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(54) **Title:** PRINTER HAVING AN ALTERNATE SCAVENGER GEOMETRY

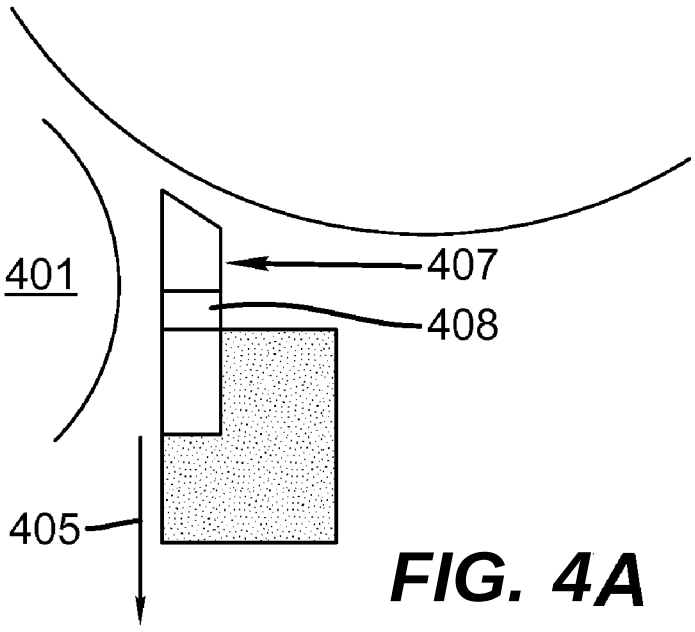


FIG. 4A

(57) **Abstract:** A printer having a developer station for holding a supply of developer which includes magnetized carrier particles, a magnetized development roller (401), and an imaging roller proximate the development roller which collects carrier particles during operation of the printer. A scavenger (407) proximate the imaging roller and the development roller removes the carrier particles from the imaging roller during operation of the printer which are then urged through a slot (408) in the scavenger by the magnetized development roller.

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PRINTER HAVING AN ALTERNATE SCAVENGER GEOMETRY

FIELD OF THE INVENTION

The present invention pertains to electrographic printers and copiers utilizing developer comprising toner, carrier, and other components.

BACKGROUND OF THE INVENTION

Electrographic printers and copiers utilizing developer comprising toner, carrier, and other components use a developer mixing apparatus and related processes for mixing the developer and toner used during the printing process. As is well known, the carrier can comprise permanently magnetized ferrite core particles, dispersed in a developer station with toner, whereupon the toner is attracted to and is "carried" by the ferrite core to an imaging roller for printing on a print medium. The gram weight of the carrier can be approximately 6 - 8% of the toner, which together comprises the developer. As part of this process, the carrier is intended to be reused and recirculated within the developer station. Certain conditions will cause the carrier to leave the developer station and deposit on the surface of the imaging member. Typically, there exists an electrically biased electrode 103 (the scavenger electrode), as shown in FIG. 1, that urges this carrier off the surface of the imaging member 102 because the biasing induces magnetism in the electrode, whereupon the magnetic force of the development roller 101 will direct the carrier, under gravity, back into the development station substantially in the general direction 105. The scavenger is electrically biased via a combination of high frequency AC imposed on a DC waveform whose function is to provide the motive force for the movement of carrier off of the photoconductor surface. Under the alternating AC field, the carrier rocks free and breaks from the photoconductor surface. The magnetic field from the rotating core magnet then pulls the carrier particle through the slotted scavenger back into the developer station

There are conditions, however, that result in the release of the carrier from the imaging (photoconductor) member 102, but the trajectory of the carrier is such that it will overshoot the trailing edge of the electrode 103. This can result in carrier accumulating, shown as 204 in FIG. 2, on the outside vertical face of the

scavenger electrode 203 or other surfaces, such as on the outer surfaces of the developer station or other surfaces in the imaging engine. Since this carrier is intended to be reused within the developer station, the loss of carrier can result in degradation of the image due to compromised mixing in developer sump. This carrier loss can also accumulate to the point where this carrier mass 204 can make contact with the imaging member 202, thereby physically disrupting the image, resulting in a loss of image quality.

SUMMARY OF THE INVENTION

The primary issues solved by the present invention include, first, defining a geometry of the scavenger that allows carrier to be returned to the developer station in the circumstance that the carrier has been successfully scavenged off of the surface of the imaging member and has a trajectory that overshoots the trailing edge of the scavenger electrode. Second, defining a scavenger geometry such that carrier buildup on the vertical face is minimized. Third, defining a scavenger geometry that preserves stiffness (moment of inertia) in both x-x and y-y planes, such that the requirement for straightness of the leading edge of the electrode (about 0.004" deflection over a length of about 14.5") can be maintained and, fourth, defining a scavenger geometry that facilitates economical production.

A preferred embodiment of the present invention comprises a printer that includes a developer station for holding a supply of carrier particles, a rotating member which accumulates carrier particles during its rotation, and a scavenger for removing the particles from the rotating member during the rotation. The scavenger includes a pathway fabricated therethrough for the carrier particles to travel over to return to the developer station. A magnetic source urges the carrier particles along the pathway through the scavenger. The carrier particles are also magnetized and the magnetic source comprises a magnetic field for urging the carrier particles through the scavenger along the pathway. The pathway is formed as a slot through the scavenger. The magnetic source is situated on a side of the scavenger opposite the carrier particles for attracting the particles through the slot. Any number of slots can be formed or cut through the

scavenger and are separated by an inter slot web having a cycloidal cross section. The cross section can optionally be shaped as a trapezoid.

Another preferred embodiment of the present invention comprises the scavenger itself which includes a first major surface and a second major surface, aka predominant flat surfaces, and the slot through the scavenger comprises a first opening on one side of the scavenger that is larger the opening on the other side of the scavenger, and the sidewalls converge toward the other side in cycloid shaped curves. As mentioned above, the scavenger can comprise any number of slots through the scavenger.

