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ELECTROPHOTOGRAPHIC COPYING APPARATUS

Filed Dec. 15, 1958

4 Sheets-Sheet 1

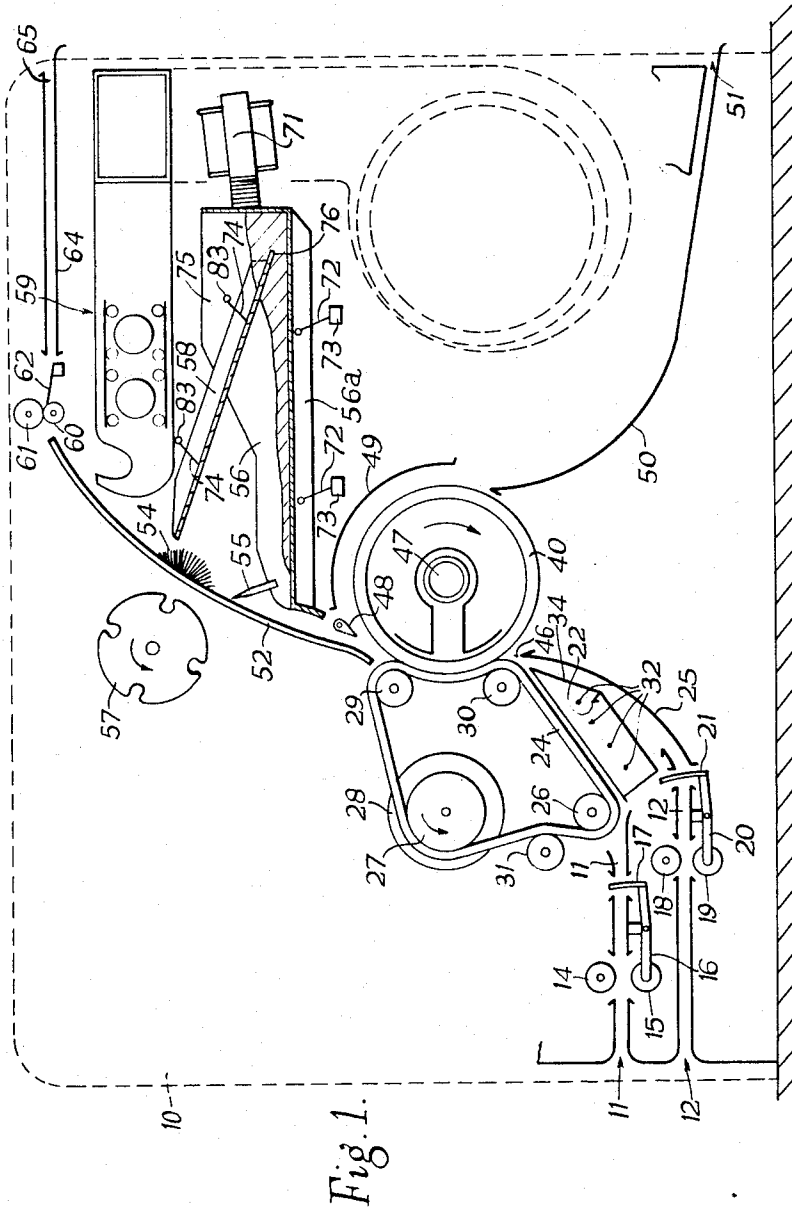


Fig. 1.

