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Reichart, Jr.

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[54] **CROSS-CHANNEL MIXER**

[75] Inventor: **Louis W. Reichart, Jr.**, Rochester, N.Y.

[73] Assignee: **Xerox Corporation**, Stamford, Conn.

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[52] **U.S. Cl.**.....**118/637**, 117/17.5, 118/DIG. 24

[51] **Int. Cl.**.....**G03g 13/00**

[58] **Field of Search**.....118/637, DIG. 24; 117/17.5; 355/3

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Primary Examiner—Mervin Stein

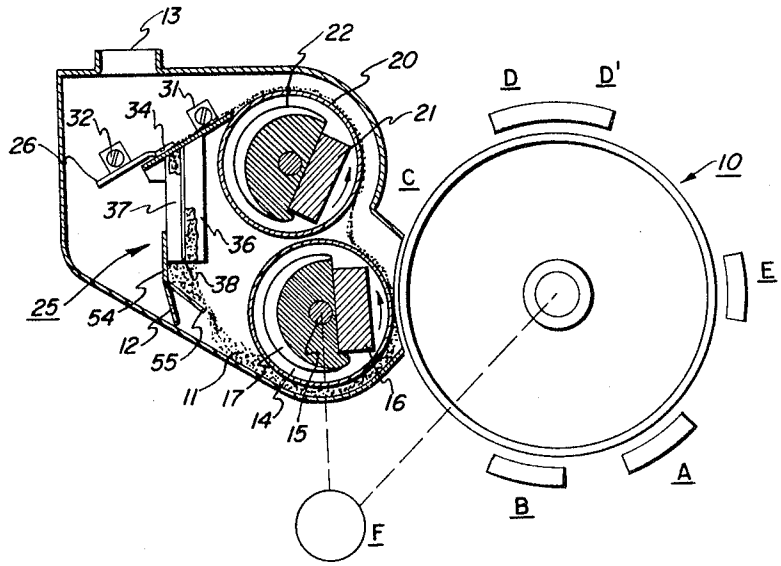
Assistant Examiner—Leo Millstein

Attorney—James J. Ralabate, Donald F. Daley and Kenneth E. Merklen

[57] **ABSTRACT**

A developer circulating system, part of an electrostatic printing device, includes apparatus for mixing, agitating and distributing developer cyclically by diverting the normal gravitational flow of the developer in its circulating cycle. The mixing, agitating and distributing device includes at least two banks of channels, with the channels common to one bank slanted in one direction and the channels common to the other bank slanted in the opposite direction. The channels of one bank are so slanted or offset so as to efficiently walk the circulating developer, in cyclic steps, along the bank, channel by channel to the last channel in the bank and the last channel causes the circulating developer to switch banks thereby cyclically walking the developer back and forth along the banks effectively mixing, agitating and distributing the developer.

