United States Patent

Howell

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[45] **Aug. 8, 1972**

[54] **MAGNETIC INCREMENTAL CASCADE DEVELOPEMENT SYSTEM**

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[73] Assignee: **Xerox Corporation, Rochester, N.Y.**

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[52] **U.S. Cl.** .....**346/74 ES, 117/37 LE, 117/17.5, 118/637 LX, 346/74 MP**

[51] **Int. Cl.** **G01d 15/12**

[58] **Field of Search**.346/74 ES, 74 MP; 118/637 LX, 118/637 R; 117/37 LE, 37 R, 17.5; 198/41

[56] **References Cited**

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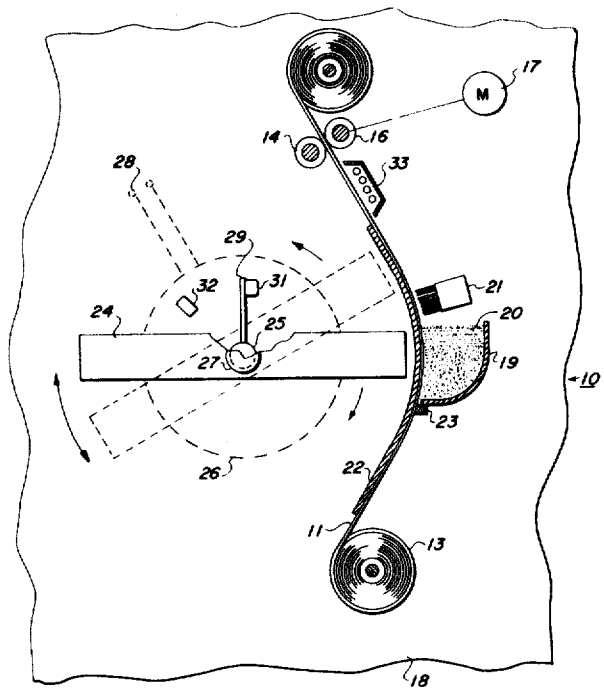
[57] **ABSTRACT**

Electrographic recording device wherein development takes place at the recording station in such a manner that obscuring of the developed image by the developer unit is minimized. A developer trough or retaining structure constituting one part of the developing unit precedes the recording station. An oscillating magnet, forming another part of the developing unit and positioned adjacent the rear surface of the recording medium, effects movement of developer over latent electrostatic images printed upon the recording medium and its rapid return to the trough so that the developed image can be seen almost immediately.