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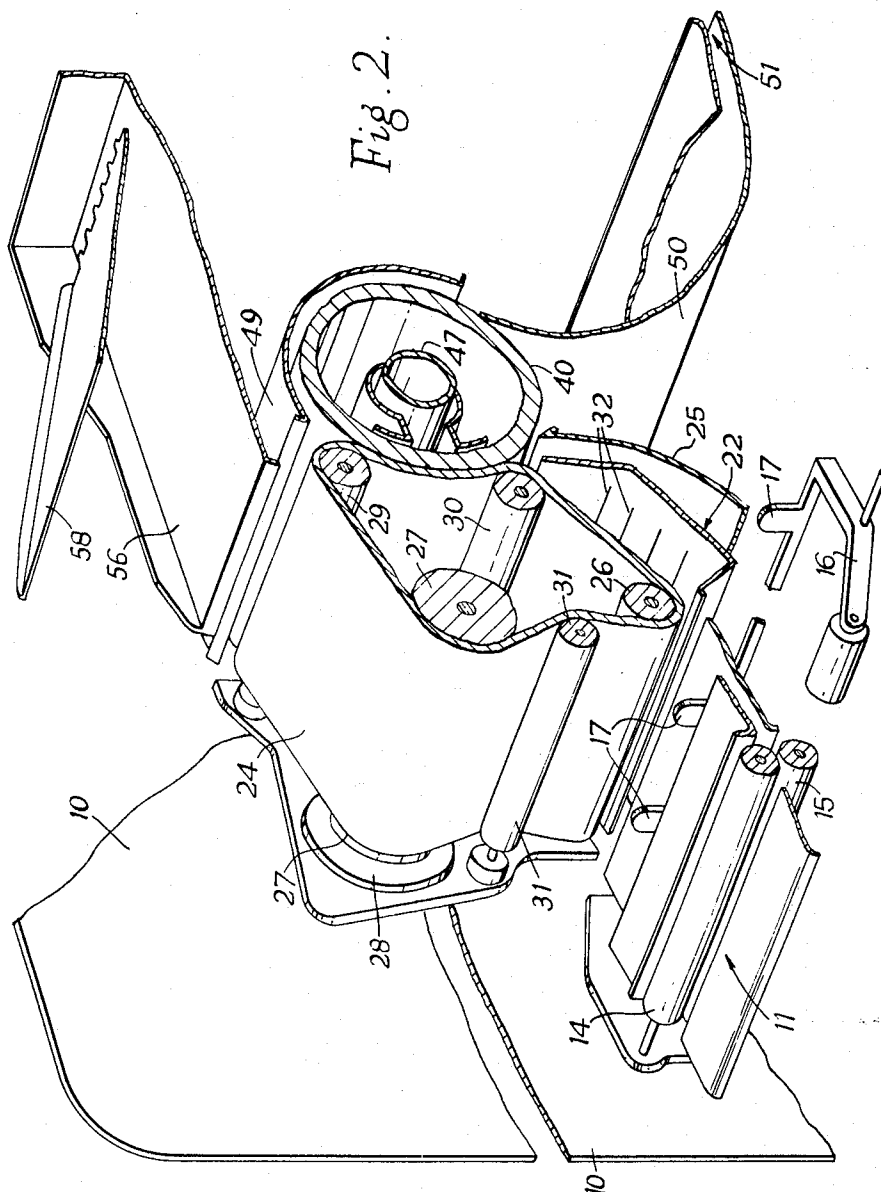
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4 Sheets-Sheet 2



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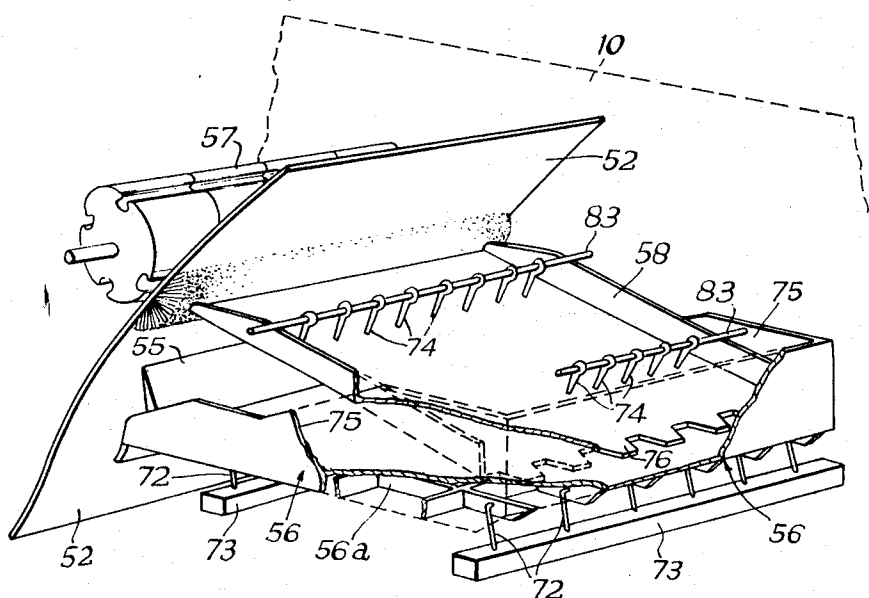
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4 Sheets-Sheet 3