5 Claims, 3 Drawing Figures



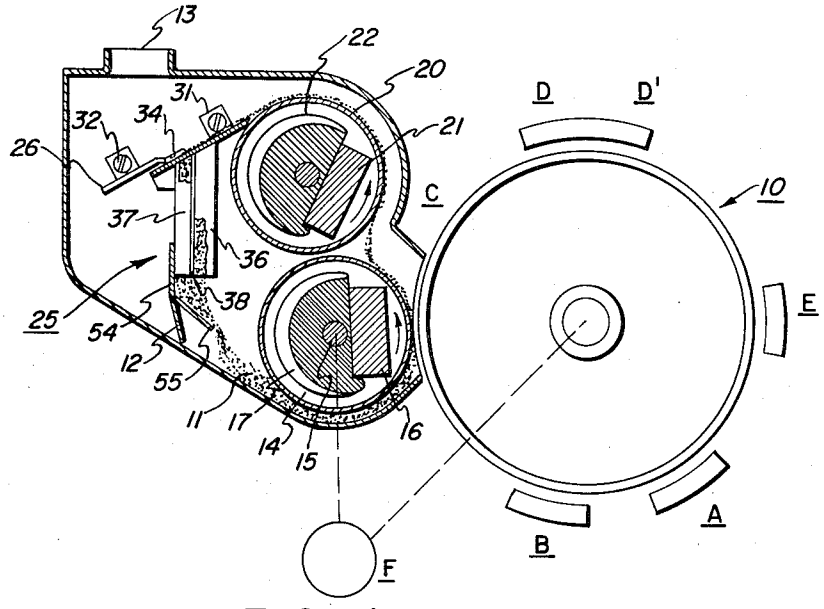


FIG. 1

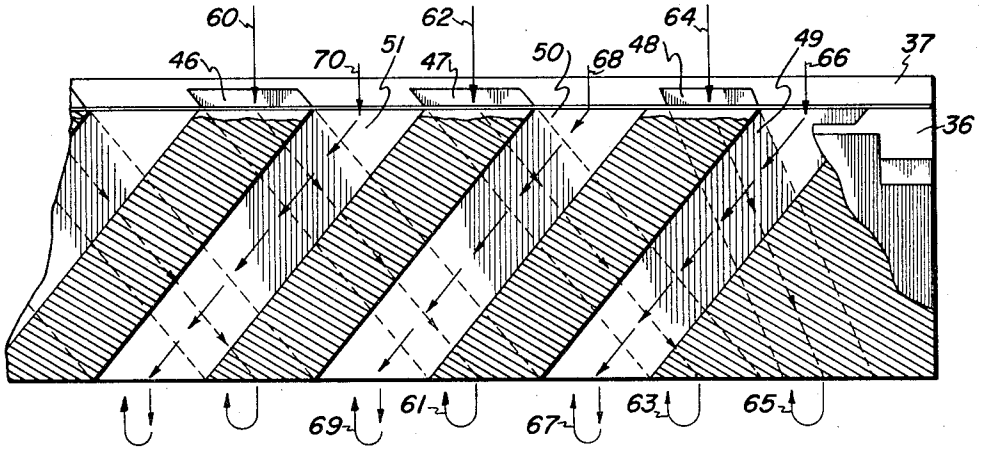


FIG. 3

INVENTOR.
LOUIS W. REICHART JR.
BY
Kenneth E. Merkley
ATTORNEY

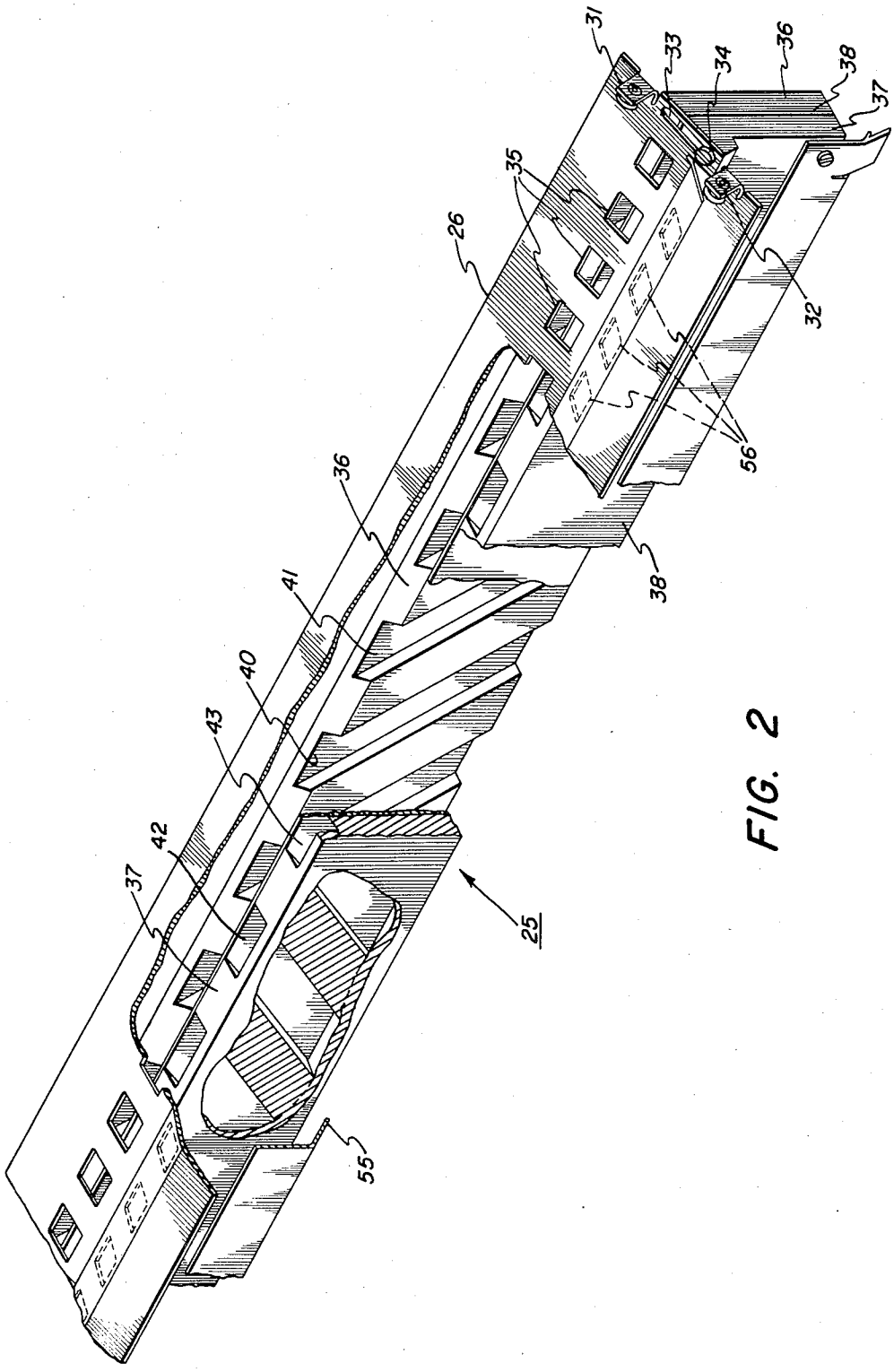


FIG. 2

CROSS-CHANNEL MIXER

The present invention relates to xerographic methods and apparatus and in particular novel apparatus for mixing, agitating and/or distributing what is generally referred to as "developer", used in a xerographic machine.

Development of a latent electrostatic image in the electrostatic printing or photographic process is sometimes accomplished by flowing or cascading the developer over the surface of the xerographic plate.

Developer may include a form of a fine powder sometimes referred to as "toner". Sometimes the toner is mixed with a relatively coarse, beaded or other coarse material normally referred to as the "carrier" and thus the developer is a two-component material. Sometimes the developer is more than two-components. Sometimes the material from which the carrier particles are made has magnetic characteristics.

Preferably, the toner materials and the carrier materials are mixed thoroughly and the mixed multi-component developer is evenly distributed over the surface of the xerographic plate. Mixing or agitating the materials charges the materials triboelectrically and, according to the type of materials and the triboelectric charge, the toner is attracted to and held to the surface of the carrier. This attraction, although sufficiently strong to hold the toner on the surface of the carrier for purposes of conveyance, is overcome by the electrostatic charge of the latent image so that when the developer comes in contact with the electrostatically charged surface, toner will transfer from the carrier materials to join the electrostatic charge on the xerographic plate.

When the cascading technique is based on the phenomenon of triboelectrification, it becomes important that all the components of the developer be mixed actively, with respect to each other so that the toner particles and the carrier particles each become charged triboelectrically and cling to the surface of the carrier beads or other materials in the multi-component mixture.

It is also important that the developer be distributed over the entire surface of the xerographic plate so that the entire latent image on the plate is developed and becomes a complete visible image.

Prior mixing and agitating techniques employing dynamic mixing devices have been used successfully but dynamic mixing devices are subject to wear and have a tendency to abrade or damage the individual particles in the coarse or beaded carrier material thus reducing the useful life of the mixing device and the life of the carrier material of the multi-component developer.