9 Claims, 3 Drawing Figures



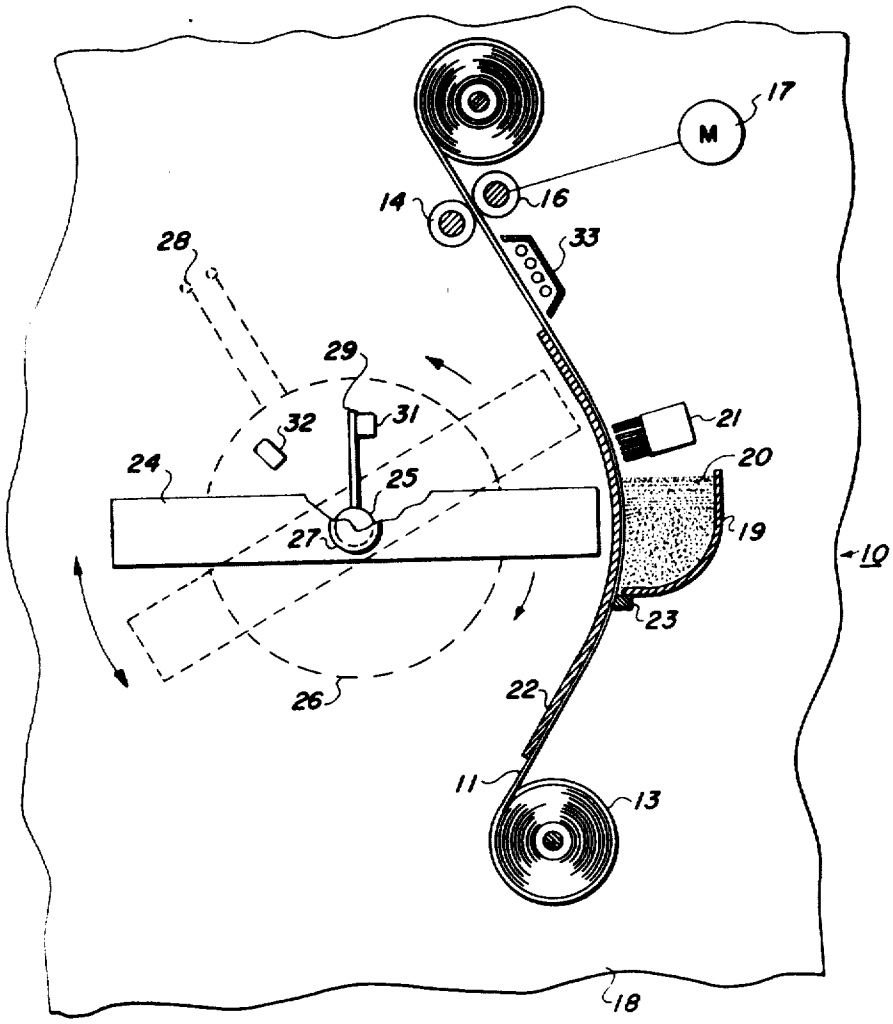


FIG. 1

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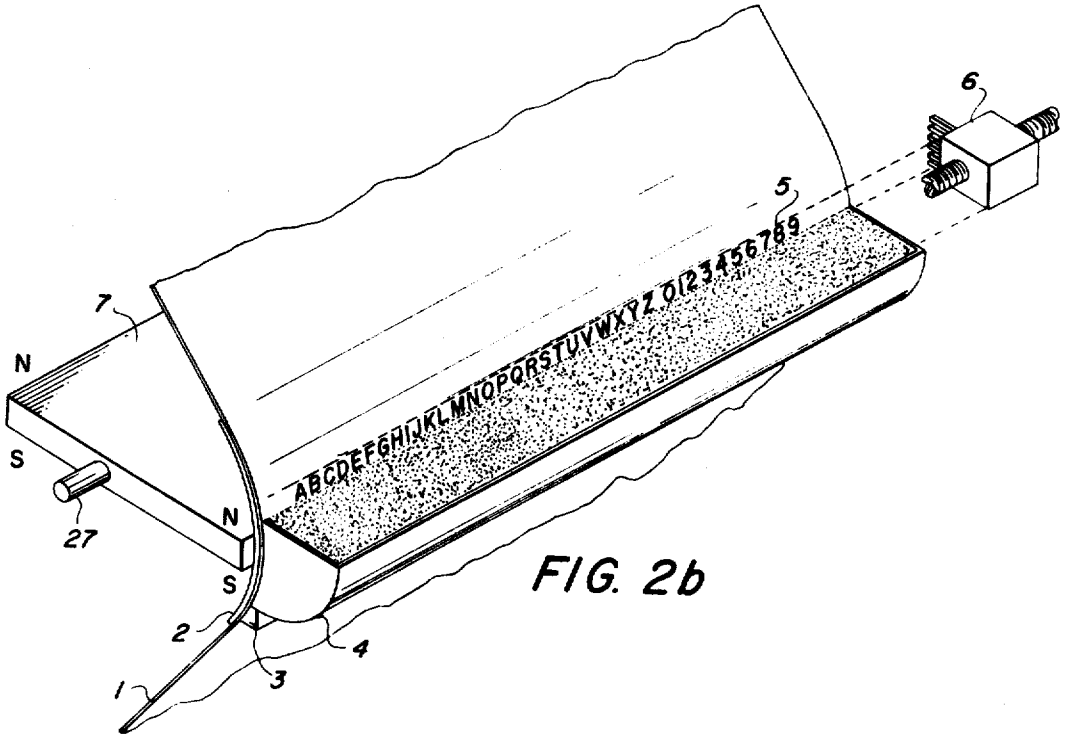
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FIG. 2b

