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CENTRAL DISTRICT OF CALIFORNIA
BY _____ DEPUTY

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Attorneys for Plaintiff: FBA HOLDING, INC.

UNITED STATES DISTRICT COURT

CENTRAL DISTRICT OF CALIFORNIA

FBA HOLDING, INC., Plaintiff, v. LEXMARK INTERNATIONAL, INC. Defendant.	Case No. CV13-1300 DDP-JEMx **COMPLAINT** **JURY TRIAL DEMANDED**

Plaintiff FBA Holding, Inc. ("FBA"), for its complaint against Defendant Lexmark International, Inc. ("Lexmark") alleges as follows:

I. NATURE OF THIS ACTION

1. This action arises under 28 U.S.C. §§ 1331, 1338, 2201, and 2202, and the United States Patent Laws at 35 U.S.C. §§ 1 *et seq.*

2. FBA brings this action seeking a declaration that FBA does not infringe any valid claim of the following U.S. Patents ("the Patents-in-Suit"). True and correct copies are attached as Exhibits 1-21.

Patent No.	Abbreviation	Title	Exhibit No.
5,337,032	("the '032 Patent")	Reduced Component Toner Cartridge	1
5,634,169	("the '169 Patent")	Multiple Function Encoder Wheel For Cartridges Utilized In An Electrophotographic Output Device	2
5,758,231	("the '231 Patent")	Venting Plug In Toner Cartridge	3
5,758,233	("the '233 Patent")	Toner Cartridge With Locating [Surfaces] On Photoconductor Shaft	4
5,768,661	("the '661 Patent")	Toner Cartridge With External Planar Installation Guides	5
5,802,432	("the '432 Patent")	Toner Cartridge with Housing and Pin Construction	6
5,875,378	("the '378 Patent")	Toner Cartridge With Hopper Exit Agitator	7
5,995,772	("the '772 Patent")	Imaging Apparatus Cartridge Including An Encoded Device	8

6,009,291	("the '291 Patent")	Control Of Photosensitive Roller Movement	9
6,078,771	("the '771 Patent")	Low Friction Doctor Blade	10
6,397,015	("the '015 Patent")	Encoded Device Having Positioned Indicia For Use With A Toner Cartridge	11
6,459,876	("the '876 Patent")	Toner Cartridge	12
6,487,383	("the '383 Patent")	Dynamic End-Seal For Toner Development Unit	13
6,496,662	("the '662 Patent")	Optical Toner Low Sensor	14
6,678,489	("the '489 Patent")	Two Part Cartridges With Force Biasing By Printer	15
6,816,692	("the '692 Patent")	Support Assembly For Roller Including Roller Body And Support Shaft	16
6,871,031	("the '031 Patent")	Coupling Mechanism For A Two Piece Printer Cartridge	17
6,879,792	("the '792 Patent")	Two Part Cartridges With Force Biasing By Printer	18
7,139,510	("the '510 Patent")	Two Part Cartridges With Force Biasing By Printer	19
7,233,760	("the '760 Patent")	Method and Device for Doctor Blade Retention	20
7,305,204	("the '204 Patent")	Two Part Cartridges With Force Biasing By Printer	21

II. THE PARTIES

3. Plaintiff FBA Holding, Inc. is a Florida corporation having its principal place of business at 200 Fentress Boulevard, Suite B, Daytona Beach, FL 32114. FBA Holding, Inc. does business in Florida and California under seven DBAs, which are: Core Recovery Company, Unitone Imaging Supply, Unitone Imaging Group, Martek Supply Source, Imcopex America, Velox Systems, Inc., and International Digital Solutions.

4. Core Recovery Company acquires and recycles empty toner and inkjet cartridges for use in remanufacturing. It is located at 9035 Canoga Avenue, Canoga Park, CA 91304.

5. Unitone Imaging Supply remanufactures and distributes cartridges for printers for wholesale customers. It is also located at 9035 Canoga Avenue, Canoga Park, CA 91304.

6. Unitone Imaging Group directly sells printer cartridges to retail customers. It is located at 9035 Canoga Avenue, Canoga Park, CA 91304.

7. Martek Supply Source is a distributor of office products, including supplies for copiers, facsimiles, printers, point of sale products, and furnitures. It is located in Florida at 4270 Dow Road, Suite 209, Melbourne, FL 3294.

8. Imcopex America is also a distributor of office products, including supplies for copiers, facsimiles, and printers. It is located in Florida at 4270 Dow Road, Suite 209, Melbourne, FL 3294.

9. Velox Systems, Inc. is an authorized Sharp office equipment distributor also located at 4270 Dow Road, Suite 213, Melbourne, FL 3294.

10. International Digital Solutions is a distributor of office products, including supplies for copiers, facsimiles, and printers. It is located in Florida at 1620 NW 82nd Avenue, Doral, FL 33126.

11. On information and belief, Lexmark is a Delaware corporation with its principal place of business at 740 New Circle Rd., Dept. 968, Lexington, KY 40511.

12. Lexmark is the assignee and the owner of each of the Patents-in-Suit.

III. JURISDICTION AND VENUE

13. This declaratory judgment action arises under the patent laws of the United States, 35 U.S.C. § 1 *et seq.*, and the Declaratory Judgment Act, 28 U.S.C. §§ 2201 and 2202.

14. This Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a) because this is a civil action arising under the patent laws of the United States.

15. This Court has personal jurisdiction over Lexmark because Lexmark is engaged in substantial and continuous business activities in this judicial district and because Lexmark, its agent and affiliates, have purposefully availed themselves of this forum by engaging in enforcement and licensing efforts related to the Patents-in-Suit, as well as by making express allegation of infringement against Plaintiff with respect to the Patents-in-Suit.

16. Venue is proper in this District under 28 U.S.C. §§ 1391 and 1400.

17. There is an actual and justiciable controversy between FBA and Lexmark. On August 20, 2010, Lexmark filed a patent infringement action against Ink Technologies Printer Supplies, LLC and several other parties, including John Does 1-20, in the United States District Court for the Southern District of Ohio (hereinafter the "Ohio Action"). The case number is 10-CV-564-MRB and is still pending. The lawsuit does not as yet name FBA Holding, Inc. or any of its DBAs as a defendant.

18. On July 26, 2012, Lexmark served a subpoena on Core Recovery Company requesting information that Lexmark purports to be relevant to Lexmark's infringement claims asserted in the Ohio Action. Lexmark's subpoena sought, among other things, information about Core Recovery Company's purchases, acquisitions, importations, and sales of Lexmark cartridges.

19. On December 18, 2012, Lexmark served subpoenas on Martek Supply Source and Imcopex America, seeking the same information as from Core Recovery. On January 17, 2013, Lexmark's attorneys requested from FBA Holding, Inc.'s attorneys the same information from Core Recovery Company, Unitone Imaging Supply, Unitone Imaging Group, Martek Supply Source, Imcopex America, Velox Systems, Inc., and International Digital Solutions.

20. On January 29, 2013, Lexmark's attorneys followed up via e-mail on the requested information "to enable Lexmark to make a final demand offer regarding your client's acquisitions and distribution of infringing Lexmark cartridges." Lexmark's attorneys further stated in the same e-mail: "[w]e are filing the Amended Complaint in the Southern District of Ohio action in the coming weeks, and will name Core Recovery as a defendant if this matter is not settled before then." Lexmark's attorneys made a similar threat in their February 19, 2013 email to FBA Holding, Inc.' attorneys, indicating "we will name Core Recovery and Martek as defendants if this issue is not resolved before then. To that end, we are amendable to allowing Core Recovery and Martek until Tuesday, February 26, to respond to Lexmark's settlement offer."

21. FBA disputes that its products infringe, directly or indirectly, literally, contributorily, by way of inducement, or under the doctrine of equivalents, any valid claim of any of the Patents-in-Suit. FBA also asserts that any patent rights that Lexmark may have with respect to its products arising from the Patents-in-Suit have been exhausted. Accordingly, an immediate and substantial controversy

exists in this District between FBA and Lexmark with respect to whether any FBA product infringes any valid claim of the Patents-in-Suit.

IV. COUNT I

(Declaratory Judgment of Non-Infringement of the Patents-in-Suit)

22. FBA incorporates and realleges the preceding paragraphs as if set forth fully herein.

23. Lexmark has asserted that FBA's products infringe each of the Patents-in-Suit.

24. FBA has not and does not infringe any valid claim of any of the Paatents-in-Suit, directly or indirectly, literally, contributorily, by way of inducement, or under the doctrine of equivalents. FBA also asserts that any patent rights that Lexmark may have with respect to its products arising from the Patents-in-Suit have been exhausted.

25. An actual and justiciable controversy exists between FBA and Lexmark regarding the asserted infringement of the Patents-in-Suit.

26. A judicial declaration of non-infringement of the Patents-in-Suit is necessary and appropriate to resolve this controversy.

27. Pursuant to the Federal Declaratory Judgment Act, 28 U.S.C. § 2201, *et seq.*, FBA is entitled to judgment from this Court that FBA does not infringe any valid claim of any of Patents-in-Suit.

V. DEMAND FOR JURY TRIAL

Pursuant to Federal Rule of Civil Procedure 38(b), FBA hereby demands a trial by jury of all issues so triable in this action.

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VI. PRAYER FOR RELIEF

WHEREFORE, FBA respectfully requests that this Court enter judgment in its favor as follows:

a. declaring that FBA has not, and does not, infringe any valid claim of the '032, '169, '231, '233, '661, '432, '378, '772, '291, '771, '015, '876, '383, '662, '489, '692, '031, '792, '510, '760, or '204 Patents, directly or indirectly, literally, or under the doctrine of equivalents;

b. declaring that FBA has not induced, and does not induce, infringement of any valid claim of the '032, '169, '231, '233, '661, '432, '378, '772, '291, '771, '015, '876, '383, '662, '489, '692, '031, '792, '510, '760, or '204 Patents;

c. declaring that FBA has not contributorily infringed, and does not contributorily infringe, any valid claim of the '032, '169, '231, '233, '661, '432, '378, '772, '291, '771, '015, '876, '383, '662, '489, '692, '031, '792, '510, '760, or '204 Patents;

d. declaring that any patent rights that Lexmark may have with respect to its products arising from the Patents-in-Suit have been exhausted;

e. enjoining Lexmark, its assigns, and all those in privity therewith from asserting the '032, '169, '231, '233, '661, '432, '378, '772, '291, '771, '015, '876, '383, '662, '489, '692, '031, '792, '510, '760, and '204 Patents against FBA or any of its customers or suppliers;

f. declaring this case to be exceptional pursuant to 35 U.S.C. § 285, and awarding FBA its reasonable attorneys' fees and costs to the fullest extent permitted by law; and

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f. awarding FBA such other and further relief as the Court may deem just and proper.

Dated: February 21, 2013

By: /s/ William E. Thomson

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Attorneys for Plaintiff:
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EXHIBIT 1

US005337032A

United States Patent [19]

Baker et al.

[11] Patent Number: 5,337,032

[45] Date of Patent: Aug. 9, 1994

[54] **REDUCED COMPONENT TONER CARTRIDGE**

[75] Inventors: **Ronald W. Baker**, Versailles; **Robert L. Burdick**, Nicholasville; **Martin V. DiGirolamo**, Lexington; **Paul D. Horrall**, Lexington; **David L. Merrifield**, Lexington; **James J. Molloy**, Lexington; **Earl D. Ward, II**, Lexington; **Bernard L. Wilzbach**, Lexington, all of Ky.

[73] Assignee: **Lexmark International, Inc.**, Greenwich, Conn.

[21] Appl. No.: **23,459**

[22] Filed: **Feb. 26, 1993**

[51] **Int. Cl.**[5] **G03G 15/06**; G03G 15/08; G03G 21/00

[52] **U.S. Cl.** **355/260**; 355/200

[58] **Field of Search** 355/245, 259, 260, 200

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,012,289	4/1991	Aldrich et al.	355/260
5,085,171	2/1992	Aulick et al.	118/653
5,086,728	2/1992	Kinoshita	118/653
5,101,237	3/1992	Molloy	355/245
5,183,964	2/1993	Stelter et al.	355/259 X
5,220,129	6/1993	Nishio et al.	355/259 X
5,220,383	6/1993	Enoki et al.	355/259 X
5,239,344	8/1993	Enoki et al.	355/259
5,245,391	9/1993	Suzuki et al.	355/259 X

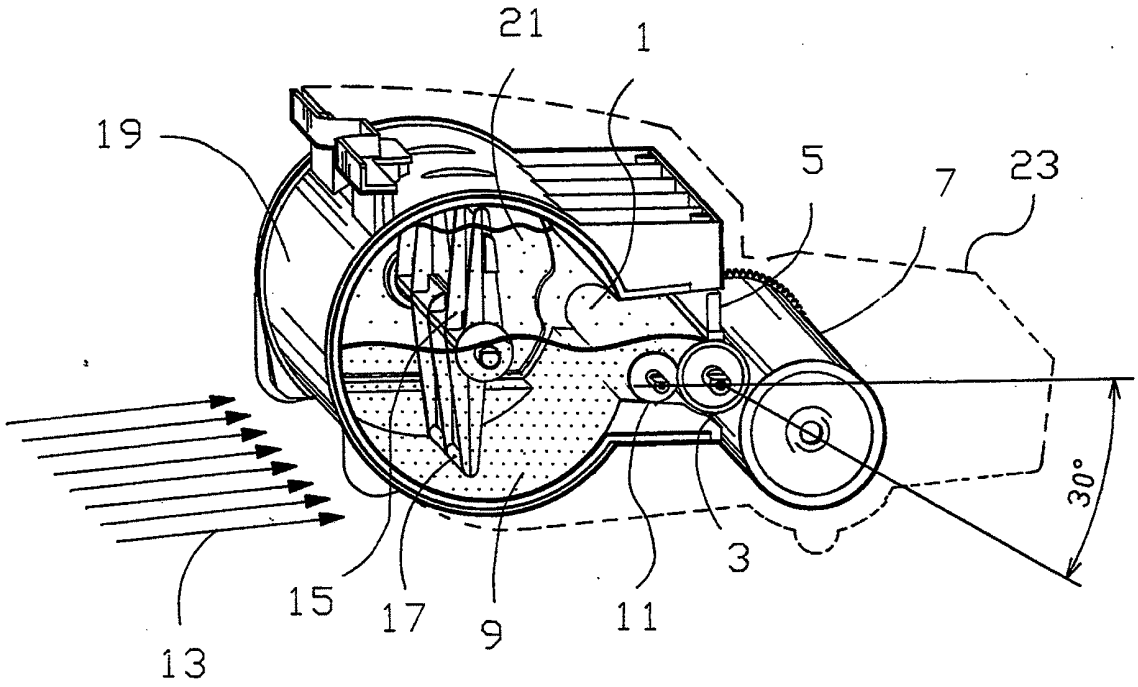
Primary Examiner—Fred L. Braun

Attorney, Agent, or Firm—John A. Brady

[57] **ABSTRACT**

A toner cartridge having no toner pump with the toner adding roller (**11**) positioned horizontal to the developer roller (**3**), the toner chamber (**9**) located predominantly below the developer roller, the photoconductive drum located 120 degrees from the top of tile developer roller, and the doctor blade (**5**) is located near the top. The cartridge has a minimal number of operational parts.

9 Claims, 1 Drawing Sheet



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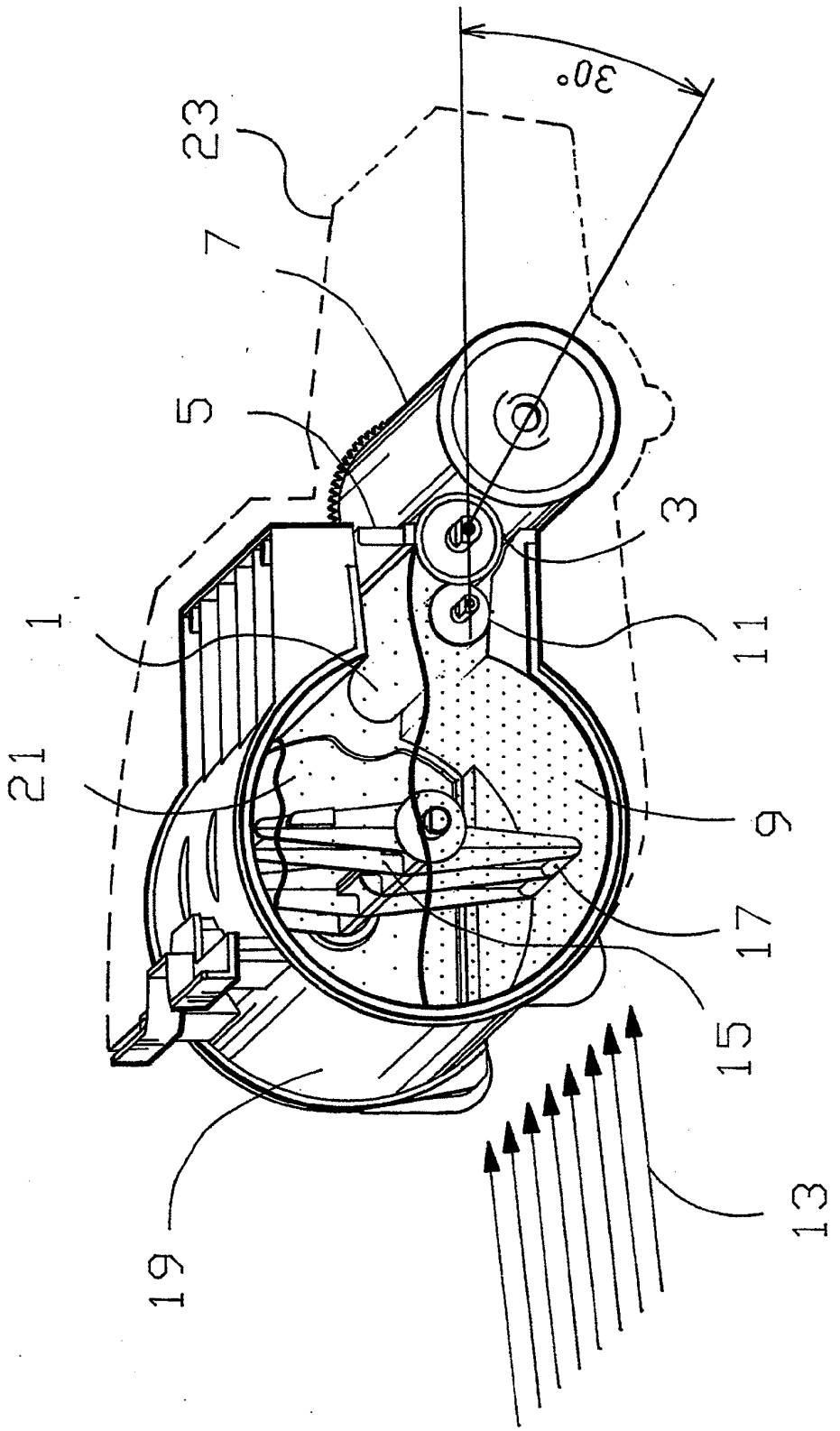

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REDUCED COMPONENT TONER CARTRIDGE

TECHNICAL FIELD

This invention relates to electrophotographic development and, more particularly, relates to a toner cartridge having no toner pump and associated structure.

BACKGROUND OF THE INVENTION

The toner pump is described in U.S. Pat. No. 5,012,289 to Aldrich et al. It is a device which meters toner from a chamber above the developer station. The developer station employs a toner adding roller, which is at a predetermined electrical potential higher than that of the developer roller. The toner adding roller rotates in a bed of toner in contact with the developer roller and thereby applies toner onto tile surface of the developer roller charged primarily to the same electrical sign as that of both the toner adding roller and the developer roller. The developer roller then rotates past a doctor blade which is charged to a potential higher than the developer roller and rejects much toner having the other potential (termed wrong sign toner). Such a system does not operate reliably under the pressures of a high column of toner which can reach the doctor blade-developer roller nip. The toner pump is employed to limit the toner head reaching the doctor blade-developer roller nip.

Elimination of the toner pump reduces manufacturing and material cost and unwanted pressure variations during operation caused by the operation of the pump, which have been remedied by a vent between both sides of the toner pump and by close tolerances. A two phase toner pump has also been developed to remedy this effect and is the subject of U.S. Pat. No. 5,101,237 to Molloy.

Elimination of the toner pump reduces variations in torques, since the other rollers are driven off the same power source as the toner pump. Reduction in such fluctuations can reduce jitter or, alternatively, reduces costs in powering the system adequately to avoid jitter.

U.S. Pat. No. 5,086,728 to Kinoshita shows a toner applying roller horizontal to a developer roller, but is not otherwise closely similar to this invention.

DISCLOSURE OF THE INVENTION

In the toner cartridge of this invention the primary toner chamber is located lower than the developer station. This chamber has a paddle which rotates constantly during operation, as was true with the cartridge with toner pump. In this cartridge, the paddle operation brings sufficient toner to the developing station even as the toner supply drops under the developing station. In the preferred embodiment a top half of the toner chamber exists to permit the paddle to smoothly rotate and to constrain airborne toner. However, the maximum filling of the toner chamber is to roughly the nip between the doctor blade and the developer roller.

BRIEF DESCRIPTION OF THE DRAWING

The details of this invention will be described in connection with the accompanying drawing in which the figure is an illustrative, side-perspective, cross sectioned view of the preferred cartridge in accordance with this invention.

BEST MODE FOR CARRYING OUT THE INVENTION

As seen in the drawing, the level of dry, powder toner **1** is not substantially above the nip of the developer roller **3** and the doctor blade **5**. Doctor blade **5** contacts developer roller **3** substantially at the top of roller **3**. In the drawing the loading of toner **1** is the maximum permitted in normal operation, and, of course, during use the amount of toner **1** will diminish. Developer roller **3** contacts photoconductive drum **7** at an angle of 30 degrees from the horizontal, which is 120 degrees from the location of contact of doctor blade **5** with roller **3**. Since the toner chamber **9** occupies an area predominantly below roller **3**, space is conserved by locating photoconductive drum **7** also predominantly below roller **3** (the foregoing cartridge with toner pump had a 13 degree angle).

The toner adder roller **11** is located generally horizontal with the developer roller **3** (i.e., with its nip control at 90 degrees from the top of roller **3**). This position blocks excess toner from the chamber **9**, and is important to reliable operation. With toner adder roller **11** physically between developer roller **3** and chamber **9**, chamber **9** can extend downward more than twice the diameter of toner adder roller **11** as shown. Photoconductive drum **7** is located on the side of developer roller **3** opposite the location of toner adder roller **11**. The bottom level of chamber **9** is determined by tile toner volume requirements. The paper path **13** must be lowered to clear chamber **9**.

During operation, paddle **15** continually moves toner in chamber **9** by blades **17** at the outer periphery of chamber **9**. The developer unit housing **19** defines chamber **9** and a corresponding upper chamber **21**, to form a closed chamber of chamber **9** and chamber **21** of circular configuration in which paddle **15** turns freely. The upper chamber **21** is never filled with toner **1** and exists to capture flying toner. The lack of toner in this region is to prevent excessive toner pressure.

Operation is inherent and characterized by a minimal number of operational parts in the cartridge. Paddle **15** rotates during all operation in a simple circle, and is therefore a minimal source of torque fluctuations. Toner adder roller **11** and developer roller **3** are electrically charged and rotate in the manner of the previous cartridge having a toner pump. Doctor blade **5** is preferably the low-cost, compliant doctor blade described in U.S. Pat. No. 5,085,171 to Aulick et al. Doctor blade **5** is electrically charged but not rotated or otherwise moved directly.

It will be understood that the elements described exist across the width of the cartridge, as shown in perspective in the drawing. It will also be understood that the photoconductive drum **7** is a part of the cartridge, the elements being unified by an outer housing **23**, shown in phantom outline, as is now conventional. Toner is essentially the same as that in the cartridge with toner pump now widely distributed by the assignee of this invention for the IBM LaserPrinters 4019 and 4029, and as summarized in the foregoing U.S. Pat. No. 5,012,289.

What is claimed is:

1. An electrophotographic imaging toner cartridge comprising a developer roller, a doctor blade in contact with said developer roller near the top of said developer roller, a toner applying roller in contact with said developer roller and located on substantially the same horizontal plane as said developer roller, a chamber for

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electrophotographic toner positioned predominantly below said developer roller and on the side of said toner applying roller away from said developer roller, said chamber extending downward from the top of said toner applying roller more than twice the diameter of said toner applying roller.

2. The toner cartridge as in claim 1 also comprising a photoconductive roller in contact with said developer roller, said photoconductive roller being positioned substantially below said developer roller.

3. The toner cartridge as in claim 2 containing dry toner in an amount to fill said chamber up to about the level of the contact of said doctor blade and said developer roller.

4. The toner cartridge as in claim 2 containing dry toner in an amount less than an amount to fill said chamber up to about the level of the contact of said doctor blade and said developer roller.

5. The toner cartridge as in claim 1 containing dry toner in an amount to fill said chamber up to about the level of contact of said doctor blade and said developer roller.

6. The toner cartridge as in claim 1 containing dry toner in an amount less than an amount to fill said chamber up to about the level of the contact of said doctor blade and said developer roller.

7. An electrophotographic imaging toner cartridge comprising a developer roller, a doctor blade in contact with said developer roller near the top of said developer roller, a toner applying roller in contact with said developer roller, the location of said contact being 90 degrees from the location of said contact of said doctor blade, a photoconductive roller in nip relationship with said developer roller, the location of said nip relationship being substantially 120 degrees from the location of said contact of said doctor blade on the side of said developer roller opposite the location of said toner applying roller, and a chamber for electrophotographic toner positioned on the side of said toner applying roller opposite said developer roller and having a predominate portion below said developer roller said chamber extending downward from the top of said toner applying roller more than twice the diameter of said toner applying roller.