Fig. 3.



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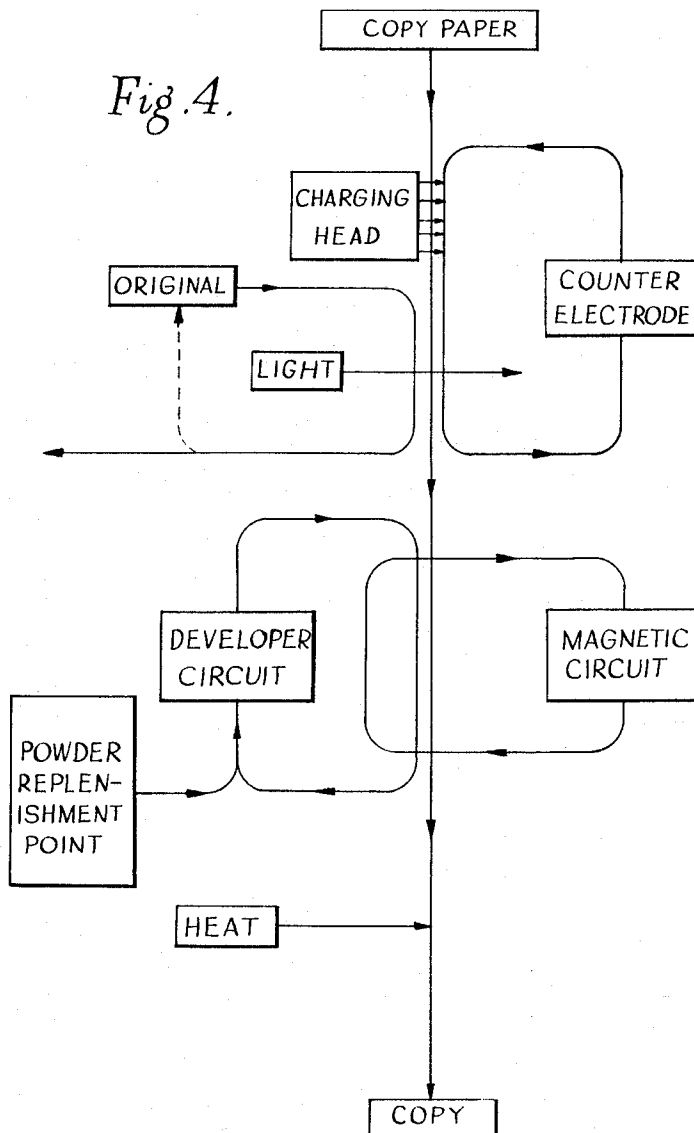
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ELECTROPHOTOGRAPHIC COPYING APPARATUS

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5 Claims. (Cl. 95—1.7)

The present invention relates to electrophotographic copying apparatus and is concerned in particular with improved apparatus for carrying out electrophotographic copying processes of the kind in which an electrosensitive copy paper is given an electrostatic charge in the dark, so as to render the copy paper sensitive to light, a translucent original to be copied is placed in contact with the charged copy paper (both face up) and the assembly is then exposed to light, so as to produce a latent electrostatic image of the original on the copy paper, the original and the copy paper are separated and the latter is treated with a developer mixture comprising toner powder, after separation of the original, so that the toner powder adheres to the copy paper in the form of the electrostatic image produced thereon by the exposure and is thereafter treated to fix the toner powder particles in the form of a prepared copy of the original document.