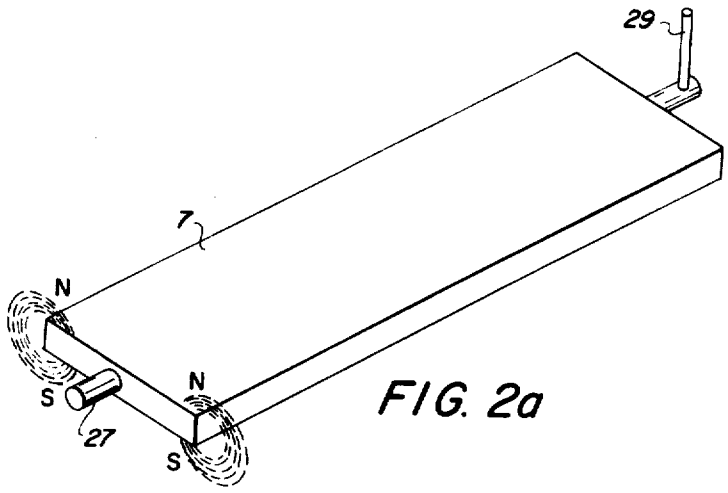
29
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FIG. 2a

MAGNETIC INCREMENTAL CASCADE DEVELOPEMENT SYSTEM

BACKGROUND OF THE INVENTION

This invention relates, in general, to electrographic recording and, more particularly, to structure for applying developer powder to the recording.

With the advent of high-speed data-processing systems such as those including digital computers, the speed at which information can be processed has been substantially increased. Accordingly, a definite time lag has developed between the rate at which information can be handled within the computer itself and the rate at which the information can be supplied to, and/or read out from, the computer. To bridge this gap in the over-all data handling picture, various high-speed equipments have been developed. By way of example, one such equipment is an electrostatic "recorder" which forms visible, information-representing marks and/or characters on a moving tape from information supplied by a computer during readout, or compiled from other sources and inserted on the tape to provide a suitable source for feeding information into the computer at a high speed.

In certain electrostatic recorders, a dielectric medium such as a tape or web comprised of polyethelene or vinyl plastic with a conductive backing surface is fed through a charging station, at which station a recording head issues electrical discharges which are directed onto the moving tape or web in certain areas to define a latent electrostatic image. Thereafter the tape carrying the charged areas is passed through an inking station which contains a supply of colored electroscopic developing powder, known in the art as toner. The particles are attracted to the charged surface areas and adhere thereto, rendering the latent image visible. Some means may be provided for removing excess powder from the background or uncharged portions of the tape or web, thus sharply defining the image. The ink or more precisely, powdered areas on the tape or web are then permanently fixed by various means such as the application of heat, pressure, coating with laquer, or other known means.

Such electrostatic recording systems are capable of very high speed operation, especially as contrasted to older systems which utilize mechanical means for punching holes or slots in a tape or card. In such punching arrangements, the tape is stepped or displaced in increments, being halted as the punch means is operated to produce apertures at the desired locations.

In utilizing the foregoing process in high speed devices such as "line-at-time" character printers or displays, it is highly desirable to have the recorded information available for viewing as quickly as possible. Presently, known developing units have been recognized as being unsatisfactory in this respect, due to the construction of the developing unit and its spatial relationship relative to the recording medium. In other words the size and particular configuration of the developing unit relative to the dimension of a single line of information causes the developed recording to be obscured. Furthermore, since the developer unit must succeed the recording unit, there is an undesirable time delay between recording and display of the information.

Accordingly, the general object of this invention is to provide a new and improved electrographic recording apparatus.

It is a more particular object of this invention to provide a new and improved structure for applying developer to an electrostatic recording.

Another object of this invention is to provide, in high speed electrographic recording apparatus, a developer unit which minimizes the time between information recording and display.

A further object of this invention is to provide a new and improved method of electrographic printing wherein the time elapsed between information recording and display is minimimized.

BRIEF SUMMARY OF THE INVENTION

Briefly, the above-cited objects are accomplished through the provision of electrographic recording apparatus wherein an elongated recording, which is supported by a relatively thin non-magnetic platen, is moved upwardly between the platen and a horizontally disposed trough and thereafter past a recording station disposed immediately above the trough. The trough contains a developer mixture of finely divided magnetic material such as iron filings and toner particles. The recording station comprises, by way of illustration, a recording transducer which traverses the width of the web at high speed, on command, while depositing latent electrostatic images.