8. The toner cartridge as in claim 7 contained dry toner in an amount to fill said chamber up to about the level of contact of said doctor blade and said developer roller.

9. The toner cartridge as in claim 7 containing dry toner in an amount less than an amount to fill said chamber up to about the level of the contact of said doctor blade and said developer roller.

* * * * *

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EXHIBIT 2

US005634169A

United States Patent [19]

Barry et al.

[11] Patent Number: 5,634,169

[45] Date of Patent: May 27, 1997

[54] **MULTIPLE FUNCTION ENCODER WHEEL FOR CARTRIDGES UTILIZED IN AN ELECTROPHOTOGRAPHIC OUTPUT DEVICE**

[75] Inventors: **Raymond J. Barry**, Lexington; **Steven A. Curry**, Nicholasville; **Benjamin K. Newman**; **Gregory L. Ream**, both of Lexington; **Earl D. Ward, II**, Richmond; **Phillip B. Wright**, Lexington, all of Ky.

[73] Assignee: **Lexmark International, Inc.**, Lexington, Ky.

[21] Appl. No.: **602,648**

[22] Filed: **Feb. 16, 1996**

[51] **Int. Cl.**[6] **G03G 15/08**; G03G 15/00

[52] **U.S. Cl.** **399/12**; 399/27; 235/461

[58] **Field of Search** 355/260, 200, 355/206, 208, 203; 222/DIG. 1, 160; 414/411; 235/461; 340/615, 612, 603–617; 73/862.328, 862.329, 862.424, 862.425, 862.426

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4,592,642	6/1986	Imaizumi et al.	355/3 DD
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4,711,561	12/1987	Tsuruoka	355/3 R
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5,099,278	3/1992	Sato	355/200
5,115,275	5/1992	Suzuki	355/245
5,184,181	2/1993	Kurando et al.	355/260
5,194,896	3/1993	Buch et al.	355/212
5,208,631	5/1993	Jacobs et al.	355/204
5,216,462	6/1993	Nakajima et al.	355/203
5,241,525	8/1993	Taylor	369/70
5,257,077	10/1993	Peters, Jr. et al.	355/260
5,287,151	2/1994	Sugiyama	355/260
5,289,242	2/1994	Christensen et al.	355/260
5,331,388	7/1994	Marotta et al.	355/260
5,349,377	9/1994	Gilliland et al.	346/153.1
5,355,199	10/1994	Bray	355/245
5,365,312	11/1994	Hillmann et al.	355/206
5,392,102	2/1995	Toyoizumi et al.	355/245
5,436,704	7/1995	Moon	355/245

FOREIGN PATENT DOCUMENTS

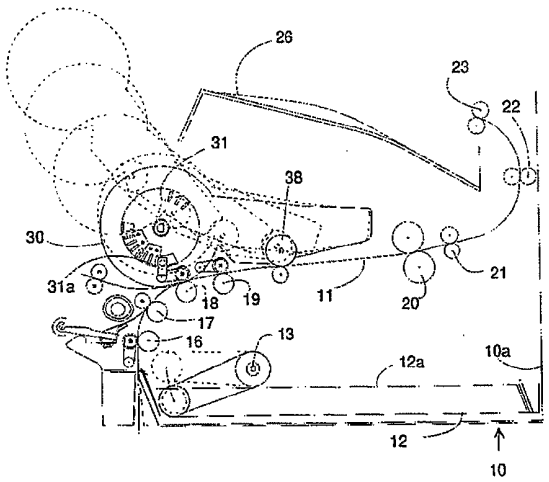
62-86382 4/1987 Japan .

Primary Examiner—Joan H. Pendegrass
Assistant Examiner—Quana Grainger
Attorney, Agent, or Firm—Ronald K. Aust

[57] **ABSTRACT**

Disclosed is a cartridge having an encoder wheel thereon for encoding EP supply cartridge characteristic information for an electrophotographic machine, the cartridge comprising, a sump for carrying an initial amount of toner. A shaft is mounted for rotation in said sump, and an agitator or paddle is mounted thereon in such a manner that when the shaft rotates, the paddle rotates into, through and out of engagement with toner carried by the sump. A single encoder wheel is mounted on the shaft, external of the sump, the encoder wheel positioned for proximate mating coaction with a coded wheel reader when the cartridge is mounted in position in the electrophotographic machine. A drive means, and a variable torque flexible coupling connects the drive means to the shaft to effect rotation thereof. The encoder wheel is configured for indicating, in conjunction with said coded wheel reader, a component of resistance to paddle movement through the portion of said sump having toner therein to give an indication of the amount of toner remaining in said sump. Other portions of the wheel, in a portion thereof which confronts the reader during a substantially constant velocity of rotation thereof, carries additional characteristic information of the cartridge to permit proper operation of the machine as well as increased efficiency of operation thereof.

42 Claims, 10 Drawing Sheets



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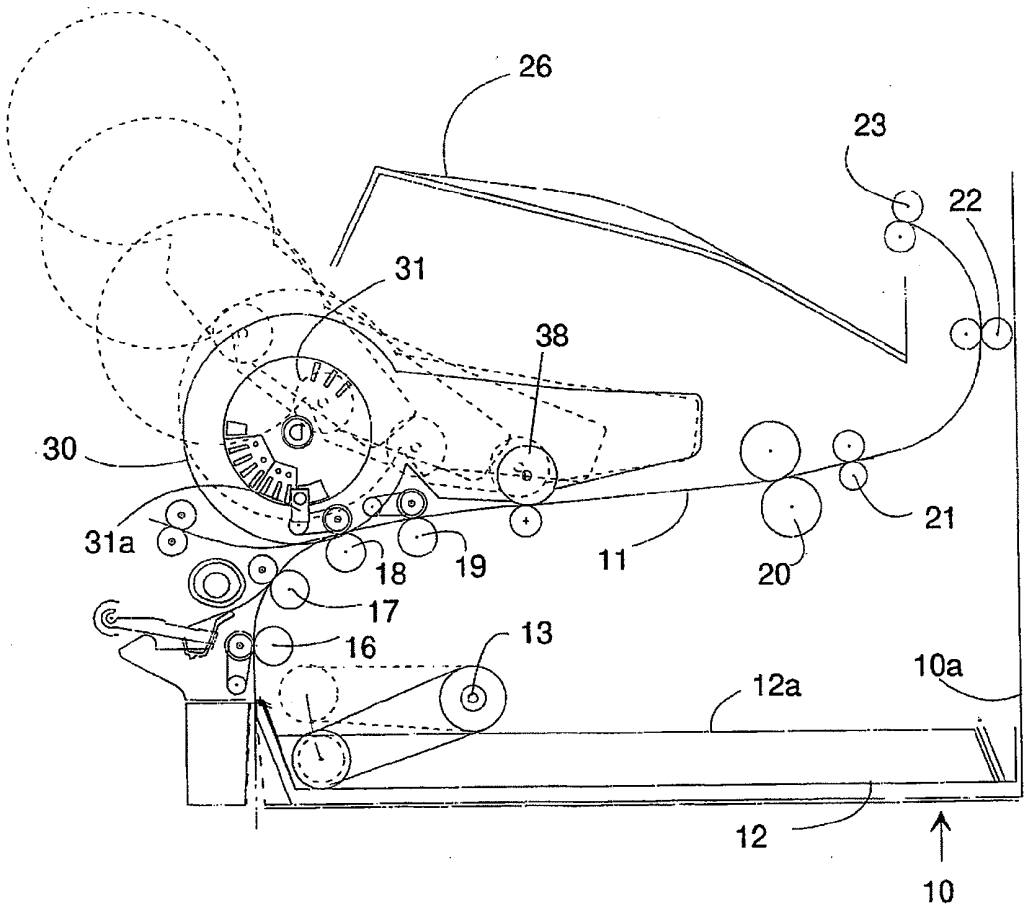

Fig. 1

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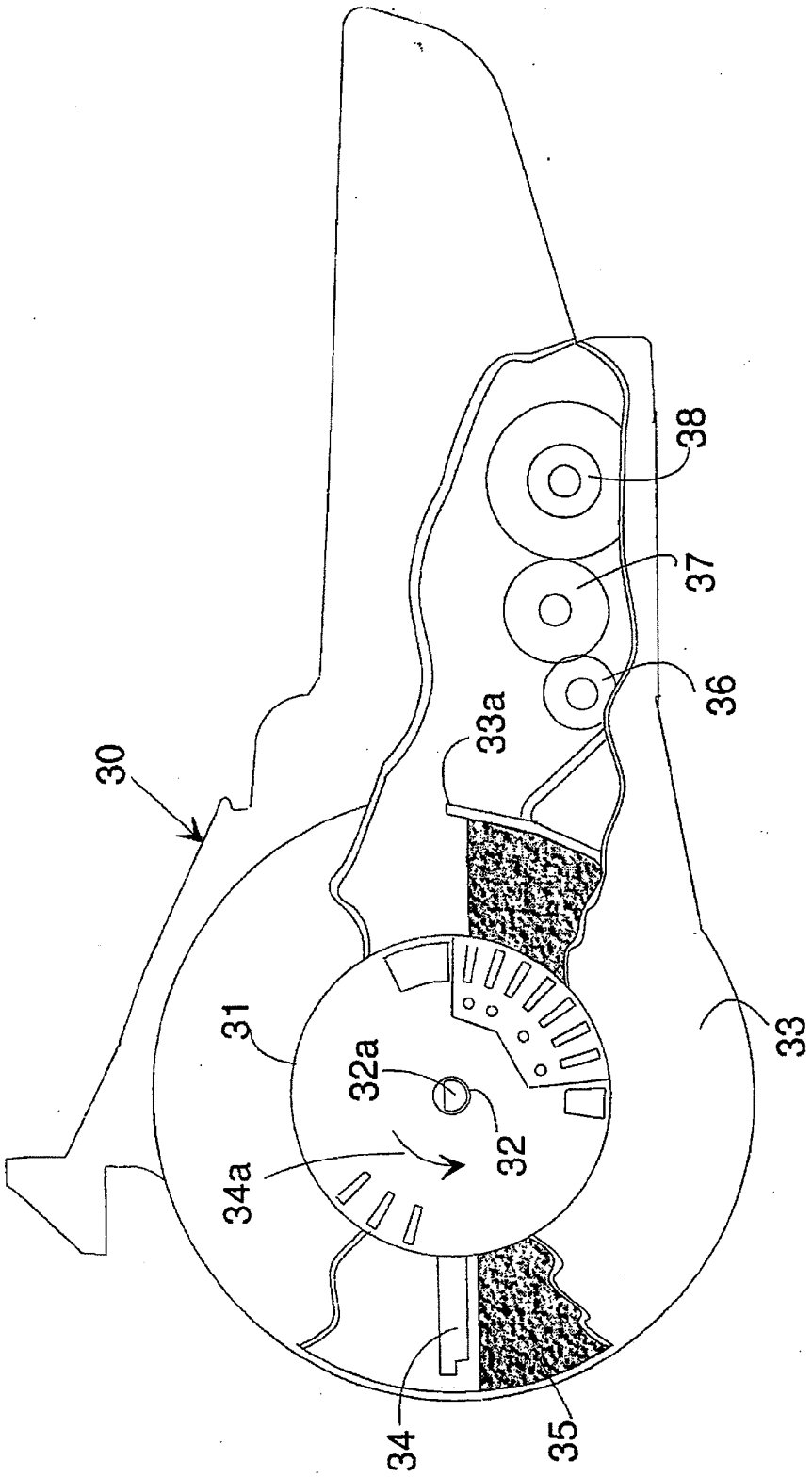

Fig. 2

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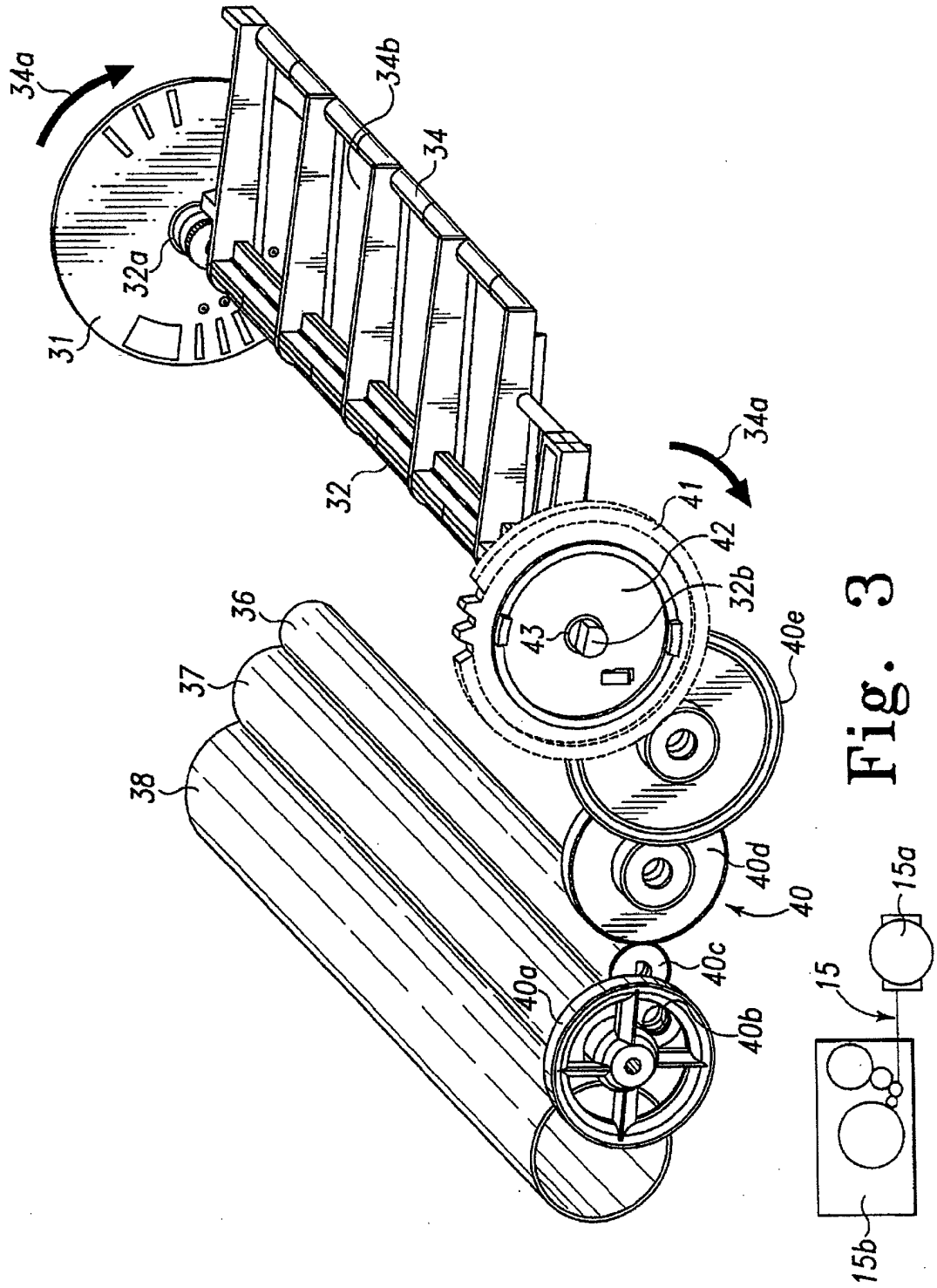

Fig. 3

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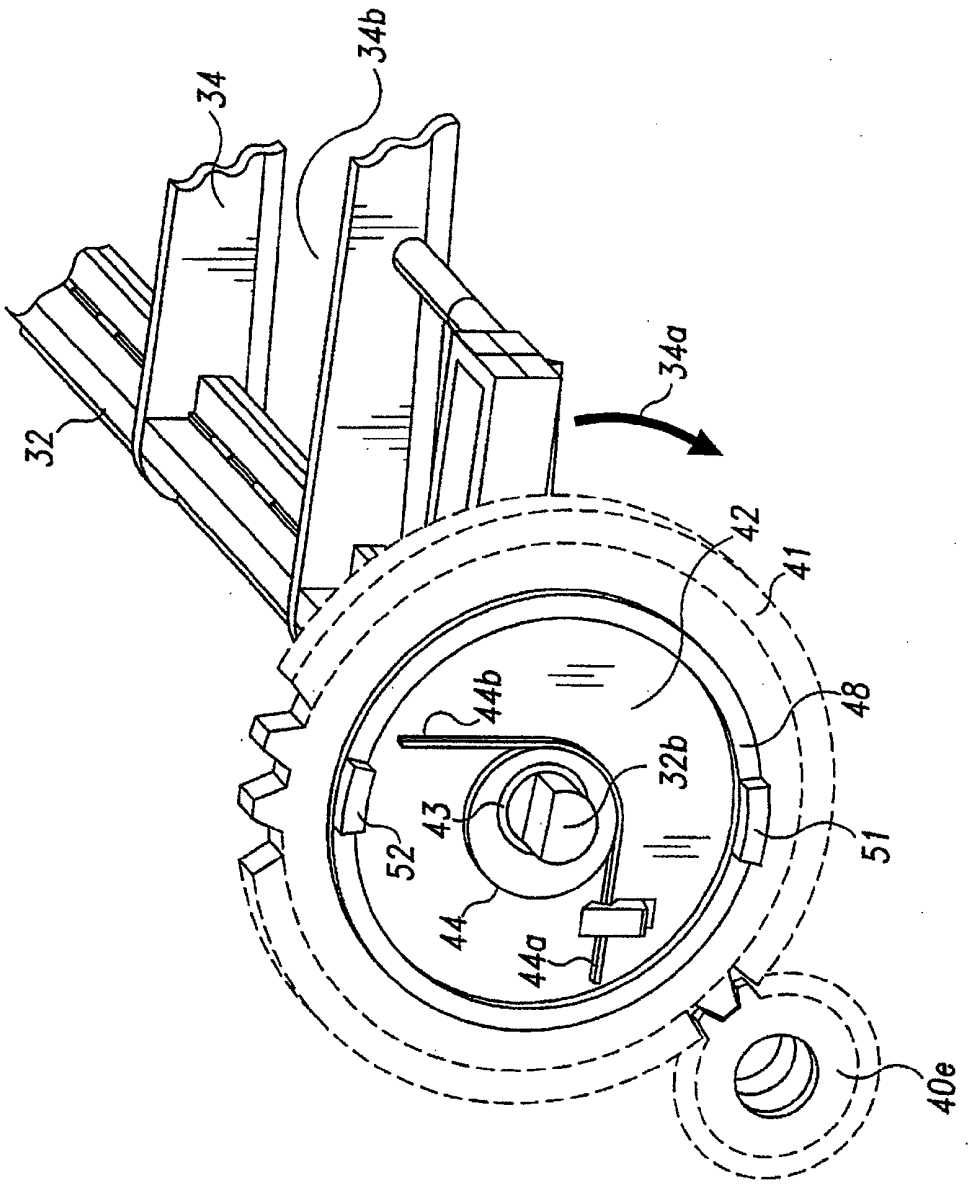

Fig. 4

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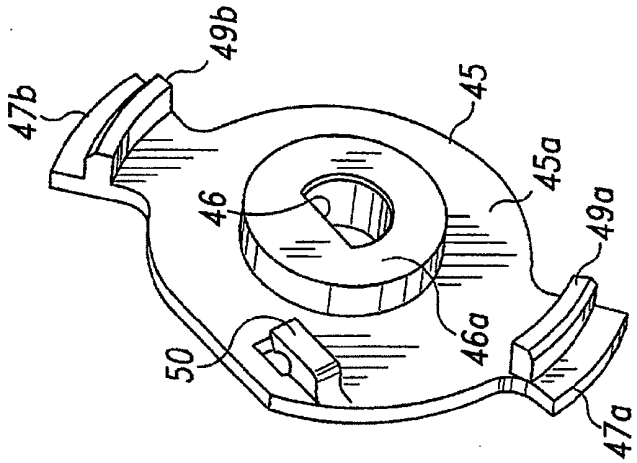

Fig. 5B

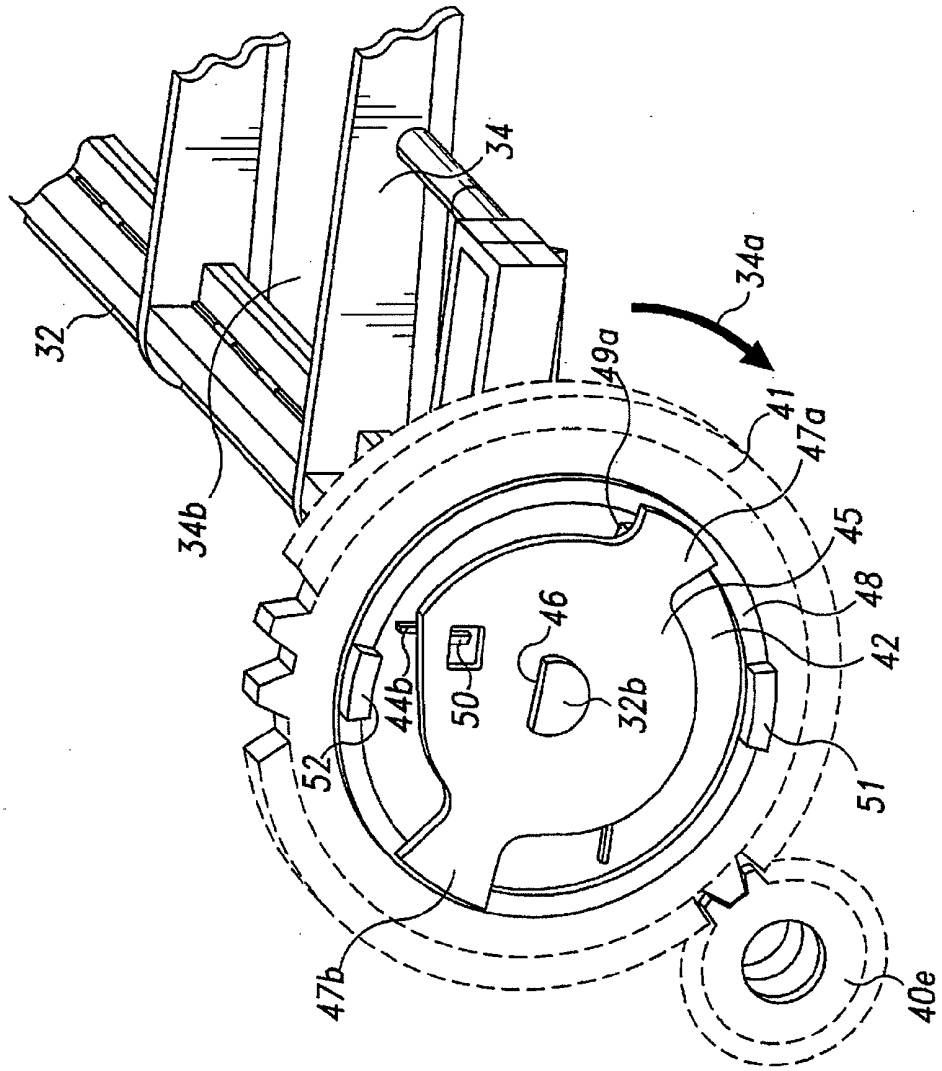

Fig. 5A

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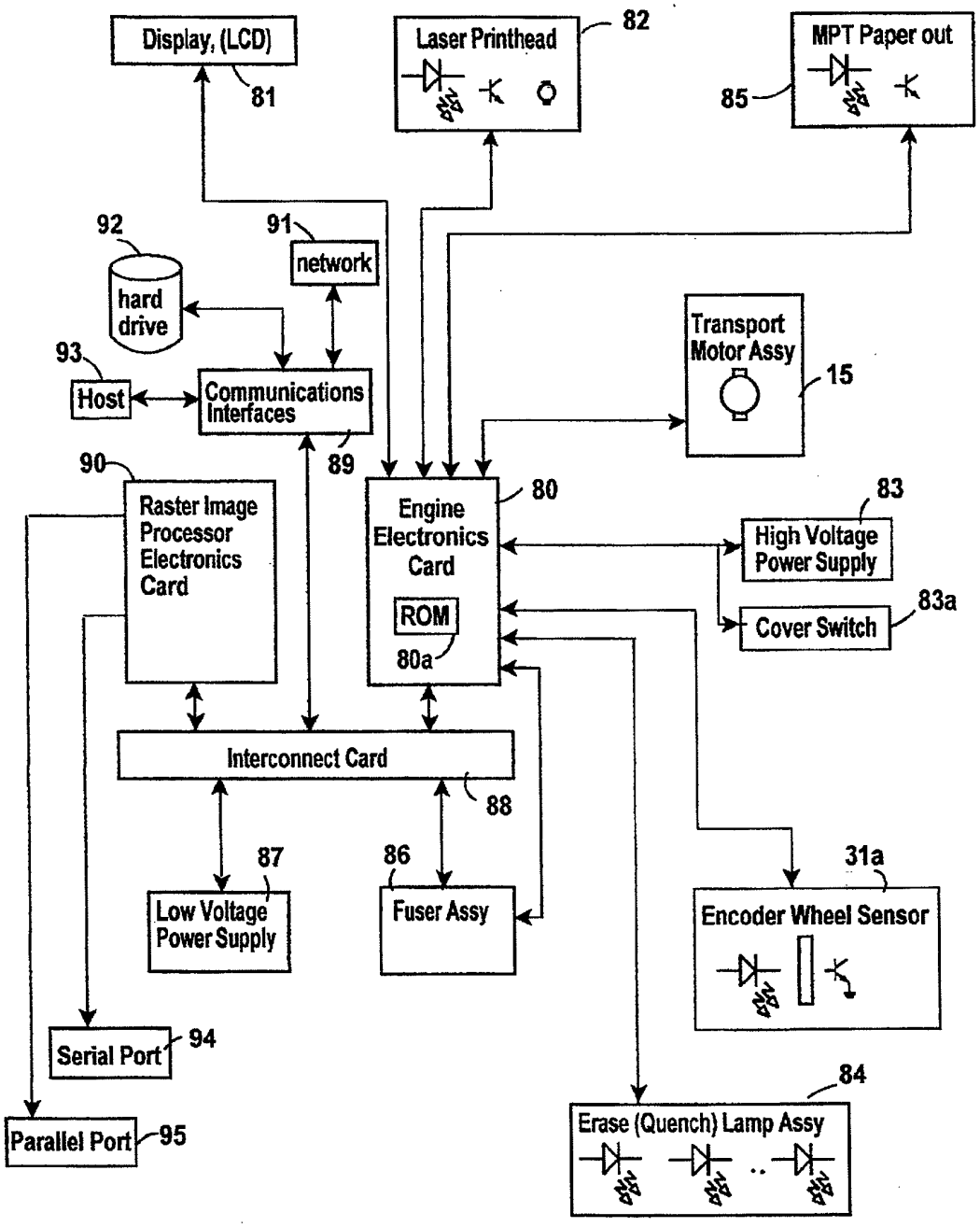