It is necessary for the toner powder in the developer mixture to be capable of adhering to those parts of the copy paper still carrying an electrostatic charge after exposure, of not adhering to the other parts of the copy paper and of being fixable to the copy paper. The present invention is particularly concerned with apparatus and processes in which the toner powder comprises a colored, heat-fusible powder, such as particles of pigment-containing resin materials, which is admixed with a carrier material which enables the toner powder to be conveyed to the surface of the copy paper. This carrier material is conveniently iron fillings or granules, enabling magnetic means to be used for supplying the toner powder to the copy paper, and carries the coloured, heat-fusible toner powder by reason of the slight attractive forces set up between the two materials by a triboelectric effect.

When a developer mixture of this kind is caused to brush across the copy paper so that the coloured toner powder particles adhere to the electrostatic image on the copy paper, the iron carrier particles eventually become starved of toner powder and this effect can be a considerable disadvantage.

It is therefore an object of the invention to provide a toner supply device in or for an electrophotographic copying apparatus in which this disadvantage is avoided.

According to the present invention, an electrophotographic copying apparatus is provided, which comprises, in combination, a substantially enclosed light-tight housing, a first inlet slot in the housing for introducing electrosensitive copy paper into the apparatus, a second inlet slot in the housing for introducing a translucent original to be copied into the apparatus, a corona discharge device for electrically charging the copy paper, copy paper feed means for feeding the copy paper from the first inlet slot past the corona discharge device, original feed means for feeding the original from the second inlet slot into contact with the charged copy paper, a source of light for exposing the charged copy paper when in contact with the original, thereby to produce a latent electrostatic image on one side of the copy paper, separating means

2

for separating the original from the charged and exposed copy paper, a treating zone for treating the copy paper with a developer mixture comprising toner powder and a magnetic carrier therefor thereby to render visible the latent electrostatic image, means for advancing the charged and exposed copy paper through the treating zone, a toner powder supply device arranged to supply toner powder to the treating zone at the side of the copy paper carrying the electrostatic image, a rotatable magnetic field source associated with the toner powder supply device and located on the side of the copy paper opposite to that carrying the electrostatic image as the copy paper passes through the treating zone, the rotatable magnetic field source serving to draw an accumulation of developer mixture into the path of movement of the copy paper through the treating zone and rotation of the magnetic field source serving to cause intermixing of the toner powder and the magnetic carrier therefor, without the accumulation of developer mixture contacting the rotatable magnetic field source, whereby toner powder is attracted to charged areas of the copy paper to develop the electrostatic image, heating means for heating the copy paper to fix the developed electrostatic image, an outlet slot in the housing for delivering the thus-developed and fixed copy from the apparatus, and means for advancing the copy paper from the treating zone past the heating means to the outlet slot to be delivered from the apparatus.

It has been found that if the iron particles constituting the carrier for the developer mixture rotate in this way, an intense dusting action takes place and sufficient toner powder particles are always available for developing the charged image. It has also been found that an efficient toner powder supply device must be provided for renewing or maintaining an adequate supply of developer mixture or toner powder therefor, so as to offset the consumption of toner powder.

In a preferred embodiment of the invention, the toner powder supply device comprises two superposed vibratory surfaces, one surface serving to supply fresh developer mixture or toner powder therefor to the copy paper treating zone and the other surface serving to remove spent carrier particles therefrom.

The two vibratory surfaces are preferably arranged to have angles of vibration such that spent carrier particles collecting upon one surface travel thereon under the influence of the vibration to a toner replenishment zone and the fresh developer mixture produced at the replenishment zone by mixing the spent carrier particles with toner powder travels upon the other surface under the influence of the vibration from the replenishment zone to the treating zone, whereby the carrier particles undergo a cyclic movement between the replenishment and treating zones. In this cyclic movement, the depleted carrier particles return to the replenishment zone from the treating zone, are intermixed by the vibration with fresh toner powder and return in the form of fresh developer mixture to the treating zone.

