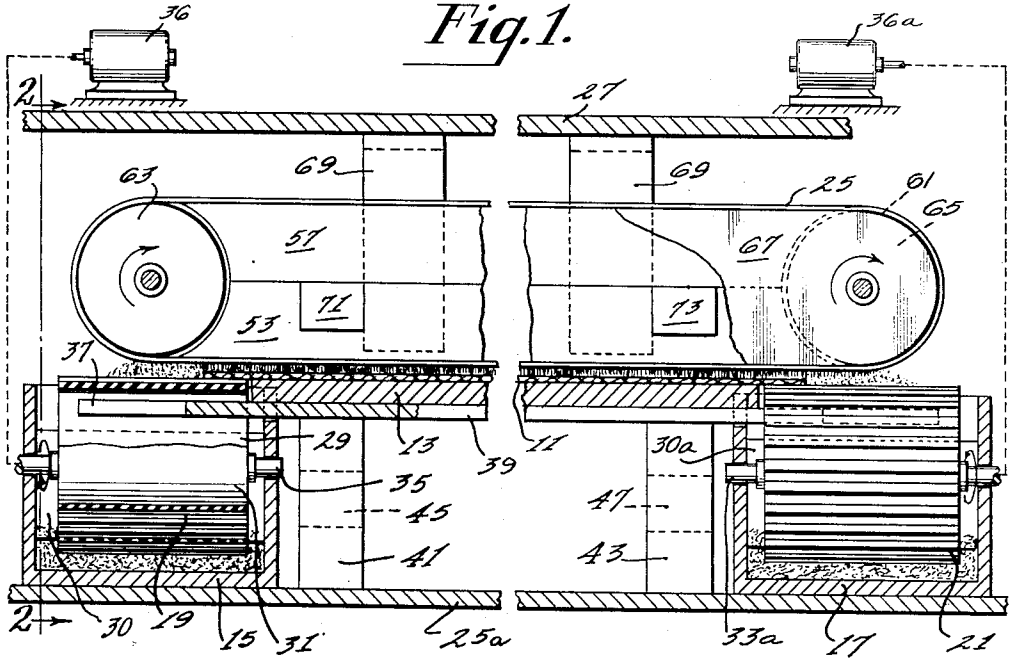
Sept. 16, 1958 H. G. REUTER, JR 2,851,988

ELECTROSTATIC PRINTING

Filed June 1, 1956

Fig. 1.



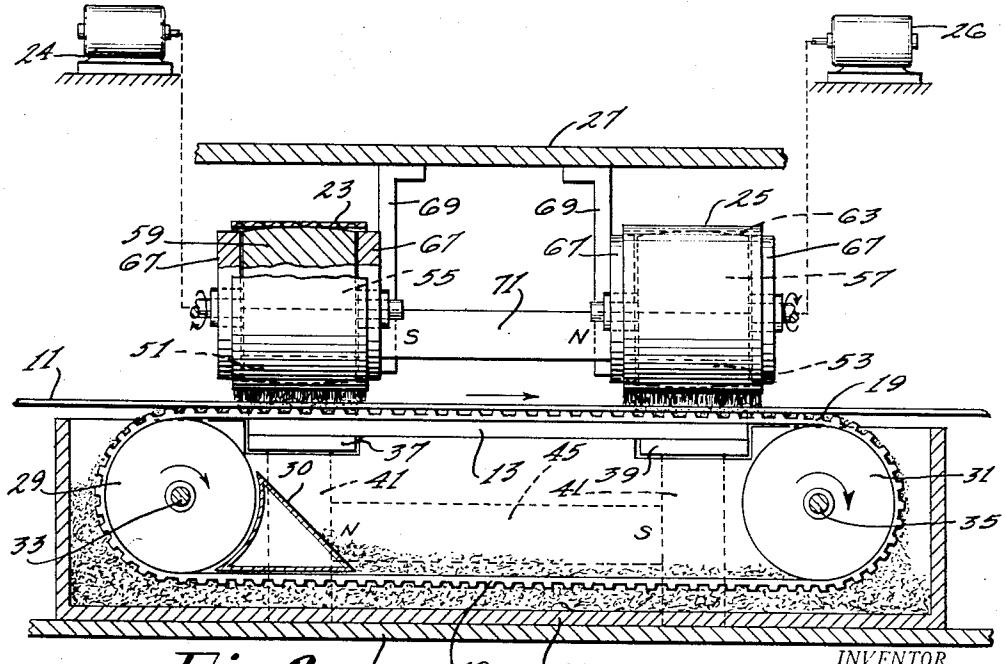




Fig. 2.