The present invention is a passive device that, when positioned in the flow path of the toner-carrier materials, hereinafter referred to as developer, subjects the developer to a passive force which interferes with the normal gravitational flow path of the developer causing a change in the flow path and agitating the mixture causing a thorough mixing of the components, and, at the same time substantially evenly distributing the thoroughly mixed materials substantially uniformly over an area which may correspond to the surface of the xerographic plate. Since the present invention is a passive device, wear on the device from moving parts is eliminated while frictional wear is limited to that caused by the flowing developer through the parts or chambers of the device and pulverization, abrasion, or other damage of the coarse carrier material is reduced substantially.

The present invention may generally be referred to as a multiple bank, cross-channel, developer mixer and distributor. Each of the multiple banks includes one or more channels having its exit port offset or out-of-line with its entrance port, relative to the normal flow path of the developer in a developer circulating system.

The channels or chutes of each bank of chutes are offset or slanted so as to ideally direct or divert the flowing developer material out of its normal flow path so that the diverted material may be agitated and/or actively co-mingled thereby inducing triboelectrification as well as cyclically walking developer back and forth, from chute to chute of the same bank, sequentially in each successive flow or circulating cycle. The last chute in each bank of chutes is so offset or slanted that when exiting from the last chute of one bank, the flowing developer may be transferred to the other bank of chutes, upon cyclic return in its new flow path. By cyclic interruption and change of the flow path of the circulating developer material the developer is maintained in thoroughly mixed condition and is substantially evenly distributed across the length of the cross-channel mixer.

A successfully employed embodiment of the present invention includes a first bank of substantially parallel inclined channels except for the last channel in the direction of incline, with spaced entrance ports and spaced exit ports with the exit port of one inclined channel offset from its entrance port substantially the distance between adjacent entrance ports so that the exit port of one channel is substantially in gravitational alignment with the entrance port of the adjacent channel in the direction of inclination of the channel. A second bank of substantially parallel inclined channels is essentially in reverse image of the first bank with the entrance ports of the channels of the second bank positioned at a location substantially between the entrance ports of the first bank and offset frontwardly or rearwardly as the case may be. The multi-bank, cross-channel developer mixer and distributor was positioned in a developer circulating device used for applying developer to a xerographic drum and for maintaining the toner-carrier mixture charged triboelectrically. The circulating device includes a rotating magnetic roll which when rotated comes in contact with developer stored in a retaining or storage area or sump and becomes pregnant with the developer in the sump. Due to the magnetic characteristics of the roll, a "brush" of developer material is formed. The rotating brush then makes contact with the xerographic drum and some of the toner conveyed by the brush adheres to the electrostatically charged surface of the drum. As the brush continues to rotate, the remaining toner and carrier is transferred to another rotating magnetic roller which further conveys the remaining toner and carrier to the entrance ports of the cross-channel mixer. The developer is released from the influence of the magnetic roller and gravitational flow carries the developer to the mouth of the multi-bank, cross-channel mixer which interrupts the normal gravitational flow of the

developer, as above described, and returns the developer to the retaining area or sump.

The above-described system is a closed circulating system where the cross-channel mixer serves to passively agitate the developer as the mixture is cyclically circulated around the system.

The multiple bank, cross-channel developer mixer and distributor may be used as a component in a cascade system if desired. The toner-carrier or other developer passing through the channels of the multiple bank, cross-channel mixer and exiting therefrom may be flowed directly over or onto the surface of a xerographic plate in a cascade manner. The excess developer material may be removed from the xerographic plate and may, through the use of a bucket or other conveyor system, be returned to the entrance or input ports of the cross-channel mixing device.

It will be appreciated that although the toner-carrier mixture is circulated through the system, some toner is used to develop the electrostatic latent image and therefore the toner content of the mixture may gradually become depleted. It may be desirable to add toner to the mixture periodically and when adding toner to the mixture this may be done conveniently by dispensing small amounts of toner into the cross-channel mixer so that toner material may be mixed with the carrier.

It is a principle object of the invention to provide a multiple bank, cross-channel developer mixing device for passively mixing and agitating developer in a developer circulating system for thoroughly mixing the developer materials and for charging the materials triboelectrically.