In order that the invention may be readily understood, reference is made to the following description of a preferred embodiment thereof illustrated in the accompanying drawings in which:

Fig. 1 shows diagrammatically one form of electrophotographic copying apparatus in vertical section;

Fig. 2 shows a diagrammatic perspective view of copy paper brushing and developer mixture applying circuit devices in the apparatus of Fig. 1;

Fig. 3 shows a diagrammatic perspective view of the toner supply and removal surfaces;

Fig. 4 is a flow sheet illustrating the principal steps in the copying process.

Referring to Figs. 1 and 2 of the drawings, an electro-

photographic copying machine is shown for making single copies of original records, drawn, written or printed on transparent or translucent sheets. The machine is constructed of a series of sub-assemblies built into a frame comprising a pair of opposed side members, one of which is indicated diagrammatically at 10. The side members 10 conveniently form part of a substantially enclosed light-tight housing for the machine and this housing includes inlet slots 11 and 12 for receiving copy paper and the original to be copied, the two slots preferably being adjacent and located at the same side of the machine.

The slot 11 for the electrophotographic paper extends horizontally into the machine and is interrupted to receive an upper driven roller 14 and a lower counterpressure roller 15 for advancing the copy paper. The roller 14 causes the copy paper to feed into the machine when the roller 15 is brought into contact with it by rocking movement of a lever 16 which has the roller 15 mounted on one end and upstanding pins 17 at the other end, i.e. the end remote from the inlet slot 11. The pins 17 locate the sheet of copy paper and rocking of the lever 16 removes the pins 17 from the path of the copy paper and also causes the roller 15 to press the paper against the driven roller 14, so that the paper is advanced into the machine.

A similar arrangement comprising a driven roller 18 and an idle roller 19 mounted on a rockable lever 20 having locating pins 21 at its forward end is provided in the inlet slot 12 for the original.

The electrophotographic copy paper is fed by the rollers 14 and 15 between a corona discharge device 22 and a conductive endless belt 24, whereas the original follows a curved plate 25 disposed beneath the discharge device 22. The continuous belt 24 effects three functions, namely (1) it carries the copy paper past the corona discharged evice 22 and an exposure device including a transparent cylinder 40, (2) it provides a return path for the corona discharge from the device 22 and (3) it causes the coated paper and the original to be held firmly together as they pass the exposure device within the cylinder 40.

Referring now to Figs. 1 and 2, at the point 46 the copy paper meets the original document and the two sheets of paper pass between the endless belt 24 and the transparent cylinder 40, when an exposing light 47 is switched on, which causes the areas strongly illuminated on the copy paper to be electrically discharged. In areas of black on the original document, however, the light is screened from the copy paper and the charge remains intact. Thus, the copy paper has on it an electrostatic charge pattern of the original document.

The original document and the copy paper are separated by a guide edge 48 which causes the original document to follow the surface of the cylinder 40 and a curved plate 49 until it falls on to a plate 50 and is discharged via an exit slot 51. The copy paper, however, follows a brass or other non-magnetic guide plate 52 which is provided between the magnetic field source and the path of movement of the copy paper so that the latter is guided past the rotating magnetic field and thus through the magnetic brush developer unit (Fig. 1).

For purpose of clarification, this unit may be considered to include two parts, i.e. the magnetic brush proper and the feed of material to and from the magnetic brush, namely, the toner powder supply device. The electrostatic image is rendered visible by brushing on to the coated surface of the copy paper a developer mixture of toner powder and iron filings disposed in an accumulation 54, which is formed at the treating zone by the magnetic field, as described in more detail below. As shown in Fig. 1, this magnetic brush is formed upon the side of the non-magnetic guide plate 52 remote from the magnetic field source. In areas on the copy paper where the electrostatic charge remains, the toner powder transfers from the iron filings to the charged image owing to the stronger attraction of the charged image. To prevent the de-