Mounted for reciprocating motion about a horizontal axis and having one surface thereof adjacent the back surface of the platen is a magnet in the form of a rectangular parallelepiped whose longitudinal axis is substantially coextensive with the trough. Subsequent to a row or line of latent information being disposed on the web and before the web is advanced from the recording station, the magnet is rotated from its initial position thereby causing the developer to "jump" up from the trough after which the carrier returns to the trough either by gravity or under the influences of the lines of force of the magnet depending upon the degree of rotation of the magnet.

Where speed is of the essence, it is desirable to return the residual developer to the trough as quickly as possible (i.e., other than by gravity which occurs when the magnet is rotated approximately 180°). In this instance the magnet is rotated first away from the trough, through an angle of approximately 45° and then abruptly returned to its original position. In this manner it is believed the residual developer (i.e., carrier particles and toner not attracted to electrostatic images) remain captured by the field of the magnet thereby forcing the developer back down into the trough.

Further objects and advantages of the present invention will become more apparent when considered in view of the detailed description of the preferred embodiment of the invention and drawings forming a part hereof.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view illustrating electrostatic printing apparatus embodying the present invention; and

FIGS. 2*a* and 2*b* are perspective views of the charging and developing units forming a part of this apparatus illustrated in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, especially FIG. 1, reference character **10** designates generally apparatus for electrostatically printing on a charge-retentive recording medium **11**. While the medium **11** as herein contemplated constitutes a plastic dielectric or plastic coated paper web, it will be appreciated that other suitable media can be employed, for example, predried sheet paper or other material insulating enough to hold electrostatic charges.

The recording medium or web **11** is fed from a supply reel **13** and is moved past various units or stations of the system by a pair of drive rollers **14** and **16**, motion to which, is imparted by means of a drive motor **17**. The shafts of the supply reel and rollers are suitably supported intermediate opposed support plates **18**, only one of which is shown.

The web **11** is first moved past or through a developer trough **19** which contains a developer mixture **20** of magnetic steel carrier beads or iron filings and finely divided electroscopic marking particles known in the art as "toner." Suitable mixtures are described in U.S. Pat. No. 2,874,063, issued in the name of H. G. Greig. The trough has open top and back areas, the latter of which allows the developer to be continuously in contact with the recording medium **11**. The open top area allows the developer to be moved in and out of the trough in order to develop a latent electrostatic image on the recording medium **11**.

The latent electrostatic image referred to is formed on the recording medium **11** as it passes between a frontal electrode in the form of a transversely movable stylus or recording transducer **21** and a backing electrode herein disclosed as a relatively thin non-magnetic platen **22** which is stationarily mounted between the support plates **18**. The platen is fabricated from a material, for example, aluminum, that is electrically conductive and able to pass a magnetic field. Since the trough **19** is open at its back surface, a seal **23** is provided.

With the foregoing arrangement, printing of a latent electrostatic image on the charge-retentive recording medium occurs when a suitable difference of potential is produced between the moveable stylus and the backing electrode which together, form mutually insulated and spaced apart electrode means. Printing results from the application of independently controlled voltage pulses, to these two electrode means. One means of the pair, however, may under certain conditions, be held at a constant potential, corresponding to a predetermined threshold value, as the other is pulsed.

The recording electrode on one side of the displaceable record sheet or continuous web may be a single pin-shaped electrode which is selectively energized as it moves across the web or a vertical line of pin electrodes as shown in FIG. **1**. It may also comprise a combination of pin or elongated bar electrodes in a two dimensional electrode matrix from which the image of a whole character is recorded as the matrix indexes across the paper, one character space at a time. Typically, a pin matrix of this latter type includes 35 pins in columns of seven pins each.

In each of these embodiments suitable pulsing and pin selection circuitry is provided so that short electrical recording pulses are applied to selected electrodes as the recording head scans across the web. In this way a complete line of latent electrostatic character images is formed and ready for development.

Since the trough **19** is opened at its back surface, a seal **23** is provided. The seal may be of any conventional type utilized in the art, for example, a permanent magnet. While the seal **23** is herein disclosed as a permanent magnet, other types such as a rubber wiper may be employed since the movement past the seal is accomplished prior to forming of the latent electrostatic image and consequently, prior to the development of the latent electrostatic image. Since both the forming and developing of the image take place subsequent to the passing of the seal by the recording medium, the seal may be electrically conductive and in direct contact with the recording medium without disturbing either the latent electrostatic image or the developed image.