This and other objects will become apparent from reading the following description with reference to the accompanying drawings in which:

FIG. 1 illustrates one form of xerographic developer material circulating system employing one embodiment of the present invention;

FIG. 2 is an orthographic presentation with cut-away of the preferred embodiment of the present invention, and

FIG. 3 is a schematic diagram, in cut-away view showing the flow path of the developer when changing from one bank to another bank.

Referring to FIG. 1, a xerographic drum 10 is represented in association with a circulating toner-carrier developer system. The apparatus which may be used along with the xerographic drum 10 for making xerographic copies have been represented as blocks A, B, D and E, since the practice of xerographic copying is well known in the art.

However, it is understood that the xerographic drum 10 may at least have associated therewith a means at A for charging the surface thereof electrostatically, a means at B for illuminating the charged area with a pattern to be copied, a means at C for applying toner to the surface of the xerographic drum for changing the latent image formed by the electrostatic charges into a visible image of toner, a copy material and a means at D to effect transfer of the toner making such visible image from the xerographic drum to the copy material, a means at D' for fixing or fusing the toner to the copy material to form a permanent copy, a means at E for cleaning the drum and a means at F for driving the apparatus including rotating the drum 10 and the magnetic brushes 14 and 20.

The developer material 11 is stored in the retaining or storage portion or sump of the cartridge housing or case 12 which may be used to encapsulate the developer circulating system. The top of the case 12 may include an opening 13 and/or could have a removable cover or cap (not shown). The system could include a toner dispenser, disposed over the opening, which periodically dispenses toner into the case or hopper 12. A toner dispenser which could be used to dispense toner into the case 12 may be similar to that taught by F. W. Hudson in his copending application Ser. No. 796,965 or similar to that taught by F. W. Hudson and W. C. Emerson in their joint copending application Ser. No. 796,964, both copending patent applications and the present application having been assigned to the same assignee.

The circulating system could be of the type where toner and/or toner-carrier may be added periodically by an operator of or attendant to the machine.

The developer circulating system includes a magnetic brush or magnetic roller 14 which rotates on an axle 15 driven by a drive, represented at F. The magnetic brush or roller 14 may be a single magnetic brush or roller or a multiple magnetic brush or roller, however, one magnet of permanent magnetic material is indicated at 16. The magnet 16 is suspended in its position by a brace 17 coupled to the mounting (not shown). A second magnetic brush or magnetic roller 20 is mounted substantially above the magnetic brush or roller 14. The magnetic brush or roller 20 may be the same as magnetic brush or roller 14, that is, either a single magnet or a multi-magnet device. The magnetic device 21 suspended by the brace 22 is set at an angle with respect to magnetic device 16 so that the magnetic brush or roller 20 may receive material from the magnetic brush 14 at a point beyond the maximum magnetic influence of magnet 16. Thus the brush or roller 20 will receive the transferred developer materials and convey them through the cyclic flow to the multi-bank, cross-channel mixer.

Mounted slightly offset from the magnetic brush 20 and outside the maximum magnetic influence of the magnetic device 21 is the multiple-bank, cross channel mixer 25. As presented, the cross-channel mixer is mounted or suspended in the cavity of the cartridge or case by mounting screws adjustably attached to the slide mount 26. The slide mount 26 is positioned to receive the developer material on its upper surface being carried by the magnetic brush 20, away from the magnetic brush 14.

As the brush 20 rotates, the developer is conveyed away from the influence of the magnet 21 and is deposited on the surface of the slide mount 26. The developer slides down the smooth surface of the slide mount 26 toward openings over the entrance or inlet ports of the cross-channel mixer 25. The slide mount 26 is so positioned with respect to the magnetic brush or roller 20 so as to substantially tangently communicate with the surface or circumference of the brush or roller 20 at a point where the influence of the magnet 21 holding the toner-carrier material is minimal. The toner-carrier slides down the angularly mounted slide mount to the entrance ports of the cross-channel mixing device.

The materials of the toner-carrier developer become triboelectrically charged when the toner and carrier are actively mixed or agitated so that the toner clings to the surface of the carrier. The carrier, preferably very small, bead-like ferrous material is thus covered with the toner powder and the mixture of materials is directed to the sump of the cartridge or container **12** so that the developer mixture may be captured magnetically via attraction of the ferrous material by the magnetic brush **14** and circulated through the developer circulating system.