Fig. 6

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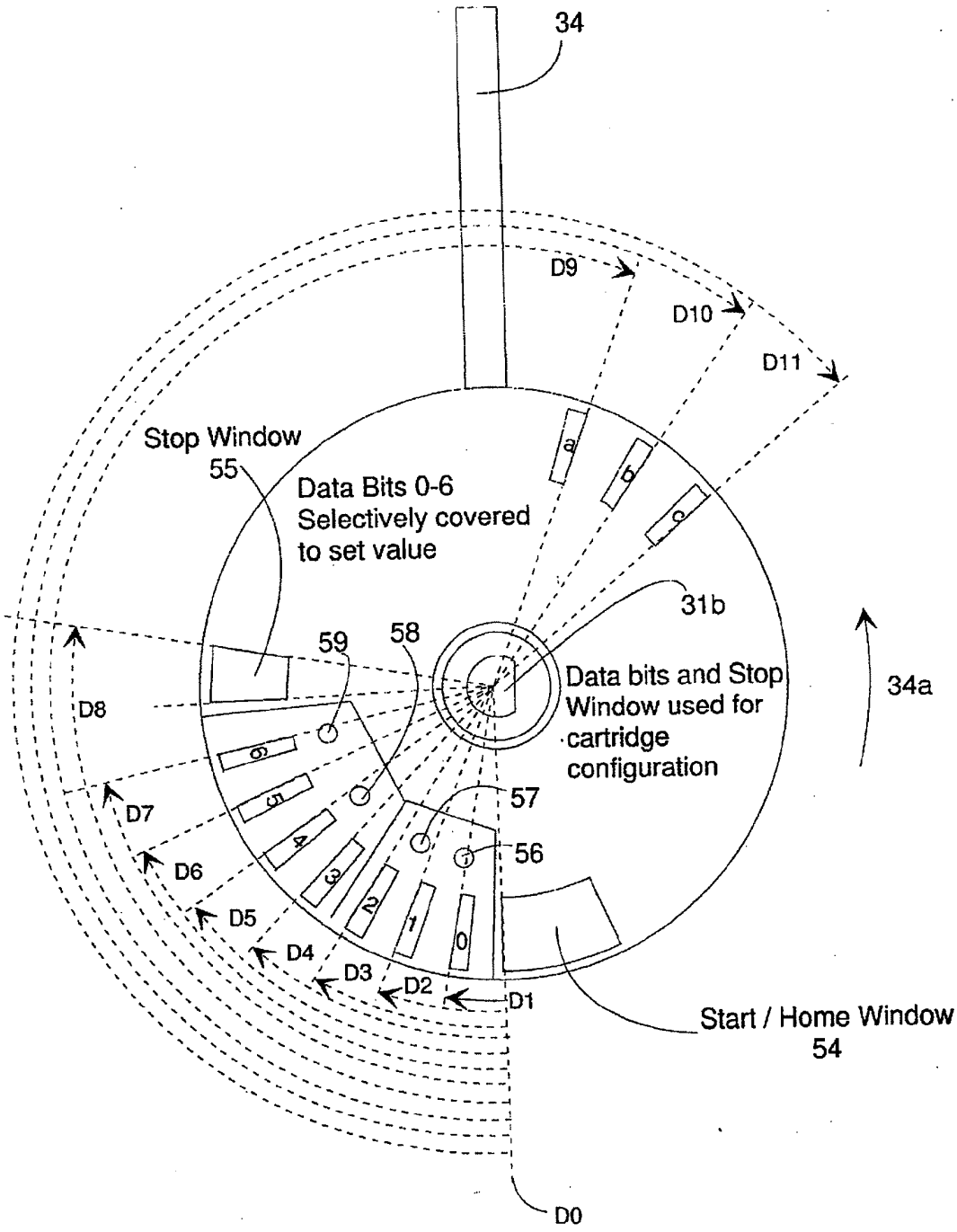

Fig. 7

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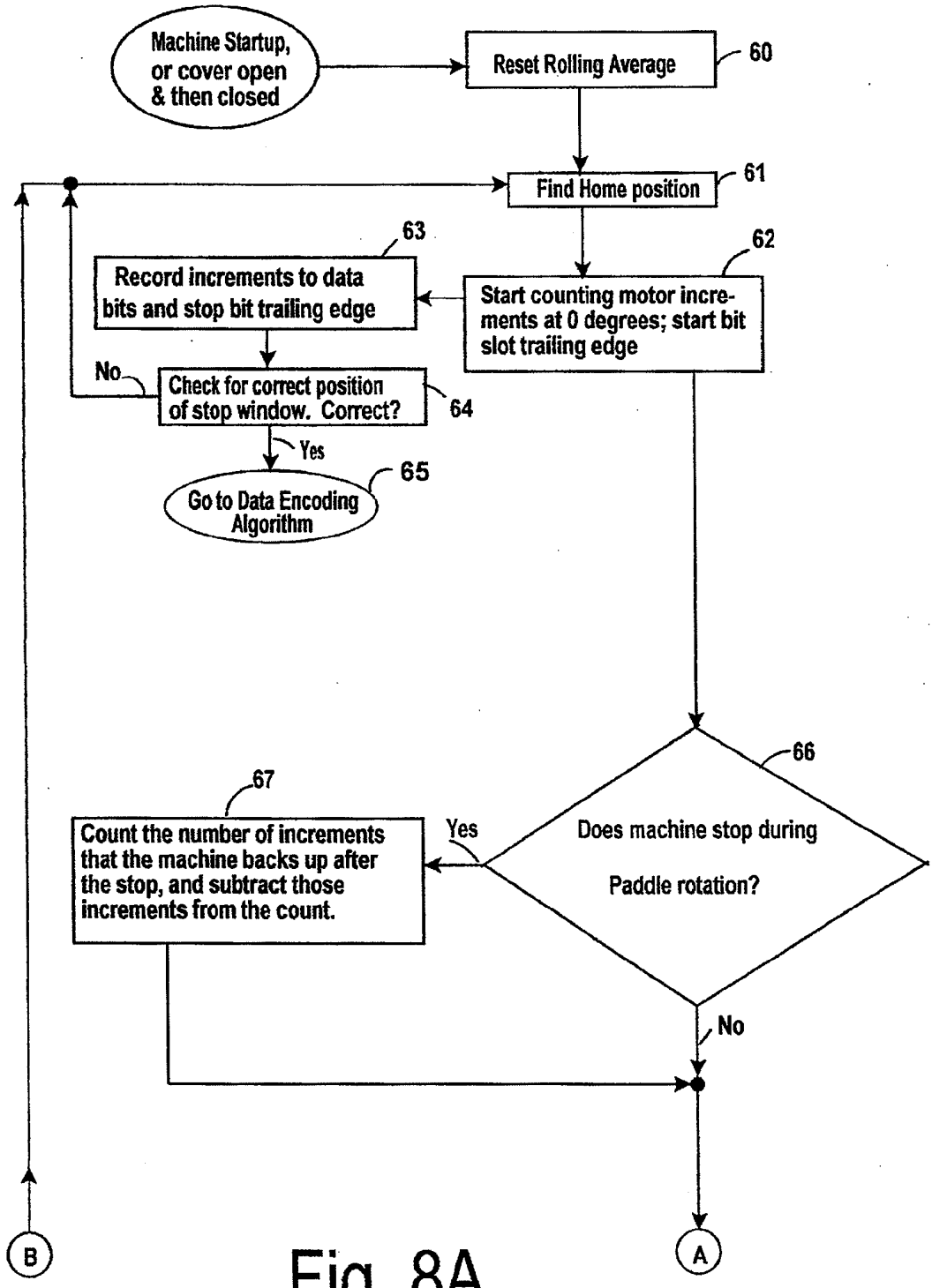

Fig. 8A

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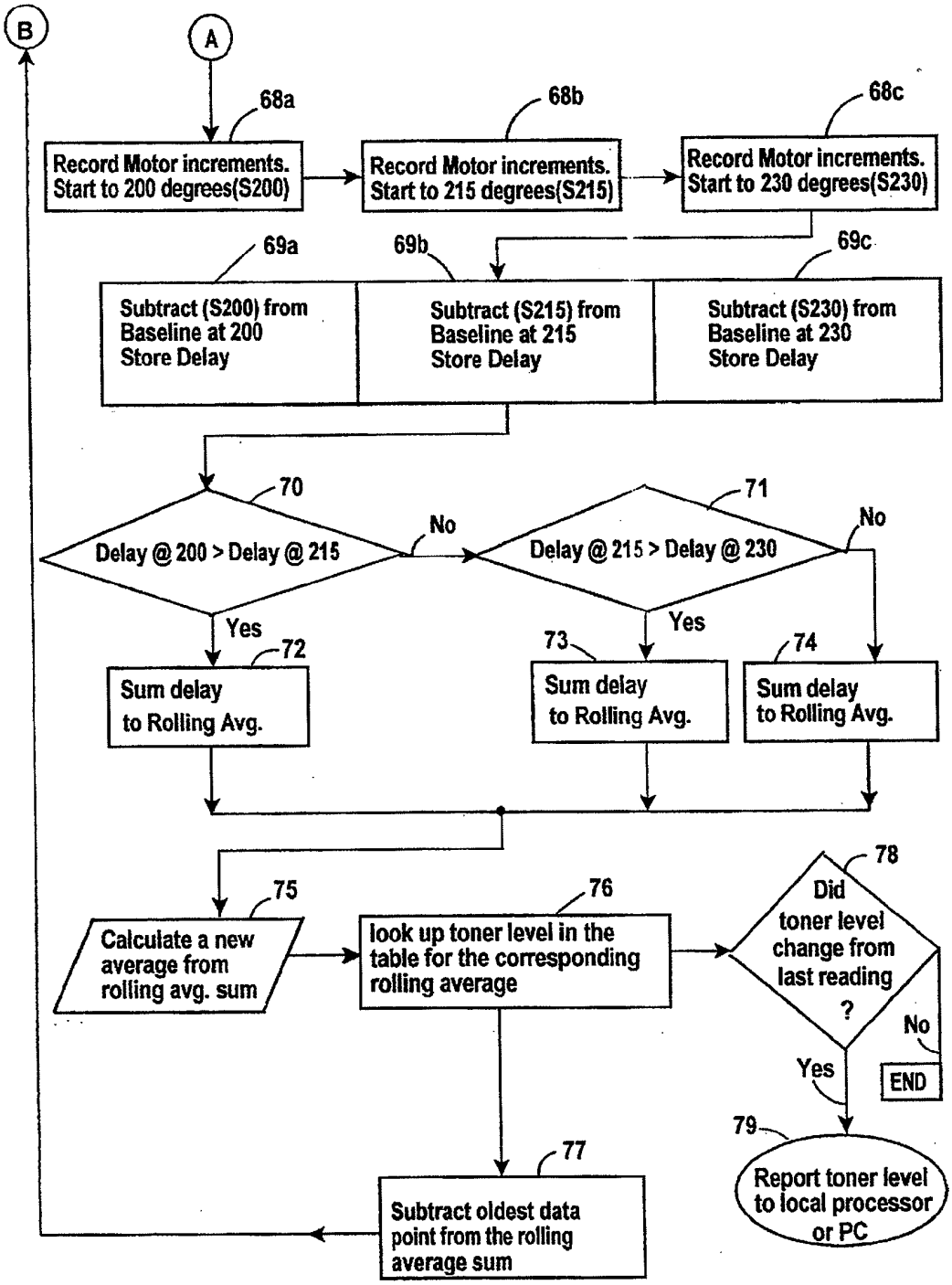

Fig. 8B

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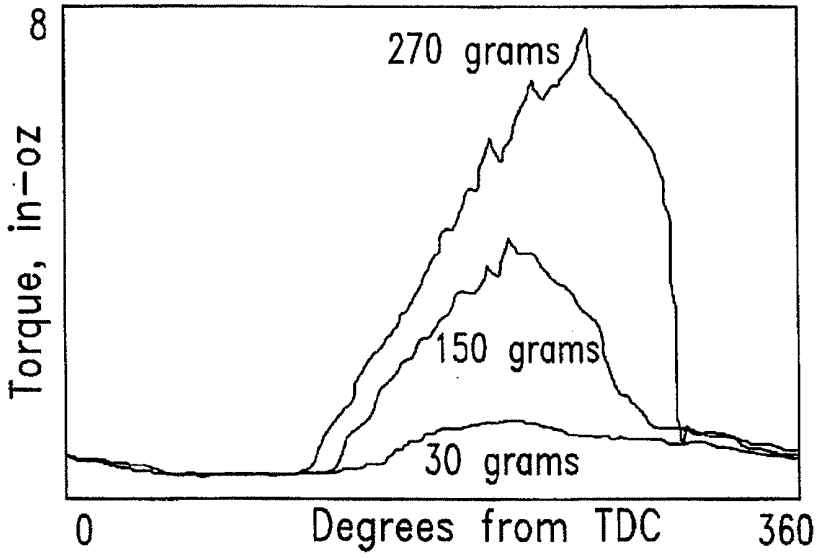

Fig. 9

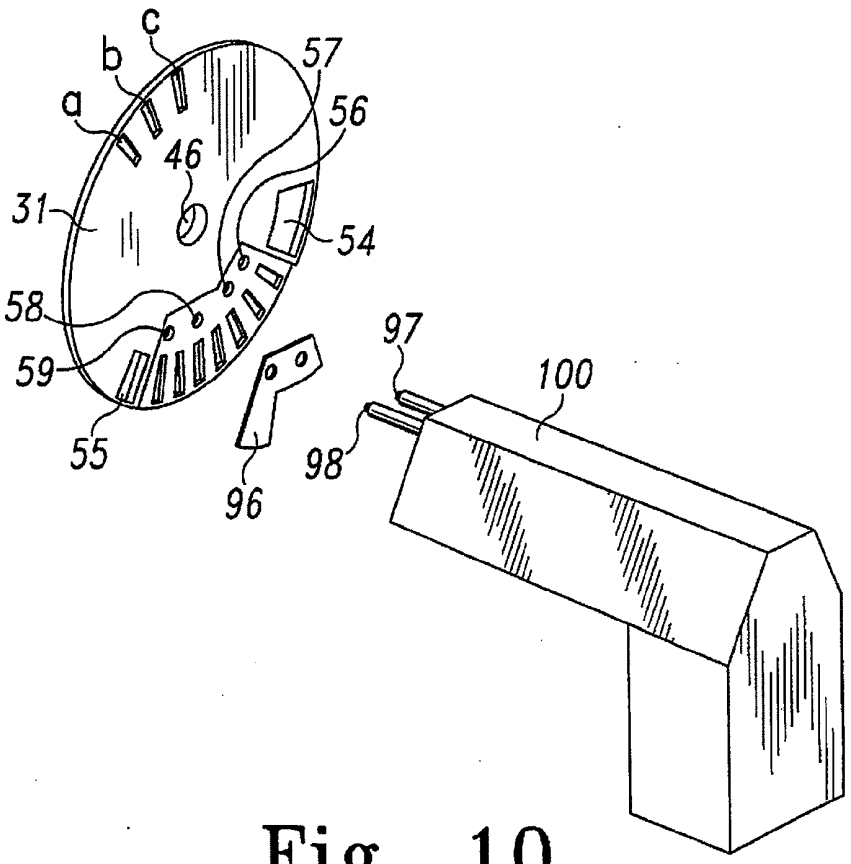

Fig. 10

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MULTIPLE FUNCTION ENCODER WHEEL FOR CARTRIDGES UTILIZED IN AN ELECTROPHOTOGRAPHIC OUTPUT DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to Electrophotographic (EP) machines and more particularly relates to methods and apparatus associated with replaceable supply cartridges for such machines wherein information concerning the cartridge is provided to the machine for not only increasing the efficiency of operation thereof but to permit correct operation of the machine.

2. Description of Related Art

Many Electrophotographic output device (e.g., laser printers, copiers, fax machines etc.,) manufacturers such as Lexmark International, Inc., have traditionally required information about the EP cartridge to be available to the output device such that the control of the machine can be altered to yield the best print quality and longest cartridge life.

The art is replete with devices or entry methods to inform the EP machine about specific EP cartridge characteristics. For example, in U.S. Pat. No. 5,208,631 issued on May 4, 1993, a technique to identify colorimetric properties of toner contained within a cartridge in a reproduction machine by imbedding in a PROM within the cartridge specific coordinates of a color coordinate system for mapping color data, is disclosed.

In other prior art, for example U.S. Pat. No. 5,289,242 issued on Feb. 22, 1994, there is disclosed a method and system for indicating the type of toner print cartridge which has been loaded into an EP printer. Essentially, this comprises a conductive strip mounted on the cartridge for mating with contacts in the machine when the lid or cover is dosed. The sensor is a two position switch which tells the user the type of print cartridge which has been loaded into the printer. While this method is effective, the amount of information that can be provided to the machine is limited

In still other prior art, such as in U.S. Pat. No. 5,365,312 issued on Nov. 15, 1994, a memory chip containing information about the current fill status or other status data is retained. The depleted status of print medium is supplied by counting consumption empirically. The average of how much toner is required for toning a charge image is multiplied by the number of revolutions of the charge image carrier or by the degree of inking of the characters via an optical sensor. In either method, the count is less than accurate and depends upon average ink coverage on the page, or alternatively, the character density which can change dramatically due to font selection. Therefore at best, the consumption count lacks accuracy.

The literature suggests several methods for detecting toner level in a laser printer. Most of these methods detect a low toner condition or whether toner is above or below a fixed level. Few methods or apparatus effectively measure the amount of unused toner remaining. As an example, Lexmark® printers currently employ an optical technique to detect a low toner condition. This method attempts to pass a beam of light through a section of the toner reservoir onto a photo sensor. Toner blocks the beam until its level drops below a preset height.

Another common method measures the effect of toner on a rotating agitator or toner paddle which stirs and moves the toner over a sill to present it to a toner adder roll, then developer roll and ultimately the PC Drum. The paddle's axis of rotation is horizontal. As it proceeds through it's full 360 degree rotation the paddle enters and exits the toner supply. Between the point where the paddle contacts the toner surface and the point where it exits the toner, the toner resists the motion of the paddle and produces a torque load on the paddle shaft. Low toner is detected by either 1) detecting if the torque load caused by the presence of toner is below a given threshold at a fixed paddle location or 2) detecting if the surface of the toner is below a fixed height.

In either method there is a driving member supplying drive torque to a driven member (the paddle) which experiences a load torque when contacting the toner. Some degree of freedom exists for these two members to rotate independently of each other in a carefully defined manner. For the first method 1) above, with no load applied to the paddle, both members rotate together. However, when loaded the paddle lags the driving member by an angular distance that increases with increasing load. In the second method 2), the unloaded paddle leads the rotation of the driving member, under the force of a spring or gravity. When loaded (i.e., the paddle contacts the surface of the toner), the driving and driven members come back into alignment and rotate together. By measuring the relative rotational displacement of the driving and driven members (a.k.a. phase difference) at an appropriate place in the paddle's rotation, the presence of toner can be sensed.

In the prior art, this relative displacement is sensed by measuring the phase difference of two disks. The first disk is rigidly attached to a shaft that provides the driving torque for the paddle. The second disk is rigidly attached to the shaft of the paddle and in proximity to the first disk. Usually both disks have matching notches or slots in them. The alignment of the slots or notches, that is how much they overlap, indicates the phase relationship of the disks and therefore the phase of the driving and driven members.

Various art showing the above methods and variations are set forth below.

In U.S. Pat. No. 4,003,258, issued on Jan. 18, 1977 to Ricoh Co., is disclosed the use of two disks to measure toner paddle location relative to the paddle drive shaft. When the paddle reaches the top of its rotation the coupling between paddle and drive shaft allows the paddle to free fall under the force of gravity until it comes to rest on the toner surface or at the bottom of its rotation. Toner low is detected if the angle through which the paddle falls is greater than a fixed amount (close to 180 degrees). A spring connects the two disks, but the spring is not used for toner detection. It is used to fling toner from the toner reservoir to the developer.

In U.S. Pat. No. 5,216,462, issued to Oki Electric Co., Jun. 1, 1993, is described a system where a spring connects two disks so that the phase separation of the disks indicates torque load on the paddle. An instability is noted in this type of system. It further describes a system similar to the Patent above where the paddle free falls from its top dead position to the surface of the toner. The position of the paddle is sensed through magnetic coupling to a lever outside of the toner reservoir. This lever activates an optical switch when the paddle is near the bottom of its rotation. A low toner indication results when the time taken for the paddle to fall from top dead center to the bottom of the reservoir, as sensed by the optical switch, is less than a given value.

In U.S. Pat. No. 4,592,642, issued on Jun. 3, 1986 to Minolta Camera Co., is described a system that does not use the paddle directly to measure toner, but instead uses the

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motion of the paddle to lift a "float" above the surface of the toner and drop it back down on top of the toner surface. A switch is activated by the "float" when in the low toner position. If the "float" spends a substantial amount of time in the low toner position the device signals low toner. Although the patent implies that the amount of toner in the reservoir can be measured, the description indicates that it behaves in a very non-linear, almost binary way to merely detect a toner low state.

U.S. Pat. No. 4,989,754, issued on Feb. 5, 1991 to Xerox Corp., differs from the others in that there is no internal paddle to agitate or deliver toner. Instead the whole toner reservoir rotates about a horizontal axis. As the toner inside rotates with the reservoir it drags a rotatable lever along with it. When the toner level becomes low, the lever, no longer displaced from its home position by the movement of the toner, returns to its home position under the force of gravity. From this position the lever activates a switch to indicate low toner.

In still another U.S. Pat. No. 4,711,561, issued on Dec. 8, 1987 to Rank Xerox Limited, this patent describes a means of detecting when a waste toner tank is full. It employs a float that gets pushed upward by waste toner fed into the tank from the bottom. The float activates a switch when it reaches the top of the tank.

U.S. Pat. No. 5,036,383, issued on Jul. 30, 1991 to Fujitsu Limited, describes the use of a commercially available vibration sensor to detect the presence of toner at a fixed level. The patent describes a simple timing method for ignoring the effect of the sensor cleaning mechanism on the sensor output.

U.S. Pat. No. 5,349,377, issued on Sep. 20, 1994 to Xerox Corp. discloses an algorithm for calculating toner usage and hence amount of toner remaining in the reservoir by counting black pixels and weighting them for toner usage based on pixels per unit area in the pixel's neighborhood. This is unlike the inventive method and apparatus disclosed hereinafter.

SUMMARY OF THE INVENTION

In view of the above, it is a principal object of the present invention to provide a simple yet effective method and apparatus for transmitting to a machine of the type utilizing toner, information concerning the contents of the cartridge, but also combining with such information continuing data relating to the amount of toner left in the cartridge during machine operation.

Another object of the present invention is to provide suitable software to automatically determine, upon machine power-on-reset (POR) or other resumption of functions, whether conditions have changed or altered since the last period of running of the machine, and to alter the machine running conditions in view of those determinations or findings.

Still another object of the present invention is to provide a simplified, but effective method and means for changing the initial information concerning the cartridge, but one that is accurate enough and simple enough to allow for end of manufacturing line or field alterations.

Yet another object of the present invention is to provide, in a single encoder wheel associated with the supply EP cartridge, information which may include, but is not limited to, PC drum type; "Vendor ID" which inhibits unauthorized cartridges from being employed in the machine; indicates original cartridge capacity; whether the toner is MICR (magnetic for bank checks etc.) or non-MICR toner and may include detection of the level of the toner in the cartridge sump.

To this end, the present invention encompasses a method and apparatus for providing information to a machine about the characteristics of an EP cartridge, which alter the operation of the machine in which it is employed. The invention uses an encoder wheel mounted to the shaft of a portion of the machine associated with the replaceable supply cartridge which, through at least a portion of its rotation, rotates at a substantially constant velocity. The wheel contains encoded information that can be read by conventional sensing methods and means are provided to create a serial bit stream which is then decoded to obtain information about the cartridge. Another portion of the wheel provides on a continuing basis, variable data on how much toner is left in the cartridge.

With regard to the latter function, the invention disclosed herein improves upon the prior art by using only one disk rigidly attached to the paddle shaft, along with knowledge of the cyclical nature of the torque load due to the resistance encountered by the paddle when it moves through the toner. In this manner, the lag between the driven and driving members is a function of this resistance and the amount of toner in the toner sump. This invention also improves upon prior art by distinguishing between several different levels of toner in the sump, not just one. This capability arises from being able to measure the magnitude of the torque load and from the ability to measure the torque in more than one circumferential agitator or paddle location.