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2,851,988

# ELECTROSTATIC PRINTING

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8 Claims. (Cl. 118—637)

This invention relates to electrostatic printing, and more particularly to improved means for applying a developer mix having magnetic properties to a record, such as a continuously moving web bearing an electrostatic charge.

The invention is applicable to a process and apparatus for making reproductions, the reproductions being formed on a record, such as a continuously moving paper web, having a photoconductive surface coating. A uniform electrostatic surface charge is first applied to the coated surface of the record. The record is then exposed to light through a photographic transparency or other master so that a latent electrostatic image of the transparency is formed on the record. This latent image is developed by applying a pigmented electroscopic powder or toner to the coated surface. The toner is provided with a charge of opposite polarity from the surface charge and adheres to the charged portions of the surface. The developed image may then be fixed by heating.

One means of applying the toner to the record, is to intimately mix the toner with a powdered magnetic carrier. The developer mix toner and magnetic carrier may then be carried by a member which is magnetized or by a member lying in or passing through a magnetic field, the mix adhering to the member in the form of bristles or tufts. As the developer mix is swept across the charged surface of the record, the toner is attracted from the bristles onto the surface in accordance with the electrostatic image charge. The intimate mixing of the toner and carrier provides the toner particles with the desired electrostatic charge through a triboelectric effect.

A problem which arises is that of applying a uniform amount of developer powder over the surface of a continuously moving record, especially if the record is of a substantial width.

An object of this invention is to provide an improved mechanism for carrying a developer mix having magnetic properties to the surface of a continuously moving record.

Another object of this invention is to provide an improved mechanism for intimately mixing toner and magnetic carrier particles to provide a magnetic developer mix in which the toner particles are provided with an electrostatic charge and delivering the mix to a moving record surface.

A further object of this invention is to provide an improved mechanism for automatically and continuously introducing a fresh charge of a developer mix having magnetic properties to a moving record surface.

A still further object of this invention is to provide an improved mechanism for applying a developer mix having magnetic properties to a relatively wide moving record wherein the developer mix is uniformly distributed over the surface of the record to provide uniform development of the record.

In accordance with the present invention, a pair of endless belt carriers move adjacent to and transverse



to a record path. A magnetic system provides an individual magnetic field or flux path associated with each of the carriers, each of the fields passing through its associated carrier and the record path adjacent to the carrier. At each end of the pair of belt carriers, an endless belt conveyor is mounted in a reservoir and mixing chamber for a developer mix having magnetic properties. The belt conveyors pass in close proximity to the belt carriers. The magnetic system extends the fields associated with each carrier to include one of the conveyors. The carriers are driven in opposite directions with respect to each other and the conveyors are driven in opposite directions with respect to each other. Each conveyor delivers developer mix from its reservoir for transfer to one carrier by means of the magnetic system and receives mix from the other carrier for return to the reservoir. Each carrier sweeps the developer mix across the record path, the mix being held to the carriers by means of the magnetic fields.

The novel features of the invention, as well as additional objects and advantages thereof, will be understood more fully from the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a sectional view in elevation, partially broken away, of a mechanism in accordance with the present invention; and

Figure 2 is a sectional view in elevation, partially broken away, taken along the line 2—2 of Figure 1 looking in the direction of the appended arrows.

Referring now in more detail to the accompanying drawing, a single embodiment of the present invention will be described. A record 11, which comprises a continuously moving web having a photoconductive surface coating on its upper surface, is driven in a direction either into or out of the drawing, in Figure 1, and from left to right, or vice versa, in Figure 2. The record may move in either direction indicated without affecting the operation of the mechanism. Assume, for purposes of illustration, that the record moves from left to right in Figure 2. The record is supported by a platen 13. A pair of reservoirs 15 and 17 are mounted beneath the record path on either side. The reservoirs 15 and 17 also serve as mixing chambers. The reservoirs contain endless belts 19 and 21 which will be referred to hereafter as conveyors. These conveyors carry developer mix over their upper surfaces adjacent the edge of the record path. A second pair of endless belts 23 and 25, which will be referred to hereafter as carriers, are supported above the record path. These carriers 23 and 25 extend beyond the width of the record path and over the conveyors 19 and 21. Each conveyor transfers developer mix to one carrier and receives developer mix from the other carrier. The carriers then sweep the developer mix across the record in opposite directions.