veloper mixture from falling on to the original document, a deflector bar 55, preferably of thin plastics material, is loosely hung or otherwise mounted in such a way that it lightly contacts that side of the guide plate 52 upon or against which the copy paper travels. The loose mounting of the deflector bar 55 enables the copy paper to pass between it and the guide plate 52. This ensures that any developer mixture falling from the magnetic brush accumulation 54 is prevented from falling on to the original document or from otherwise falling away from the toner powder supply device, i.e. the circuit or cyclic movement of the carrier particles; in the embodiment shown, any such developer mixture ingredients falling from the accumulation 54 are deflected by the bar 55 so as to fall on to a tray 56, which is described in more detail below. However, when the leading edge of the copy sheet reaches the bar 55, it moves the bar slightly so that the paper passes between the bar 55 and the plate 52. The magnetic brush is operated by a rotatable bar magnet 57 placed the other side of the non-magnetic metal plate 52 and having, in the embodiment shown, a quadrifoil section. The bar magnet 57 is preferably arranged to rotate so that its surface adjacent the guide plate 55, i.e. its surface adjacent the treating zone, moves in the same direction as the copy paper, namely, anti-clockwise as shown in Fig. 1. The effect of the rotating magnetic field on the opposite side of the guide plate 52 from the magnet 57 is to cause the developer mixture 54 to form a bristle structure, in which the bristles tend to rotate end over end. This action causes a bulk movement of the developer mixture in the opposite direction to the travel of the copy paper. This downward movement is limited by the fact that the bulk of the powder is moving from the magnetic field. As the magnetic field rotates, the magnetic brush 54 is seen to slide upwards once more into the magnetic field. Thus, as the copy paper enters the treating zone constituted by the magnetic brush, the end over end movement of the "bristles" climbs over the leading edge of the copy paper and the return sliding action has both a positive action in the transport of the copy paper through the machine and a brush action due to the sliding of the mixture on the copy paper.

The second part of the magnetic brush unit concerns the removal of iron filings or other carrier particles depleted of toner powder from the "brush" and the supply of fresh developer mixture to the magnetic brush proper. This cyclic movement of the mixture, or at least the carrier ingredient thereof, is advantageously achieved by the use of two vibratory surfaces, such as the two rigid non-magnetic vibratory trays 56 and 58, shown in Figs. 1, 2 and 3, one of which is mounted for vibratory oscillation with respect to the apparatus and being connected to an electromagnetic vibrator and the other being mounted for vibratory oscillation above and in driving connection with the first-mentioned tray, whereby spent carrier particles are caused to travel from the treating zone to the replenishment zone upon the first-mentioned tray and fresh developer mixture is caused to travel from the replenishment zone to the treating zone upon the second-mentioned tray.

In the embodiment illustrated in the drawings, the tray 56 is vibrated in such a way, by having a magnetic vibrator 71 attached to it that, when the vibrator 71 is energised, the developer mixture resting on the tray 56 moves towards the vibrator end of the tray 56 (i.e. to the right as shown in Fig. 1). Thus, particles falling from the magnetic brush 54 are transported to and accumulate at the right-hand end of the tray 56, where they enter a replenishment zone for the developer mixture. Into this mass of iron filings and toner powder, fresh toner powder is added which mixes rapidly into the iron filings owing to the vibration which in fact fluidises the mass of iron filings. The replenished developer mixture is carried back to the magnetic brush 54 by the vibrating tray 58. The tray 56 is held in such a way that, when vibration

5

is applied to it, using for example an electromagnetic vibrator 71 connected to an alternating current supply of electricity, particles are caused to move in a uniform manner from one end of the tray 56 to the other. To achieve this movement, it is necessary that all parts of the tray should be given the correct proportions of horizontal and vertical vibration. The tray 56 is heavily ribbed on its undersurface to give the required rigidity without unduly increasing the inertia of the tray. The tray 56 is connected to the frame 10 by two banks of resilient links 72 each link being hinged to a rib 56a of the tray 56 at one end and clamped to a cross member 73 of the main frame at the other end. The angle of each link 72 is set at right angles to the direction of thrust of the vibrator 71.

In this particular instance, twelve links 72 are used each being about $\frac{3}{4}$ " long and set at an angle of about 75° to the tray surface. An equally effective means of support would be to use links of flexible material such as spring steel clamped at both ends.