Referring to FIG. **2** in more detail, the cross-channel mixing device **25** is illustrated in part pictorially with portions thereof cut away to expose the interior structure of the device. The slide mount **26** is clearly shown with mounting tabs **31** and **32** which may be used to mount the mounting slide **26** in the housing or case **12**. Although only one end of the slide mount **26** is shown it should be understood that the other end would be substantially similar.

The slide mount **26** includes a slot **33** through which a mounting screw **34** may be used to couple the cross-channel mixing device to the mounting slide. The mounting slide **26** includes a plurality of apertures **35** positioned over each entrance of each channel of the cross-channel mixer.

The cross-channel mixer **25** is illustrated as two banks of internal channels, one bank of channels formed in the rear housing **36** and the second bank of channels formed in the forward housing **37**, the two housings separated by a separator plate **38**. The separator plate **38** forms the fourth side of each channel of each bank. For the purpose of illustrating one embodiment, the chutes or channels in the rear housing **36** are each illustrated as being slanted or offset to the right side or end of the housing as clearly shown by the channels **40** and **41**. The channels in the front housing **37** are each offset to the left side or end of the housing as shown clearly by the channels **42** and **43**. The mouth of each channel of each bank is spaced or separated from its adjacent channel by a spacing substantially equal to the width of the channel itself and all channels, except for the last channel in each bank in the direction of offset, are in parallel relation.

Examining the illustrated chutes **40** and **41** in the cut-away section of FIG. **2**, it will be seen that the chute or channel **40**, for example, is slanted to the right so that the outlet or exit opening is substantially directly under the mouth or input opening of the adjacent channel **41**, in the direction of slant or offset.

If one would follow a single particle through a plurality of cycles, ideally, the particles, starting from the sump, would be lifted by the magnetic brush **14** and then by brush **20** (assume for this explanation that the particle does not attach itself to the drum **10**) to the upper surface of the slide mount **26**. The particle then would slide down the slide mount **26** and enter one of the channels in its gravitational flow path, for example, channel **40**. The path of the particle would be diverted, to the right, for example, and would be returned to the sump in a position slightly offset to the right from where it was in the previous cycle. The particle would then be captured by the brush **14** and lifted straight up. Transfer of the particle to brush **20** would follow with continued ascension by brush **20** after which the particle would be deposited onto the slide mount **26**. This time the particle would slide down the slide mount **26** somewhat to the right of its last particle slide path bringing the particle to the opening of the chute or channel **41**. The path of the particle through channel **41** would again be directed to the right and it would be returned to the sump in a position slightly offset to the right of where it had been at the beginning of the just finished cycle. Thus, by repeating the cyclic operation each particle of the developer which as it continued cycling would be "walked" from one end of the bank of channels to the other end.

FIG. **3** illustrates relationship between the slant of the channels of the same bank with respect to each other and the relationship of the slant of the last channel of one bank with respect to the first channel of the other bank of channels. The channels **46**, **47** and **48**, in heavy line, represent the channels of one bank, for example, the forward bank while the channels **49**, **50** and **51** in broken line, represent the channels of the other bank, for example, the rear bank. The short arrows represent the flow path of particles through the rear bank of channels while the long arrows represent the flow path of particles through the forward bank of channels. The arrows with the curved tail indicate that the flow continues in its cycle of full circulation as aided by the rotating magnetic brushes. This may be easily seen in FIG. **1**. Different weight lines are used in FIG. **3** for clarity. The flow arrows in FIG. **3** show how the flow of circulating material is cyclically walked or stepped from channel to channel of the same bank and, when reaching the last channel of one bank is stepped to the first channel of the other bank. Assume that a circulating particle slides down the slide mount **26** and enters channel **46** as indicated by arrow **60**. The particle will follow channel **46** to the right, for example, diverting its normal gravitational flow and enter the sump at the exit end of chute **46**. Arrow **61** represents the circulatory return of the particle via the elevating effect of the magnetic brushes. The particle will then enter channel **47** as indicated by arrow **62** and exit from channel **47** and begin the return phase of the cycle as indicated by arrow **63**. The particle will slide down the slide mount as indicated by arrow **64** and enter channel **48**, the last channel of the rear bank in the direction of offset. As will be seen, channel **48** is less offset than the other channels in the rear bank and in fact, the exit end of less slanted chute **48** is under the mouth or inlet end of the first channel **49** of the forward bank. The particle will flow down channel **48** and start the return movement as indicated by arrow **65**. The particle having been offset only one half the usual distance in the direction of offset of the rear bank. This positioned the particle to slide into the first channel **49** of the forward bank, as indicated by arrow **66**. Channel **49** is one of the channels, actually the first channel, in the direction of offset of the other (forward) bank. Diversion of the gravitational flow of the particle will now be reversed (to the left, for example) and return of the particle upon exit from channel **49**, as indicated by arrow **67** will position the particle in a flow path, indicated by arrow **68**, which brings the particle into the mouth of channel **50**. The particle will be diverted or stepped to the left and return in its cycle as indicated by arrow **69**, entering the mouth of channel **51**, as indicated by arrow **70**. Thus, by reducing the amount of