The developer mix is a powder comprising an intimate mixture of pigmented toner particles and magnetic carrier particles. The magnetic developer mix is transferred from the conveyors to the carriers and is retained on the carriers by means of a magnetic system to be described.

The supporting structure for the mechanism is indicated by lower support member 25*a* and upper support member 27. The reservoirs 15 and 17 are mounted directly on the lower support member 25*a*. The reservoirs are rectangular boxes and are disposed with their longitudinal dimensions parallel to the path of the record 11.

Referring to the reservoir 15, the conveyor 19 is supported on two pulleys 29 and 31 mounted on shafts 33 and 35, respectively, which lie in a common horizontal plane. The shafts 33 and 35 are supported in the side walls of the reservoir 15. The shaft 35 is driven by a

motor 36 to drive the conveyor 19. The conveyor 19 comprises a belt, made of rubber or other suitable non-magnetic material, and has a plurality of ridges or grooves on its outer surface. These grooves extend transversely of the longitudinal dimension of the belt and form pockets which collect the developer mix and carry it over the upper run of the conveyor 19. In operation, the reservoir 15 is filled with developer mix to a point somewhat above the shafts 33 and 35 to permit the conveyor pockets to carry the developer out of the reservoir. A shield 30 prevents the developer mix from being carried between the conveyor 19 and the pulley 29. The conveyor pockets also effect mixing of toner and magnetic carrier particles within the reservoir. The reservoir, pulleys, shafts, etc., are preferably constructed of a non-magnetic material.

Since the reservoir 17 and its associated structure is identical to the reservoir 15, it will not be described further. Corresponding parts not previously identified by a reference numeral are indicated in the drawing by the subscript (*a*).

The platen 13 extends between the conveyors 19 and 21. The upper surfaces of the conveyors and the upper surface of the platen lie in a common plane to provide a substantially continuous supporting surface for the record 11. The marginal portions of record 11 are then supported by the conveyors 19 and 21 for a reason to be described subsequently.

A pair of parallel magnetic pole pieces 37 and 39 extend between the reservoirs 15 and 17 perpendicular to the path of the record 11. These pole pieces are supported by several pairs of posts 41 and 43 which are made of a magnetic material. Since these posts are supported by the lower support member 25*a* it is preferable that this support member be of a non-magnetic material. Each of the pairs of posts 41, 43 are joined by a permanent magnet 45 and 47, respectively, which is in the form of a bar. The magnets are disposed so that their north poles are joined to the posts supporting one of the pole pieces, 37 for example, and their south poles are joined to the posts supporting the other pole piece, 39 for example. The pole piece 37 then forms the north pole of a lower magnetic structure, comprising magnets 45, 47, posts 41, 43, and pole pieces 37 and 39, and the pole piece 39 forms the south pole of this lower magnetic structure. The platen 13 is supported on the pole pieces 37 and 39. The pole piece 37 extends into the reservoir 15 a substantial distance beneath the upper run of the conveyor 19. The pole piece 39 extends into the reservoir 17 a substantial distance beneath the upper run of the conveyor 21. The opposite ends of these pole pieces extend only a slight distance beyond the edges of the record 11. The reasons for this arrangement will become evident.

A pair of magnetic pole pieces 51 and 53 are disposed immediately above the pole pieces 37 and 39, respectively, and extend substantially across the width of the record path. These pole pieces 51 and 53, together with associated non-magnetic members 55 and 57, respectively, disposed immediately above them, define the courses for the upper and lower runs of the carriers 23 and 25, respectively. Each pole piece, with its associated non-magnetic member, forms a structure of rectangular cross section having substantially semi-circular cutouts at each end for the accommodation of pulleys. Pulleys 59 and 61 are associated with the pole piece structure 51 and pulleys 63 and 65 are associated with the pole piece structure 53. The pulleys are disposed immediately above the conveyors 19 and 21.