Other objects and a more complete understanding of the invention may be had by referring to the following description taken in conjunction with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWING(S)

FIG. **1** is a schematic side elevational view illustrating the paper path in a typical electrophotographic machine, in the illustrated instance a printer, and showing a replacement supply EP cartridge, constructed in accordance with the present invention, and the manner of insertion thereof into the machine;

FIG. **2** is a fragmentary, enlarged, simplified, side elevational view of the cartridge illustrated in FIG. **1**, and removed from the machine of FIG. **1**;

FIG. **3** is a fragmentary perspective view of the interior driven parts of the EP cartridge illustrated in FIGS. **1** and **2**, including the encoder wheel and its relative position with regard to the drive mechanism for the cartridge interior driven parts;

FIG. **4** is an enlarged fragmentary perspective view of the agitator/paddle drive for the toner sump, and illustrating a portion of the torque sensitive coupling between the drive gear and the driven shaft for the agitator/paddle;

FIG. **5A** is a fragmentary view similar to FIG. **4**, except illustrating another portion of the torque sensitive coupling for coupling the driven shaft for the agitator/paddle, through the coupling to the drive gear, and FIG. **5B** depicts the reverse side of one-half of the torque sensitive coupling, and that portion which connects to the agitator/paddle shaft;

FIG. **6** is a simplified electrical diagram for the machine of FIG. **1**, and illustrating the principal parts of the electrical circuit;

FIG. **7** is an enlarged side elevational view of the encoder wheel employed in accordance with the present invention, and viewed from the same side as shown in FIG. **2**, and from the opposite side as shown in FIG. **3**;

FIG. **8A** is a first portion of a flow chart illustrating the code necessary for machine start up, and the reading of information coded on the encoder wheel;

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FIG. 8B is a second portion of the flow chart of FIG. 8A illustrating the measurement of toner level in the toner sump;

FIG. 9 is a graphical display of the torque curves for three different toner levels within the sump, and at various positions of the toner paddle relative to top dead center or the home position of the encoder wheel; and

FIG. 10 is a perspective view of an encoder wheel with novel apparatus for blocking off selected slots in the encoder wheel for coding the wheel with EP cartridge information.

DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENT(S)

Turning now to the drawings, and particularly FIG. 1 thereof, a laser printer **10** constructed in accordance with the present invention, is illustrated therein. FIG. 1 shows a schematic side elevational view of the printer **10**, illustrating the print receiving media path **11** and including a replacement supply electrophotographic (EP) cartridge **30**, constructed in accordance with the present invention. As illustrated, the machine **10** includes a casing or housing **10***a* which supports at least one media supply tray **12**, which by way of a picker arm **13**, feeds cut sheets of print receiving media **12***a* (e.g., paper) into the media path **11**, past the print engine which forms in the present instance part of the cartridge **30**, and through the machine **10**. A transport motor drive assembly **15** (FIG. 3) affords the driving action for feeding the media through and between the nips of pinch roller pairs **16–23** into a media receiving output tray **26**.

In accordance with the invention, and referring now to FIGS. 1 & 2, the cartridge **30** includes an encoder wheel **31** adapted for coaction, when the cartridge **30** is nested in its home position within the machine **10**, with an encoder wheel sensor or reader **31***a* for conveying or transmitting to the machine **10** information concerning cartridge characteristics including continuing data (while the machine is running) concerning the amount of toner remaining within the cartridge and/or preselected cartridge characteristics, such as for example, cartridge type or size, toner capacity, toner type, photoconductive drum type, etc. To this end, the encoder wheel **31** is mounted, in the illustrated instance on one end **32***a* of a shaft **32**, which shaft is coaxially mounted for rotation within a cylindrical toner supply sump **33**. Mounted on the shaft **32** for synchronous rotation with the encoder wheel **31**, extending radially from the shaft **32** and axially along the sump **33** is a toner agitator or paddle **34**. The toner **35** level for a cartridge (depending upon capacity) is generally as shown extending from approximately the 9:00 position and then counter clockwise to the 3:00 position. As the paddle **34** rotates counter clockwise in the direction of the arrow **34***a*, toner tends to be moved over the sill **33***a* of the sump **33**. (The paddle **34** is conventionally provided with large openings **34***b*, FIG. 3, to provide lower resistance thereto as it passes through the toner **35**.) As best shown in FIGS. 2 & 3, the toner that is moved over the sill **33***a*, is presented to a toner adder roll **36**, which interacts in a known manner with a developer roll **37** and then a photo conductive (PC) drum **38** which is in the media path **11** for applying text and graphical information to the print receiving media **12***a* presented thereto in the media path **11**.

Referring now to FIG. 3, the motor transport assembly **15** includes a drive motor **15***a*, which is coupled through suitable gearing and drive take-offs **15***b* to provide multiple and differing drive rotations to, for example, the PC drum **38** and a drive train **40** for the developer roll **37**, the toner adder roll **36** and through a variable torque arrangement, to one end **32***b* of the shaft **32**. The drive motor **15***a* may be of any convenient type, e.g. a stepping motor or in the preferred embodiment a brushless DC motor. While any of several types of motors may be employed for the drive, including stepping motors, a brushless DC motor is ideal because of the availability of either hall effect or frequency generated feedback pulses which present measurable and finite increments of movement of the motor shaft. The feedback accounts for a predetermined distance measurement, which will be referred to as an increment rather than a 'step' so as not to limit the drive to a stepping motor.

The drive train **40**, which in the present instance forms part of the cartridge **30**, includes driven gear **40***a*, which is directly coupled to the developer roll **37**, and through an idler gear **40***b* is coupled to the toner adder roll **36** by gear **40***c*. Gear **40***c* in turn through suitable reduction gears **40***d* and **40***e* drives final drive gear **41**. In a manner more fully explained below with reference to FIGS. 5 & 6, the drive gear **41** is coupled to the end **32***b* of shaft **32** through a variable torque sensitive coupling.

In FIG. 3, the gear **41** is shown as including an attached web or flange **42** connected to a collar **43** which acts as a bearing permitting, absent restraint, free movement of the gear **41** and its' web **42** about the end **32***b* of the shaft **32**. Referring now to FIG. 4, the driving half of the variable torque sensitive coupling is mounted on the web **42** of the gear **41**. To this end, the driving half of the coupling includes a coiled torsion spring **44**, one leg **44***a* of which is secured to the web **42** of the gear **41**, the other leg **44***b* of which is free standing.

Turning now to FIG. 5A, the other half (driven half) of the coupling is illustrated therein. To this end, an arbor **45** having a keyed central opening **46** dimensioned for receiving the keyed (flat) shaft end **32***b* of the shaft **32**, is depicted therein. For ease of understanding, an inset drawing is provided wherein the reverse side of the arbor **45** is shown. The arbor **45** includes radially extending ear portions **47***a*, **47***b*, the extended terminal ends of which overlay the flange **48** associated with the web **42** of the gear **41**. The rear face or back surface **45***a* of the arbor **45** (see FIG. 5B) confronting the web **42**, includes depending, reinforcing leg portions **49***a*, **49***b*. A collar **46***a* abuts the web **42** of the gear **41** and maintains the remaining portion of the arbor **45** spaced from the web **42** of the gear **41**. Also attached to the rear of the back surface **45***a* of the arbor **45** is a clip **50** which grasps the free standing leg **44***b* of the spring **44**.

Thus one end **44***a* (FIG. 4) of the spring **44** is connected to the web **42** of the gear **41**, while the other end **44***b* of the spring **44** is connected to the arbor **45** which is in turn keyed to the shaft **32** mounted for rotation in and through the sump **33** of the cartridge **30**. Therefore the gear **41** is connected to the shaft **32** through the spring **44** and the arbor **45**. As the gear **41** rotates, the end **44***b* of the spring presses against the catch **50** in the arbor **45** which tends to rotate causing the paddle **34** on the shaft **32** to rotate. When the paddle first engages the toner **35** in the sump **33**, the added resistance causes an increase in torsion and the spring **44** tends to wind up thereby causing the encoder wheel **31** to lag the rotational position of the gear **41**. Stops **51** and **52** mounted on the flange **48** prevent over winding or excessive stressing of the spring **44**. In instances where the sump **33** is at the full design level of toner **35**, the ears **47***a*, **47***b* engage the stops **52** and **51** respectively. The spring **44** therefore allows the paddle shaft **32** to lag relative to the gear **41** and the drive train **40** because of the resistance encountered against the toner **35** as the paddle **34** attempts to move through the sump **33**. The more resistance encountered because of toner

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against the paddle **34**, the greater the lag. As shall be described in more detail hereinafter, the difference in distance traveled by the gear **41** (really the motor **15***a*) and the encoder wheel **31**, as the paddle **34** traverses the sump **33** counter clockwise from the 9:00 position (see FIG. **2**,) to about the 5:00 position, is a measure of how much toner **35** remains in the sump **33**, and therefore how many pages may yet be printed by the EP machine or printer **10** before the cartridge **30** is low on toner. This measurement technique will be explained more fully with regard to finding the home position of the encoder wheel **31** and reading the wheel.

Turning now to FIG. **6** which is a simplified electrical diagram for the machine **10**, illustrating the principal parts of the electrical circuit thereof, the machine employs two processor (micro-processor) carrying boards **80** and **90**, respectively labeled "Engine Electronics Card" and "Raster Image Processor Electronics Card" (hereinafter called EEC and RIP respectively). As is conventional with processors, they include memory, I/O and other accouterments associated with small system computers on a board. The EEC **80**, as shown in FIG. **6**, controls machine functions, generally through programs contained in the ROM **80***a* on the card and in conjunction with its on-board processor. For example, on the machine, the laser printhead **82**; the motor transport assembly **15**; the high voltage power supply **83** and a cover switch **83***a* which indicates a change of state to the EEC **80** when the cover is opened; the Encoder Wheel Sensor **31***a* which reads the code on the encoder wheel **31** informing the EEC **80** needed cartridge information and giving continuing data concerning the toner supply in the sump **33** of the EP cartridge **30**; a display **81** which indicates various machine conditions to the operator, under control of the RIP when the machine is operating but capable of being controlled by the EEC during manufacturing, the display being useful for displaying manufacturing test conditions even when the RIP is not installed. Other functions such as the Erase or quench lamp assembly **84** and the MPT paper-out functions are illustrated as being controlled by the EEC **80**. Other shared functions, e.g. the Fuser Assembly **86** and the Low Voltage Power Supply **87** are provided through an interconnect card **88** (which includes bussing and power lines) which permits communication between the RIP **90** and the EEC **80**, and other peripherals. The Interconnect card **88** may be connected to other peripherals through a communications interface **89** which is available for connection to a network **91**, non-volatile memory **92** (e.g. Hard drive), and of course connection to a host **93**, e.g., a computer such as a personal computer and the like.

The RIP primarily functions to receive the information to be printed from the network or host and converts the same to a bit map and the like for printing. Although the serial port **94** and the parallel port **95** are illustrated as being separable from the RIP card **90**, conventionally they may be positioned on or as part of the card.

Prior to discussing, via the programming flow chart, the operation of the machine in accordance with the invention, the structure of the novel encoder wheel **31** should be described. To this end, and referring now to FIG. **7**, the encoder wheel **31** is preferably disk shaped and comprises a keyed central opening **31***b* for receipt by like shaped end **32***a* of the shaft **32**. The wheel includes several slots or windows therein which are positioned preferably with respect to a start datum line labelled **D0**, for purposes of identification. From a "clock face" view, **D0** resides at 6:00, along the trailing edge of a start/home window **54** of the wheel **31**. (Note the direction of rotation arrow **34***a*.) The paddle **34** is schematically shown positioned at top-dead-center (TDC) with respect to the wheel **31** (and thus the sump **33**). The position of the encoder wheel sensor **31***a*, although stationary and attached to the machine, is assumed, for discussion purposes, aligned with **D0** in the drawing and positioned substantially as shown schematically in FIG. **1**.

Because the paddle **34** is generally out of contact with the toner in the sump, from the 3:00 position to the 9:00 position (counter clockwise rotation as shown by arrow **34***a*), and the shaft velocity may be assumed to be fairly uniform when the paddle moves from at least the 12:00 (TDC) position to the 9:00 position, information concerning the cartridge **30** is preferably encoded on the wheel between 6:00 and approximately the 9:00 position. To this end, the wheel **31** is provided with radially extending, equally spaced apart, slots or windows **0–6**, the trailing edges of which are located with respect to **D0** and labelled **D1–D7** respectively. Each of the slots **0–6** represents an information or data bit position which may be selectively covered as by one or more decals **96**, in a manner to be more fully explained hereinafter with reference to FIG. **10**. Suffice at this point that a plurality of apertures **56–59** are located along an arc with the same radius but adjacent the data slots or windows **0–6**. Note that the sparing between apertures **56** and **57** is less than the sparing between apertures **58** and **59**.

The coded data represented by combinations of covered, not-covered slots **0–6** indicate to the EEC **80** necessary information as to the EP cartridge initial capacity, toner type, qualified or unqualified as an OEM type cartridge, or such other information that is either desirable or necessary for correct machine operation. Adjacent slot **6** is a stop window **55** which has a width equal to the distance between the trailing edges of adjacent slots or windows e.g. **D1**=(**D2**–**D1**,=**D3**–**D2** etc.)=the width of window **55**. Note that the stop window **55** is also spaced from the trailing edge of slot **6** a distance equal to the stop window width **55**. That is, the distance **D8**–**D7**=twice the window **55** width while the window width of window **55** is greater than the width of the slots **0–6**.

Adjacent slot **0**, from approximately the 5:00 to the 6:00 position is a start/home window **54**. The start/home window **54** is deliberately made larger than any other window width. Because of this width difference, it is easier to determine the wheel position and the start of the data bit presentation to the encoder wheel sensor **31***a*. The reason for this will be better understood when discussing the programming flow charts of FIG. **8**A and **8**B.

In order to provide information to the EEC **80** as to the lag of the encoder wheel **31** relative to the transport motor **15***a* position (counted increments), three additional slots or windows "a", "b" and "c" are provided at **D9**, **D10** and **D11** respectively. The trailing edge of slot "a", (angular distance **D9**) is 200° from **D0**; the trailing edge of slot "b" (angular distance **D10**) is 215° from **D0** and the trailing edge of slot "c" (angular distance **D11**) is 230° from **D0**. From FIG. **7** it may be seen that when the slot "a" passes the sensor **31***a* at **D0**, the paddle **34** will have already passed bottom dead center (6:00 position) by 20°, (200°–180°); window or slot "b" by 35° (215°–180°), and slot "c" by 50° (230°– 180°). The significance of the placement of the slots "a", "b" and "c" will be more fully explained, hereinafter, with respect to FIG. **9**.

Referring now to FIGS. **8**A and **8**B which shows respectively a programing and functional flow chart illustrating the code necessary for machine start up, and the reading of information coded on the encoder wheel, including the measurement of toner **35** level in the toner sump **33**. At the

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outset, it is well that it be understood that there is no reliance on or measurement of the speed of the machine, as it differs depending upon the operation (i.e., resolution; toner type; color etc.) even though a different table may be required for look up under gross or extreme speed change conditions. Accordingly, rather than store in the ROM **80***a* a norm for each of several speeds to obtain different resolutions to which the actual could be compared to determine the amount of toner left, what is read instead is the angular 'distance' traversed by the encoder wheel **31** referenced to the angular distance travelled by the motor, and then comparing the difference between the two angular measurements to a norm or base-line to determine the amount of toner **35** left in the sump **33**. By observation, it can be seen that the distance that the encoder wheel travels between start or home (**D0**) and "a", "b", "c" is always the same. So what is being measured is the distance the motor has to travel before slot "a" is sensed, slot "b" is sensed and slot "c" is sensed, and then taking the difference as being the measured lag. In essence, and perhaps an easier way for the reader to understand what is being measured, is that the angular displacement of the paddle **34** is being measured with respect to the angular displacement of the gear **41** (gear train **40** as part of transport motor assembly **15**). As discussed below, the greatest number (lag number) indicates the paddle position which gives the highest torque (the most resistance). This number indicates which look up table in ROM should be employed and gives a measure of how much toner **35** is left in the sump **33** of the cartridge **30**.

Referring first to FIG. **8**A, after machine **10** start up or the cover has been opened and later closed, the Rolling Average is reset, as shown in logic block **60**. Simply stated, 'n' (e.g. 5 or 6) sample measurements are examined and the average of them is stored and the code on the encoder wheel **31** of the cartridge **30** is read, compared to what was there before, and then stored. The reason for doing this is that if a user replaces an EP cartridge since the last power on or machine **10** startup, there may be a different toner type, toner level etc. in the new sump. Accordingly, so as not to rely on the old data, new data is secured which includes new cartridge data and/or amount of toner **35** remaining in the cartridge **30**. Therefore a new 'rolling average' is created in the EEC **80**. With regard to host notification, the old data would be reported because the great majority of time when the machine is started up or the cover is closed once opened, a new cartridge will not have been installed, and reliance may usually be placed upon the previous information.

The next logical step at **61** is to 'Find the Home position' of the encoder wheel **31**. In order for either the toner level or cartridge characteristics algorithms to operate properly, the "home position" of the wheel **31** must first be found. Necessarily, the EEC **80**, through sensor **31***a* must see the start of a window before it begins determining the home or start position of the wheel, since the engine could be stopped in, for instance, the stop window **55** position and due to backlash in the system, the motor may move enough distance before the encoder wheel actually moves that the measured "total window width" could appear to be the start/home window **54**. Below is set forth in pseudo code the portion of the program for finding the start/home window **54**. As previously discussed, the start/home window **54** is wider than the stop window **55** or for that matter, any other slot or window on the encoder wheel **31**.

```
'Find the home window first
' This loop runs on motor "increments"
HomeFound = False
while ( ! HomeFound)
  If (found the start of a Window) Then
    WindowWidth = 0
    While (not at the end of Window) {increment WindowWidth}
    If (WindowWidth > MINIMUM_HOME_WIDTH
        AND WindowWidth < MAXIMUM_HOME_WIDTH) Then
          HomeFound = True
  End if
End While
```

In the above algorithm, 'HomeFound' is set false and a loop is run until the window or slot width meets the conditions of greater than minimum but less than maximum, then 'HomeFound' will be set true and the loop is ended. So the algorithm in essence is articulating: see the window; compare the window with predetermined minimum and maximum widths, for identification; and then indicate that the 'home window' **54** has been found when those conditions are met.

To ensure that the algorithm found home properly, after it identifies the stop window **55**, it checks to ensure that the position of the stop window **55** is within reason with respect to the start/home window **54** and of course that the window width is acceptable. This occurs in logic blocks or steps **62**, **63** and **64** in FIG. **8**A. If this condition is not met, then the configuration information should be taken again. If this check passes, then there is no need to continue to look at the configuration information until a cover dosed or power on cycle occurs.

This guards against the potential conditions wherein the engine misidentifies the start/home window **54** and thus mis-characterizes the cartridge **30**.

Prior to discussing the pseudo-code for 'Reading the Wheel', it may be helpful to recall that a portion of the encoder wheel's **31** revolution is close enough to constant velocity to allow that section to be used and read almost as a "windowed bar code". With reference to FIG. **7**, that is the section of the wheel **31** from the trailing edge of the start/home window **54** to the trailing edge of the stop window **55** including the slots or windows **0–6**. This is preferably in the section of the encoder wheel **31** in which the paddle **34** is not impinging upon or in the toner **35** in the sump **33**. Passage of this section over the optical sensor **31***a* creates a serial bit stream which is decoded to gather read-only information about the cartridge. The information contained in this section may comprise information that is essential to the operation of the machine with that particular EP cartridge, or "nice to know" information. The information may be divided, for example into two or more different classifications. One may be cartridge 'build' specific, i.e. information which indicates cartridge size, toner capacity,

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toner type, photo conductor (PC) drum type, and is personalized when the cartridge is built, the other which may allow for a number of unique "cartridge classes" which may be personalized before cartridge shipment, depending, for example, upon the OEM destination. The latter classification may, for example inhibit the use of cartridges from vendors where it is felt that the cartridge will give inferior print, may have some safety concern, or damage the machine in some way. Alternatively, if the machine is supplied as an OEM unit to a vendor for his own logo, the cartridges may be coded so that his logo cartridge is that which is acceptable to the machine. The selective coding by blocking of the windows may be performed via a stick-on-decal operation which will be more fully explained with reference to FIG. **10**.

The 'Find Home' code determines the start/home window **54** and measures the distance corresponding to the trailing edge of each window **0–6** from the trailing edge of the window **54**. This acquisition continues until the engine detects the stop window **55** (which is designed to have a greater circumferential width then the data windows **0–6** but less than the start/home window **54**). Using a few integer multiplications, the state of each bit in the byte read is set using the recorded distance of each window **0–6** from the trailing edge of the home window **54**.

The portion of the program for reading the encoder wheel, in pseudo-code, is as follows:

```
'Find Home' (see above)
' Gather distances for all of the data window
  ' This loop runs on motor "increments"
Finished = False
WindowNumber = 0
CumulativeCount = 0
while (!Finished)
    CumulativeCount = CumulativeCount + 1
    If (the start of a window is found) Then
      WindowWidth = 0
      While (not at the end of Window)
        increment WindowWidth
        increment CumulativeCount
      End While
    If (WindowWidth > Minimum Stop window Width
        AND WindowWidth < Maximum Stop Window Width
        AND CumulativeCount > Minimum Stop Position
        AND CumulativeCount < Maximum Stop Position)Then
        ' we must ensure that the stop window is really what we found
        Finished = True
        StopDistanceFromHome = CumulativeCount
      Else
        DistanceFromHome(WindowNumber) =CumulativeCount
        WindowNumber = WindowNumber + 1
      End if' check for stop window
    End ifcheck for start of window
End While
' Now translate measurements into physical bits
DataValue = 0
' First divide the number of samples taken by 9
BitDistance = StopDistanceFromHome / 9
FOR I = 0 To WindowNumber - 1
    BitNumber = DistanceFromHome(I) / BitDistance
      'What is being determined is the bit number corresponding to the
      ' measurement by rounding up DistanceFromHome(I)/BitDistance.
    If((DistanceFromHome(I) - (BitDistance * BitNumber)) * 2 > BitDistance)
    Then
      BitNumber = BitNumber + 1
    End If
    DataValue = DataValue + 1 (SHIFTLEFT) BitNumber - 1
Next' Window number
DataValue = -DataValue ' invert result since windows are logic 0's
```

The program depicted above in pseudo code for reading the wheel is quite straight forward. Thus in logic step **63**, (FIG. **8A**) where the motor increments are recorded for each data bit, and stop bit trailing edge, as was discussed with regard to FIG.**7** that the distances D1–D7 between the trailing edges of windows or slots **0** through **6**, are equally spaced. (i.e., D7–D6=some constant "K", D5–D4=constant "K" etc.) The trailing edge of the stop window **55** is also a distance of twice "K" from the trailing edge of slot **6**. While the distance from the trailing edge of stop window **55** to its leading edge (i.e. the window **55** width) is equal to one 'bit' distance or "K" from the leading edge, this width may be any convenient distance as long as its' width is>than the width of the slots **0–6** and<the width of the start/home window **54**. Thus the line of pseudo code above 'First divide the number of samples taken by 9', (from the trailing edge of the start/home window or slot **54**) means that there are 7 bits from D1 through D7, plus two more through D8, and therefore '/9' gives the sparing "K" between the windows (trailing edge of the start/home window **54** to the trailing edge of the stop window **55**) which may be compared to what this distance is supposed to be, and in that manner insure that the bit windows **0–6** and stop window **55** have been found. If the stop window **55** is not identified correctly by the technique just described, then a branch from logic step **64** to logic step **61** will once again initiate the code for finding the home position, as in block **61** and described above.

In logic block or step **65**, the next logical step in the program is to go to the Data Encoding Algorithm portion of

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the program. In the pseudo code set forth above, this starts with the REM statement "Now translate measurements into physical bits". Now, assume that when coded, the encoder wheel **31** has several of the bits **0–6** covered, as by a decal so that light will not pass therethrough. Suppose all data bit slots but **6** and the stop window **55** are covered. A reading of distance **D8/9** will give the sparing between the data slots or windows **0–6**. Therefore, the distance to slot **D7**, i.e. the trailing edge of slot **6**, will be 7 times "K" (bit sparing) and therefore will indicate that it is bit **7** that is emissive and that the bit representation is 1000000, or if the logic is inverted, 0111111. Notice that the number found is rounded up or down, as the case may be dependant upon such factors as paddle mass, rotational speed etc. In certain instances, this may mean rounding up with a reading above 0.2 and rounding down with a reading below 0.2. E.g., 6.3 would be rounded to 7, while 7.15 would be rounded to a 7.

In logic step **66** the question is asked: "Does the machine stop during paddle rotation?" If it does, logic step **67** is initiated. The reason for this is that if the paddle is stopped, especially when in the portion of the sump **33** containing a quantity of toner **35**, in order to release the torsion on the spring **44** the motor **15***a* is backed up several increments. This will allow removal, and/or replacement, if desired, of the EP cartridge **30**. This logic step allows for decrementing the number of steps "backed up" from the incremental count of motor increments which was started in logic block **62**.

Turning now to FIG. **8B**, as the encoder wheel **31** rotates, the paddle **34** enters the toner **35** in the sump **33**. As described above relative to logic step **62**, the motor increments are counted. The motor increments are then recorded as **S200**, **S215** and **S230**, in logic step **68***a*, **68***b* and **68***c* at the trailing edges of slots "a", "b", and "c" respectively of the wheel **31**. These numbers, **S200**, **S215** and **S230** are subtracted from the baseline of what the numbers would be absent toner **35** in the sump **33**, (or any other selected norm) which is then directly indicative of the lag due to resistance of the toner in the sump, with the paddle **34** in three different positions in the sump. This is shown in logic steps **69***a*–**69***c* respectively. As has previously been stated, there is a correlation between load torque on the toner paddle **34** and the amount of toner **35** remaining in the toner supply reservoir or sump **33**. FIG. **9** illustrates this relationship. In FIG. **9**, torque is set in inch-ounces on the ordinate and degrees of rotation of the paddle **34** on the abscissa.