Another preferred embodiment of the present invention comprises a printer having a developer station for holding a supply of developer which includes magnetized carrier particles, a magnetized development roller, an imaging roller proximate the development roller which collects carrier particles during operation of the printer. A scavenger proximate the imaging roller and the development roller removes the carrier particles from the imaging roller during operation of the printer which are then urged through a slot in the scavenger by the magnetized development roller and then fall back into the developer station.

These, and other, aspects and objects of the present invention will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings. It should be understood, however, that the following description, while indicating preferred embodiments of the present invention and numerous specific details thereof, is given by way of illustration and not of limitation. For example, the summary descriptions above are not meant to describe individual separate embodiments whose elements are not interchangeable. In fact, many of the elements described as related to a particular embodiment can be used together with, and possibly interchanged with, elements of other described embodiments. Many changes and modifications may be made within the scope of the present invention without departing from the spirit thereof, and the invention includes all such modifications. The figures below are intended to be drawn neither to any precise scale with respect to relative size, angular relationship, or relative position nor to any combinational

relationship with respect to interchangeability, substitution, or representation of an actual implementation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1: Depiction of carrier scavenger electrode and electrostatographic module components;

FIG. 2: Scavenger electrode showing carrier buildup;

FIG. 3: Depiction of horizontal slots cut into vertical face of the scavenger electrode;

FIGS. 4A-B: Depiction of inside and outside vertical surfaces of the scavenger electrode and slot form options;

FIG. 5: Graph of inter slot web angle vs. magnetic field;

FIG. 6: Depiction of total included angle of inter slot web;

FIG. 7: Specification for inter web slots of a trapezoidal design;

FIG. 8: Top view of scavenger electrode showing slot geometry;

FIG. 9: Specification drawing for slots of a cycloidal design;

FIG. 10: Depiction of how carrier covers a greater area of the electrode surface when process speed is increased;

FIG. 11: Depiction of carrier buildup on inter slot webs.

FIG. 12: Depiction of improved geometry.

DETAILED DESCRIPTION OF THE INVENTION

A preferred embodiment of the present invention provides return of carrier back into a printer's developer station by forming horizontal slots (separated by inter slot webs) through the vertical face of the scavenger electrode, as illustrated in FIG. 3 which shows a front view of the scavenger electrode as seen while looking at the outside vertical face 303. A preferred embodiment of these slots 301, having sidewalls 304, formed through the scavenger electrode comprise slots defined as follows:

Slot (sidewall) height: range from 3.2mm to 5.5mm, or 36% to 61% of the vertical face height of the Scavenger Electrode (approx. 9mm vertical wall height). The interior and exterior vertical faces of the slots can be referred to as sidewalls.

Slot Width: range of 20mm - 30mm.

Total slot area is 20%-30% of the total area of the inside vertical face of the scavenger electrode. Carrier buildup on the outside vertical face of the scavenger electrode is minimized by reducing the projected area of the inter slot web 302 on the outside vertical face. Scavenger stiffness is increased by maximizing the projected area of the inter slot web's inside vertical face of the scavenger electrode, as will be explained.

Referring to FIG. 4A, buildup of carrier on the outside vertical face 407 of the scavenger electrode is minimized when the total included angle of the inter slot web is proportional to the normal component of the magnetic field imposed by the development roller 401 on the built up carrier. This draws the carrier along a pathway from where the carrier accumulates 204 through the slots 408 which is then returned by earth gravitational force in direction 405 back to the developer station. An optional slot configuration is illustrated in FIG. 4B wherein the slot 409 is angled downward which requires less attractive force from the magnetic field provided by the development roller 401 to move the carrier out of the scavenger in the direction 405. This is due to gravity acting on the carrier and causing the carrier to travel through the slot. The magnetic field imposed by the development roller 401 is sufficiently described, with $R^2 = 99.93\%$, per the following equation, supported by data shown in FIG. 5.

$$TIA = -37.39 \times FIELD^2 + 23.9 \times FIELD + 96.438$$, where

TIA = Total Included Angle (in Degrees)

Field = Normal Component of Magnetic Field (in mT)

where $TIA \leq 139 Deg$

The total included angle 601 is measured rail to rail as shown in FIG. 6 which illustrates a top view of a single inter slot web.

In general, slots that use a trapezoidal geometry for the inter slot web can partially satisfy the requirements of returning carrier back into the developer station, minimizing carrier buildup on the outside vertical face of the scavenger electrode, and increasing overall stiffness of the scavenger as compared to an inter slot web having a constant thickness. The requirements for the

trapezoidal geometry of the inter slot web are described as follows and are shown in the top view of the scavenger electrode depicted in FIG. 7. The 'a' dimension of the trapezoid 702 faces the outside vertical face of the scavenger electrode. The length of the 'a' dimension is preferably less than or equal to about 1.5mm. The total calculated moment of inertia about the specified axis of interest 701, as illustrated in FIG. 7 for the inter slot web should be about 58 mm^4. The total included angle of the inter slot web geometry provided by the trapezoidal inter slot web should partially satisfy requirements for allowing a return of built up carrier to the developer station.

Another preferred embodiment of the inter slot web is to cut or form openings in a fashion that describes a cycloid (cusp at origin) such as illustrated in FIG. 6, depicted in greater detail in FIGs. 8 and 9, with the addition of the following.