The pulleys and pole piece structures are of identical width and depth. Plates 67 are fixed to the sides of each pole piece structure and extend beyond the ends of the structure to provide bearing supports for the pulley shafts. The plates 67, which completely cover the sides of the pole piece structures and pulleys, are of a non-magnetic material such as brass. The carriers 23 and 25 comprise endless belts of rubber or other suitable non-magnetic material and each runs a course over its associated pulleys and immediately adjacent its associated pole piece structure. The pole piece structures are supported from the upper support member 27 by brackets 69. The carriers 23 and 25 are driven, respectively, by motors 24 and 26.

The pulleys 59 and 65, associated with the pole pieces 51 and 53, respectively, are of a magnetic material while the pulleys 61 and 63 are of a non-magnetic material. The magnetic pulleys 59 and 65 form extensions of their respective pole pieces and are magnetized by induction from the pole pieces. The magnetic pulleys 59 and 65 are disposed immediately above the lower pole pieces 37 and 39, respectively, where the latter extend beneath the conveyors 19 and 21, respectively.

The upper pole pieces 51 and 53 are joined by permanent magnets 71 and 73. The magnets are disposed so that their north poles are joined to the pole piece 53 and their south poles are joined to the pole piece 51. The pole pieces 51, 53, pulleys 61, 65, and magnets 71, 73 form an upper magnetic structure of which the pole piece 53 is the north pole and the pole piece 51 is the south pole. It will be noted that the upper pole piece 53 (N) is adjacent the lower pole piece 39 (S) and the upper pole piece 51 (S) is adjacent the lower pole piece 37 (N). The upper and lower magnetic structures then comprise a complete magnetic system providing a concentrated magnetic field between each of the adjacent pairs of upper and lower pole pieces. Each field extends across the width of the record 11 which moves between the upper and lower pole pieces and traverses a portion of one conveyor at one end.

A particular feature of the magnetic system is that the upper and lower structures which comprise the system are structurally independent of each other. This provides the advanatge of permitting adjustment of either or both of these structures to vary the gap between them or to vary the distances of the pole pieces from the plane of the record to be developed. Such adjustment is desirable in order that the apparatus may be made to accommodate different types of records and developer mixes having different electrostatic and magnetic properties.

The upper pole pieces, with their associated pulleys, and the lower pole pieces are of identical width in order to provide uniform magnetic fields. The carriers 23 and 25 are of a slightly greater width so that, as they are driven over the pulleys and pole pieces, they extend beyond these magnetic members and overlap the non-magnetic plates 67. This arrangement is desirable so that the magnetic developer mix carried by the carriers will be concentrated away from the edges of the carriers and will not tend to find their way between the carriers and the magnetic members to cause clogging or jamming of the mechanism.

The supporting plane for the record 11, between the upper and lower pole pieces, is defined by the platen 13 and the conveyors 19 and 21. This plane is fixed to lie above a plane intermediate the upper and lower pole pieces or, in other words, closer to the upper pole pieces. Since the pole pieces exert an equal magnetic force upon magnetic particles lying within the field intermediate the pole pieces, by maintaining the record above the plane intermediate the pole pieces the magnetic developer mix is attracted toward the upper pole piece and not toward the record 11. With this arrangement, the developer mix is not forcefully urged against the record surface through the action of the magnetic fields.

In operation, sufficient developer mix is provided in the reservoirs 15 and 17 so that, when the conveyors are driven, the surface pockets carry the developer over the upper runs of the conveyors. As the lower runs of the conveyors pass through the reservoirs, the surface pockets of the conveyor agitate the mix and work it from one end

to the other. This provides an intimate mixing of the toner and magnetic carrier particles and causes the toner particles to assume an electrostatic charge due to a triboelectric effect. This charge is opposite in polarity to the charge on the surface of the record being developed.

Referring to Figure 2, the conveyor **19** is driven in a clockwise direction and the conveyor **21**, which is not shown, is driven in a counter-clockwise direction. As the conveyor **19** passes between the lower pole piece **37** and the magnetic pulley **59**, associated with the upper pole piece **53**, the developer mix is transferred from the conveyor **19** to the carrier **23**. This transfer is effected since the upper surface of the conveyor lies in a plane which is above the plane lying intermediate the upper and lower pole pieces. Simultaneously the conveyor **21**, as it passes between the lower pole piece **39** and the magnetic pulley **65**, associated with the upper pole piece **53**, transfers developer mix to the carrier **25**. The carriers **23** and **25** are driven in opposite directions to sweep the developer mix across the records as soon as the mix is transferred from the conveyors **19** and **21**, respectively.