Referring briefly to FIG. **9**, several characteristics of this data stand out as indicating the amount of toner remaining. The first one is the peak magnitude of the torque. For example, with 30 grams of toner **35** remaining in the sump **33**, the torque is dose to 2 inch-ounces, while at 150 grams the torque approximates 4 inch-ounces and at 270 grams the torque approximates 8 inch-ounces. The second characteristic is that the location of the peak of the torque curve does not move very much as the amount of toner changes. This suggests that measuring the torque near the location where the peak should occur could provide a measure of remaining toner. That is why, as shown in FIG. **7**, the trailing edge of slot "a", (distance **D9**) is 200° from **D0**; the trailing edge of slot "b" (distance **D10**) is 215° from **D0** and the trailing edge of slot "c" (distance **D11**) is 230° from **D0**. Another obvious indicator is the location of the onset of the torque load. Yet a third indicator is the area under the torque curves.

Another way of looking at this process is that while the angular distance measurements of **D9**, **D10** and **D11** are known, the number of increments the motor has to turn in order that the resistance is overcome as stored in the torsion spring **44**, is the difference in distance the motor has to travel (rotational increments) to obtain a reading at window "a", then "b" and then "c". The delay is then compared as at logic step **70** and **71**, and the largest delay is summed as at logic steps **72**, **73** or **74** to the rolling average sum. Thereafter a new average calculation is made from the rolling average sum. This is shown in logic step **75**. As illustrated in logic block **76**, the toner **35** level in the sump **33** may then be determined from a look up table precalculated and stored in the ROM **80***a* associated with the EEC **80** in accordance with the new rolling average.

In logic block **77**, the oldest data point is subtracted from the rolling average sum and then the rolling average sum is reported for use back to logic block **61** (Find Home position). If the toner level changed from the last measurement, as in compare logic block **78**, this condition may be reported to the local RIP processor **90** and/or the host machine, e.g. a personal computer as indicated in logic block **79**.

Coding of the encoder wheel **31** is accomplished, as briefly referred to above, by covering selected ones of slots **0–6** with a decal. For customization for an OEM vendee, and in order to reduce inventory, and in accordance with another feature of the invention, the problem of quickly and accurately applying such a decal to the correct area of the wheel **31**, even under circumstances of limited space, is provided. Due to the dose sparing of the slots **0–6** in the encoder wheel **31**, a pre-cut, preferably adhesive backed decal **96** is employed to selectively cover pre-selected slots depending on how the decal is cut or stamped. Very accurate positioning of the decal **96** is achieved by use of alignment pins in conjunction with an alignment tool **100**. Because another decal can be placed on another region of the wheel, the sparing of the alignment holes **56–59** on the encoder wheel **31** is different in each region.

To this end, as previously discussed, there are two pairs of apertures in the encoder wheel or disk, adjacent the slots, the apertures of one of the pairs **58**, **59** being spaced apart a greater distance than the apertures **56–57** of the other of the pairs. Referring now to FIG. **10**, a decal **96** is sized to fit over at least one of the slots **0–2**, or **3–6** to cover the same. As illustrated, the decal **96** has spaced apart apertures therein corresponding to one of the pairs of apertures, i.e. **58**, **59** or **56**, **57**. A tool **100** has a pair of pins **97**, **98** projecting therefrom and corresponding to the sparing of one of the pairs of apertures, whereby when the apertures in the decal are mated with the projecting pins of the tool, the projecting pins of the tool may be mated with the one pair of apertures in the encoder wheel or disk to thereby accurately position the decal over the selected slot in the disk. The decal **96** is installed on the tool with the adhesive side faring away from the tool. The tool **100** is then pushed until the decal **96** makes firm contact with the surface of the wheel.

If the pins **97** and **98** are spaced equal to the sparing between apertures **56** and **57**, the decal cannot, once on the tool **100**, be placed covering slots associated with the incorrect apertures **58** and **59**. The opposite condition is also true. Accordingly, two such tools **100** with different pin **97**, **98** spacing may be provided to insure proper placement of the correct decal for the proper slot coverage. Alternatively, a single tool **100** with an extra hole for receipt of a transferred pin to provide the correct spacing, may be provided.

This method of selective bit blocking is preferred because the process is done at the end of the manufacturing line where less than all of the wheel **31** may be exposed. Use of this tool **100** with differing spaced apart pins allows the operator to get to the encoder wheel **31** easily and prevents misplacement of the decal.

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Thus the present invention provides a simple yet effective method and apparatus for transmitting to a machine of a type employing toner, information concerning the characteristics of an EP cartridge, but also combines with such information continuing data relating to the amount of toner left in the cartridge during machine operation. In this connection the present invention provides suitable software to automatically determine, upon machine power-on-reset (POR) or other resumption of functions, whether conditions have changed or altered since the last period of running of the machine, and to alter the machine running conditions in view of those determinations or findings. Moreover, the present invention provides a simplified, but effective method and means for changing the initial information concerning the cartridge, which means and method is accurate enough and simple enough to allow for either in field alterations or end of manufacturing coding of the EP cartridge. The present invention provides, in a single encoder wheel associated with the supply EP cartridge, information which is essential for proper and efficient operation of the machine but which also provides on-going information concerning the amount of toner left in the cartridge for continued use.

Although the invention has been described with a certain degree of particularity, it should be recognized that elements thereof may be altered by person(s) skilled in the art with out departing from the spirit and scope of the invention as hereinafter set forth in the following claims.

What is claimed is:

1. A cartridge for an electrophotographic machine, comprising:

a sump for carrying an initial quantity of toner;

a shaft mounted for rotation in said sump, and a paddle mounted thereon in such a manner that when said shaft rotates, said paddle rotates therewith, into, through and out of engagement with toner carried within said sump;

an encoder wheel mounted on said shaft, externally of said sump; said encoder wheel positioned for mating coaction with a code wheel reader when said cartridge is in a home position in an electrophotographic machine; and

a torque sensitive coupling connected to said shaft for connection to a drive means in said machine, when said cartridge is installed in said machine, to effect rotation of said shaft, paddle and encoder wheel;

said encoder wheel configured for indicating, in conjunction with said coded wheel reader, one or more cartridge characteristics to said machine.

2. A cartridge for an electrophotographic machine in accordance with claim 1, wherein said encoder wheel includes;

means on said encoder wheel for coaction with said code wheel reader on said machine to indicate a component of resistance to paddle movement through the portion of said sump having toner therein to give an indication of the amount of toner remaining in said sump.

3. A cartridge for an electrophotographic machine in accordance with claim 2, wherein:

said encoder wheel is mounted on one side of said torque sensitive coupling; and,

said drive means on said machine is connected to the other side of said torque sensitive coupling; and,

said component of resistance is measured by the lag between drive means travel and encoder travel.

4. A cartridge for an electrophotographic machine in accordance with claim 1, including a section of said encoder wheel containing coded information indicating said one or more characteristics of said cartridge;

said section positioned on said encoder wheel so that during normal rotational operation in said machine by drive means in said machine, said section is read by said code wheel reader prior to said paddle entering said toner material in said sump.

5. A cartridge for an electrophotographic machine in accordance with claim 4, said encoder wheel including;

another section on said encoder wheel configured for coaction with said code wheel reader on said machine to signify a component of resistance to paddle movement through the portion of said sump having toner therein to give an indication of the amount of toner remaining in said sump.

6. A cartridge for an electrophotographic machine in accordance with claim 5, wherein:

said encoder wheel is connected to one side of said torque sensitive coupling, by said shaft, and at one end of said cartridge,

the other side of said torque sensitive coupling being adapted for connection to said drive means and at the opposite end of said cartridge,

and said component of resistance is measured by the lag between drive means travel and encoder travel.

7. A cartridge for an electrophotographic machine in accordance with claim 1, wherein:

said encoder wheel comprises a disk having a keyed central aperture therein for located positioning thereof on said shaft in a predetermined and oriented placement relative to said paddle;

a home window in said disk positioned for detection by said code wheel reader when said cartridge is installed in a machine and upon rotation of said disk;

a plurality of serially positioned, equally spaced apart slots therein, adjacent said home window, for indicating, by covering or not covering of said slots, said one or more characteristics of said cartridge for communication to said machine, through said code wheel reader when said cartridge is installed in said machine.

8. A cartridge for an electrophotographic machine in accordance with claim 7, wherein:

said home or start window has a first different width than other windows or slots in said encoder wheel intended for reading by said code reader;

said disk also including a stop window adjacent to said slots and angularly spaced from said home window, said stop window having a second different width than other windows or slots in said encoder wheel intended for reading by said code wheel reader.

9. A cartridge for an electrophotographic machine in accordance with claim 8, said encoder wheel including:

a plurality of spaced apart slots positioned in said encoder wheel to be read by said code wheel reader when said paddle is rotating through different positions in toner in said sump.

10. A cartridge for an electrophotographic machine in accordance with claim 7 including in said cartridge;

a toner adder roll, a developer roll and a photo conductive drum;

a drive train comprising gears connected to said developer roll, toner adder roll and the driver side of said torque sensitive coupling.

11. A cartridge for an electrophotographic machine in accordance with claim 10 wherein said sump of said cartridge is cylindrical and includes first and second ends, and

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said encoder wheel is connected to the driven side of said torque sensitive coupling, by said shaft, and at a first end of said cartridge,

the driver side of said torque sensitive coupling being connected to said drive train for connection to said drive means and at the second end of said cartridge,

means on said encoder wheel for coaction with said code wheel reader on said machine to indicate a component of resistance to paddle movement through the portion of said sump having toner therein to give an indication of the amount of toner remaining in said sump.

12. A cartridge for an electrophotographic machine in accordance with claim **11** wherein:

said component of resistance is measured by the lag between drive means travel and encoder travel when said cartridge is installed in said machine.

13. A cartridge for an electrophotographic machine in accordance with claim **12** wherein said torque sensitive coupling comprises:

a gear of said drive train mounted for rotation about said shaft;

a torsion spring having one end thereof connected to said gear;

an arbor connected to said shaft and including means on said arbor for connection to the opposite end of said torsion spring whereby when said gear rotates about said shaft the spring effects rotation through said arbor to said shaft said spring being torqued proportionally to the resistance encountered during paddle rotation through said sump.

14. An electrophotographic (EP) machine, comprising:

a replaceable EP cartridge having at least a sump for containing a supply of toner material;

drive means for moving print receiving media through the machine, and for effecting rotation of a paddle within said sump, into, through and out of toner material carried in said sump;

an encoder wheel on said cartridge, in a preselected and predetermined orientation with respect to said paddle in said sump and connected thereto, and a code wheel reader in mating relation with respect thereto when said cartridge is installed in said machine; and

a variable torque sensitive coupling connecting said drive means to said paddle to effect rotation thereof, said encoder wheel configured for indicating, in conjunction with said coded wheel reader, characteristics of the cartridge including a component of resistance to paddle movement as reflected in said torque sensitive coupling through the portion of said sump having toner therein to give an indication of the amount of toner remaining in said sump.

15. An electrophotographic (EP) machine in accordance with claim **14** including a shaft extending through said sump and connected to said paddle;

said encoder wheel comprising a disk having a keyed central aperture therein for located positioning thereof on said shaft in a predetermined and oriented placement relative to said paddle; P1 a home window in said disk positioned for detection by said code wheel reader upon rotation of said disk by said drive means;

a plurality of serially positioned, equally spaced apart slots in said disk, adjacent said home window, for indicating, by covering or not covering of said slots, one or more characteristics of said cartridge for communication to said machine, through said code wheel reader.

16. An electrophotographic (EP) machine in accordance with claim **15** wherein:

said home or start window has a first different width than other windows or slots in said encoder wheel intended for reading by said code reader;

said disk also including a stop window adjacent to said slots and angularly spaced from said home window, said stop window having a second different width than other windows or slots in said encoder wheel for reading by said code wheel reader upon rotation of said disk.

17. An electrophotographic (EP) machine in accordance with claim **16** wherein said component of resistance is measured by the lag between said drive means travel and encoder travel.

18. An electrophotographic (EP) machine in accordance with claim **14** wherein said machine includes a processor coupled to said code wheel reader, a program in non-volatile memory associated with said processor for determining the home position of said disk, and a table in said non-volatile memory for comparing the measured lag with the lag associated with paddle resistance stored in said table and associated with predetermined quantities of toner in said sump.

19. An electrophotographic (EP) machine in accordance with claim **18** including another plurality of serially arranged slots in said disk positioned to be read at different locations of said paddle in toner in said sump, and look up tables in said memory for comparing the measured lag at each said another slot to determine the quantity of toner in said sump.

20. An electrophotographic (EP) machine in accordance with claim **14**, including in said cartridge:

a toner adder roll, a developer roll and a photo conductive drum;

a drive train comprising gears connected to said developer roll, adder roll and the driver side of said torque sensitive coupling and to said drive means.

21. An electrophotographic (EP) machine in accordance with claim **20**, wherein said sump of said cartridge is cylindrical and includes first and second ends, and

said encoder wheel is connected to the driven side of said torque sensitive coupling, by said shaft, and at a first end of said cartridge,

the driver side of said torque sensitive coupling being connected to said drive train for connection to said drive means and at the second end of said cartridge,

said component of resistance being measured by the lag between drive means travel and encoder travel when said cartridge is installed in said machine.

22. An electrophotographic (EP) machine in accordance with claim **21**, wherein said torque sensitive coupling comprises:

a gear of said drive train mounted for rotation about said shaft;

a torsion spring having one end thereof connected to said gear;

an arbor connected to said shaft and including means on said arbor for connection to the opposite end of said torsion spring whereby when said gear rotates about said shaft the spring effects rotation through said arbor to said shaft, said spring being torqued proportionally to the resistance encountered during paddle rotation through said sump.

23. A method of determining characteristics of a replaceable cartridge for an electrophotographic machine, said

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cartridge including a sump for holding toner therein and a paddle mounted for rotation within said sump, an encoder wheel mounted externally of said sump and connected to said paddle for rotation therewith, said wheel having a plurality of slots therein, some of said slots being coded for indicating characteristics of the cartridge when rotated by drive means for reading by a code wheel reader on said machine, comprising the steps of:

rotating said wheel and determining the home position of said wheel and the position thereon of encoded slots representing bits relative to the paddle in said sump of toner by counting drive means increments from a predetermined start or home position;

recording increments to encoded slots and stop window trailing edge;

subtracting an incremental count of said drive means as if no toner were in said sump from an actual incremental count to selected predetermined positions of said paddle in said sump containing toner to determine delay being measured in known distances traveled by said paddle under no toner to actual toner contained conditions;

and determining from said difference the quantity of toner remaining in said sump.

24. A method of determining characteristics of a replaceable cartridge for an electrophotographic machine in accordance with claim **23** wherein, if said machine stops, including the steps of:

counting the number of increments the drive means backs up; and

subtracting that number of increments from said count.

25. A method of determining characteristics of a replaceable cartridge for an electrophotographic machine in accordance with claim **24** including the step of:

checking for a correct position of a stop window relative to a start window.

26. A method of determining characteristics of a replaceable cartridge for an electrophotographic machine in accordance with claim **23** wherein said selected predetermined positions of said paddle, in said sump are angularly separated in the direction of rotation for reading serially during rotation subsequent to said paddle entering toner in said sump.

27. A method of determining characteristics of a replaceable cartridge for an electrophotographic machine in accordance with claim **26** including the steps of:

summing the delay, during prescribed revolutions of said paddle, and

calculating an average of such delays on a continuing basis to determine if said quantity of toner changed from the last reading.

28. A method of determining characteristics of a replaceable cartridge for an electrophotographic machine in accordance with claim **27** including the step of:

reporting toner level conditions to a user.

29. A method of determining characteristics of a replaceable cartridge for an electrophotographic machine in accordance with claim **28** including the steps of:

continuing the steps of subtracting and determining for each rotation of said wheel.

30. A method of determining characteristics of a replaceable cartridge for an electrophotographic machine in accordance with claim **23** including the steps of:

continuing the steps of subtracting and determining for each rotation of said wheel.

31. An electrophotographic (EP) machine including a replaceable EP cartridge having at least a sump for containing a supply of toner material, said machine including a drive means for moving print receiving media through the machine, and for effecting rotation of a shaft extending into and out of said sump, said shaft having a paddle mounted thereto for rotation within said sump, into, through and out of toner material carried in said sump, comprising means for indicating characteristic information for said cartridge via a single encoded wheel coupled to said shaft.

32. A cartridge for an electrophotographic machine, comprising:

a sump for carrying a quantity of toner;

a toner agitator mounted in said sump; and

a single encoded wheel rotating in relation to said toner agitator, said encoded wheel including coding for determining a quantity of toner in said cartridge.

33. The cartridge of claim **32**, wherein said coding comprises one or more openings formed in said wheel.

34. The cartridge of claim **33**, wherein said one or more openings comprise a plurality of openings located in spaced relation in said wheel.

35. The cartridge of claim **34**, wherein said wheel further comprises encoding for one or more preselected cartridge characteristics.

36. A toner cartridge for an imaging apparatus, the improvement comprising a wheel having coding representing one or more preselected cartridge characteristics.

37. The cartridge of claim **36**, wherein at least one of said one or more preselected cartridge characteristics is formed on said wheel by one or more openings located in a section of said wheel.

38. The cartridge of claim **37**, wherein a presence or absence of said one or more openings in said section of said wheel correspond to binary data for identifying said preselected characteristics of said cartridge.

39. The cartridge of claim **36**, further comprising a plurality of openings in spaced relation in said wheel for use in measuring a quantity of toner in said cartridge.

40. The cartridge of claim **36**, wherein said wheel is coded with said one or more preselected cartridge characteristics by covering at least one of a plurality of openings.

41. The cartridge of claim **36**, wherein said coding comprises a plurality of openings in said wheel.

42. The cartridge of claim **36**, wherein said wheel further comprises coding for determining a quantity of a toner carried by said cartridge.

* * * * *

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EXHIBIT 3

US005758231A

United States Patent [19]

Coffey et al.

[11] Patent Number: 5,758,231

[45] Date of Patent: May 26, 1998

[54] **VENTING PLUG IN TONER CARTRIDGE**

[75] Inventors: **Johnnie A. Coffey**, Winchester; **Steven Alan Curry**, Nicholasville; **Robert Flynt Strean**, Lexington; **Earl Dawson Ward, II**, Richmond, all of Ky.

[73] Assignee: **Lexmark International, Inc.**, Lexington, Ky.

[21] Appl. No.: **770,329**

[22] Filed: **Dec. 20, 1996**

[51] **Int. Cl.**[6] **G03G 15/08**; G03G 21/00

[52] **U.S. Cl.** **399/106**; 220/254; 220/371; 222/189.09; 399/93; 399/98

[58] **Field of Search** ..... 399/103, 106, 399/98, 93; 55/385.4, 441; 222/180.09, DIG. 1; 220/253, 254, 371

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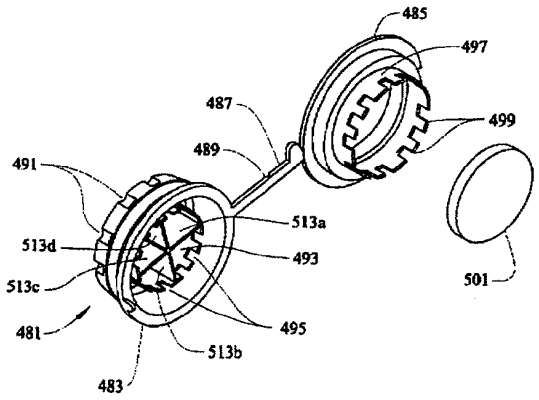
Primary Examiner—Arthur T. Grimley
Assistant Examiner—Sophia S. Chen
Attorney, Agent, or Firm—John A. Brady

[57] **ABSTRACT**

Hopper plug (**143**) vents out air pressure build-up which cause toner leaks. One side of the plug has a series of entrance openings (**491**) which communicate with the inside of the hopper (**61**). Air, potentially containing some toner particles, passes through those openings and enters a first chamber (**507**). The first chamber has exit holes (**499**) which do not face the entrance openings. Air passing through the exit holes of the first chamber enters a second chamber (**509**). The second chamber has exit holes (**495**) which are at the opposite end and do not face the entrance openings. Third chamber (**511**) of this labyrinth faces a mat toner filter (**501**) which leads to exit holes (**503**).