The profile of the inter slot web is thinner than the equivalent trapezoidal inter slot web towards the outside vertical face of the scavenger electrode, which further discourages carrier buildup on the outside face of the scavenger electrode because the favorable cycloidal geometry presents less resistance to the carrier when it is drawn through the slots by magnetic force from the development roller. This can be seen by comparing FIG. 7 with FIG. 8 where the cycloid inter slot web 802 is thinner in the trapezoidal inter slot web 702 "a" dimension. The cycloidal slots 803 are defined by the following dimensions, with reference to FIG. 9 which shows a top view of the scavenger electrode:

In an experimental laboratory construction, the following dimensions were found to provide improved scavenger performance. The 'a' dimension is of the apex of the inter slot web that faces the outside vertical edge of the scavenger electrode. The length of the 'a' dimension should be less than or equal to about 1.5mm, but within a range of about 1- 2mm. The 'b' dimension should be about 49.2mm, but within a range of about 47 - 52mm; the 'c' dimension should be about 4.78mm, but within a range of abut 3 - 6mm; and the 'd' dimension should be about 50.8mm, but within about 47 - 53mm. Slot height can range from about 3mm to about 6mm (36% to 61%) of the vertical face of the scavenger electrode (approx. 9mm vertical wall height). Slot width (dimension

'e') ranges from about 20 - 30mm. Total slot area should be about 20%-30% of the total area of the vertical face of the scavenger. The total calculated moment of inertia about the specified axis of interest 801 for the inter slot should be about 58 mm^4, as depicted in FIG. 8. The dimensions just described were measured for a scavenger electrode manufactured for a printer having a size of approximately 454mm in length. The length of the scavenger is consistent with the maximum imaging width of the particular print process, and should not be considered as required dimensions for implementations in any other printer.

In a two component development system, some loss of carrier is inevitable, and management of carrier loss turns out to be a very important part of the development station design. Specifically, the need to effectively scavenge escaping carrier and return it back to the development station is crucial to the overall life of the developer. It has been shown that as the speed of the electrostatographic process is increased, the trajectory of the carrier is such that it landed farther downstream from the developer station resulting in increased build up, as depicted in FIG. 10, which depicts build up amounts for print speeds of 70 ppm and 100 ppm (pages per minute).

It is essential to place the scavenger electrode at the point where the influence of the developer station magnet is such that it could no longer urge the carrier back into the developer station. As the speed of the process continues to increase, the trajectory of the carrier is such that a large portion of the scavenged carrier lands far past the trail edge of the scavenger electrode. This results in carrier accumulating on the scavenger and associated mounting surfaces, and results in increased maintenance and eventual degradation in image quality. The mass of escaping carrier is such that a simple strategy of placing a tray downstream of the developer station to catch and collect the carrier is unmanageable, since it is not guaranteed that escaping carrier caught in the external tray would be returned to the developer station. A practical solution requires that the majority of this escaping carrier be returned back to the developer station.

Initial attempts at a solution involved drilling holes and cutting slots into the vertical face of the scavenger electrode. This resulted in a vast

majority of the carrier returning back to the developer station. This design was not completely effective, because the inter slot web areas accumulated carrier to the point where it would make contact with the imaging member surface, causing an image defect. With reference to FIG. 12, this geometry for the inter slot web was ineffective because the magnetic field 1202 is normal to the vertical surface of the scavenger, such that there is no force to urge the carrier 1203 to move in the transverse direction (along the face of the scavenger electrode). The carrier is urged in the direction 1201 through the slot by the magnetic field. Thus, the carrier is held tight on the horizontal face of the inter slot web, as depicted in FIG. 12.

With reference to FIG. 13, the addition of the cycloidal inter slot web urges the carrier in transverse direction (along the length of the cycloidal inter slot web) and through the openings, allowing for the proper return of carrier back into the development station. The angle of the inter slot web increases and approaches an angle normal to the magnetic field where the magnetic field is stronger and able to overcome this increased resistance. Where the magnetic field is weaker, near the apex of the inter slot web, the inter slot web geometry is almost parallel to the magnetic field lines and provides very little resistance to the movement of the carrier. This geometry also preserves the required rigidity and stiffness of the scavenger electrode over other web geometries. In particular, the wider profile of the inter slot web on the inside surface of the scavenger provides this increased rigidity. With the geometry described by the present invention, this buildup is substantially eliminated.

With reference to FIG. 9, a method of fabricating, cutting, forming, or manufacturing the slotted, planar, scavenger will now be described. FIG. 9 illustrates a top view of the scavenger. The scavenger is typically cut from a sheet of aluminum. Important characteristics of the scavenger material include low magnetic permeability, so as not to induce eddy currents with the rotating magnet nearby and sufficient rigidity as to be able to be machined and hold the proper tolerances for the parts, and a width selected to fit in a particular printer. Stainless steel is an option but is not preferred. While having low permeability, stainless

steel is expensive and hard to machine. Plastic, while easy to machine, is not as rigid and must have an added conductive coating to the electrode surface.

The edges of the sheet can be distinguished from the two opposite major surfaces of the sheet, also referred to as predominant flat surfaces. The slots may be fabricated prior to separating the scavenger from the supply sheet, or afterwards, and are formed through the two major surfaces. A rotating, or other, tool for cutting, grinding, milling, melting, or abrading is brought into contact with the scavenger moving from the bottom, which is the outside surface as defined herein, towards the top, as viewed in FIG. 9. The tool will penetrate a major surface of the scavenger plate through thickness "c" and emerge at the top major surface, as viewed in FIG. 9, or the inside surface as defined herein when the scavenger is in use in the printer, thereby forming a slot, opening, aperture, hole, or slit of width "e". The thickness of the cutting tool preferably is equivalent to the desired height of the slots as defined herein, so that the tool is applied during one operation upon the scavenger plate for each slot that is fabricated, or a thinner tool may be applied repeatedly to increase a height of the slot with each repeated application. A single rotating head can be applied multiple times to form multiple slots in the scavenger plate, or a tool having multiple rotating heads can also be applied, thereby requiring fewer fabrication steps. The particular material selected for the scavenger plate may be more compatible with particular materials used as cutting tools. In a preferred embodiment of the present invention. Using the preferred dimensions of the slots and the inter slot web as described and defined herein, it is a matter of practical art to apply the rotating cutting tools for fabricating the preferred scavenger structure illustrated herein. The rotating tool can be a grinding wheel, circular saw, or similar milling tool.