The upper vibrating tray 58 is mounted in a similar manner, but from above, as the tray 56 in the main surrounds the tray 58. In this distance, the flexible links 74 are clamped rigidly at both ends (the lower end to the tray 58 and the upper end to a frame cross-member 83) and the flexibility of the links 74 permits the requisite vibratory motion of the tray 58 to occur. It may be seen in the accompanying drawing that these links 74 will pass through the mass of fluidised iron filings/toner powder mixture as it flows towards the magnetic brush 54. The mix, however, easily flows round these links 74. As with the tray 56, the links 74 and electromagnetic vibrator 71 are set at an angle to the tray surface.

The tray 58 preferably has a serrated edge 76 adjacent the replenishment zone to facilitate collection of developer mixture thereon. As the iron powder leaves the tray 58, it is attracted into the magnetic brush, thus completing the cycle.

The copy paper emerges from the magnetic brush 54 with the electrostatic pattern now visible due to the deposit of toner powder but free from iron particles. The copy paper then passes a thin stream of hot air which is generated by a fuser unit 59. This causes the toner particles to soften and fuse into the copy paper. To fix the toner material more firmly on to the copy paper, the copy paper then passes between a chromium-plate polished roller 60 and a resilient plastics roller 61. The chromium-plated roller 60 is used to minimise pick-off as the toner material is still soft at this point. To prevent accumulation of toner material on this roller 60, a scraper blade 62 is provided. The rollers 60 and 61 also serve to control the sheet of copy paper. The copy thus formed is then discharged from the machine along a plate 64 leading to a copy paper exit slot 65.

Referring to Fig. 4, this shows in flow-sheet form the essential steps in the process carried out in the apparatus according to the invention.

Copy paper is advanced past a charged head when backed by a moving counterelectrode, such as the endless belt 24 (Fig. 1), and the original is brought into contact therewith beyond the charging head, while the copy paper is still backed by the counterelectrode. The assembly of copy paper and the original is exposed to light and the original is then separated from the copy paper, as shown by the continuous arrow, or recycled for multiple copying, as shown by the dotted arrow.

The charged paper then passes into the influence of a magnetic circuit and a developer circuit where development of the latent electrostatic image occurs, the developer circuit including powder replenishment as shown at the left of Fig. 4. The powdered copy sheet is finally heated to fuse the adhering powder particles and produce a prepared copy.

It will thus be seen that the apparatus of the invention provides an efficient means for treating copy paper with developer mixture and further provides a simple and

6

reliable means by which the supply of toner powder to the treating zone may be maintained. The intense dusting and brushing action which occurs in the treating zone ensures that the whole of the latent electrostatic image on the copy paper is adequately treated with toner powder and therefore good, clear and even copies are obtained when the image is developed.

We claim:

1. An electrophotographic copying apparatus comprising, in combination, a substantially enclosed light-tight housing, a first inlet slot in the housing for introducing electrosensitive copy paper into the apparatus, a second inlet slot in the housing for introducing a translucent original to be copied into the apparatus, a corona discharge device for electrically charging the copy paper, copy paper feed means for feeding the copy paper from the first inlet slot past the corona discharge device, original feed means for feeding the original from the second inlet slot into contact with the charged copy paper, a source of light for exposing the charged copy paper when in contact with the original, thereby to produce a latent electrostatic image on one side of the copy paper, separating means for separating the original from the charged and exposed copy paper, a treating zone for treating the copy paper with a developer mixture comprising toner powder and a magnetic carrier therefor thereby to render visible the latent electrostatic image, means for advancing the charged and exposed copy paper through the treating zone, a toner powder supply device arranged to supply toner powder to the treating zone at the side of the copy paper carrying the electrostatic image, a rotatable magnetic field source associated with the toner powder supply device and located on the side of the copy paper opposite to that carrying the electrostatic image as the copy paper passes through the treating zone, the rotatable magnetic field source serving to draw an accumulation of developer mixture into the path of movement of the copy paper through the treating zone and rotation of the magnetic field source serving to cause intermixing of the toner powder and the magnetic carrier therefor, without the accumulation of developer mixture contacting the rotatable magnetic field source, whereby toner powder is attracted to charged areas of the copy paper to develop the electrostatic image, heating means for heating the copy paper to fix the developed electrostatic image, an outlet slot in the housing for delivering the thus-developed and fixed copy from the apparatus, and means for advancing the copy paper from the treating zone past the heating means to the outlet slot to be delivered from the apparatus.