deflection from the flow path by the last channel **48** of one bank of channels, a particle may be stepped or walked to the first channel **49** of the other bank of channels. The last channel of the other (forward) bank is also of reduced offset and functions to position a particle to continue its cycle and enter the first channel of the one (rearward) bank. It can therefore be seen that flowing developer in a developer circulating system may be cyclically walked back and forth in the developer circulating system housing so that the developer is distributed across the housing of the system and agitated to provide the triboelectric effect on the particles in the developer material.

At the bottom of the multiple bank, cross-channel mixer is a deflection plate **54**. The inwardly bent lip **55** of the deflection plate serves to position the flowing particles of the developer returning to the sump adjacent to the magnetic brush **14** so that the particles may be easily retrieved by the magnetic brush from the sump.

If desired, the mounting plate **26** may include a series of spaced apertures **56** which are located downstream in the flow of developer as the developer is released from the influence of the magnetic roller **20** and, spaced between the ports **35**. This avoids a build-up of the developer on the mounting plate **26**.

It may be desired to provide a mounting plate in the form of a slide with an open slit exposing all the inlet ports of the mixing device.

From the cut-away section in FIG. **1** it will be noted that the inlet ports of each bank are alternately positioned but spaced with respect to each other so that substantially all the flowing material released from the influence of the magnetic roller **20** and flowing down a slide will be caught by one or another chute when all the inlet ports are fully exposed. The mounting plate **26** serves to limit the amount of material entering the inlet ports thereby avoiding blockage in the chutes in the event of the appearance of a large or excess surge of flowing material. In such event the ports **56** are provided to deliver the excess of the surge of flowing material to the sump at the bottom of the housing.

Thus there has been described a multiple-bank, cross-channel mixer for mixing and distributing powdery and/or granular material such as developer and the use of such cross-channel mixer in one form of developer circulating system in an electrostatic recording device. One embodiment and use of the device having been shown and described, it will be appreciated that other forms and use, such as by substitution of parts and use in other systems may be made of the device, as will be familiar to those skilled in the art, without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In an electrostatic recording device for generating a latent image on an electrostatic plate of a predetermined pattern and for developing the latent image into a visible image by applying a developer to the surface of the electrostatic plate by use of a developer circulating device, an improved developer circulating device including;

a developer housing including a sump for collecting developer,

means for removing developer from said sump and applying the developer so removed to the surface of the electrostatic plate for developing the latent image with a portion of the developer so applied to the surface of the plate,

means for returning the remainder of the developer so applied to the electrostatic plate to the sump through a developer mixing and distributing means, said last mentioned means including;

a first plurality of adjacently spaced and parallel aligned enclosed channels extending transverse to the flow of developer returning to the sump with each channel being capable of supporting a portion of the entire developer flow returning to said sump, each enclosed channel being offset in a first direction for carrying a portion of the developer returning to the sump in a first direction so that the developer exiting from one of said first spaced channels is offset in position in said first direction to be directly under the entrance of the adjacent channel in the first direction of offset,