When the developer mix is transferred to the carriers, the mix tends to form into bristles since the magnetic carrier particles align themselves along the lines of flux extending between the upper and lower pole pieces. These lines of flux are substantially perpendicular to the pole pieces and to the record **11**. The strength of the magnetic field is fixed so that the bristles will bend to some extent as they are swept over the surface of the record by the carrier. As a result of this bending of the bristles, some mixing of the developer mix will occur in the area immediately adjacent the record surface and this is desirable to effect the release of the toner particles from the magnetic carrier particles.

As the carriers sweep the mix over the record surface, the toner particles are drawn from the magnetic carrier by the electrostatic attraction between the record surface and the toner. This electrostatic attraction must be sufficiently strong to overcome the forces of attraction between the toner and the magnetic carrier particles.

The magnetic system is physically adjusted to provide the desired amount of physical pressure of the mix on the record surface. The physical spacing and the magnetic field strength will determine the amount of wiping pressure. This wiping pressure should be great enough to encourage some frictional mixing of the bristles described above, but not so great as to encourage deposit of magnetic carrier particles on the record surface or to wipe toner particles from charged portions of the surface which have already been developed.

Referring now to Figure 1, the carrier **25** carries the developer mix from right to left sweeping the surface of the record **11** and the carrier **23**, which is not shown, carries developer mix from left to right sweeping the surface. As the developer mix is carried into engagement with the edges of the record **11**, these edges act as a knife edge and tend to scrape a portion of the developer mix bristles from the carriers. In order to prevent the loss of this developer mix from the system, the conveyors, as already described, extend beneath the margins of the record **11** and actually support the record at the margins. Any developer mix that is scraped from the carriers then falls on the conveyors and is returned to the reservoirs.

As the carriers traverse the record surface, the amount of toner particles held within the magnetic carrier becomes depleted and hence there are increasingly less toner particles to be attracted to the record surface. In the case of the carrier **25**, for example, more toner particles are deposited on the right side of the record than on the left side and hence the right side of the record is developed to a greater extent than the left side. A substantial diversity in the amount of development of a record occurs particularly if the record is of substantial width. It is for this reason that the double carrier system of the present invention has been provided. Since the carrier **23** carries the mix in the opposite direction from the carrier **25**, one carrier compensates for the other to provide a substantially even distribution of toner particles over the record surface and therefore a uniform development of the record. When the carriers reach the end of their travel across the record surface, the developer mix consists primarily of magnetic carrier particles with few toner particles remaining. Referring again to Figure 1, when the particles carried by the carrier **25** reach the left margin of the record **11**, they pass out of the magnetic field provided by the pole pieces **39** and **53**. Since there is now no force holding the magnetic particles to the carrier **25** they drop from the carrier **25** onto the conveyor **19** and are returned to the reservoir **15**. Carrier particles also drop from the carrier **23** to the conveyor **21**.

The above described process is continuous. It is apparent that, as the process continues, the ratio of toner particles to magnetic carrier particles in the developer mix decreases. The developer mix is maintained at a relatively constant ratio within the reservoirs or mixing chambers by continuously adding toner to the reservoirs. The toner is preferably added by feeding it to the conveyors at a point between the carriers. The toner is then mixed with the depleted developer mix being dropped on the conveyors by the carriers. As this mixture is then returned to the reservoirs or mixing chambers, the surface pockets of the conveyors effect the intimate mixing of the toner and carrier particles previously described. As a result of this mixing of the developer mix in the mixing chambers, a completely fresh charge is continuously presented to the record by the carriers. Since the carriers have no part in the mixing process, they can most efficiently present the developer mix to the record.