An alternative embodiment for fabricating the slotted scavenger includes forming the slotted opening or openings using other techniques known in the art while using the rotating or cutting tools described above to form a cycloid or trapezoidal inter slot web. Thus, in this alternative embodiment, the slots through the scavenger are formed prior to shaping the inter slot web. If the slots are punched through the scavenger and have a height, say, of dimension x, then a rotating or cutting tool as described above having a thickness x can be applied to

the same scavenger surface as described above to shape the inter slot web as described above, except that the slot is already formed and the rotating tool merely shapes the inter slot web as a cycloid or trapezoid. Alternatively, the thickness of the cutting tool can be less than a height of the slot so long as the inter slot web is shaped by the cutting tool coplanar with a bottom surface of the slot. This is applicable to an embodiment wherein the slot is formed at an angle normal to a major surface of the scavenger or whether the slot is angled as shown in FIG. 4B. The angle of the slot can vary between a normal direction (0°) and approximately 45° from normal.

CLAIMS:

1. A printer comprising:

a developer station for holding a supply of carrier particles;

a rotating member which accumulates carrier particles during its rotation;

a scavenger for removing the particles from the rotating member during said rotation, the scavenger including a pathway fabricated therein for the carrier particles to traverse to return to the developer station.

2. The printer of claim 1, further comprising a source for urging the carrier particles along the pathway.

3. The printer of claim 2, wherein the carrier particles comprise magnetized carrier particles and the source comprises a magnetic field for urging the carrier particles along the pathway.

4. The printer of claim 3, wherein the pathway includes a slot through the scavenger.

5. The printer of claim 2, wherein the source is situated on a side of the scavenger opposite the carrier particles.

6. The printer of claim 3, wherein the pathway includes a plurality of slots through the scavenger separated by an inter slot web having a cycloidal cross section.

7. The printer of claim 3, wherein the pathway includes a plurality of slots through the scavenger separated by an inter slot web having a trapezoidal cross section.

8. A scavenger comprising:

a first major surface and a second major surface; and

a slot through the scavenger wherein a first opening of the slot in the first major surface is larger than a second opening of the slot in the second major surface.

9. The scavenger of claim 8 wherein the slot comprises sidewalls that converge at the second major surface and are curved as a cycloid.

10. The scavenger of claim 8 wherein the scavenger comprises a plurality of slots through the scavenger wherein a first opening of each of the slots in the first major surface is larger than a second opening of each of the slots in the second major surface; and

wherein sidewalls of each of the slots converge at the second major surface and are curved as a cycloid.

11. A printer comprising:

a developer station for holding a supply of developer comprising magnetized carrier particles;

a magnetized development roller;

an imaging roller proximate the development roller whereupon the carrier particles accumulate during operation of the printer;

a scavenger proximate the imaging roller and the development roller for removing the carrier particles from the imaging roller during said operation of the printer, the scavenger including a slot formed therethrough.

12. The printer of claim 11, wherein sidewalls of the slot are curved in a cycloid shape and converge at one side of the scavenger.

13. The printer of claim 11, wherein the scavenger is disposed such that said carrier removed from the imaging roller accumulates on a first side of the scavenger and such that the magnetized development roller magnetically urges the carrier through the slot.

14. The printer of claim 13, wherein the developer station is disposed such that the carrier that is urged through the slot falls into the developer station.

15. The printer of claim 11, wherein the scavenger comprises a plurality of slots formed therethrough, the plurality of slots are separated by an inter slot web, and wherein the inter slot web comprises a cycloidal cross section.

16. The printer of claim 11, wherein the scavenger comprises a plurality of slots formed therethrough, the plurality of slots are separated by an inter slot web, and wherein the inter slot web comprises a trapezoidal cross section.

