **38**, passes entirely through the frame and carries on its outer end the follower arm **45** previously mentioned. Arm **45** is rigidly secured to the end of shaft **40** by any suitable means.

As may be best seen from Fig. 7, the arm **45** extends downward along the outer surface of the frame to a point near the bottom of the frame. At its lower end, arm **45** is provided with a suitable fitting to receive one end of a tension spring **41**, the other end of which is anchored to the frame by means of screw **42**.

Near its lower end, follower arm **45** is modified to define a lateral projection **45***a* which extends toward the rim of cam **37**, as best shown in Fig. 7, and the tension force of spring **41** urges arm **45** toward the cam.

Above the arm **45***a*, the frame is drilled and threaded to receive a screw **43**, the head of which is recessed within a manually operable knob **44**. Knob **44** is drilled centrally to provide passage for screw **43**, but its body portion **44***a* is eccentric with respect to the screw **43**, as may be seen from Figs. 4 and 7. When screw **43** is slightly loosened, the knob **44** may be turned manually and the position of the eccentric portion **44***a* is thereby shifted with respect to arm **45**. When the desired position has been determined, the knob and the eccentric portion can then be locked in place by tightening of screw **43**.

The toner magazine **38** carries within it a toner container **46** of the general type shown in Fig. 8. This container consists of an elongated, generally rectangular plastic box provided with end caps **46***a* of sufficient thickness to raise the bottom wall of container **46** a short distance above the mesh screen **38***a* when the container **46** is resting in normal position within the magazine **38**.

The bottom wall of container **46** contains a number of relatively large apertures **46***b* of ample size to permit the toner powder to escape therethrough easily. During storage and prior to actual use, the apertures **46***b* are preferably covered by a strip of plastic tape **47**, the tape being removed just before the container **46** is inserted for use in the magazine **38**.

Upon removal of the tape covering and insertion of the container **46** into the magazine, the finely divided toner power at once runs out through the apertures **46***b* and deposits on the mesh screen **38***a*, this movement being facilitated by the fact that caps **46***a* hold the bottom of container **46** spaced a short distance above the mesh screen **38***a*. Any other suitable type of projections or protuberances on the bottom of the container **46** may, of course, be employed to lift the bottom of the container a short distance above the screen surface **38***a*. The

same effect can also be obtained by providing on the upper surface of the magazine bottom 38*a* shoulders or other means for holding the container 46 in such spaced position.

It will be understood that the tray 25 and the brush 17 are provided with an adequate supply of powdered iron, the bulk of which is, by the magnetic flux in the brush, held in the form of a loose coating or "fuzz" over the surfaces of the brush.

In the operation of the invention, the brush 17, with its accumulated coating of iron powder, is rotated via the gear 34 at a speed appropriate to provide a peripheral brush speed several times the speed of advance of the sensitized sheet 13 which is to be developed. As the brush 17 turns, the cam 37 turns with it, and once each revolution of cam 37 the follower arm 45 is drawn sharply inward when the step in cam 37 overruns the projecting arm 45*a*.

This movement causes the toner magazine 38 to be rocked and agitated, the movement being quite abrupt, under the strong urging of the spring 41. This agitation causes a part of the toner powder in the magazine to sift through the mesh screen 38*a*, whereupon it drops into the brushing zone defined by the brush 17 and the tray 25. The toner powder, as previously explained, deposits on the surface of the iron particles and is thereby brushed against the surface of the sensitized paper.

The optimum operating conditions of the toner magazine are those under which just enough toner is released with each rocking action to replenish the amount of toner powder deposited on the sensitized paper by a single revolution of the brush. How much toner powder should be thus released with each revolution of the brush depends, of course, on the nature of the image being developed on the paper. In an oscillograph application, this quantity is substantially constant for any given run, since the image in such case consists of a predetermined number of continuous lines on the sheet 13, the position of which will vary but the size of which will remain essentially constant.

The magazine-agitating apparatus just described permits accurate adjustment of the sifting rate of the toner powder to approximate as closely as may be desired the optimum conditions. This adjustment may be carried out by means of the knob 44 with its eccentric portion 44*a*. As may be seen from Fig. 7, the arc through which the magazine 38 is rocked with each revolution of the cam 37 will depend upon the position of the knob 44. When the projecting portion 45*a* of arm 45 overrides the step on cam 37, the spring 41 draws the arm 45 sharply inward, and it will come to rest against the eccentric portion 44*a*. By controlled positioning of the knob 44, the amount of this movement can be adjusted to any desired value within quite wide limits. The amount of impact momentum imparted to the magazine 38 during each rocking action can thus be closely controlled, and the sifting rate of the toner powder can hence be correspondingly controlled. It will be understood, of course, that when the knob 44 has been set to the optimum position for any given application, the knob will be locked in place by tightening of screw 43.