Supported for oscillatory movement directly behind the non-magnetic platen **22** is a magnet **24** having integral trunnions **25** which are journalled in the support plates **18** in any well-known manner not forming a part of the inventive concept and therefore not disclosed. The magnet has a rectangular parallelpiped configuration and a polarization and field shape as shown in FIG. **2***a*. The magnet **24** is relatively thin and it extends the full width of the recording medium. Due to the field shape of the magnet and its particular configuration, a mass of iron carrier filings and toner rises out of the trough in response to the movement of the field of the magnet. This mass is long and thin and quite controllable. The iron filings in this mass move in the same way and for the same reasons that any small filings of magnetic material can be manipulated with a horseshoe magnet. The much smaller colored toner particles are intimately mixed with the iron filings in the trough and move with the filings when they are manipulated by the magnet because of the triboelectrically generated electrostatic attraction between the filings and toner particles. The system is capable of toning images on a plastic coated electrostatic recording paper supplied by the Plastic Coating Corporation, to full density in two passes and to a very readable level in one pass using 105–210 micron iron filings. As will be appreciated by those skilled in the art, the present invention is not limited to toning paper. Webs made of pure plastic, fiber glass or other insulating materials may also be used. In lieu of the web illustrated, an insulating drum may be employed in conjunction with means for subsequently transferring the developed image to sheets or webs of paper or other receiving material. The drum is successively rotated past the stations of the system which do not include the fusing structure but do include means for cleaning the drum after transfer. The transferred toner image is then fused on the paper. An electromagnet or system of electromagnets may be employed in lieu of the permanent magnet **24**.

A motor **26** carried by or mounted on one of the support plates **18** serves to impart motion to the magnet **24**, consequently, its shaft **27** is coupled to one of the trunnions **25**. The motor **26** may be a permanent magnet synchronous type or an inductor alternating current type. An example of a suitable motor, is a Haydon General Times series MP20 A. C. motor. Input leads **28** provide suitable electrical power to the motor **27**.

The shaft **27** of the motor has extending radially therefrom a pin member **29**. The pin member is sufficiently long to contact a pair of stop members **31** and **32** carried by one of the support members **18**. The stop members **31** and **32** cooperate with pin member **29** to effect periodic reversing of the motor depending upon the spatial relationship of the stop members. The types of motors hereinabove noted can be made to mechanically oscillate when their "no-back" system is removed. This system is generally composed of a step "no-back" gear on the rotor which gear runs against a special tooth-formed idler gear. This arrangement permits free rotation in the desired direction but prevents motion in the reverse direction. If this no-back system is eliminated, the motor can start and operate in either direction if two mechanical stops such as **31** and **32** are provided. In operation the motor shaft **27** will proceed in one direction until the pin **29** abuts one of the stops, which abutment momentarily stalls the motor, whereupon the direction of rotation is reversed. Subsequent engagement of the other of the stops by the pin **29** again causes stalling and direction reversal. While the stops **31** and **32**, as shown, are spaced approximately 45° apart to thereby effect oscillation of the magnet **24** through an angle of 45°, it will be appreciated that any desirable spacing may be employed. For example, the stops may be spaced such that the magnet rotates through an angle of 90°. In any event, rotation of the magnet counterclockwise as viewed in FIG. 1, causes the developer captured in the field thereof to move upwardly and to be cascaded over the latent image deposited by the stylus **21**. When the angle of rotation is large, return of the unused developer to the trough is effected by gravity.

For high speed operation where the required time for the carrier to return to the trough by gravity may be too long, another mode of operation is employed. Thus, the magnet is rotated counterclockwise (as seen in FIG. 1.) through an angle of 45° and then be abruptly rotated in the clockwise direction. This forces rapid return of the developer mix to the trough under the control of the oscillating magnetic field. Such a mode of operation may utilize a solenoid and bias spring combination, the former of which could be energized by a stylus-actuated switch at the termination of a print cycle or the end of the scan of stylus **21**. The aforementioned spring would, upon deenergization of the solenoid, rapidly return the magnet to its original position with the carrier particles still captured in the field of the magnet. The developed image is rendered permanent by means of a conventional fuser **33**.