16 Claims, 23 Drawing Sheets



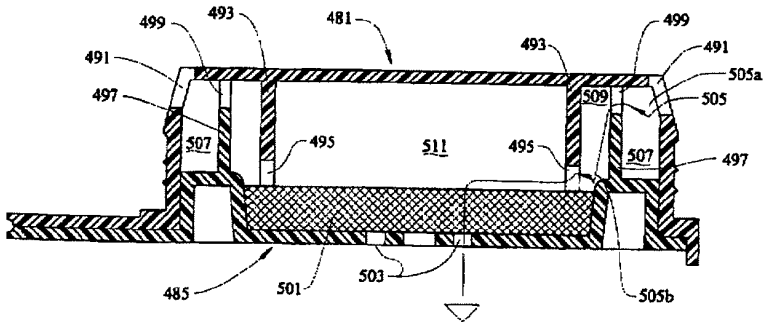


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FIG. 1

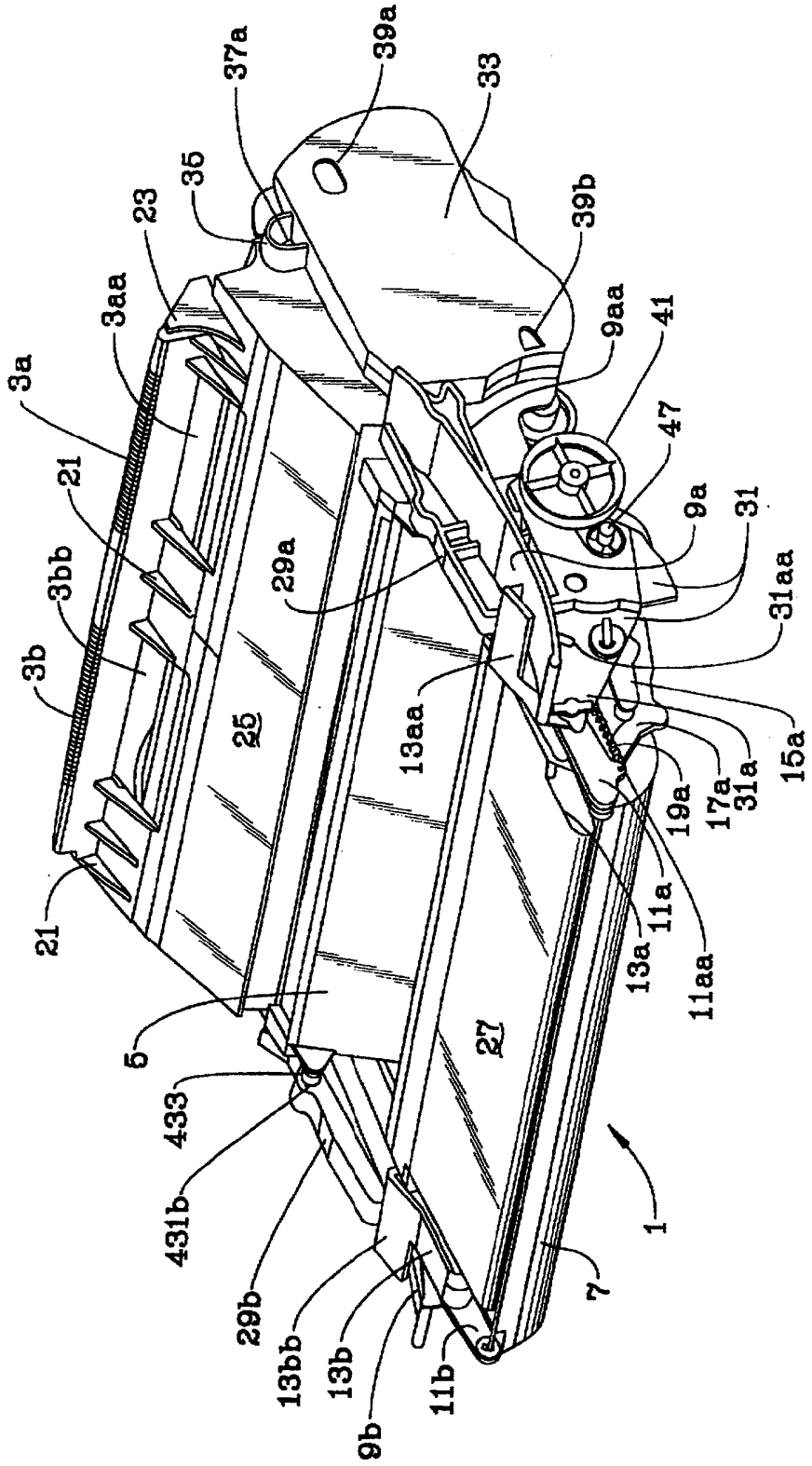

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FIG. 2

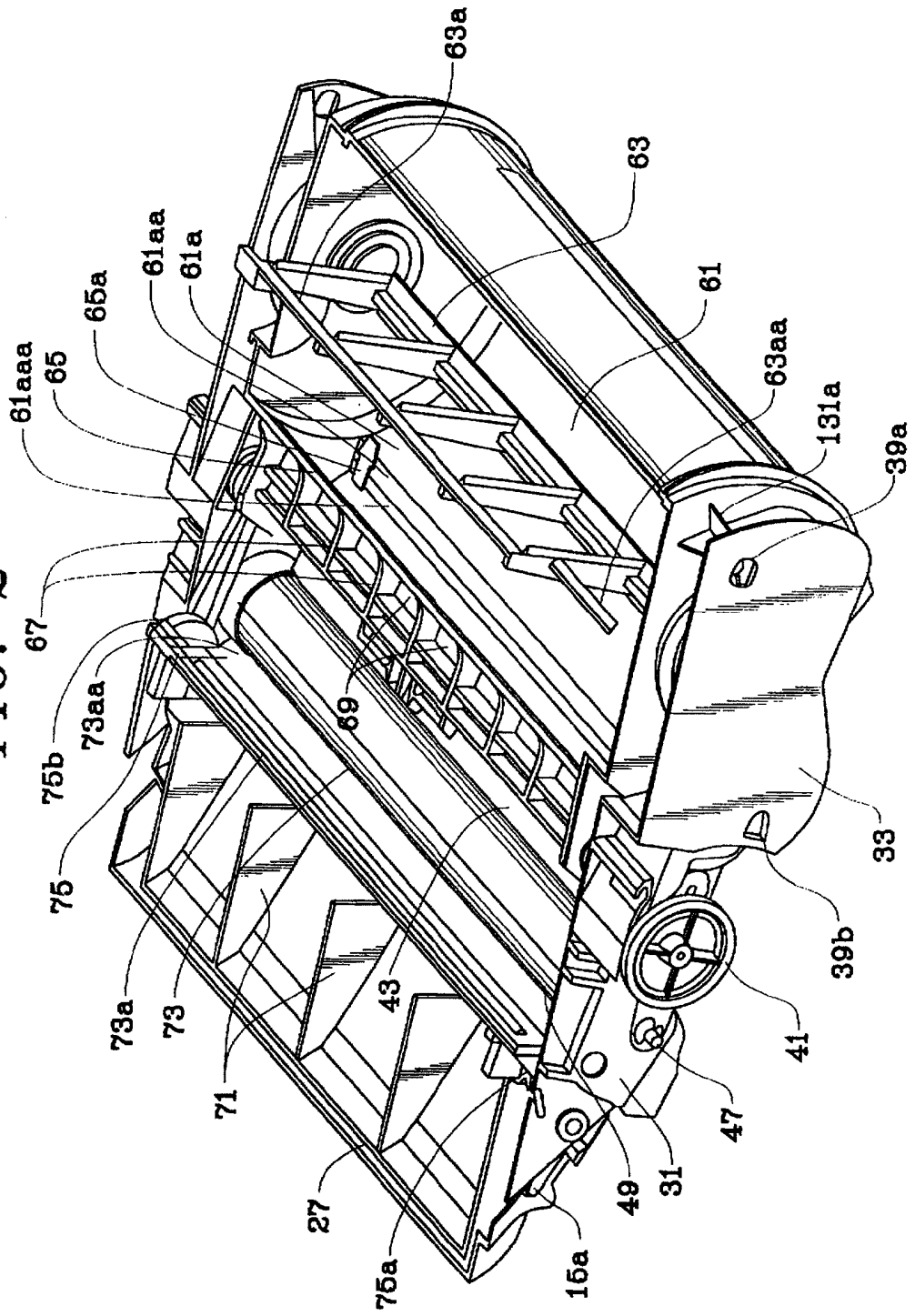

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FIG. 3

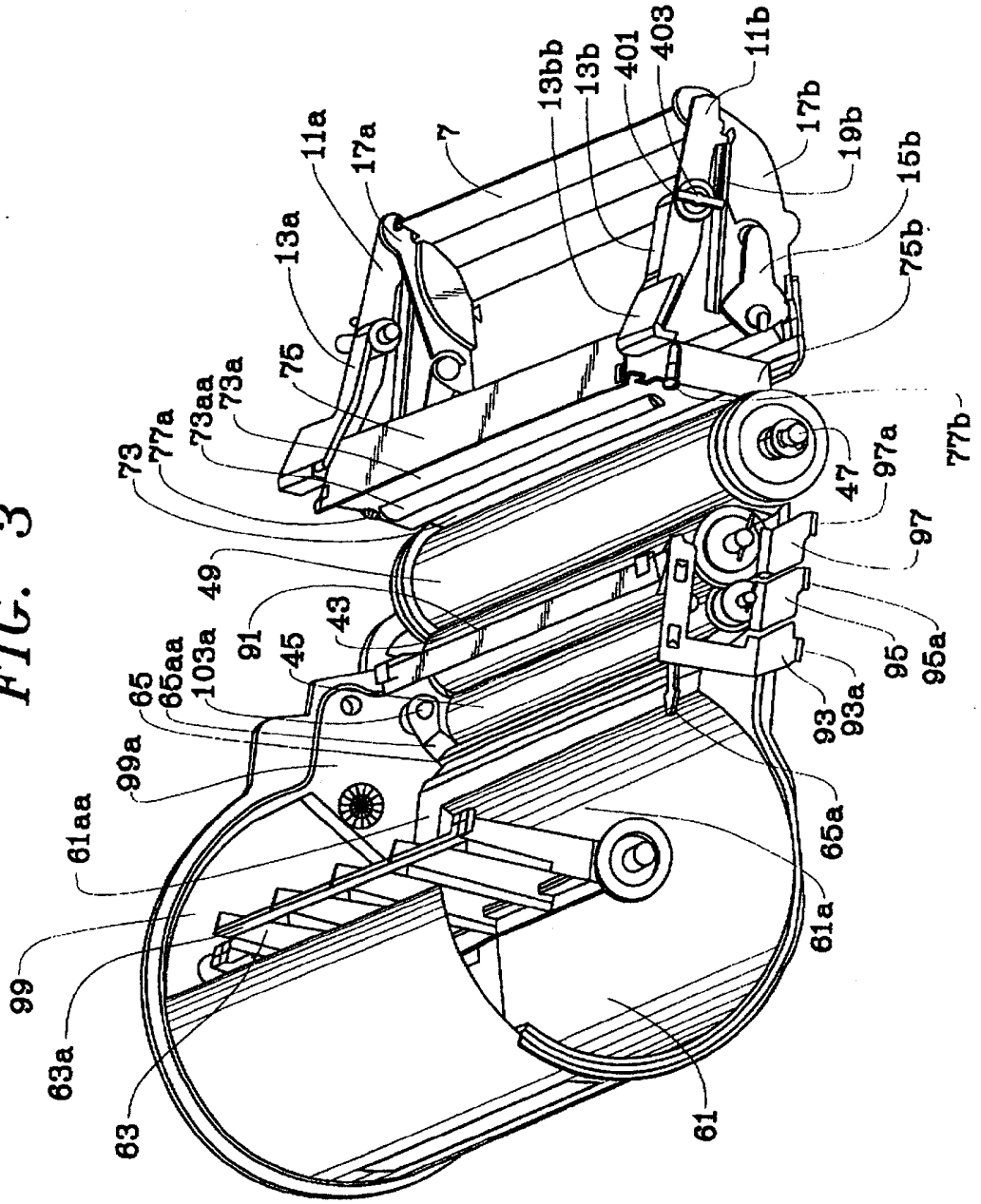

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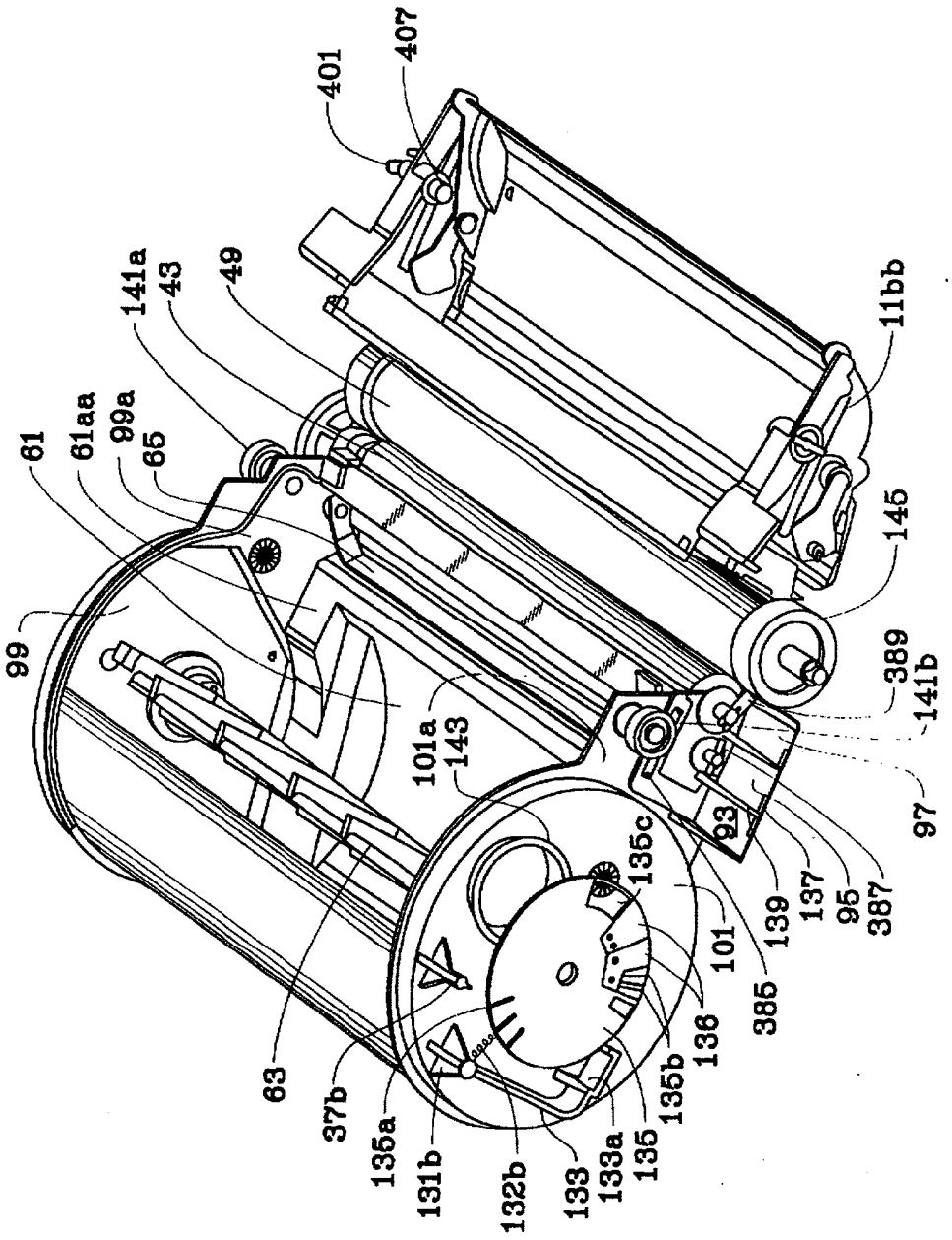
FIG. 4



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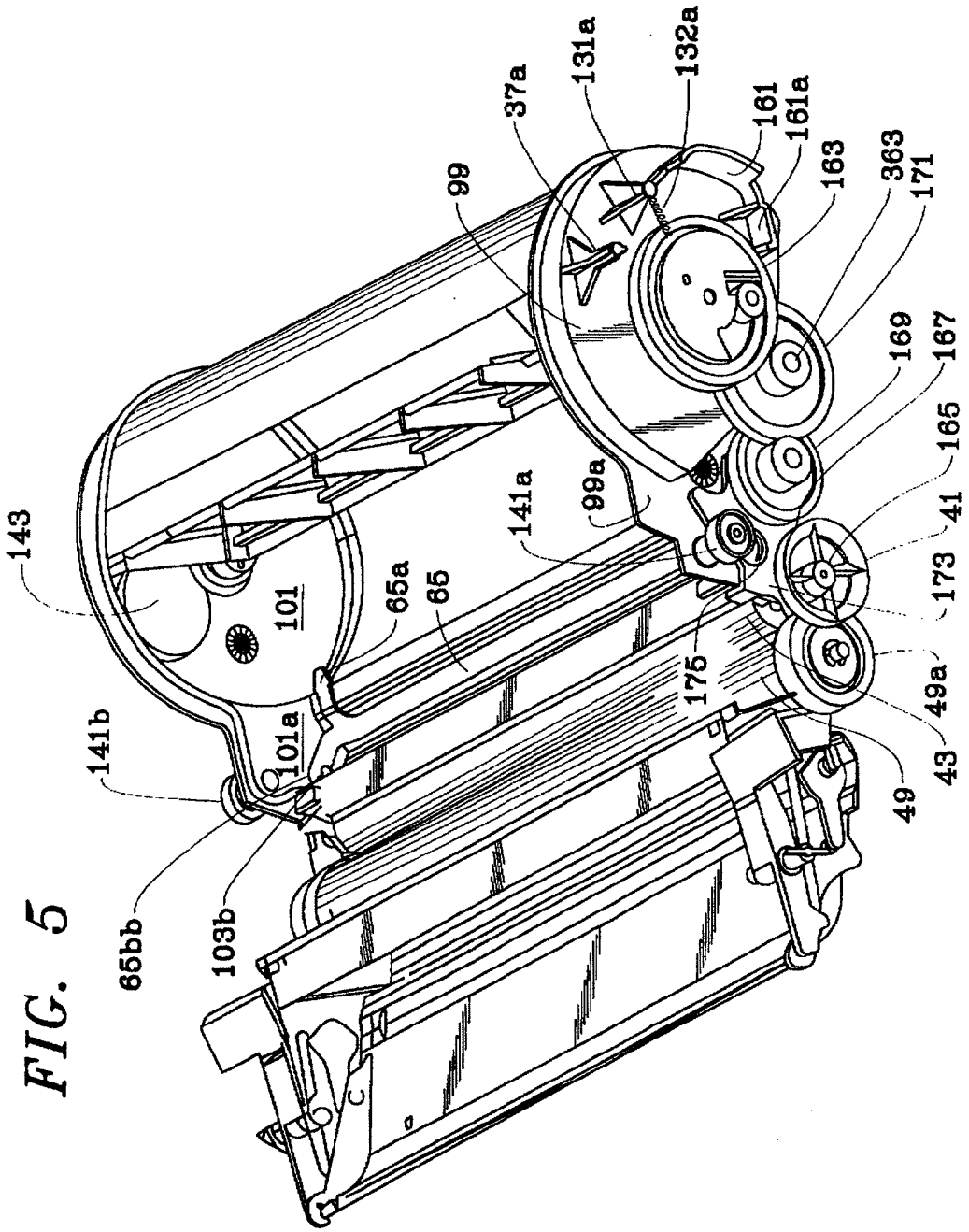

FIG. 5

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FIG. 6

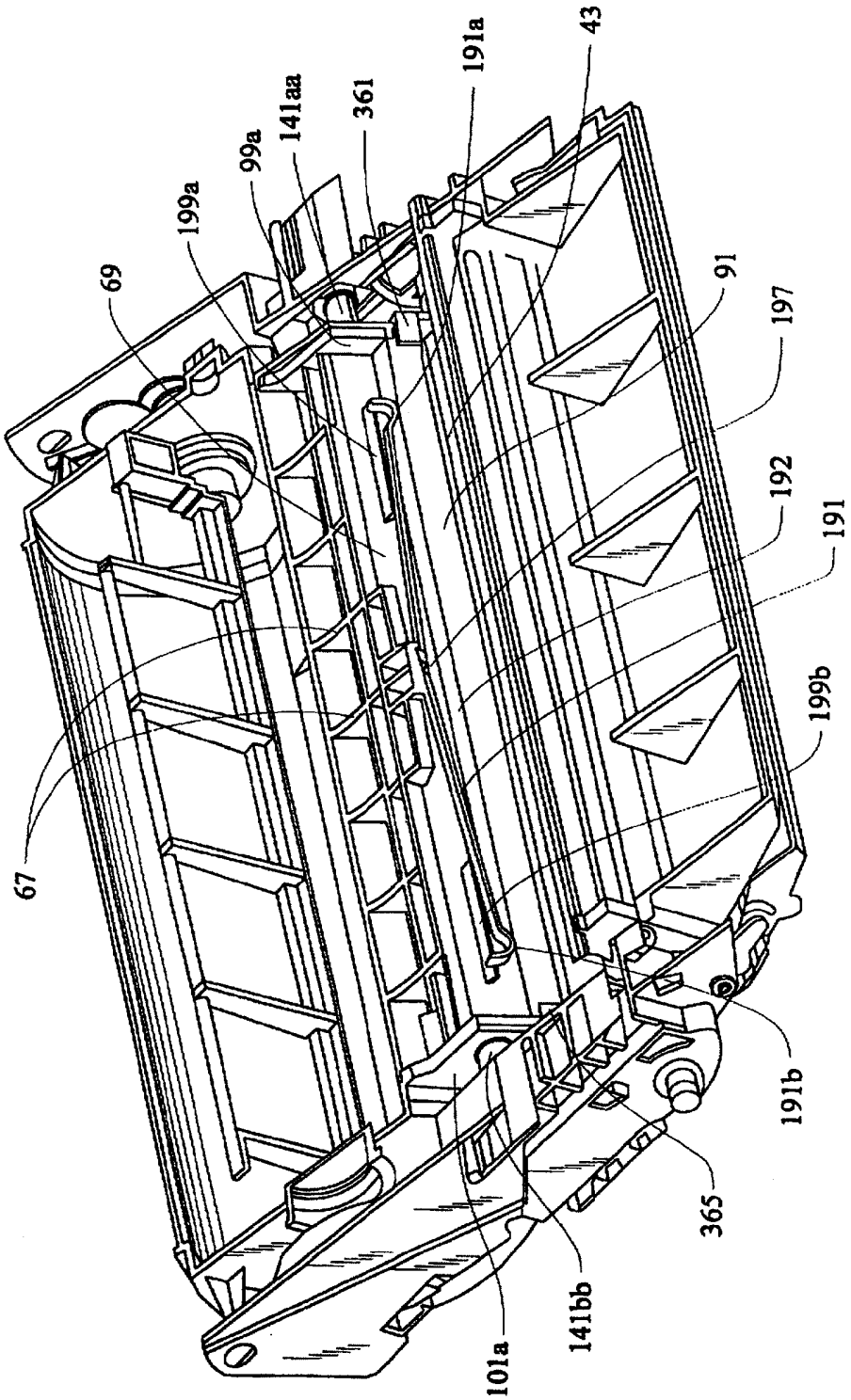

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FIG. 7

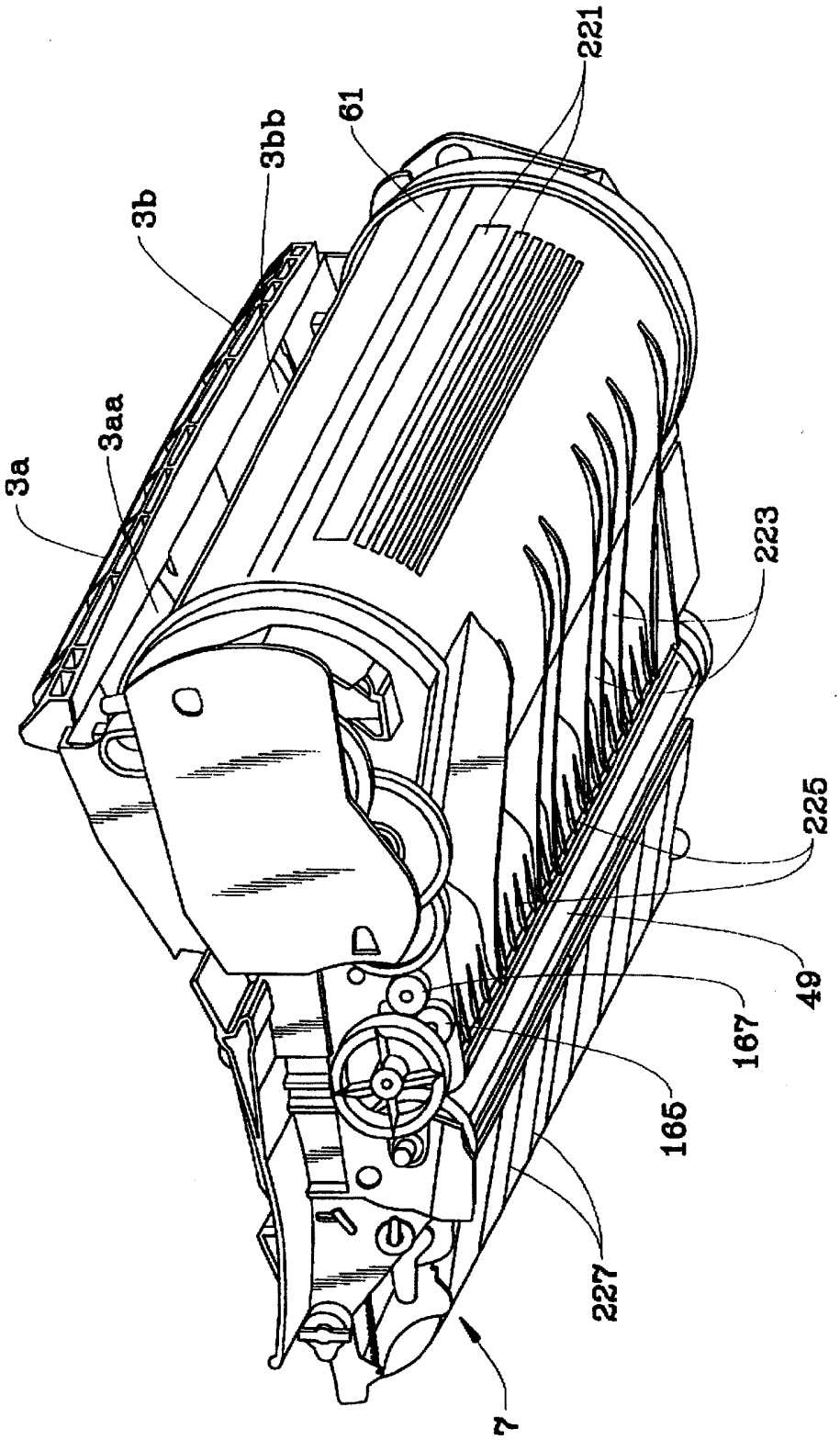

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FIG. 8

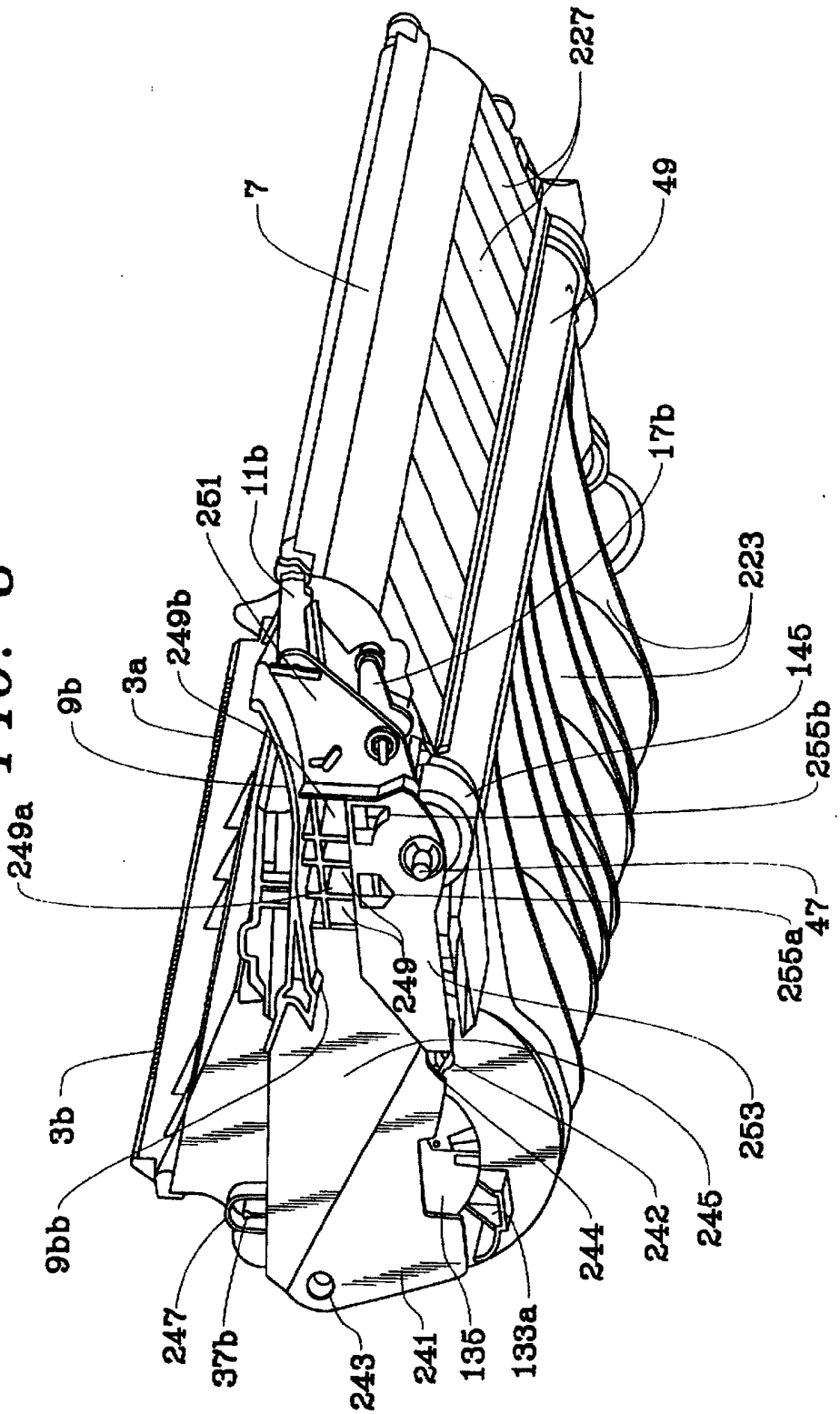

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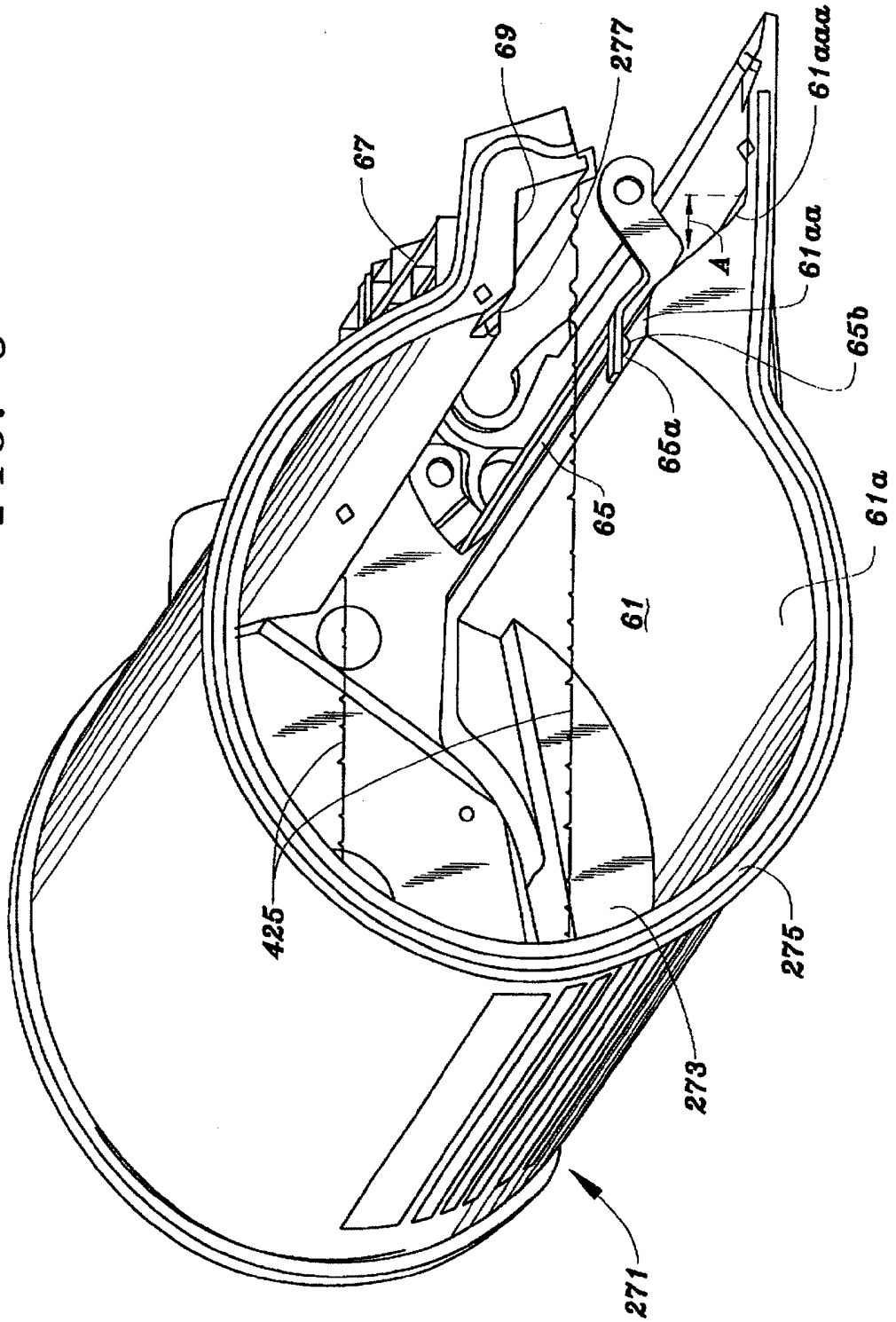
FIG. 9