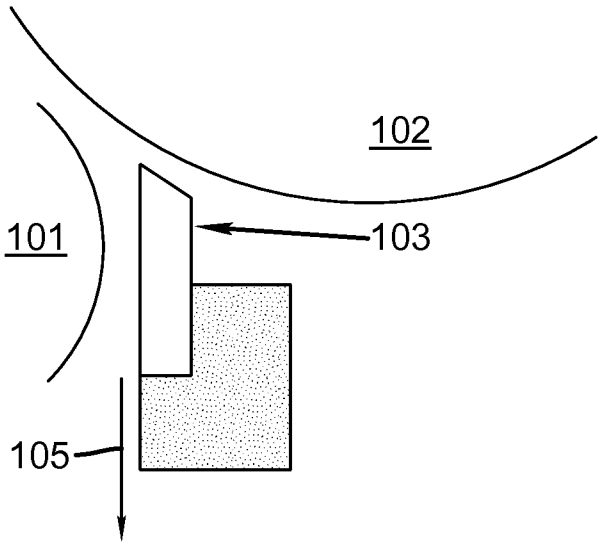


FIG. 1

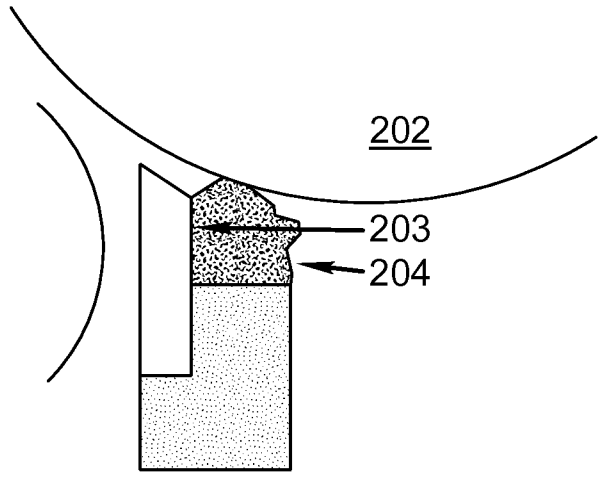


FIG. 2

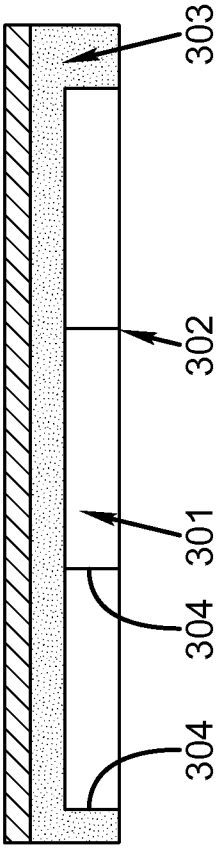


FIG. 3

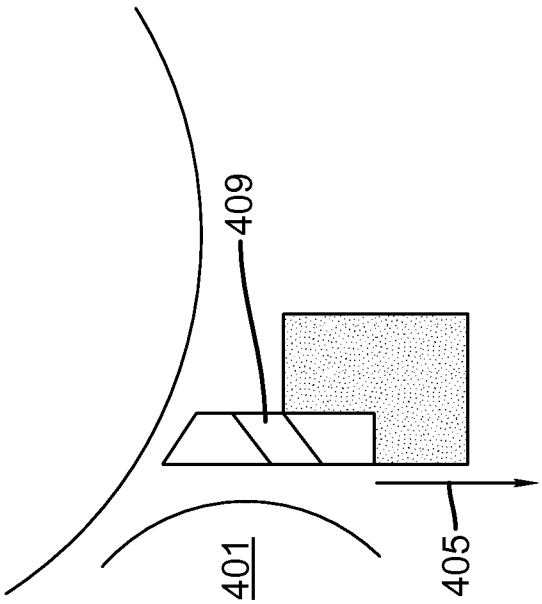


FIG. 4B

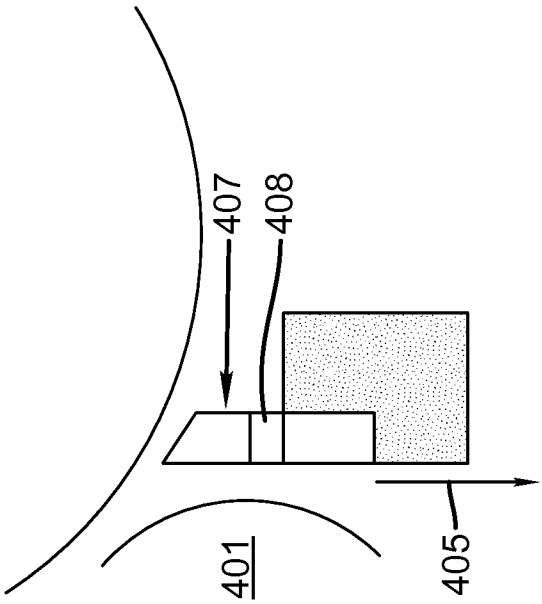


FIG. 4A

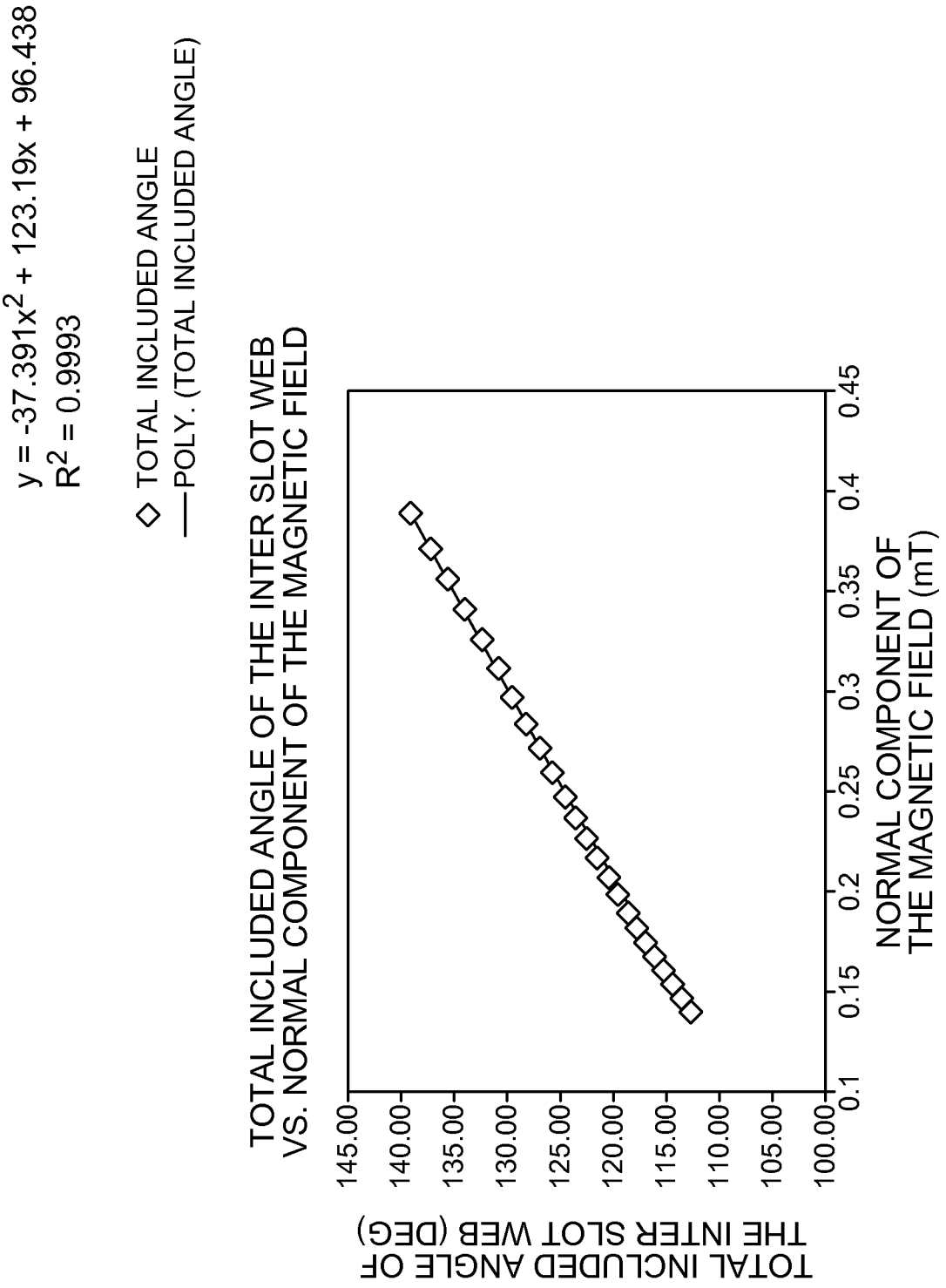

y = -37.391x2 + 123.19x + 96.438
R2 = 0.9993
◇ TOTAL INCLUDED ANGLE
—POLY. (TOTAL INCLUDED ANGLE)
TOTAL INCLUDED ANGLE OF THE INTER SLOT WEB
VS. NORMAL COMPONENT OF THE MAGNETIC FIELD
TOTAL INCLUDED ANGLE OF THE INTER SLOT WEB (DEG)
145.00
140.00
135.00
130.00
125.00
120.00
115.00
110.00
105.00
100.00
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
NORMAL COMPONENT OF THE MAGNETIC FIELD (mT)