What is claimed is:

1. Apparatus for the development of latent electrostatic images on a moving, electrostatically charged record, said apparatus comprising means defining a path for said record, a pair of endless belt carriers disposed in parallel relation adjacent said path and positioned above said path, means for driving said carriers in opposite directions with respect to each other transverse to said path, magnetic field producing means for causing powdered electroscopic developer mix having magnetic properties to adhere to said carriers for transport in physical engagement with a surface of said record, a mixing chamber adapted for holding and supplying said developer mix disposed on each side of said record path, an endless belt conveyor having external surface pockets disposed in each of said mixing chambers adjacent to said carriers, said endless belt conveyors being disposed below said path, means for driving said conveyors in opposite directions with respect to each other between said pair of carriers, said magnetic field producing means effecting transfer of developer mix from one conveyor to one carrier and from the other conveyor to the other carrier, each carrier transporting said mix across said path to the conveyor opposite that from which the mix was received.

2. Apparatus for the development of latent electrostatic images on a moving electrostatically charged record, said apparatus comprising means defining a path for said record, a pair of endless belt carriers disposed in parallel relation adjacent said path and positioned above said path, means for driving said carriers in opposite directions with respect to each other transverse to said path, means for holding and supplying powdered electroscopic developer mix having magnetic properties, magnetic field producing means for causing said mix to adhere to said carriers for transport in physical engagement with a surface of said record, said mix supplying means being effective on each side of said record path, a pair of endless belt conveyors having external surface pockets disposed for cooperation with said mix supplying means, said endless belt conveyors being disposed below said path, one of said conveyors being disposed on one side of said record path adjacent to said carriers and the other

being disposed on the opposite side of said record path adjacent to said carriers, and means for driving said conveyors in opposite directions with respect to each other between said pair of carriers, said magnetic field producing means effecting transfer of developer mix from one conveyor to one carrier and from the other conveyor to the other carrier, each carrier transporting said mix across said path to the conveyor opposite to that from which the mix was received.

3. In apparatus for applying powdered developer mix having magnetic properties to the surface of a moving record, means defining a path for said record, a pair of endless belt carriers disposed in parallel relation adjacent said path and positioned above said path, means for driving said carriers in opposite directions with respect to each other transverse to said path, magnetic field producing means for causing said developer mix to adhere to said carriers for transport over a surface of said record, an endless belt conveyor adjacent said carriers at each side of said record path, said endless belt conveyors being disposed below said path, means for driving said conveyors in opposite directions with respect to each other between said carriers, and means adapted for holding and supplying developer mix to said conveyors, said magnetic field producing means effecting transfer of developer mix from one conveyor to one carrier and from the other conveyor to the other carrier, each carrier transporting said mix across said path to the conveyor opposite to that from which the mix was received.

4. The combination set forth in claim 3 wherein said magnetic field producing means comprises upper and lower portions defining a complete magnetic circuit, said magnetic circuit including a pair of gaps through which pass said carriers and said path, and said upper and lower portions being adjustable with respect to each other and to said path.

5. Apparatus for applying a developer toner to the charged surface of a continuously moving record, said apparatus comprising means defining a record path, a reservoir disposed on each side of the record path for holding and supplying a powdered developer mix including said toner, each reservoir containing a quantity of magnetic particles adapted for mixing with said toner to provide said magnetic developer mix, a pair of endless belt carriers disposed in parallel relation above and transverse to said record path, said carriers extending over said reservoirs, each carrier having a lower run passing in close proximity to said record path, a magnetic structure for producing magnetic fields passing through the lower runs of said carriers and the portion of said record path adjacent thereto, an endless belt conveyor having external surface pockets disposed in each of said reservoirs, each conveyor having an upper run passing in close proximity to the lower runs of said carriers, said magnetic structure producing fields passing through a conveyor belt and a carrier belt on either side of said path, said field effecting transfer of said magnetic developer mix from each conveyor to one carrier, said magnetic mix adhering to the carriers in the form of bristles, and means for driving said carriers in opposite directions with respect to each other to sweep said bristle-like magnetic mix over the path of said record whereby toner particles mixed with said magnetic particles are brought in intimate engagement with a record moving in said path and whereby each carrier drops said magnetic mix onto the conveyor opposite from the conveyor from which it received the magnetic mix.