The developing system of this invention may also be used for developing latent electrostatic images formed on webs or drums of photoconductive insulating material of any of the types used in direct or transfer xerography. It is particularly valuable where the image is exposed on the photoconductor one line at a time and rapid viewing is important. In this instance a structure of the type shown in FIG. 1 is used except that recording stylus **21** is removed and the photoconductor is uniformly charged after it moves past the developer trough. This charging is accomplished by replacing the stylus **21** with a fine wire corona generating electrode connected to a high voltage source and causing it to scan across the width of the photoconductor, prior to exposure. In the alternative, a stationary corona electrode extending across the whole width of the photoconductor may be used if it is either out of the optical path during exposure or out of focus at that time. Development then proceeds as explained above.

It should now be apparent that there has been disclosed electrographic recording apparatus wherein the developing unit is so constructed as not to obscure the developed electrostatic prints whereby the transmission of intelligence is expedited.

Since numerous changes may be made in the above apparatus and different embodiments may be made without departing from the spirit thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Apparatus for recording visible images on a charge retaining recording medium comprising;

a. a recording head,

b. means for moving said head through a scan cycle across one side of a recording medium while selectively pulsing said recording head to deposit a latent electrostatic charge pattern on said medium representative of information to be recorded,

c. a receptacle adapted to support a quantity of magnetically attractable marking particles, said receptacle being positioned adjacent but out of the line of sight of the scan line made by said recording head on said recording medium,

d. magnetic means positioned adjacent said recording head on the side of said recording medium opposite thereto for attracting marking particles out of said receptacle toward said recording medium and

e. means for moving said magnetic means behind said recording medium to move said marking particles over the charge patterns formed during the scan of said recording head whereby said latent charge patterns are rendered visible.

2. Apparatus according to claim **1** further including means to oscillate said magnetic means back to its original position so that excess marking particles are returned to said receptacle after development of said latent charge patterns so as to make the developed charge patterns readily visible shortly after development.

3. Method of recording comprising the steps of:

a. providing a charge-retentive recording medium;

b. providing a charging station comprising electrostatic charging means for printing latent images on said recording medium;

c. providing developer and retaining means therefor;

d. moving said recording medium first past said retaining means and then past said recording station;

e. providing magnetic means for presenting said developer to said recording medium while the latter is at said recording station, and

f. oscillating said magnetic means to effect said presenting of developer to said recording medium.

4. The method according to claim **3** wherein, said magnetic means is disposed adjacent the surface of said recording medium opposite the surface on which said images are printed.

5. The method according to claim 3 wherein said magnetic means is oscillated through an angle of approximately 90°.

6. A method according to claim 3 wherein said magnetic means is oscillated through an angle of approximately 45° in one direction and then quickly returned to its original position.

7. Method of electrographic recording comprising the steps of:

a. providing a charge retentive recording medium in the form of an elongated web;

b. providing a charging station comprising electrostatic charging means for printing latent images on said recording medium;

c. providing developer and retaining means therefor, said retaining means being disposed subadjacent said charging station;

d. moving said recording medium upwardly past said retaining means and then past said charging means;

e. presenting developer to said recording medium when said recording medium is at said recording station and; allowing non-attracted developer to return to said retaining means.

8. Recording apparatus:

a charge-retentive surface;

means for containing magnetically attractable developer particles;

means for placing latent images on said charge-retentive surface;

means for transporting said charge-retentive surface past said means for placing latent images;

magnetic means for moving developer from said containing means then presenting the developer to said charge-retentive surface while said charge-retentive surface is adjacent said means for placing latent images;

said magnetic means and said developer containing means being disposed on opposite sides of said charge-retentive surface; and

means for moving said magnetic means through an angle of approximately 45° in one direction and then in the opposite direction to thereby effect movement of unused developer back to said containing means.

9. Recording apparatus comprising:

a charge-retentive surface;

means for placing latent images on said charge-retentive surface;

means for transporting said charge-retentive surface past said means for placing latent images;

means for containing developer;

magnetic means for attracting developer out of said containing means and presenting developer to said charge-retentive surface while said surface is disposed adjacent said means for placing latent images, said magnetic presenting means being disposed on a side of said charge-retentive surface opposite from said latent image placing means; and

means for moving said developer presenting means from a non-developing position to a developing position whereby developer is moved from said containing means and into contact with said charge-retentive surface.

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