FIG. 5

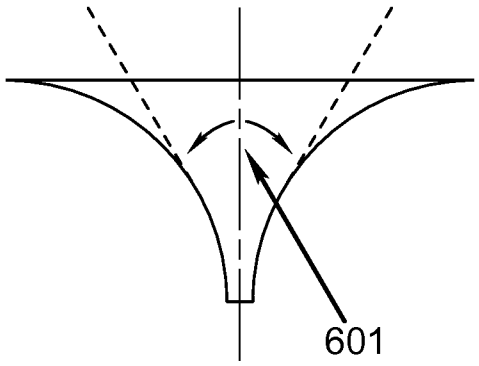


FIG. 6

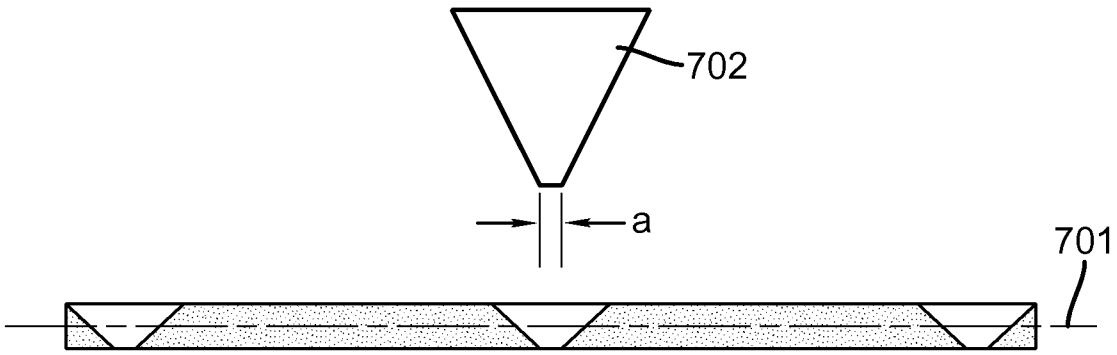


FIG. 7

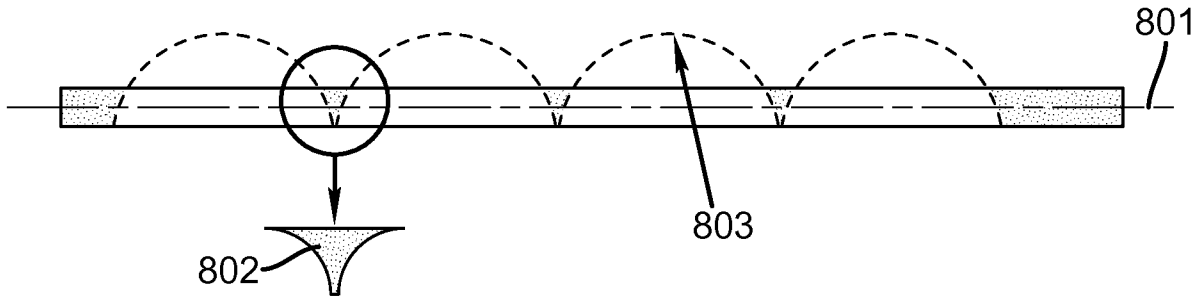


FIG. 8

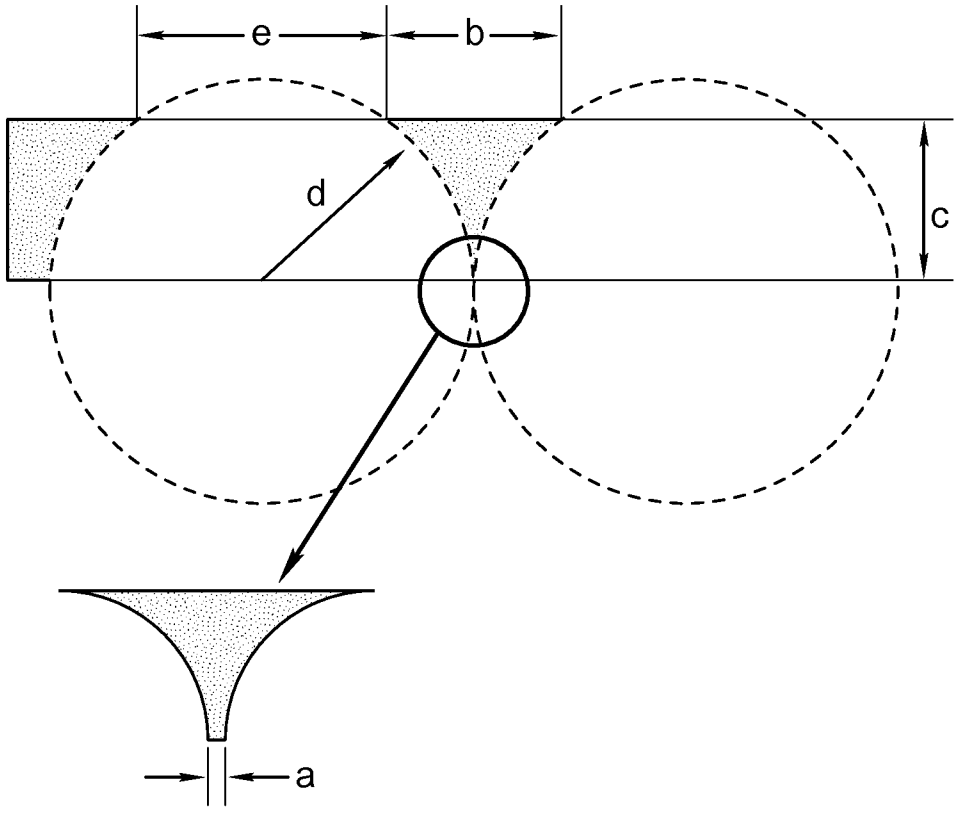


FIG. 9

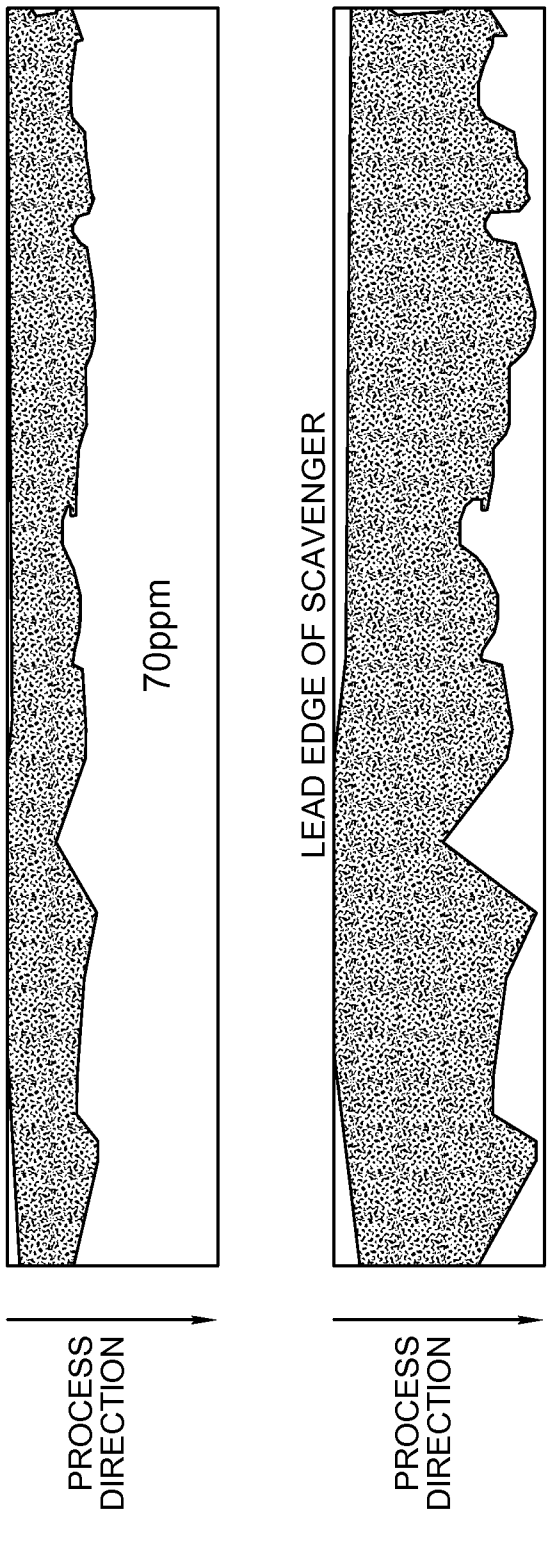

70ppm
LEAD EDGE OF SCAVENGER
PROCESS DIRECTION
PROCESS DIRECTION

FIG. 10

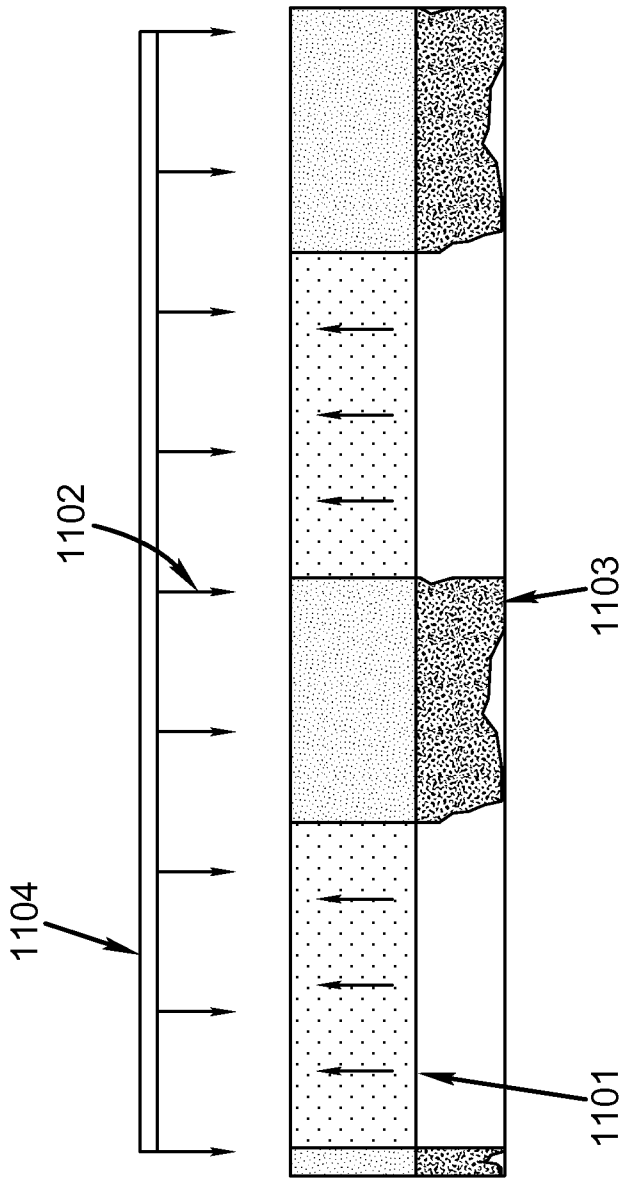


FIG. 11

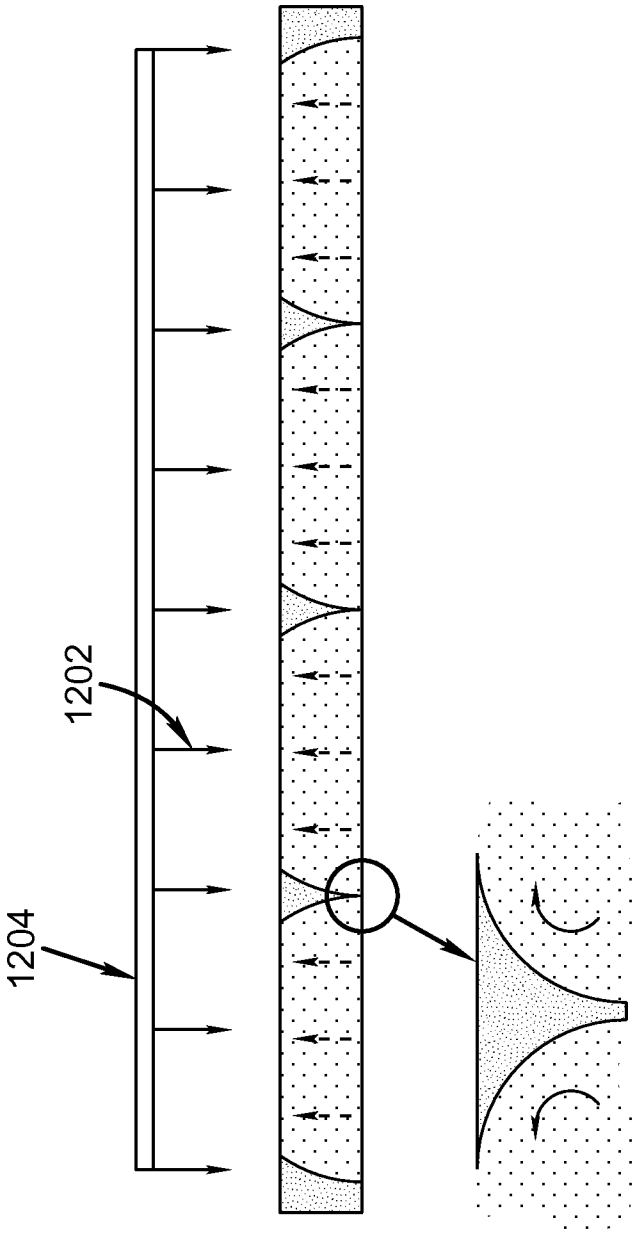


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/040462

A. CLASSIFICATION OF SUBJECT MATTER
INV. G03G15/08 G03G15/09 G03G15/095 G03G21/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G03G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 047 807 A (KALYANDURG SATYAN R [US]) 10 September 1991 (1991-09-10) column 3, line 29 - column 6, line 68; figures 1-4	1-5
X	US 2006/257175 A1 (ENDO RIE [JP] ET AL) 16 November 2006 (2006-11-16) paragraphs [0077] , [0095] - [0102] ; figures 8-10	1,2,4,5 , 7,8
Y	US 2009/136267 A1 (BROWN KENNETH J [US] ET AL) 28 May 2009 (2009-05-28) paragraph [0018] - paragraph [0029] ; figures 1-3	I-7, II- 16
Y	JP 56 144472 A (HITACHI METALS LTD) 10 November 1981 (1981-11-10) abstract; figures 1-3	I-7, II- 16

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 September 2011	27/09/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bi l lmann , Frank

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/040462

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2006/024100 A1 (OHTA NAOKI [JP] ET AL) 2 February 2006 (2006-02-02)	8-10
Y	paragraphs [0125] - [0128], [0149], [0150]; figures 2-4, 6, 7	I-7, II-16
E	US 2011/158702 A1 (BROWN KENNETH J [US] ET AL) 30 June 2011 (2011-06-30) the whole document	1-16

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Information on patent family members

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