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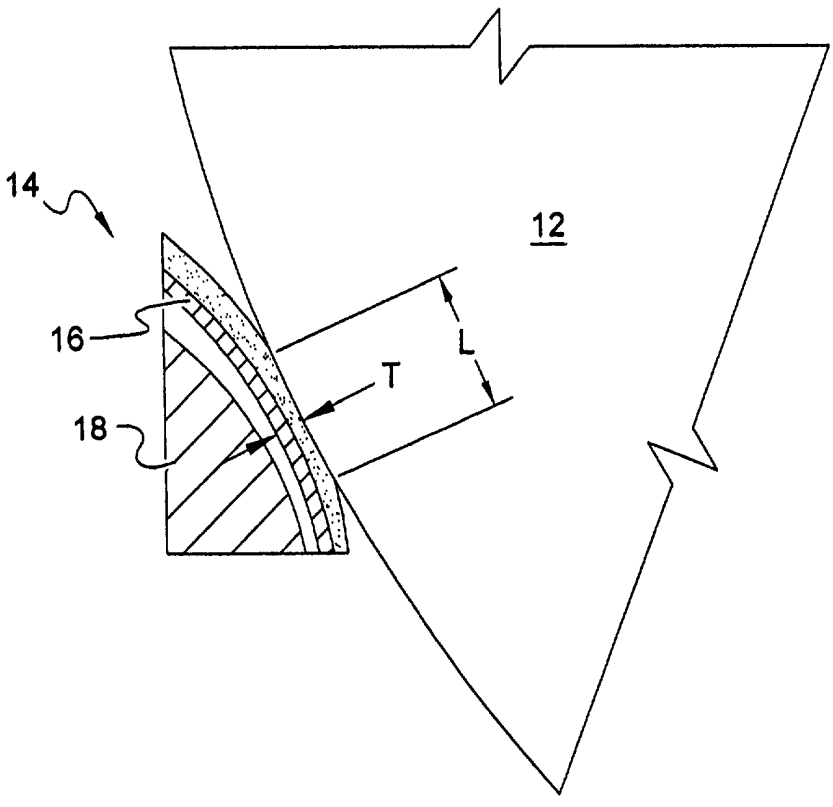
(54) Title: ELECTROSTATIC IMAGE DEVELOPING METHOD AND APPARATUS



(57) Abstract: The invention relates generally to apparatus for electrostatic image development and, in particular, apparatus that implement a magnetic brush (14) with a drum photoconductor (12). According to an aspect of the invention, a method and apparatus for developing an electrostatic image are provided implementing a drum photoconductor (12) and a magnetic brush (14) contacting the photoconductor (12). The magnet brush (14) comprises a mixture of toner and hard magnetic carriers.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ELECTROSTATIC IMAGE DEVELOPING METHOD AND APPARATUS

BACKGROUND

This application claims the benefit of U.S. Provisional Application No. 60/204,881, filed May 17, 2000.

The invention relates generally to apparatus for electrostatic image development and, in particular, apparatus that implement a magnetic brush with a drum photoconductor.

Development apparatus and processes that implement a magnetic brush to deposit toner on a photoconductor have been known for many years. Development apparatus and processes that implement a magnetic brush having hard magnetic carriers are described in United States Patents 4,473,029 and 4,546,060. The apparatus described in those patents implements a rotating shell coated with a mixture of hard magnetic carrier particles and toner, a rotating magnetic core having a multitude of magnetic poles disposed within the rotating shell, and a film (sheet-like) photoconductor. The rotating magnetic core causes the hard magnetic carrier particles to tumble on the surface of the shell, which provides increased agitation and toner contact with the film photoconductor.

The two-component dry developer composition of United States Patent 4,546,060 comprises charged toner particles and oppositely charged, magnetic carrier particles, which (a) comprise a magnetic material exhibiting "hard" magnetic properties, as characterized by a coercivity of at least 300 gauss and (b) exhibit an induced magnetic moment of at least 20 EMU/gm when in an applied field of 1000 gauss, is disclosed. As described in the '060 patent, the developer is employed in combination with a magnetic applicator comprising a rotatable magnetic core and an outer, nonmagnetizable shell to develop electrostatic images. When hard magnetic carrier particles are employed, exposure to a succession of magnetic fields emanating from the rotating core applicator causes the particles to flip or turn to move into magnetic alignment in each new field. Each flip, moreover, as a

consequence of both the magnetic moment of the particles and the coercivity of the magnetic material, is accompanied by a rapid circumferential step by each particle in a direction opposite the movement of the rotating core. The observed result is that the developers of the '060 flow smoothly and at a rapid rate around the shell while the core rotates in the opposite direction, thus rapidly delivering fresh toner to the photoconductor and facilitating high-volume copy and printer applications.

Prior applications of hard magnetic carriers have implemented a flexible photoconductor in the form of a film. Flexible or film based photoconductors have several significant advantage for high speed photocopying. In a typical apparatus, the photoconductor film is positioned under moderate tension with a series of rollers. There is an inherent resilience in the film that allows it to respond to variations in the thickness of the magnetic brush.

Drum photoconductors are also known in the art, but have not been used with magnetic brushes having hard magnetic carriers. At least part of the reason drum photoconductors have not been used is because they tend to be far more rigid than a film photoconductor, and increasing thickness of the magnetic brush can damage the surface of the drum. Conversely, decreasing thickness of the magnetic brush can cause insufficient contact with the photoconductor and poor image development.

SUMMARY

According to an aspect of the invention, an apparatus for developing an electrostatic image is provided, comprising a drum photoconductor and a magnetic brush contacting the drum photoconductor, a magnetic brush contacting said photoconductor drum, said magnetic brush comprising a mixture of toner and hard magnetic carriers.

According to a further aspect of the invention, a method for developing an electrostatic image is provided comprising applying a mixture of toner and hard magnetic carriers to a photoconductor drum with a magnetic brush.

According to a further aspect of the invention, a method for developing an electrostatic image is provided comprising applying a mixture of toner and hard magnetic carriers to a photoconductor drum with a magnetic brush comprising a magnetic core within a shell having a center of rotation, and the magnetic core is offset relative to the center of rotation toward the drum.

According to a further aspect of the invention an apparatus for developing an electrostatic image is provided, comprising a photoconductor drum, a magnetic brush contacting the photoconductor drum, the magnetic brush comprising a mixture of toner and hard magnetic carriers, the magnetic brush comprising a rotatable magnetic core within a shell.

According to a further aspect of the invention an apparatus for developing an electrostatic image is provided, comprising a photoconductor drum, a magnetic brush contacting the photoconductor drum, the magnetic brush comprising a mixture of toner and hard magnetic carriers, the magnetic brush comprising a rotatable magnetic core within a rotatable shell.

According to a further aspect of the invention an apparatus for developing an electrostatic image is provided, comprising a photoconductor drum, a magnetic brush contacting the photoconductor drum, the magnetic brush comprising a mixture of toner and hard magnetic carriers, the magnetic brush comprising a magnetic core within a rotatable shell, the magnetic core being rotatable in a direction of rotation and the shell being rotatable in a direction opposite to the direction of rotation of the magnetic core.

According to a still further aspect of the invention a method for developing an electrostatic image is provided, applying a magnetic brush to a drum photoconductor, said magnetic brush comprising a mixture of toner and hard magnetic carriers with a mass flow rate, and limiting said mass flow rate of the mixture to be less than a limiting mass flow rate for which roll-back occurs.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 presents an end view of a development apparatus according to an aspect of the invention, including a cross-sectional view of a toning station according to an aspect of the invention.

FIG. 2 presents an enlarged view of a development zone according to an aspect of the invention.

FIG. 3 presents an enlarged view of a development zone having a roll-back region.

FIG. 4 presents an exploded perspective view of the Figure 1 toning station.

FIG. 5 presents an exploded perspective view of the Figure 1 toning station from an opposite end thereof as that presented in Figure 4.

FIG. 6 presents an end view of a toning station carriage assembly according to an aspect of the invention.