a second plurality of adjacently spaced parallel aligned enclosed channels being independent of said first channels and extending transverse to the direction of developer flow returning to said sump and being capable of supporting a portion of the entire developer flow returning to said sump, each enclosed channel being offset in a second direction being opposite said first direction for carrying a portion of the developer returning to the sump in said second direction so that the developer exiting from one of said second spaced channels of said second plurality is offset in position in said second direction to be directly under the entrance of the adjacent channel in the second direction of offset for interferring with the normal gravitational flow of the developer causing the developer to be mixed and to be uniformly distributed within the developer housing.

2. In an electrostatic recording device for generating a latent image on an electrostatic drum of a predetermined pattern and for developing the latent image into a visible image by applying developer to the surface of the electrostatic drum as in claim **1** and further including;

means between said developer returning means and the developer mixing and distributing means for conveying said developer in sliding conveyance along the gravitational flow path to the entrance of the channels positioned in the flow path.

3. A static mixing device for interrupting the normal flow of particulate developer material in a system for circulating electrostatic developer material for cyclically walking the developer material back and forth along the mixing device in response to repeated circulations of the developer material, said static mixing device being positioned in the normal gravitational flow of the developer as the developer is returned to a sump for collecting developer including;

a sump for collecting developer after having passed through said static mixing device,

means for removing developer from said sump for initiating the circulating system during which development of an electrostatic image takes place,

means for returning developer to the sump after developmeans of the electrostatic image has taken place by passing the developer through the static mixing device, said static mixing device including,

a first bank of spaced parallel channels each having an inlet end and an outlet end, with the position of the outlet end offset in one direction from the position of the associated inlet end and said outlet end being substantially in gravitational alignment with the inlet end of the adjacent spaced channel, in the direction of offset except for the last channel in the said first bank, in the direction of offset,

a second bank of spaced parallel channels each having an inlet end and an outlet end, with the position of the outlet end offset in another direction from the position of the associated inlet end and said outlet end being substantially in gravitational alignment with the inlet end of the adjacent spaced channel, in the said another direction of offset except for the last channel in said second bank in the said another direction of offset,

the said last channel in the said first bank being offset in the said one direction and having its outlet end in alignment with the inlet end of the first channel of said second bank of channels, and

the said last channel in the said second bank being offset in the said another direction and having its outlet end in alignment with the inlet end of the first channel of said first bank of channels.

4. A static mixing device for interrupting the normal flow of powdery developer material in a system for circulating electrostatic developer material for cyclically walking the developer material back and forth along the mixing device in response to repeated circulations of the developer material, said static mixing device being positioned in the normal gravitational flow of the developer as the developer is returned to a sump for collecting developer including;

a sump for collecting developer after having passed through said static mixing device,

means for removing developer from said sump for initiating the circulating system during which development of an electrostatic image takes place,

means for returning developer to the sump after development of the electrostatic image has taken place by passing the developer through the static mixing device, said static mixing device including,

a first plurality of spaced chutes, each slanted in a first direction and substantially parallel with each other, the outlet end of each chute of said first plurality of spaced chutes positioned substantially directly under the inlet end of the adjacent chute of said first plurality of spaced chutes in said first direction,

a second plurality of spaced chutes, each slanted in a second direction and substantially parallel with each other, the outlet end of each chute of said second plurality of spaced chutes positioned substantially directly under the inlet end of the adjacent chute of said second plurality of spaced chutes in said second direction, and

said first plurality of spaced chutes and said second plurality of spaced chutes in juxtaposition with respect to each other with the inlet end of each chute of said first plurality offset from the inlet end of each chute of said second plurality.

5. A static mixing device for interrupting the normal flow of powdery developer material in a system for circulating electrostatic developer material as in claim 4 and in which the last chute of said first plurality of spaced chutes, in the said first direction is slanted so that its outlet end is positioned directly under the inlet end of the first chute of said second plurality of spaced chutes, and

the last chute of said second plurality of spaced chutes in the said second direction is slanted so that the outlet of such last chute is positioned directly under the inlet end of the first chute of said first plurality.

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