When the toner powder in container 46 has become exhausted, replenishment can be achieved merely by removing the empty container, stripping off the tape 47 from a new container, and placing the new container in the magazine in lieu of the empty one.

In oscillograph and similar applications, the size of the magazine 38 and of the containers 46 can be chosen so as to make the supply of toner powder carried in the magazine approximately the amount needed for development of a single roll of sensitized sheet or paper 13, so that, at the same time a new roll of sensitized sheet is inserted in the apparatus, a new dispensing container 46 of toner powder is inserted. Thus replenishment of toner powder can, with our invention, be made a routine servicing operation and the danger of running out of toner powder during the course of an operating run is eliminated.

While we have in the foregoing specification described in considerable detail a typical embodiment of our invention, it will be understood that the description is illustrative merely. Many changes and variations in details thereof can be made by persons skilled in the art without departing from the spirit of our invention. It is accordingly our wish that the scope of this invention be determined primarily by reference to the appended claims.

We claim:

1. In a magnetic-brush developer for electrostatic photography, of the type wherein a rotating magnetized brush passes a mixture of magnetically permeable powder and finely divided toner over the surface of a sensitized sheet carrying an electrostatic latent image and thereby develops on said sheet a visual image produced by selective adherence of toner thereto, the improvement which comprises a toner magazine mounted above the brush, in combination with means operative responsively to rotation of the brush to release from said magazine successive small quantities of toner at a rate proportional to the speed of rotation of said brush, said magazine and said brush being oriented to permit such released toner to fall onto said brush.

2. In a magnetic-brush developer for electrostatic photography, of the type wherein a rotating magnetized brush passes a mixture of magnetically permeable powder and finely divided toner over the surface of a sensitized sheet carrying an electrostatic latent image and thereby develops on said sheet a visual image produced by selective adherence of toner thereto, the improvement which comprises a toner magazine mounted above the brush, means operative responsively to rotation of the brush to release from said magazine successive small quantities of toner at a rate proportional to the speed of rotation of said brush, and manually adjustable means for controlling the magnitude of such successive quantities of released toner.

3. In a magnetic-brush developer for electrostatic photography, of the type wherein a rotating magnetized brush passes a mixture of magnetically permeable powder and finely divided toner over the surface of a sensitized sheet carrying an electrostatic latent image and thereby develops on said sheet a visual image produced by selective adherence of toner thereto, the improvement which comprises a toner magazine mounted above the brush, said magazine having a perforated bottom normally effective to retain the toner therein but operative on being agitated to permit the toner to sift therethrough, and means mechanically coupling the magazine to said brush operative on rotation of said brush to agitate said magazine at a rate proportional to the speed of rotation of said brush.

4. The apparatus defined in claim 3 having also adjustable means for controlling within predetermined limits the degree of agitation afforded to said magazine responsively to rotation of said brush.

5. The apparatus defined in claim 3 having also manually adjustable means for controlling the rate of escape of toner through said perforated bottom during agitation of said magazine.

6. A magnetic-brush developer for electrostatic photography comprising a frame, a brush mounted therein for rotation, means for magnetizing said brush, a toner magazine carried by said frame above said brush and being rockably mounted therein, cam means mounted for rotation with said brush, and cam-follower means mechanically coupled to said magazine and mounted in the locus of movement of said cam means, whereby said cam means during rotation periodically engages said follower means and thereby rocks said magazine, said magazine having a perforated bottom normally effective to retain toner therein but operative to permit toner to sift slowly therethrough responsively to rocking.

7. The apparatus defined in claim 6 having also a manually adjustable stop means limiting the movement of said follower means, said stop means being adjustable to fix at any value within predetermined limits the arc of rocking movement of said magazine.

8. In a magnetic-brush developer for electrostatic photography, of the type wherein a rotating magnetized brush passes a mixture of magnetically permeable powder and finely divided toner over the surface of a sensitized sheet carrying an electrostatic latent image and thereby develops on said sheet a visual image produced by selective adherence of toner thereto, the improvement which comprises a toner magazine mounted above the brush, in combination with means operative responsively to rotation of the brush to agitate said magazine at a rate proportional to the speed of rotation of said brush, said magazine comprising an outer shell having a perforated bottom normally effective to retain the toner therein but operative on the agitation of said magazine to permit the toner to sift therethrough, said magazine also comprising an inner container carrying a supply of toner and having in its bottom surface a plurality of apertures

of sufficient size to permit the contents thereof to flow freely onto the perforated bottom of said outer shell, one of the two last-mentioned components of said magazine having also means spacing apart said bottom surface of the inner container and said perforated bottom of the outer shell.

9. The apparatus defined in claim 8 having also manually adjustable means for setting at a desired value within predetermined limits the degree of agitation afforded to said magazine during rotation of said brush.

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