FIG. 7 presents a perspective view of the carriage assembly of Figure 6.

FIG. 8 presents a side plan view of a sliding rail implemented in the carriage assembly of Figure 6.

FIG. 9 presents a perspective view of the carriage assembly of Figure 6 from an opposite end thereof as that presented in Figure 7.

FIG. 10 presents an end view of the carriage assembly of Figure 6 with the toning station of Figure 1 registered with a drum photocondctor.

FIG. 11 presents an enlarged view of a registration shoe and registration pin in an unregistered state.

FIG. 12 presents an enlarged view of a registration shoe and registration pin in a registered state.

DETAILED DESCRIPTION

Various aspects of the invention are presented in Figures 1-12, which are not drawn to scale, and wherein components in the numerous views are numbered alike. Referring now to Figure 1, a toning station 10 is presented, according to an aspect of the invention, comprising a drum photoconductor 12 and a magnetic brush 14 that carries a mixture of toner and hard magnetic carriers into contact with the external surface of the drum photoconductor 12. As used herein, the term "hard magnetic carriers" means carriers having hard magnetic properties, as described in the Background section. The magnetic brush 14 operates according to the principles described in United States Patents 4,473,029 and 4,546,060, the contents of which are fully incorporated by reference as if set forth herein. The magnetic brush 14 comprises a shell 16, preferably of non-magnetizable material, and a core 18 comprising a rotating plurality of magnetic poles. The drum photoconductor 12 rotates in the direction indicated by the arrow 20 (drum 12 direction of rotation), the shell 16 rotates in the direction indicated by the arrow 22 (shell 16 direction of rotation), and the core 18 rotates in the direction indicated by the arrow 24 (core 18 direction of rotation).

For the purposes of this description, the drum 12 has a direction of rotation 20 that is opposite the direction of rotation 22 of the shell 16, and drum 12 has a direction of rotation 20 that is co-directional with the direction of rotation 24 of the magnetic core 18. The various directions of rotation are not so limited in the practice of the invention, and may be changed as may be suited for a particular application.

The toning station 10 and the drum photoconductor 12 are mounted to a frame 28 that is configured, as needed, for a particular copy machine or printer application, as desired. The toning station 10 comprises a shell 16, a sump 30, quadruple augers 32 mounted for rotation in the sump 30, a transport roller 34 above the augers 32 adjacent the shell 16, and a replenishment unit 36 that comprises a fixed perforated tube 38, and a replenishment brush 40 inside the tube 38 that rotates in the direction of arrow 42. The replenishment unit 36 adds toner to the toner/carrier mixture in response to a toner concentration monitor 44 to

maintain a weight ratio of toner to carrier, for example 1/10. More or less such components may be added or removed depending upon the particular application. The additional mixing provided by a four auger system improves cross mixing and, therefore, cross track uniformity in a developed image. Toner concentration gradients are preferably minimized, and no more than a few percent in magnitude.

In use, the mixture of hard magnetic carriers and toner covers the augers 32 to level about even with the bottom of the transport roller 34. The augers 32 comprise a multitude of angled blades 46 mounted on shafts 48. The blades mix the carriers and toners to create tribocharging and uniformity, and to provide a generally even level of toner/carrier mixture in the sump 30. The transport roller 34 rotates in the direction of arrow 50 and lifts the mixture out of the sump 30 to the shell 16.

Referring now to Figure 2, an enlarged view of the nip area of Figure 1 is presented, showing where a toner/carrier mixture 52 coating the shell 16 contacts the drum photoconductor 12. The flow of toner/carrier mixture 52 has a thickness T, and contacts the drum 12 over a length L. The flow presented in Figure 2 is very desirable. Referring now to Figure 3, an undesirable flow of the toner/carrier mixture 52 is presented wherein a roll-back region 54 has developed. The roll-back region 54 is believed to be caused by the flow of toner/carrier mixture 52 being greater than can flow through the nip between the shell 16 and the drum 12. The roll-back region may cause artifacts in the image development on drum 12, and may also physically damage the surface of the drum 12. The roll-back region 54 is not passive since the rotating core 18 tends to drive the mass of material in the roll-back region 54 into the nip with an active force.

According to an aspect of the invention, development of the roll-back region is avoided. According to a further aspect of the invention, development of the roll-back region is avoided at least in part by accurately and repeatably locating the shell 16 a predetermined distance from the drum 12. Referring again to Figure 1, the registration of the shell 16 to the drum 12 is controlled by providing a pair of registrations pins 56 on either side of the drum 12. The drum 12 comprises a shaft

58 that is mounted in a pair of bearings 60 that, in turn, are mounted to the frame 28.

The toning station 10 comprises a pair of registration shoes 62 on either end that mate with the pins 56. According to a preferred embodiment, the magnetic brush 14 is registered to the drum 12. For example, the toning station 10 is wedged into registration with the pins 56 thereby rendering it immovable during operation of the drum 12 and magnetic brush 14. The registration shoe 62 presented in Figure 1 is mostly hidden behind the toning station 10. A better representation is provided in Figure 12, which will be discussed in more detail.

According to a further aspect of the invention, development of the roll-back region is avoided at least in part by accurately controlling the thickness of the toner/carrier mixture 52 in the nip between the shell 16 and the drum 12. The center of rotation of the core 18 may be offset relative to the center of rotation of the shell toward the drum 12 (eccentric), thereby forming an area 64 wherein the inside surface of the shell 16 is closest to the outside surface of the core 18 (slightly below the point where the drum 14 and the shell are closest), referred to herein as the perigee. A metering skive 66 is located opposite the area 64 where the shell 16 is furthest from the core 18, referred to herein as the apogee. The metering skive 66 meters a predetermined thickness of toner/carrier mixture onto the shell 16. The magnetic field from applied to the toner/carrier mixture is weakest at this point, so it is not fully compacted. The thickness of the mixture decreases as it is carried around the shell to the drum 12. Therefore, any variation in the thickness decreases along with the thickness of the mixture, thereby providing a more precise thickness T. According to a preferred embodiment, a line drawn from the area 64 (the perigee) to the metering skive 66 is horizontal, and the two are 180° apart (one at the 9 o'clock position, the other at the 3 o'clock position).

According to a preferred embodiment, the flow of the toner/carrier mixture 52 is limited to be less than the limiting mass flow rate through the nip between the drum 12 and the shell 16 for which roll-back occurs. This may be accomplished, at least in part by adjusting the skive gap (the distance between the skive 66 and

shell 16) to achieve a predetermined mass flow of toner/carrier mixture 52 per unit length past the skive 66 that is less than the limiting mass flow rate. Mass flow rate of the toner/carrier mixture is also affected by numerous other parameters including speed and direction of rotation of the various rotating components, and the dimensions and physical properties of the toner/carrier mixture and various components of the development station, for example the magnetic field strength of the core. This list is not intended to be exhaustive since the effects and the limiting mass flow rate for a particular application may be determined by experimental observation and measurement.

Referring now to Figures 4 and 5, exploded isometric views of the toning station 10 from opposite ends are presented in order to show additional detail, and the relative relation of the components.

The rotating magnetic core 18 may develop eddy current losses in the photoconductor drum 12. A combination of relatively fine magnetic pole frequency (for example a 14 pole, 1.6 inch diameter) and relatively thin, 4 to 8 mm, wall thickness for the photoconductor drum 12 reduces eddy current losses. Further, the material choice for the drum wall of a relatively hard aluminum (T3 or T6) minimizes the wall conductivity, and therefore, the eddy current losses.

According to a further aspect of the invention, the metering skive 66 is provided with wings 67 at both ends that locally reduce the flow of the toner/carrier mixture proximate the ends of the photoconductor drum 12. Reducing the flow in such manner prevents physical damage that may occur at the very ends of the development zone due to edge effects that locally increase flow. Further reductions in the rate of formation of rollback regions at the ends of the development zone were obtained by placing small permanent magnets on the metering skive 66 at the wing locations 67.