6. In apparatus for applying a powdered developer mix having magnetic properties to the surface of a continuously moving record, means defining a path for said record, said means including a lower supporting platen, a pair of reservoirs disposed on either side of said platen at either side of said path, said reservoirs being adapted for holding and supplying said powdered developer mix, an endless belt conveyor mounted in each of said reservoirs, means for driving said conveyors in opposite directions with respect to each other, each conveyor having an upper run movable in the plane of said platen adjacent thereto and in a direction parallel to said record path, said path having a width which includes a portion of said conveyor on either side of said platen whereby said conveyor supports the marginal portions of a record moving in said path, a pair of endless belt carriers mounted above said path transverse thereto and extending in parallel relation between said conveyors, each carrier having a lower run moving in a plane adjacent to said platen and said conveyors, a magnetic structure for providing a magnetic field passing through the lower run of each carrier and the portions of the platen immediately beneath said lower runs, said magnetic structure extending to one end of each carrier whereby the magnetic fields are extended to include the lower run of one carrier and the upper run of one conveyor on either side of said platen, and each conveyor having external surface pockets for carrying developer mix from said reservoir over its upper run, said magnetic fields effecting transfer of said developer mix from each conveyor to one carrier in a bristle-like formation and said carriers carrying said developer mix in opposite directions across said platen in intimate engagement with a record moving in said path.

7. In apparatus for applying powdered developer mix having magnetic properties to the surface of a continuously moving record, means defining a path for said record, an endless belt conveyor mounted adjacent each side of said path and having an upper run movable in the plane of said path and parallel thereto, a reservoir associated with each conveyor for supplying developer mix thereto, said reservoirs being adapted for holding and supplying said powdered developer mix, a pair of endless belt carriers mounted in parallel relation over said path and said conveyors for movement transverse to said path, each carrier being supported by pulleys disposed over said two conveyors, said carriers each having a lower run movable in close proximity to said path and said conveyors, one of the supporting pulleys for each carrier being of a magnetic material and the other pulley being of a non-magnetic material, the two magnetic pulleys being disposed on either side of said path, an upper magnetic pole piece disposed immediately above the lower run of each carrier between these supporting pulleys, a lower magnetic pole piece disposed immediately beneath said path in vertical alignment with each of said upper pole pieces and said magnetic pulleys, said upper pole pieces being joined by at least one permanent magnet, said lower pole pieces being joined by at least one permanent magnet, said pole pieces and said magnets defining a magnetic circuit providing magnetic fields in the gaps between said vertically aligned pairs of upper and lower pole pieces and said magnetic pulleys, and said pole pieces and said magnetic pulleys having a width narrower than the width of said carrier belts whereby said magnetic fields are narrower in width than said belts, said fields effecting transfer of developer mix from said conveyors to said carriers and maintaining said mix on said carriers in a bristle-like form to be swept across said path, said mix being released from a carrier to a conveyor after said sweep.

8. Apparatus for applying a powdered developer mix having magnetic properties to the surface of a continuously moving record having an electrostatically charged surface, said apparatus comprising means defining a horizontal path for said record, means for moving said record in said path with its charged surface facing upwardly, a pair of mixing chambers for said developer mix disposed on either side of said path, said chambers being adapted for holding and supplying said powdered developer mix, an endless belt conveyor mounted in each reservoir, said conveyors each having a flat external surface provided with transverse surface pockets, each conveyor having an

upper run movable in a direction parallel to said record path and overlapping said path in a horizontal direction to provide support for the marginal portions of said record, means for driving said conveyors in opposite directions with respect to each other, a pair of endless belt carriers mounted parallel to each other above and transverse to said path, said carriers each having a lower run in close proximity to said path and extending beyond said path and adjacent said conveyors at each side of said path, means for driving said carriers in opposite directions with respect to each other, each conveyor being driven with respect to said carriers to deliver developer mix to the first carrier in the direction of movement of the conveyor and to receive unused developer mix from the second carrier in the direction of movement of the conveyor, a magnetic structure for producing magnetic fields passing through the lower run of each carrier and the portion of the record path immediately beneath each carrier, and said magnetic structure extending to one end of each



carrier on opposite sides of said path to produce a magnetic field passing through the carrier and the conveyor where they pass adjacent each other, said magnetic field effecting transfer of said developer mix from a conveyor to a carrier and effecting the formation of bristles of said developer mix on the lower run of said carrier to carry said developer mix across the record path in intimate engagement with a record passing therethrough.

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