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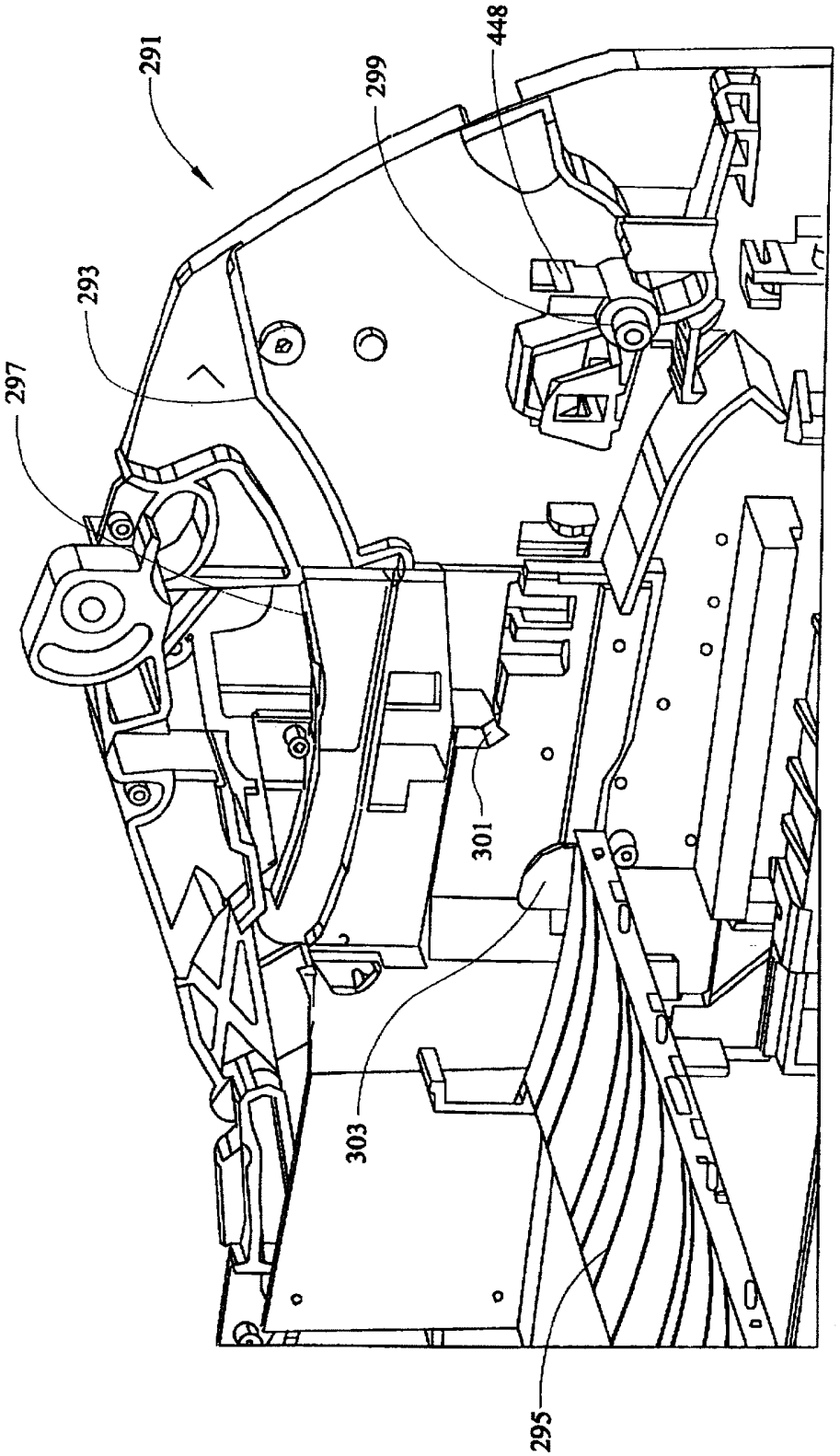

FIG. 10

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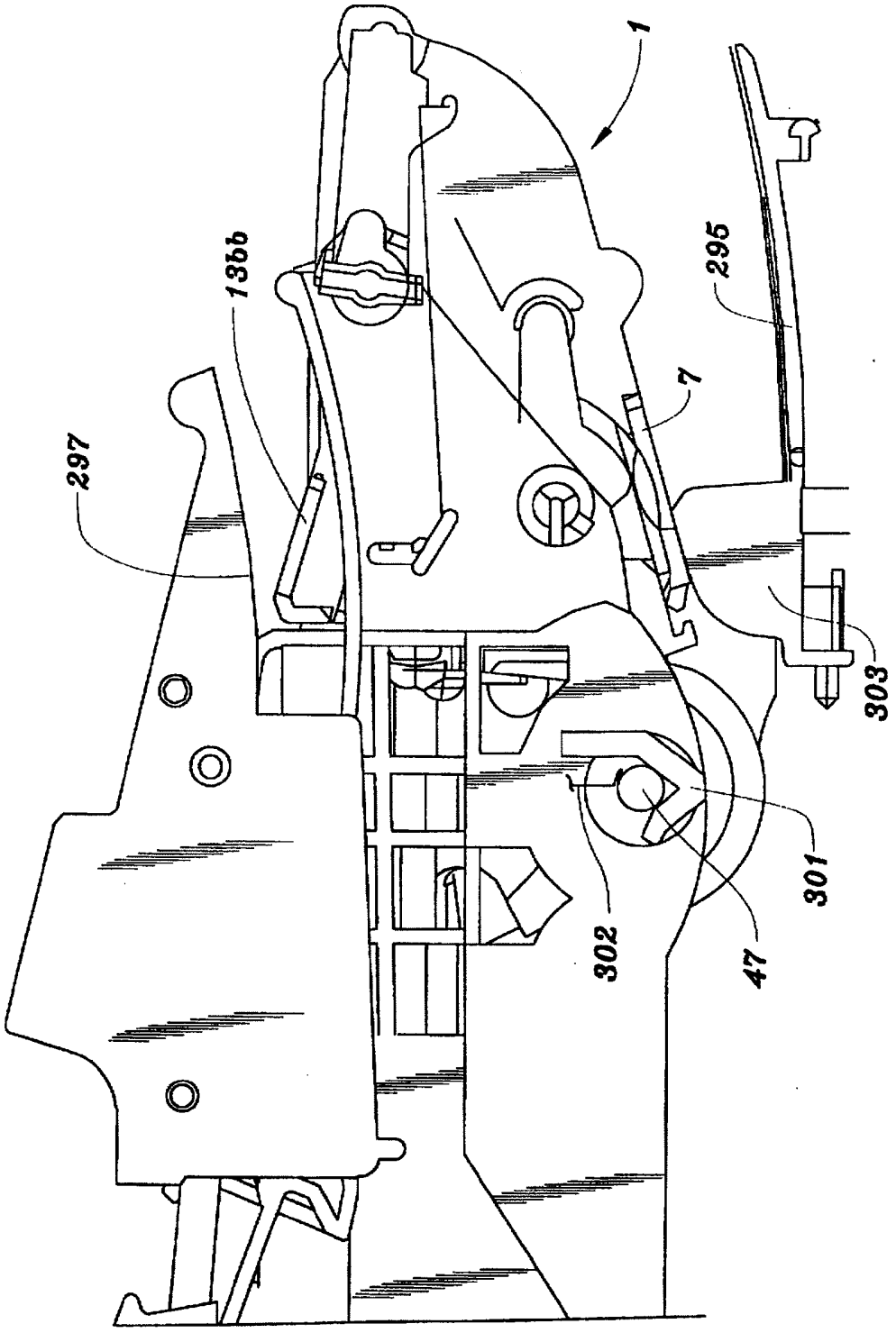

FIG. 11

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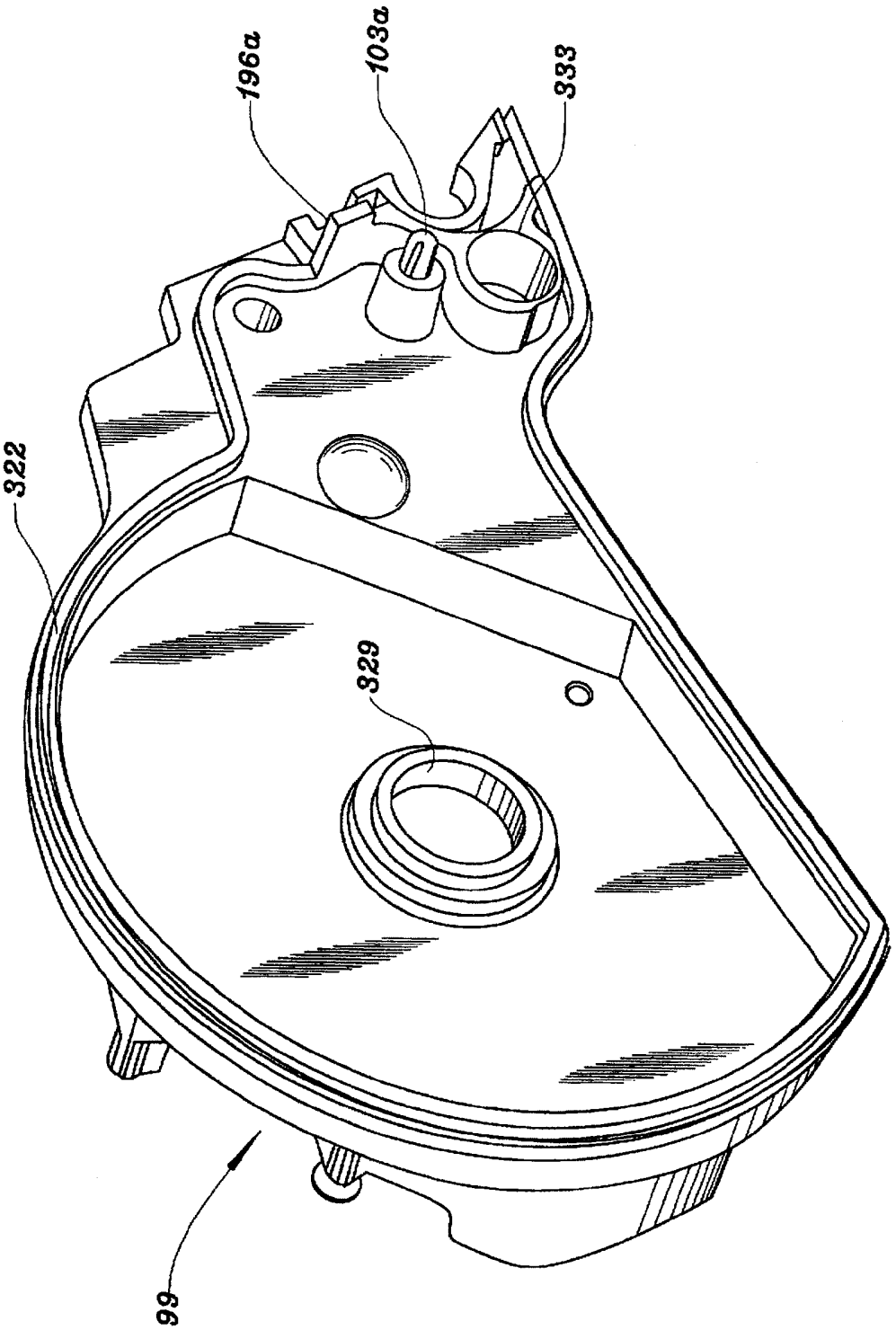

FIG. 12

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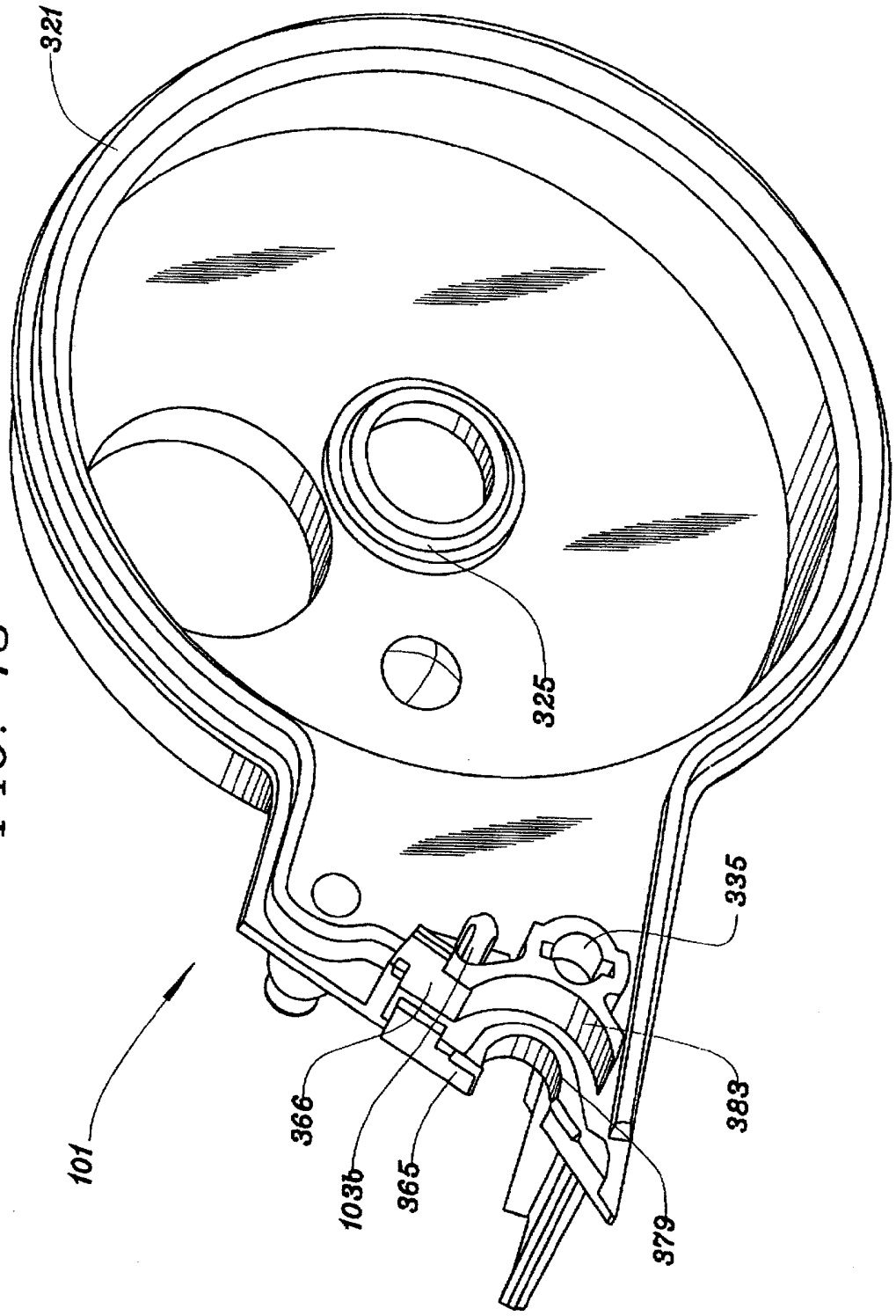