A DC bias is applied to the shell 16 in order to create an electric field that transports toner to the surface of the photoconductor drum 12. An AC bias may also be implemented to improve the development rate, and therefore the level and consistency of image quality. In solid area development systems, an electrical

bias is applied between the ground layer of the PC and the shell of the development station. If a high frequency, high voltage, e.g. 1000 to 2000 hertz and 500 to 1500 volt rms, signal is added to the constant bias, the development rate is significantly increased.

Referring now to Figures 6-12, a carriage assembly 100 is presented according to a further aspect of the invention, that may be employed in combination with the toning station 10 (Figures 1 and 10) to provide precise registration of the toning station with the photoconductor drum 12 (Figures 1 and 10). The carriage assembly 100 compensates for skew in the photoconductor drum 12. Referring now to Figures 6-9, the carriage assembly 100 comprises a support rail 102 and a sliding rail 104 suspended and guided by three rods 106, 108, and 110. The support rail 102 is rigidly attached to a structure, such as the frame 28 of Figure 1. As best shown in Figure 8, the sliding rail 104 comprises two horizontally elongated holes 132 that receive the outer rods 106, and 110, and a slightly oversized hole 134. The center rod 108 constrains movement of the sliding rail 104 in the longitudinal direction while allowing lateral movement of the sliding rail 104 along the rod 108. The two outside rods 106 and 110 maintain levelness of the sliding rail 104.

Referring again to Figure 6-9, the sliding rail 104 is attached to a side plate 116. A camshaft 112 is driven by an electrical actuator motor 114, and is captured between two components of the side plate 116 and provides the mechanism for positioning the sliding rail 114 relative to the photoconductor drum 12. The electrical actuator motor 114 is rigidly mounted to the same support structure as the support rail 102. The camshaft 112 comprises a cam bearing 113. A load arm 122 is also attached to the side plate 116 and pivoted about a vertical axis at a load arm pivot 124. The position of camshaft 112 is controlled through the use of two solid state micro switches 126 and a cam position coupling 118.

As the camshaft 112 is rotated from a disengaged position to an engaged position it pushes against a detented cam retainer plate 120 attached to the side plate 116. This motion pushes the sliding rail 114 into its engaged position, best shown in Figure 6, as indicated by arrow 132. As the sliding rail 114 travels to its

engaged position, the load arm 122 mounted to the side plate 116 encounters the toning station 10 (Figures 1 and 10) and is deflected thereby creating a spring force that pushes the toning station 10 into registration with the registration pins 56 (Figures 1 and 10). The detented cam retainer plate 120 provides a nesting force so that the camshaft 112 does not rotate away when the mechanism is in the engaged position.

Still referring to Figures 6-9, a positive vertical lift force is achieved through the use of two angled push pads 128 mounted on the load arm 122 and a corresponding angled wedge 130 mounted to the toning station 10 (see Figures 1 and 10). The push pads 128 pass through a pair of windows provided in the side plate 116. Referring now specifically to Figure 10, an angled push pad 136 is mounted to the bottom of the toning station 10, and a mating push pad 138 is mounted to the frame of the machine, such as frame 28 of Figure 1. The angled push pad 136 and mating push pad 138 provide additional vertical lift force. The net force is oriented toward the drum 12 and up, as indicated by arrow 140. As presented in Figures 11 and 12, the registration shoes 62 mounted at either end of the toning station 10 preferably comprise V-shaped notches 63, and the registration pins 56 are received with the notches 63 upon forcing the toning station 10 in the direction of arrow 140. The force holding the toning station 10 in place may exceed 100 lbf, and according to a certain embodiment is on the order of 160 lbf.

The sliding rail 104 comprises a track 105 that toning station 10 is received within and guided upon while being inserted into the machine until all electrical and mechanical interfaces are met. The sliding rail 104 and track 105 serve to accurately locate the toning station 10 in relation to the pins 56 so that, upon activation of the cam shaft 12, the registration pins 56 are received within the notches.

Although the invention has been described and illustrated with reference to specific illustrative embodiments thereof, it is not intended that the invention be limited to those illustrative embodiments. Those skilled in the art will recognize that variations and modifications can be made without departing from the true

scope and spirit of the invention as defined by the claims that follow. It is therefore intended to include within the invention all such variations and modifications as fall within the scope of the appended claims and equivalents thereof.

We claim:

1. An apparatus for developing an electrostatic image, comprising:

a photoconductor drum;

a magnetic brush contacting said photoconductor drum, said magnetic brush comprising a mixture of toner and hard magnetic carriers.

2. The apparatus of claim 1, wherein said hard magnetic carriers have a coercivity of at least 300 gauss and exhibit an induced magnetic moment of at least 20 EMU/gm when in an applied field of 1000 gauss.

3. The apparatus of claim 1, wherein said magnetic brush is registered to said drum.

4. The apparatus of claim 1, wherein said magnetic brush comprises a magnetic core within a shell having a center of rotation, and said core is offset relative to said center of rotation toward said drum.

5. The apparatus of claim 4, further comprising a skive adjacent said shell at an apogee where said shell is furthest from said core.

6. The apparatus of claim 4, wherein said shell is closest to said core at a perigee, said drum has a direction of rotation, and said drum is closest to said shell at a location offset from said perigee in a direction opposite said direction of rotation.

7. The apparatus of claim 4, further comprising a skive adjacent said shell at an apogee where said shell is furthest from said core,

and wherein said shell is closest to said core at a perigee, said drum has a direction of rotation, and said drum is closest to said shell at a location offset from said perigee in a direction opposite said direction of rotation.

8. The apparatus of claim 4, further comprising a skive adjacent said shell at an apogee where said shell is furthest from said core,

and wherein said shell is closest to said core at a perigee, said drum has a direction of rotation, and said drum is closest to said shell at a location offset from said perigee in a direction opposite said direction of rotation, and the two are 180° apart.

9. The apparatus of claim 4, further comprising a skive adjacent said shell at an apogee where said shell is furthest from said core,

and wherein said shell is closest to said core at a perigee, said drum has a direction of rotation, and said drum is closest to said shell at a location offset from said perigee in a direction opposite said direction of rotation,

and a line drawn from said perigee to said metering skive is horizontal.

10. The apparatus of claim 1, further comprising a metering skive adjacent said magnetic brush having wings at both ends that locally reduce the flow of said toner/carrier mixture proximate opposing ends of said drum.

11. An apparatus for developing an electrostatic image, comprising:

a photoconductor drum;

a magnetic brush contacting said photoconductor drum, said magnetic brush comprising a mixture of toner and hard magnetic carriers, said magnetic brush comprising a rotatable magnetic core within a shell.

12. An apparatus for developing an electrostatic image, comprising:

a photoconductor drum;

a magnetic brush contacting said photoconductor drum, said magnetic brush comprising a mixture of toner and hard magnetic carriers, said magnetic brush comprising a rotatable magnetic core within a rotatable shell.

13. An apparatus for developing an electrostatic image, comprising:

a photoconductor drum;

a magnetic brush contacting said photoconductor drum, said magnetic brush comprising a mixture of toner and hard magnetic carriers, said magnetic brush comprising a magnetic core within a rotatable shell, said magnetic core being rotatable in a direction of rotation and said shell being rotatable in a direction

14. The apparatus of claim 13, wherein said drum has a direction of rotation that is opposite said direction of rotation of said shell.

15. The apparatus of claim 13, wherein said drum has a direction of rotation that is co-directional with said direction of rotation of said magnetic core.

16. The apparatus of claim 13, wherein said drum has a direction of rotation that is opposite said direction of rotation of said shell, and

said drum has a direction of rotation that is co-directional with said direction of rotation of said magnetic core.

17. A method for developing an electrostatic image, comprising:

applying a mixture of toner and hard magnetic carriers to a photoconductor drum with a magnetic brush.

18. The method of claim 17, wherein said hard magnetic carriers have a coercivity of at least 300 gauss and exhibit an induced magnetic moment of at least 20 EMU/gm when in an applied field of 1000 gauss.