2. An electrophotographic copying apparatus comprising, in combination, a substantially enclosed light-tight housing, a first inlet slot in the housing for introducing electrosensitive copy paper into the apparatus, a second inlet slot in the housing adjacent the first inlet slot, the second inlet slot serving for introducing a translucent original to be copied into the apparatus, a corona discharge device for electrically charging the copy paper, copy paper feed means for feeding the copy paper from the first inlet slot past the corona discharge device, whereby an electrostatic charge becomes applied to one side of the copy paper, original feed means for feeding the original to be copied from the second inlet slot into contact with the charged copy paper, a source of light for exposing the charged copy paper while in contact with the original, whereby a latent electrostatic image is formed on the one side of the copy paper, separating means for separating the original from the charged and exposed copy paper, a treating zone for treating the copy paper with a developer mixture comprising toner powder and a magnetic carrier therefor, thereby to render visible the latent electrostatic image, a non-magnetic guide plate for the copy paper extending from the separating means through the treating zone, means for advancing the copy paper in contact with the guide plate through the treat-

ing zone with the other side of the copy paper in contact with the guide plate, a toner powder supply device disposed at the side of the guide plate contacted by the copy paper, the toner powder supply device being arranged to supply the developer mixture to the treating zone at the side of the copy paper carrying the electrostatic image, a rotatable magnetic field source disposed at the other side of the guide plate, the rotatable magnetic field source serving to draw an accumulation of the developer mixture into contact with the image-carrying side of the copy paper and rotation of the magnetic field source serving to cause intermixing of the toner powder and the magnetic carrier therefor comprising the developer powder, the guide plate preventing the accumulation of developer mixture from contacting the rotatable magnetic field source and toner powder thereby being attracted to charged areas of the copy paper to develop the electrostatic image, heating means for heating the copy paper to fuse the toner powder attracted thereto, thereby to fix the developed electrostatic image, a first outlet slot in the housing for delivering the thus-developed and fixed copy from the apparatus, copy paper advancing means for advancing the copy paper from the treating zone past the heating means to the first outlet slot for delivery from the apparatus, a second outlet slot in the housing for delivering the original from the apparatus and original advancing means for advancing the original from the separating means to the second outlet slot for delivery from the apparatus.

3. The electrophotographic copying apparatus of claim 2, wherein the toner powder supply device comprises two superposed vibratory surfaces, one surface being so arranged as to supply developer mixture or toner powder therefor to the treating zone and the other surface being

so arranged as to remove spent developer mixture from the treating zone.

4. The electrophotomagnetic copy apparatus of claim 2, wherein a toner powder replenishment zone is provided, the toner powder supply device extends between the replenishment zone and the treating zone and the toner powder supply device comprises a first vibratory tray mounted for vibratory oscillation with respect to the apparatus and arranged to remove spent developer mixture from the treating zone and to cause it to travel upon the first tray to the replenishment zone for the addition of fresh toner powder thereto, a second vibratory tray mounted for vibratory oscillation above and in driving connection with the first tray and arranged to collect fresh developer mixture at the replenishment zone and to cause it to travel to the treating zone and an electromagnetic vibrator connected to the first tray for effecting vibratory oscillation of the first and second trays, whereby the magnetic carrier of the developer mixture undergoes cyclic movement upon the trays between the treating zone and the replenishment zone.

5. The electrophotographic copying apparatus of claim 2, wherein the rotatable magnetic field source comprises a rotatable bar magnet arranged to rotate so that its surface adjacent the treating zone moves in the direction of advance of the copy paper on the guide plate, whereby the accumulation of developer mixture forms bristles which rotates so that the accumulation climbs over the leading edge of the copy paper advancing in contact with the guide plate.

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