19. The method of claim 17, further comprising registering said magnetic brush to said drum.

20. The method of claim 17, further comprising a metering said mixture of toner and hard magnetic carriers with a skive adjacent said magnetic brush having wings at both ends that locally reduce the flow of said toner/carrier mixture proximate opposing ends of said drum.

21. A method for developing an electrostatic image, comprising:

applying a mixture of toner and hard magnetic carriers to a photoconductor drum with a magnetic brush comprising a magnetic core within a shell having a center of rotation, and said magnetic core is offset relative to said center of rotation toward said drum.

22. The method of claim 21, further comprising metering said toner/carrier mixture with a skive adjacent said shell at an apogee where said shell is furthest from said core.

23. The method of claim 21, wherein said drum has a direction of rotation and further comprising applying said toner/carrier mixture to said drum at a location offset in a direction opposite said direction of rotation from a perigee where said shell is closest to said core.

24. The method of claim 21, further comprising metering said toner/carrier mixture with a skive adjacent said shell at an apogee where said shell is furthest from said core, and

wherein said drum has a direction of rotation and further comprising applying said toner/carrier mixture to said drum at a location offset in a direction opposite said direction of rotation from a perigee where said shell is closest to said core.

25. The method of claim 21, further comprising metering said toner/carrier mixture with a skive adjacent said shell at an apogee where said shell is furthest from said core, and

wherein said drum has a direction of rotation and further comprising applying said toner/carrier mixture to said drum at a location offset in a direction opposite said direction of rotation from a perigee where said shell is closest to said core, and said skive and said perigee are 180° apart.

26. The method of claim 21, further comprising metering said toner/carrier mixture with a skive adjacent said shell at an apogee where said shell is furthest from said core, and

wherein said drum has a direction of rotation and further comprising applying said toner/carrier mixture to said drum at a location offset in a direction opposite said direction of rotation from a perigee where said shell is closest to said core, and a line from said perigee to said metering skive is horizontal.

27. A method for developing an electrostatic image, comprising:

applying magnetic brush to a drum photoconductor, said magnetic brush comprising a mixture of toner and hard magnetic carriers with a mass flow rate; and

limiting said mass flow rate of said mixture to be less than a limiting mass flow rate for which roll-back occurs.

28. The method of claim 27, further where said magnet brush comprises a shell and further comprising a skive adjacent said shell that controls said mass flow rate, and further comprising adjusting the distance between said skive and said shell to achieve a predetermined mass flow rate.

29. The method of claim 27, further comprising determining effects on said mass flow rate by experimental observation and measurement.

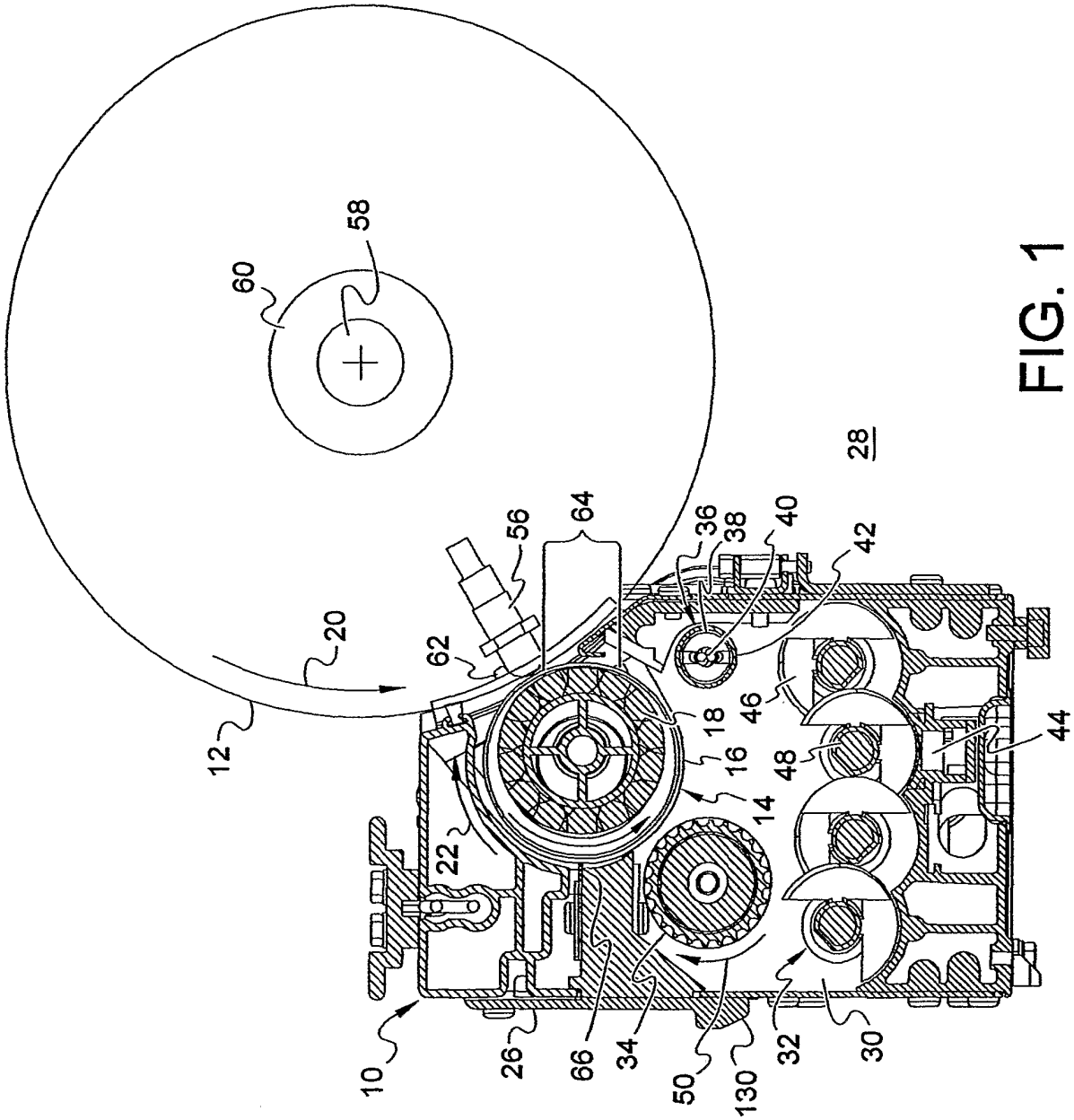
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FIG. 1

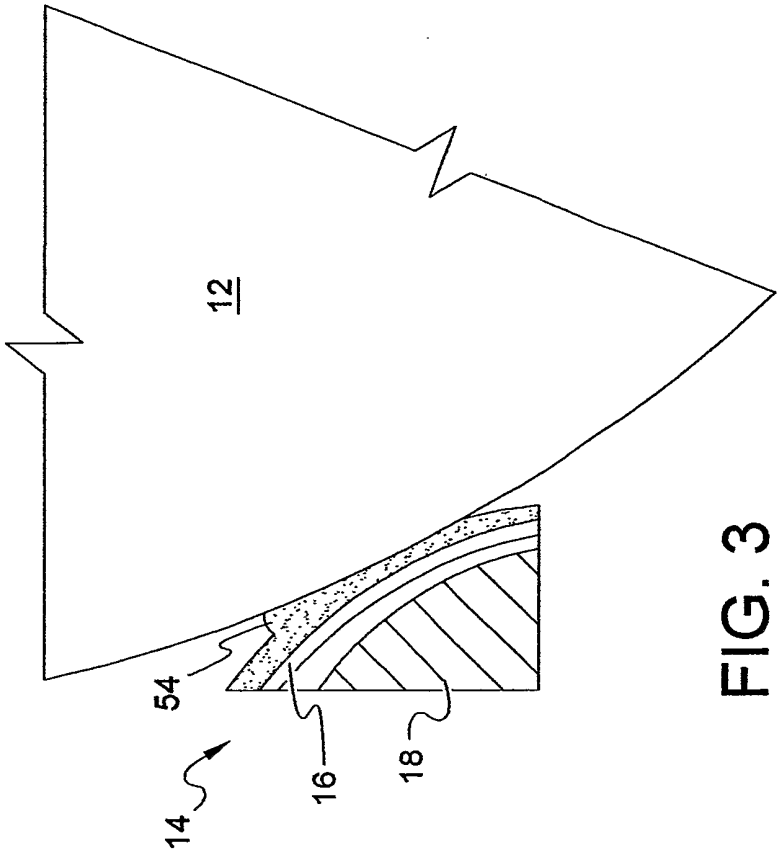


FIG. 3

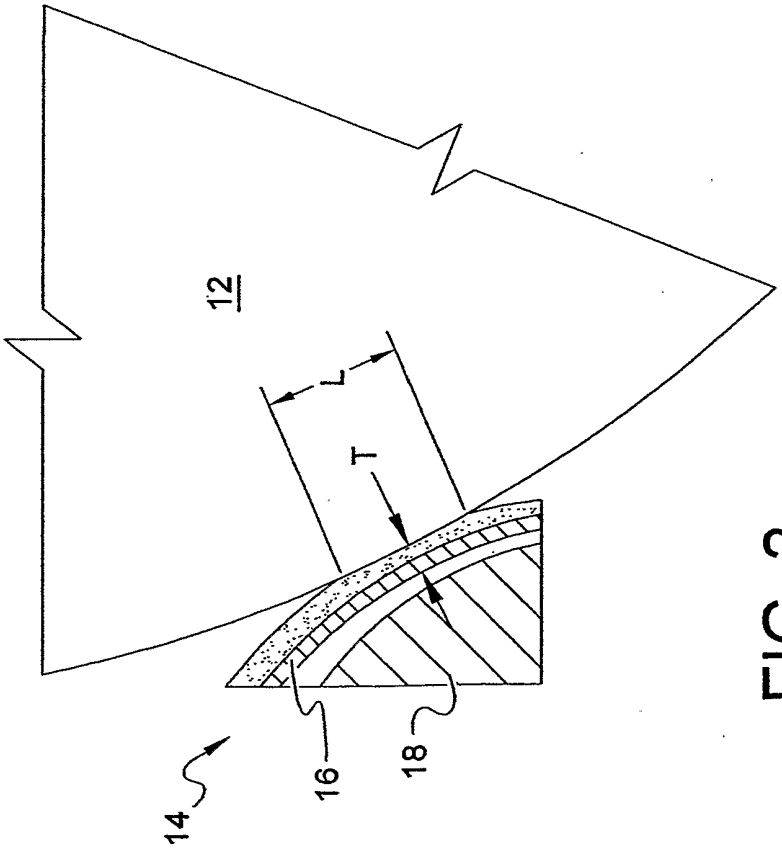


FIG. 2

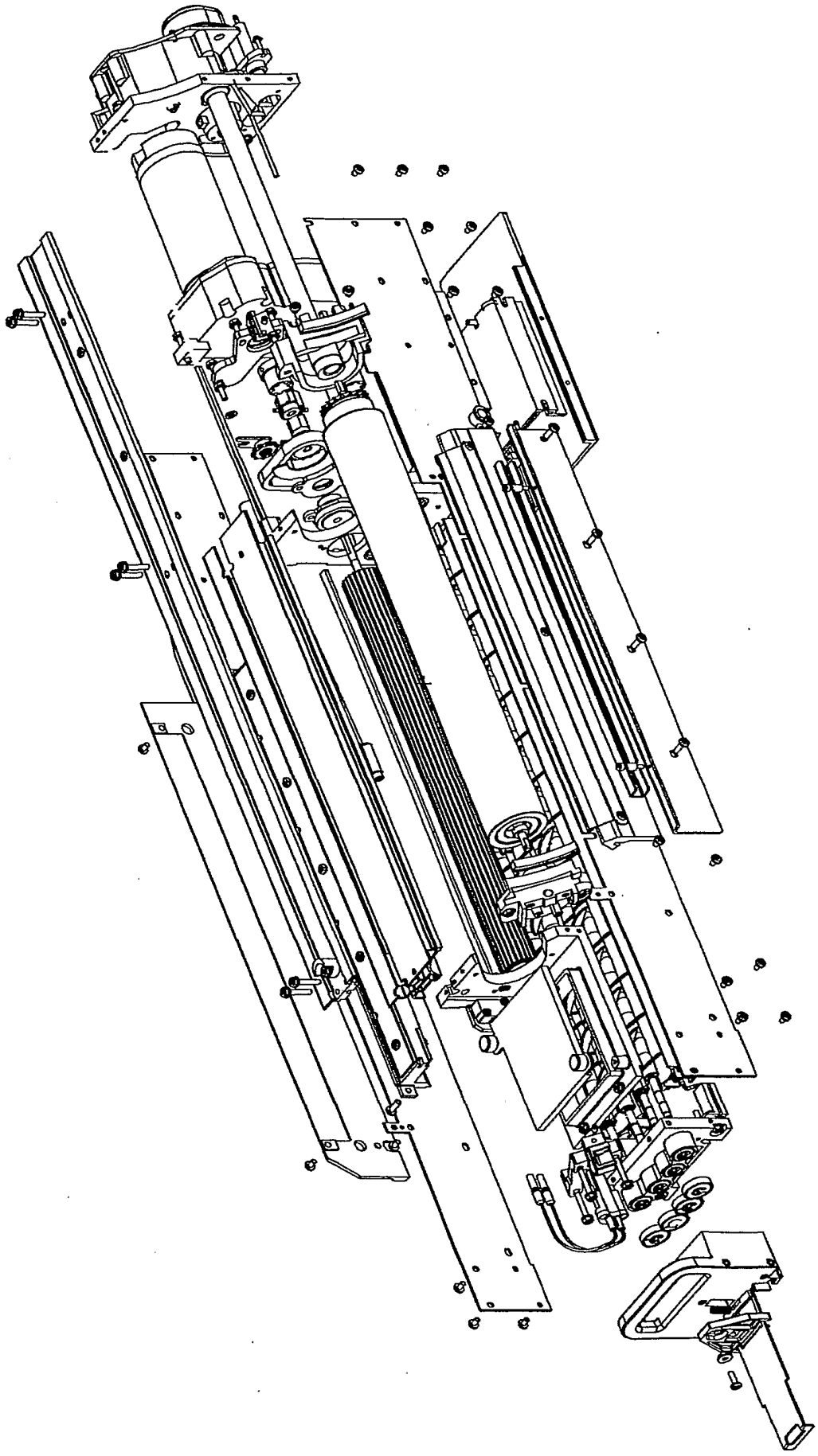


FIG. 4

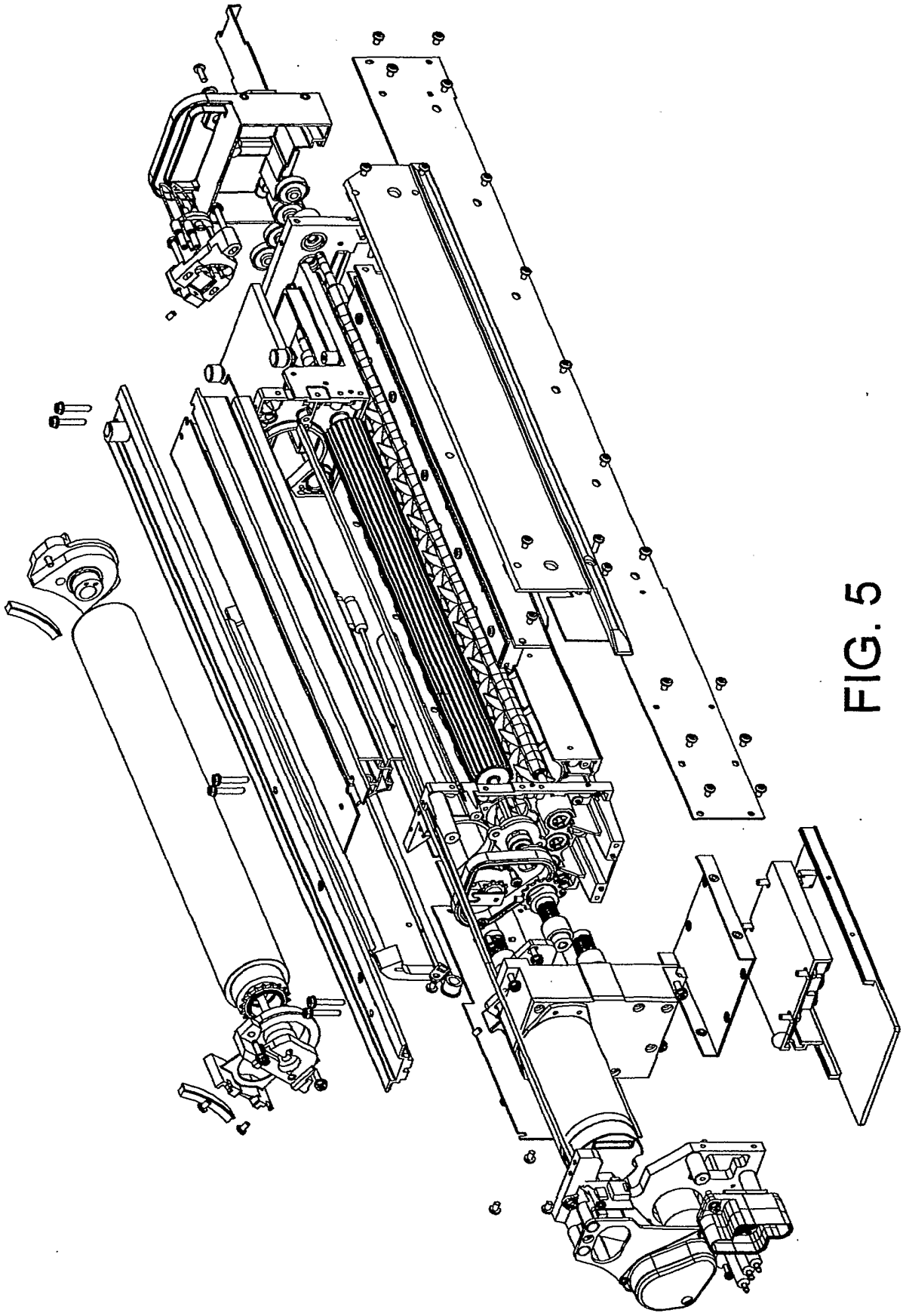


FIG. 5

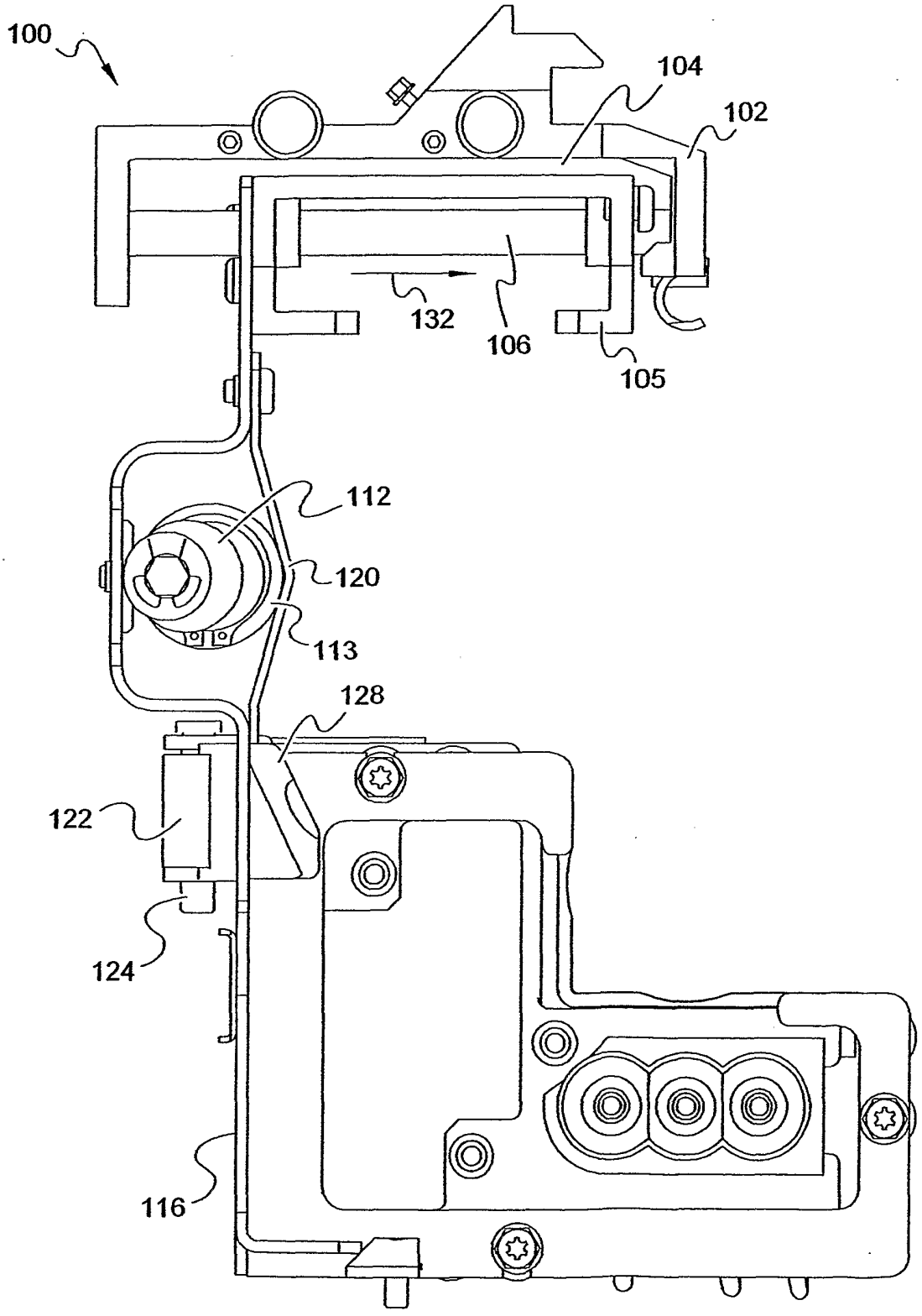
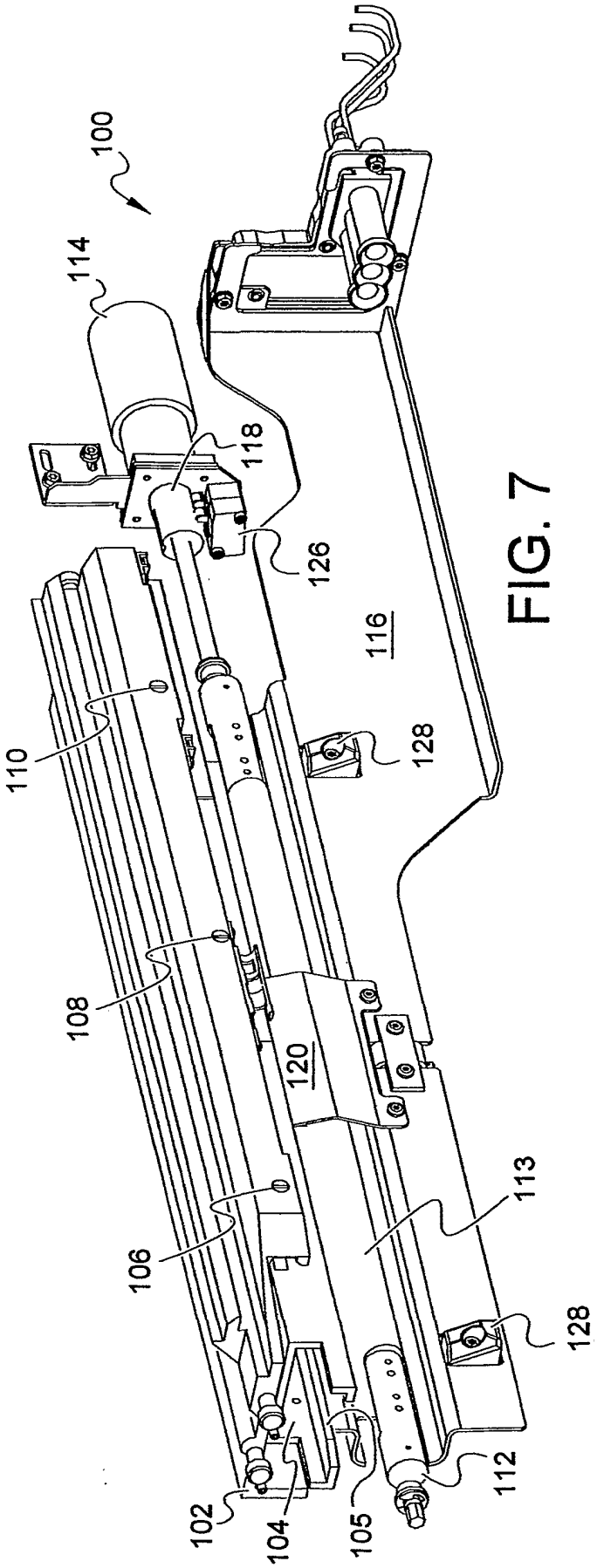


FIG. 6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105

FIG. 7

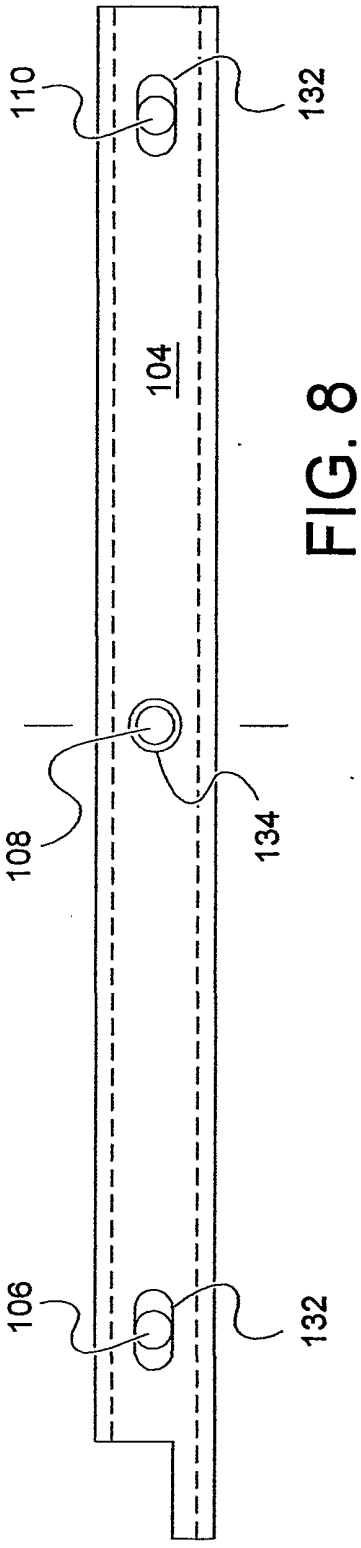
110
132
104
108
134
106
132

FIG. 8

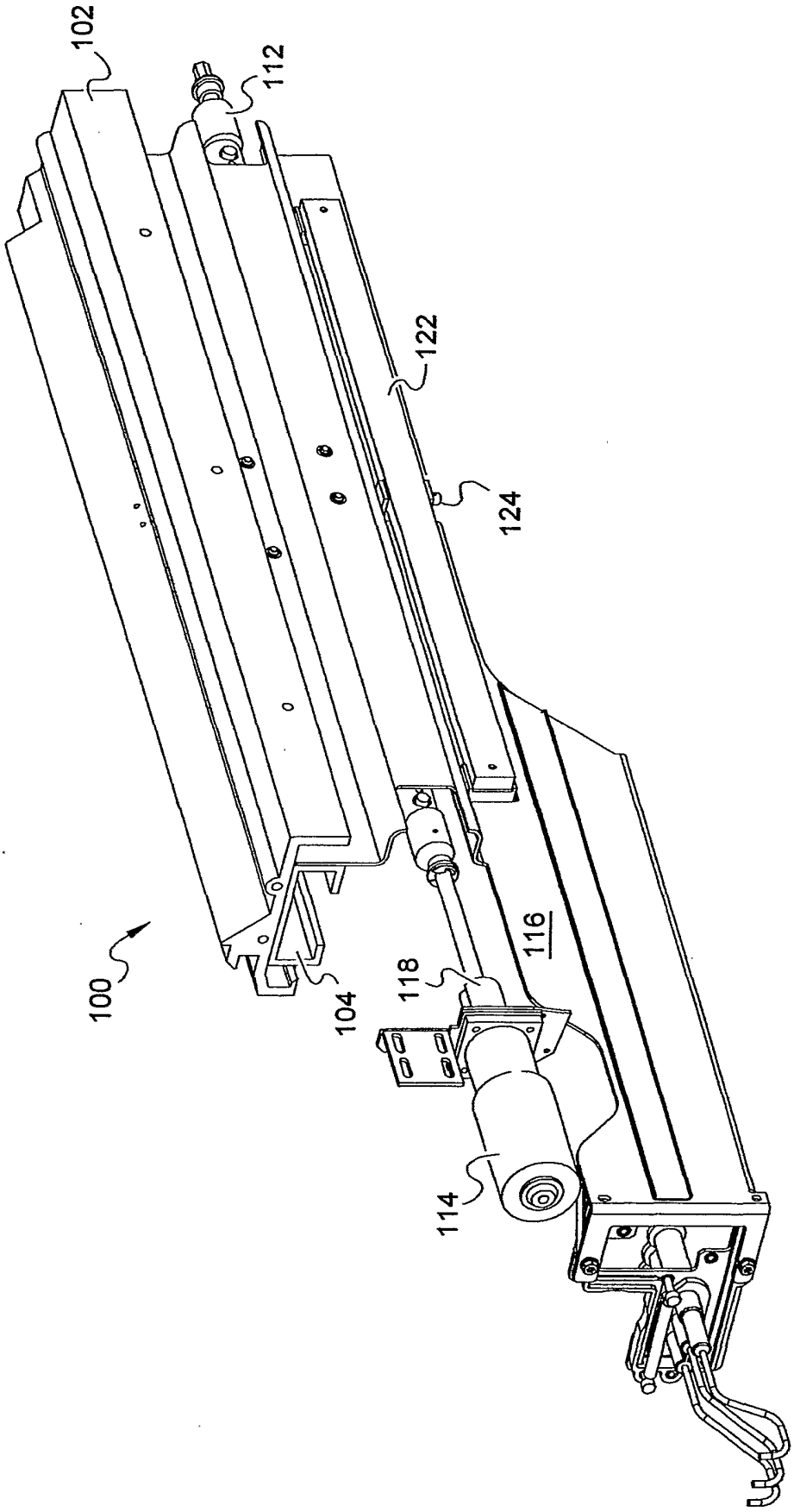

FIG. 9

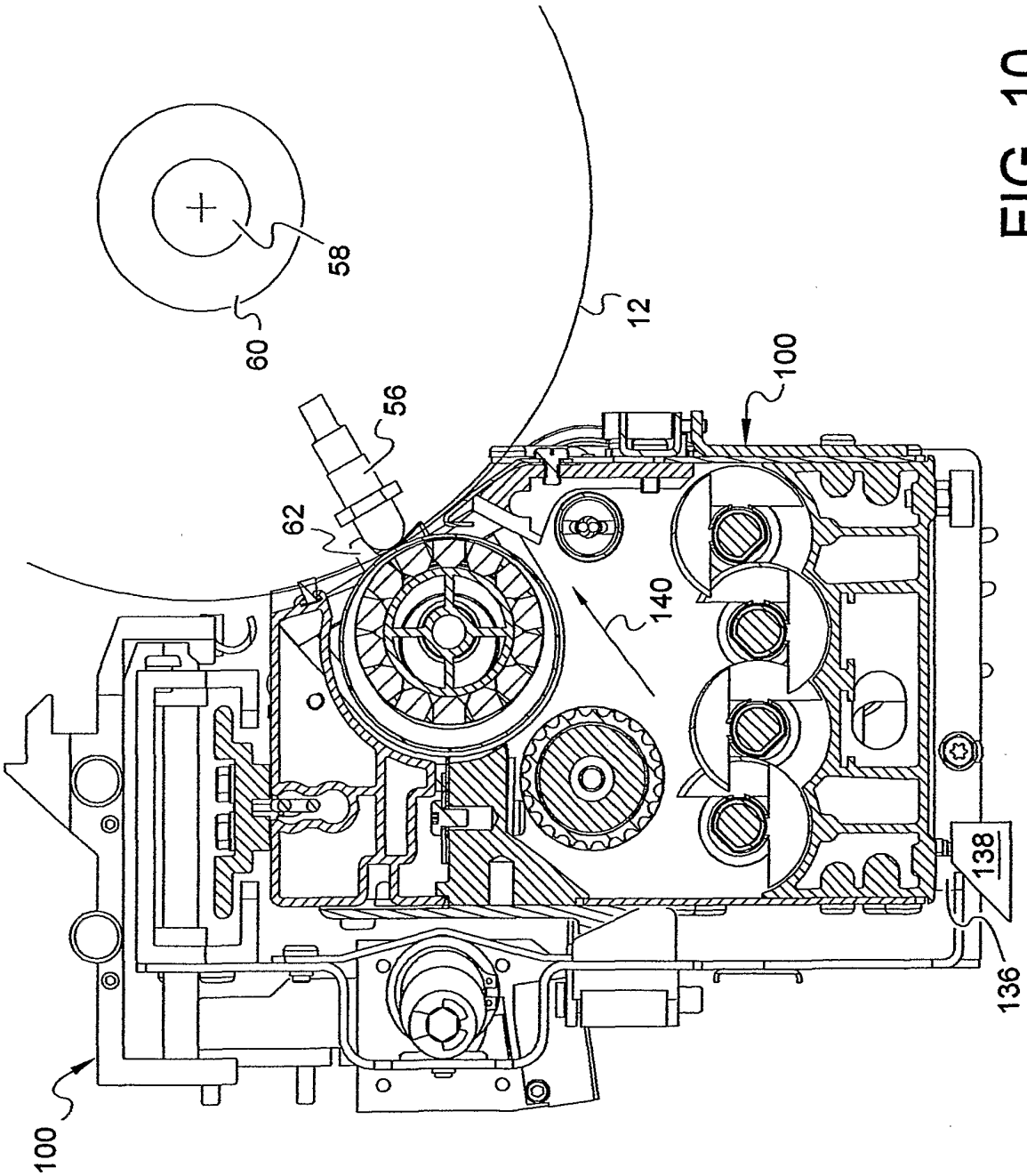

FIG. 10

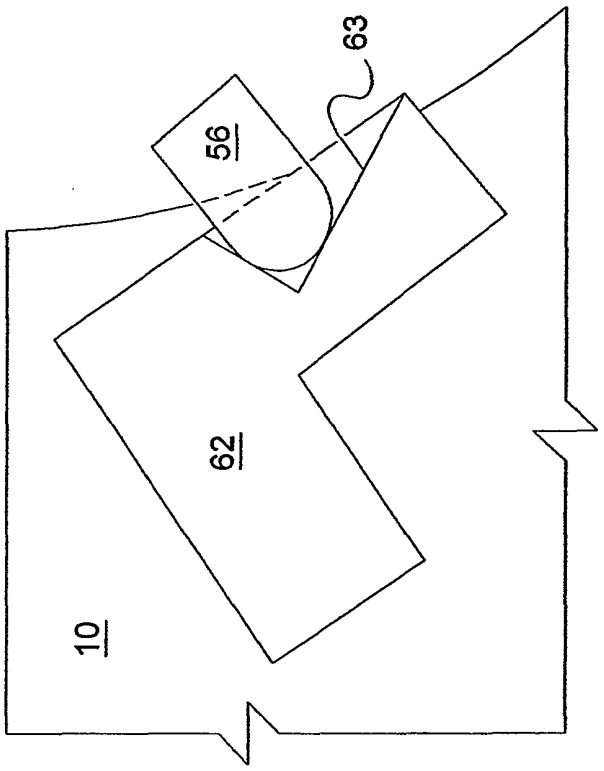

FIG. 12

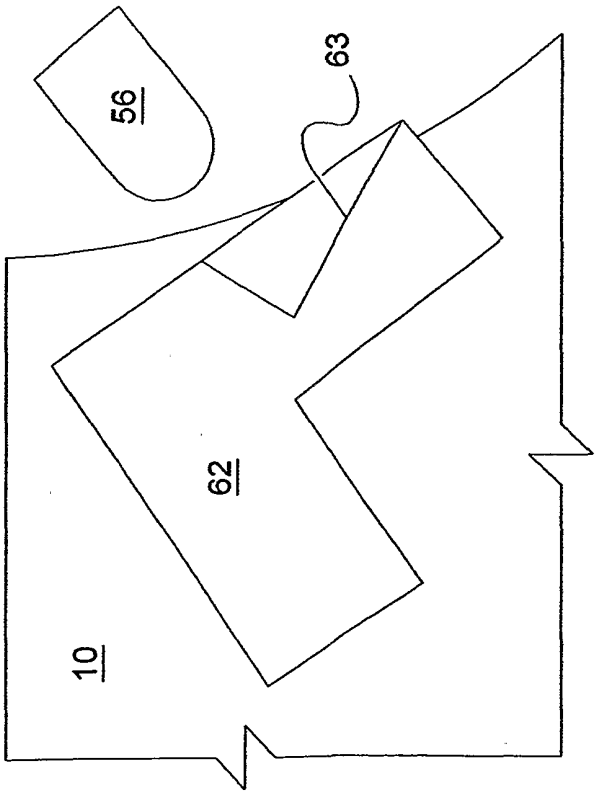

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/15689

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G03G 15/09
US CL :399/267, 274, 276; 430/113.31, 111.4, 122
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)

U.S. : 399/279, 280; 430/113.3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST, JPO, EPO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ------ Y	US 5,045,886 A (WEITZEL et al.) 03 September 1991 (03.09.1991), entire document.	1, 11-17 ---------- 2-8, 10, 18-25, 27-29
Y	US 5,606,404 A (HILBERT et al.) 25 February 1997 (25.02.1997), col. 3, lines 16-22.	4-8, 21-25
Y	US 4,546,060 A (MISKINIS et al.) 08 October 1985 (08.10.1985), col. 2, lines 19-27.	2, 18
Y	US 5,196,887 A (HILBERT et al.) 23 March 1993 (23.03.1993), col. 8, line 60 to col. 10, line 14.	3, 19
Y,P	US 6,070,037 A (SUGIHARA et al.) 30 May 2000 (30.05.2000), col. 11, lines 46-62.	10, 20

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
12 JULY 2001	28 AUG 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer SOPHIA S. CHEN Telephone No. (703) 308-7617

Form PCT/ISA/210 (second sheet) (July 1998)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/15689

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,585,328 A (MOSER et al.) 29 April 1986 (29.04.1986), col. 2, line 62 to col. 3, line 19.	27-29
A	US 4,473,029 A (FRITZ et al.) 25 September 1984 (25.09.1984), entire document.	1, 2, 17, 18