FIG. 13

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FIG. 14

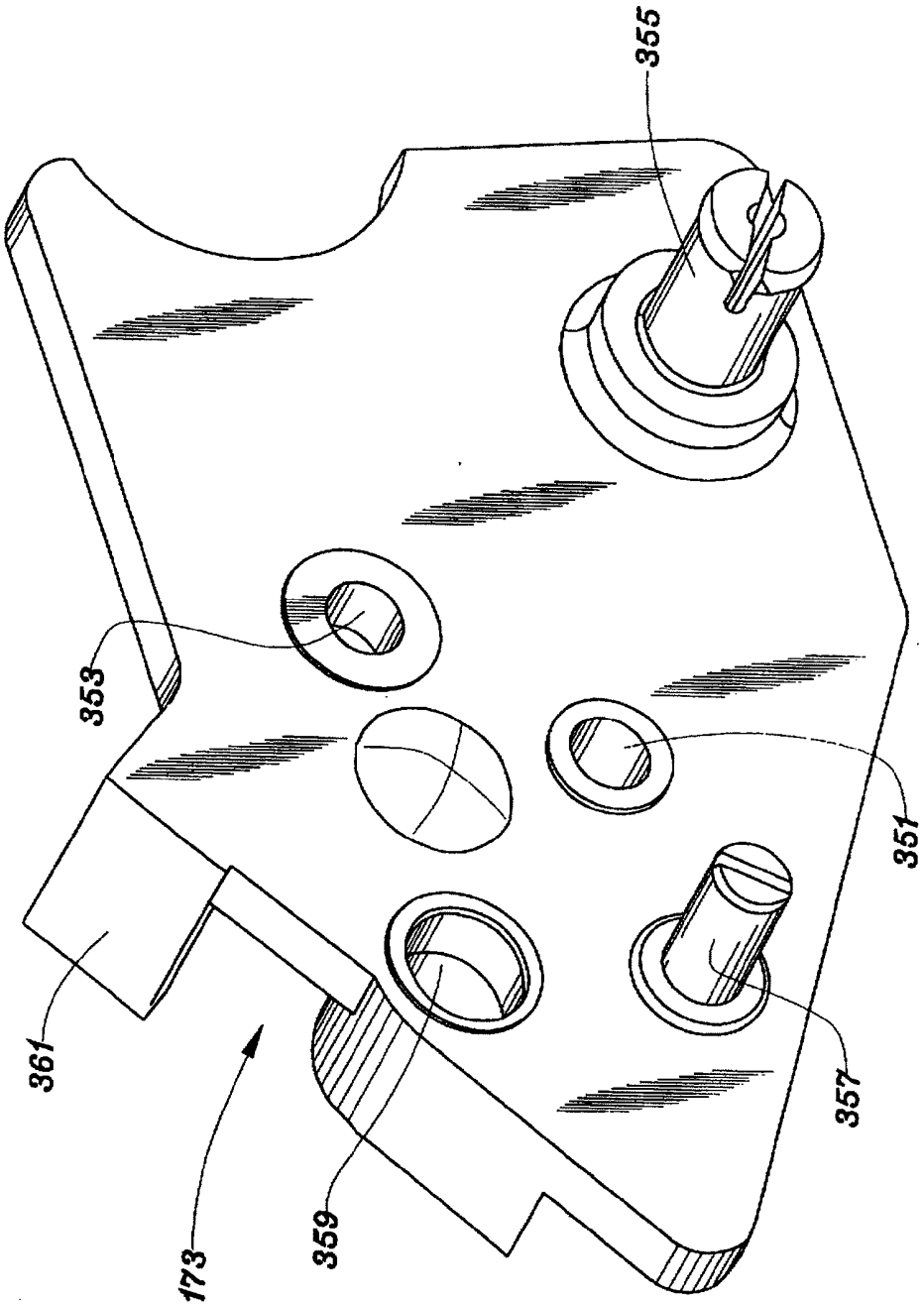

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FIG. 15

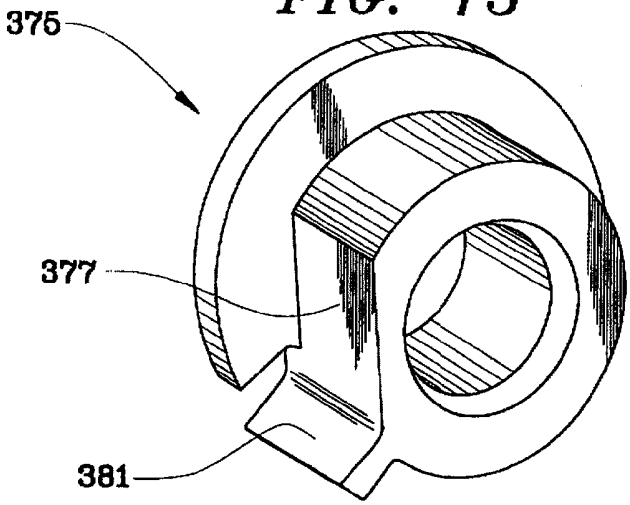

FIG. 18

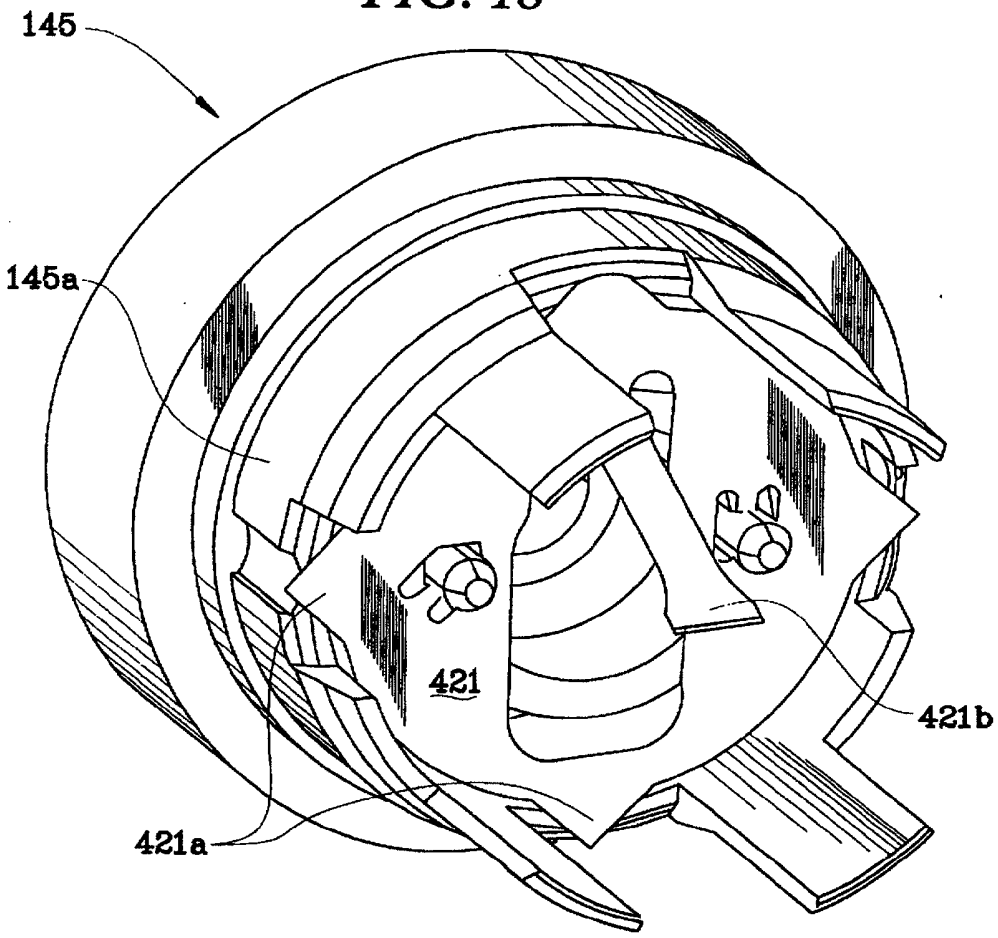

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FIG. 16

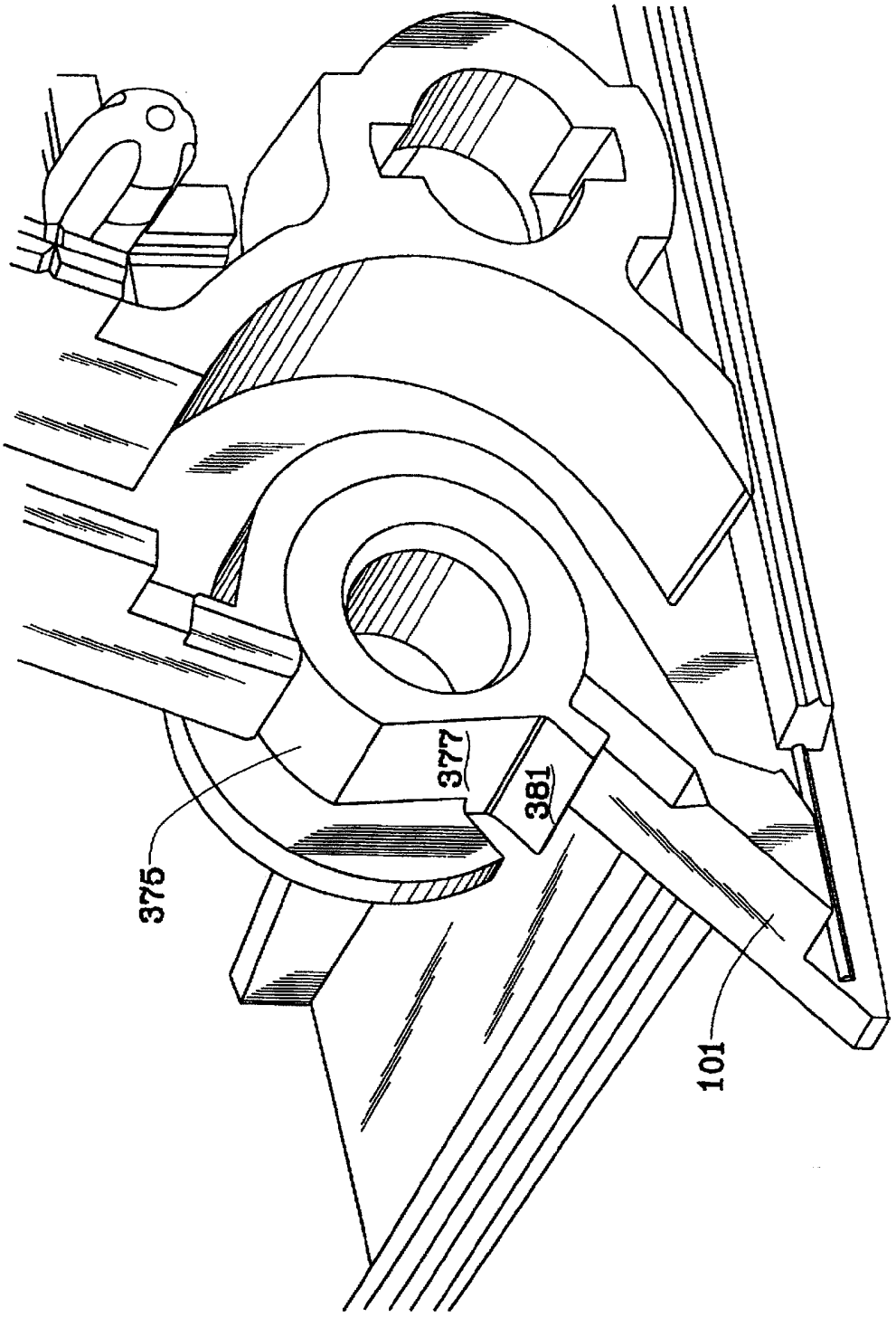

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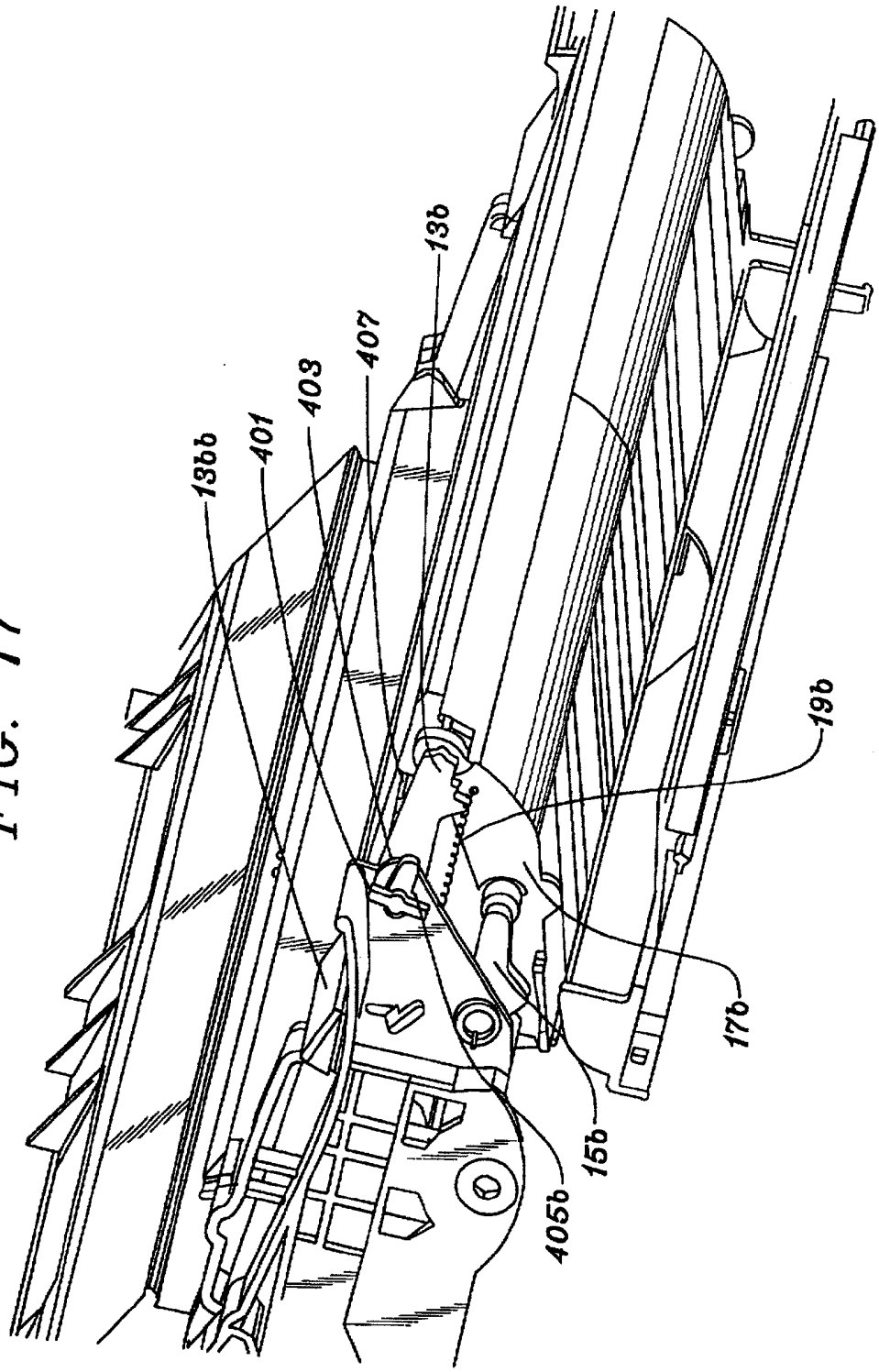
FIG. 17



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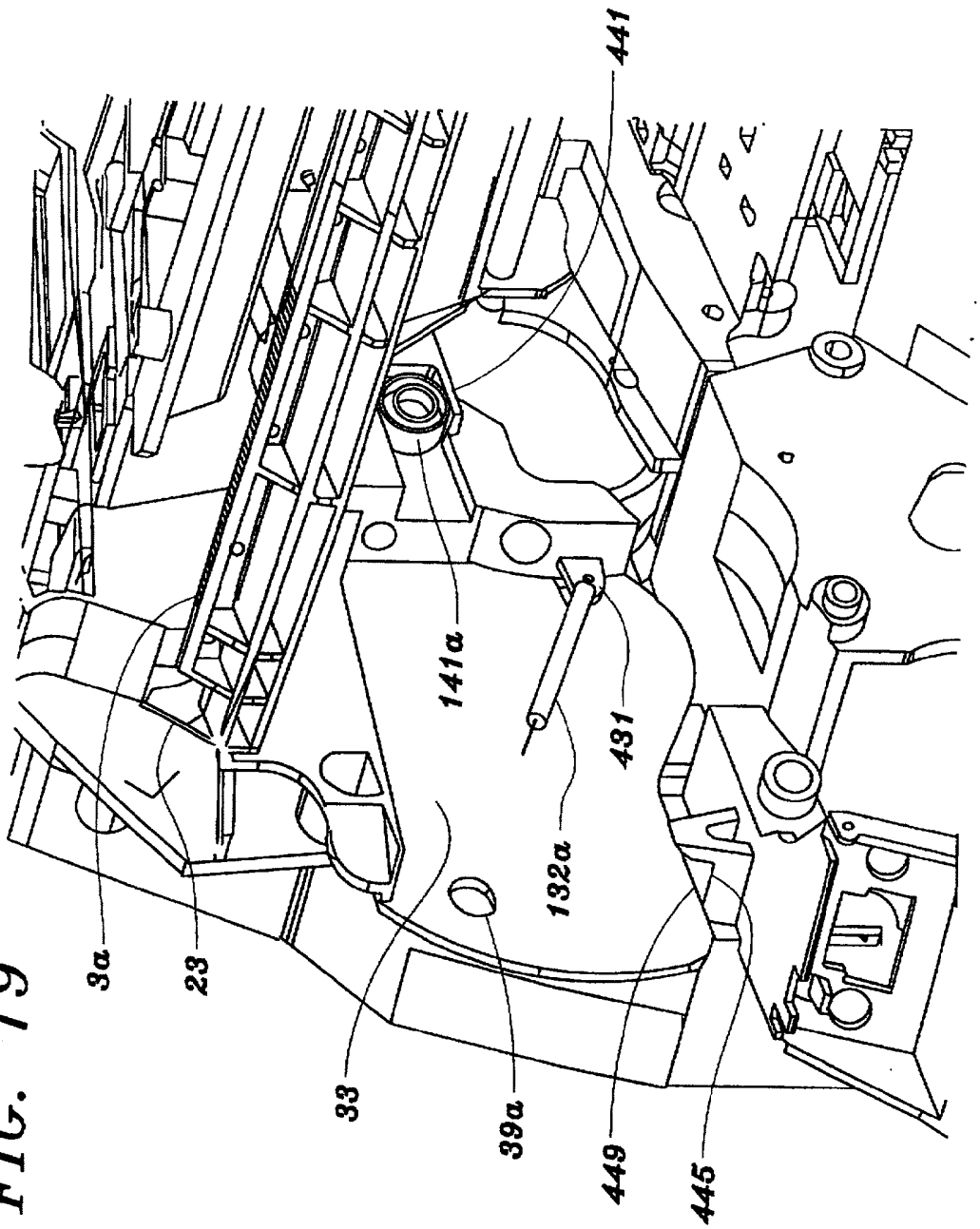

FIG. 19

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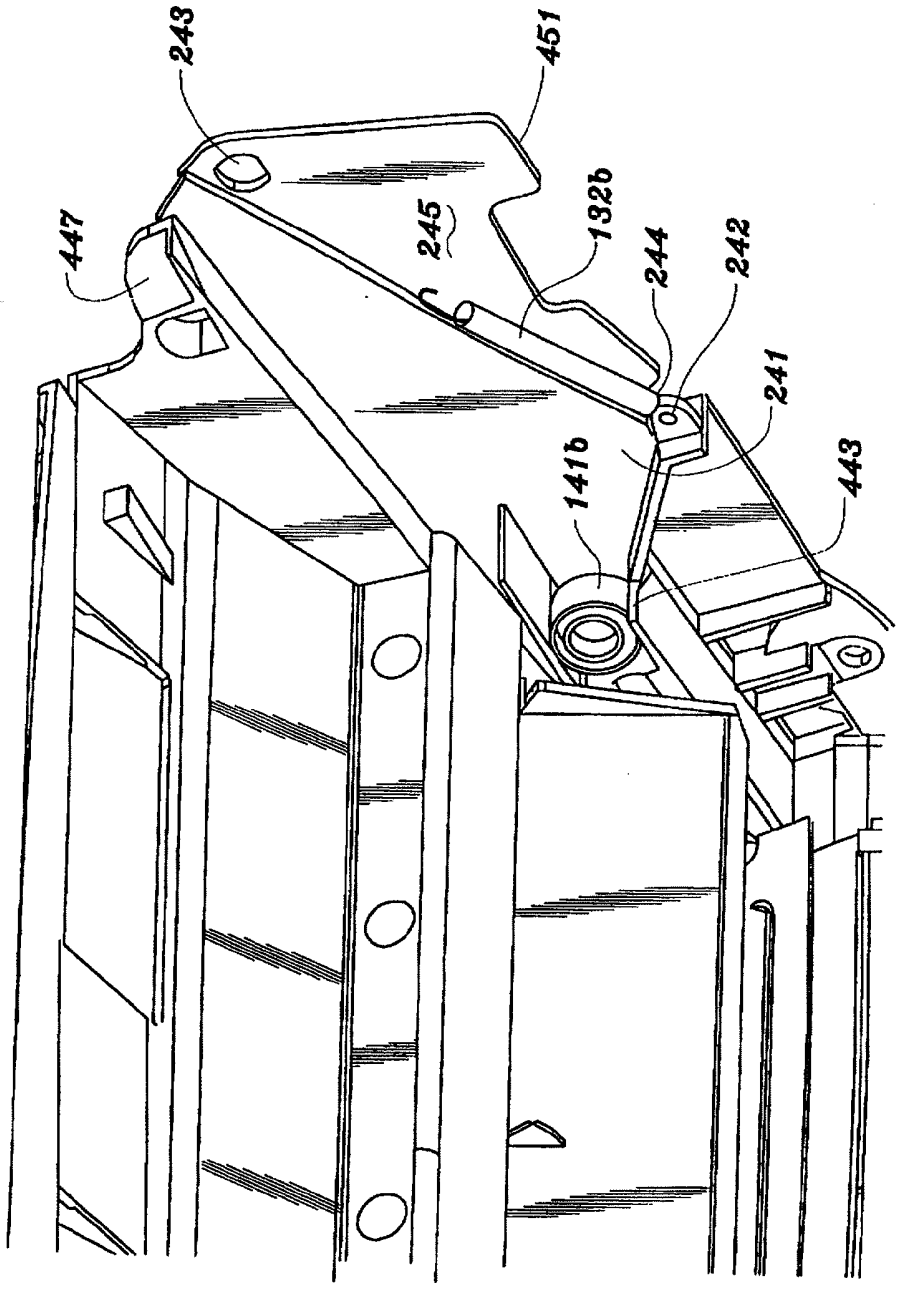

FIG. 20

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FIG. 21

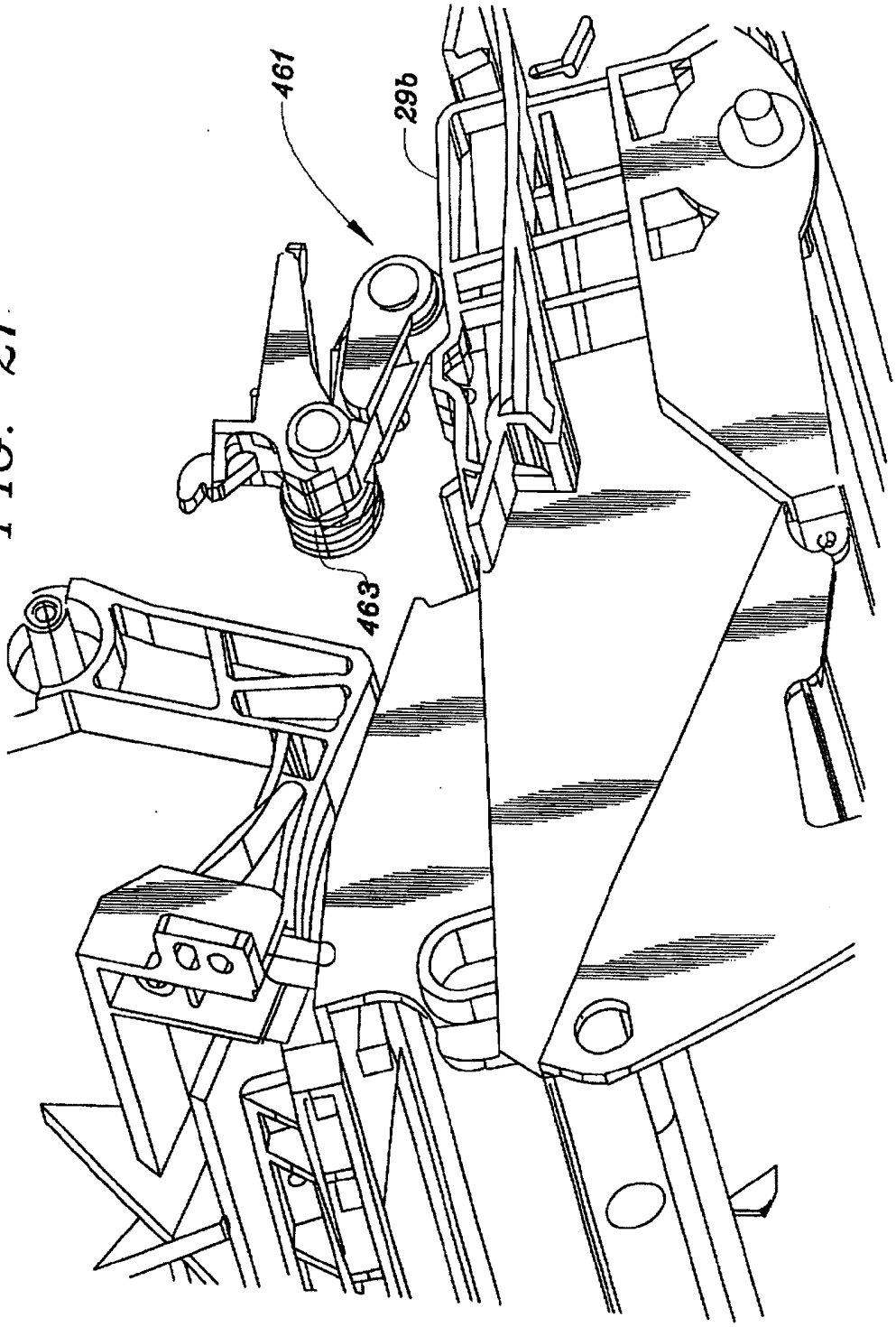

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FIG. 22

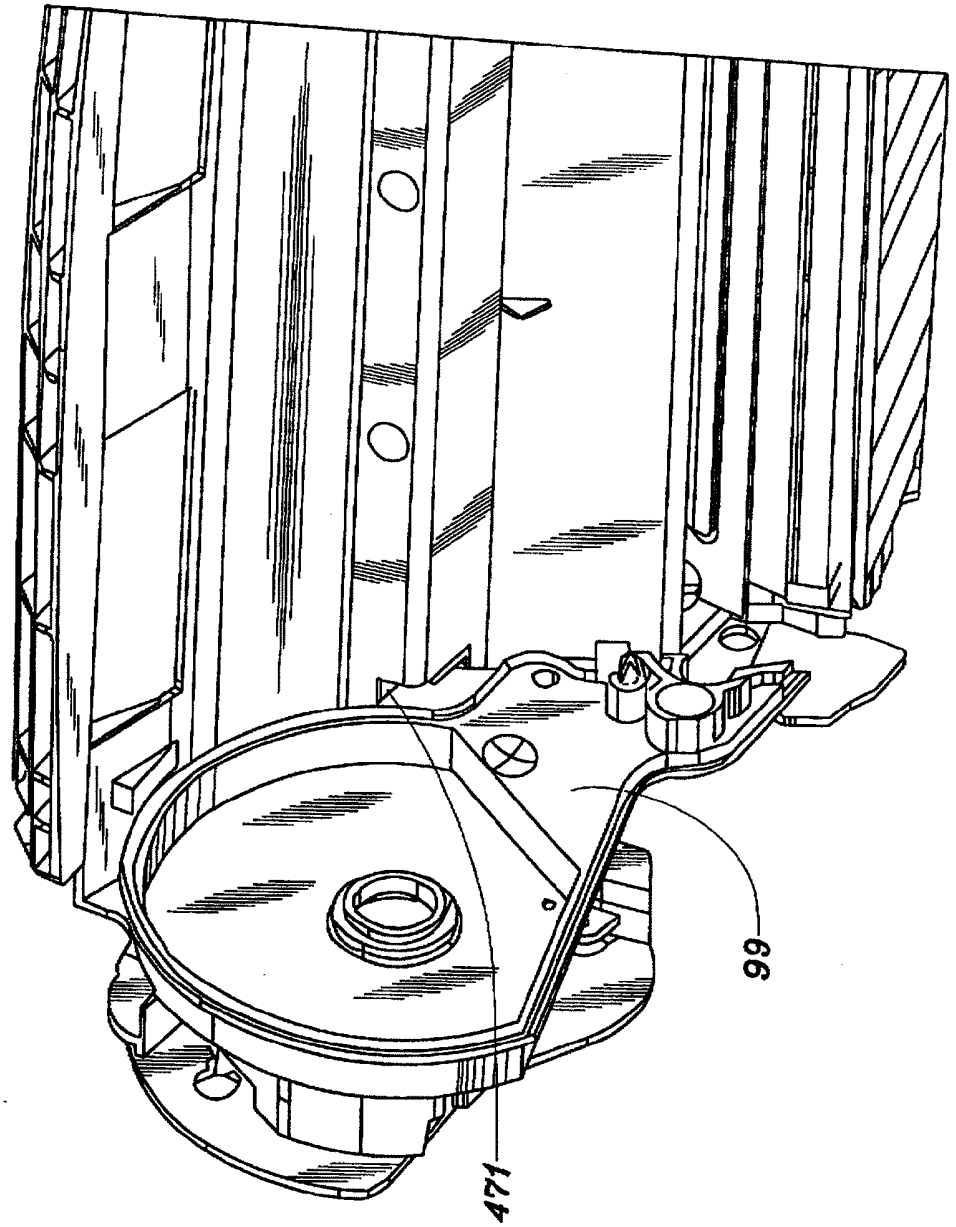

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FIG. 24

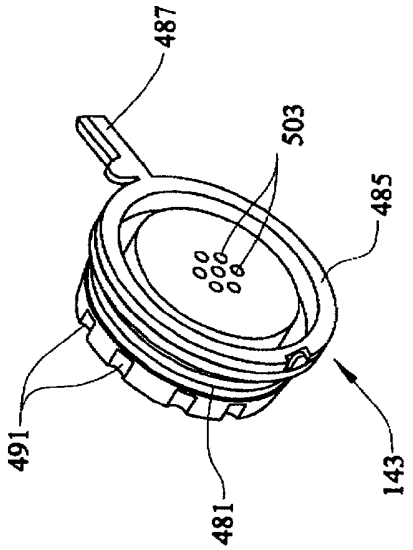
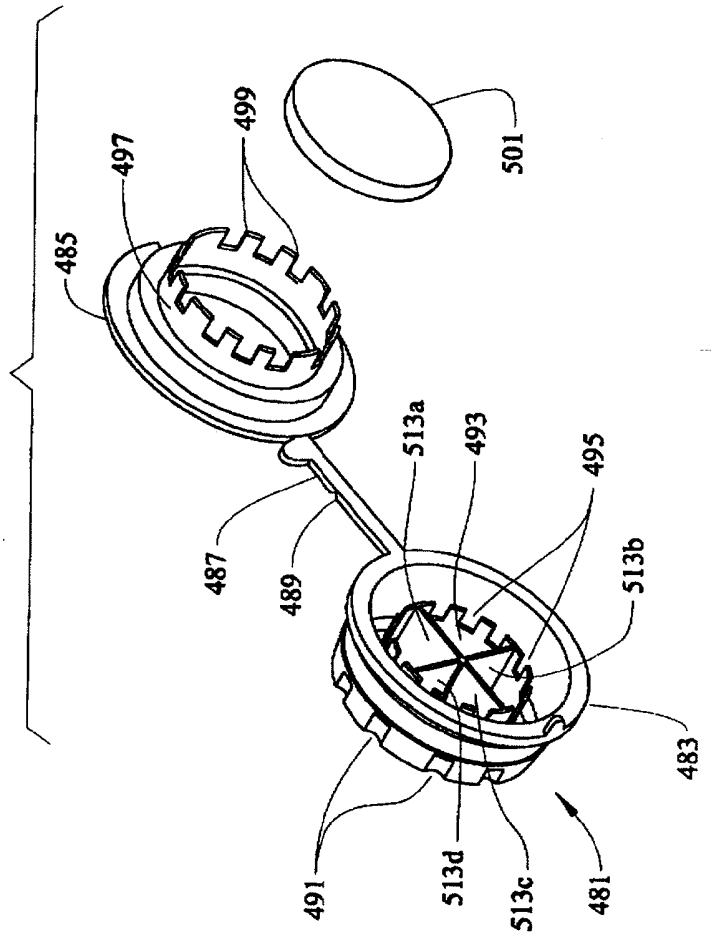


FIG. 23



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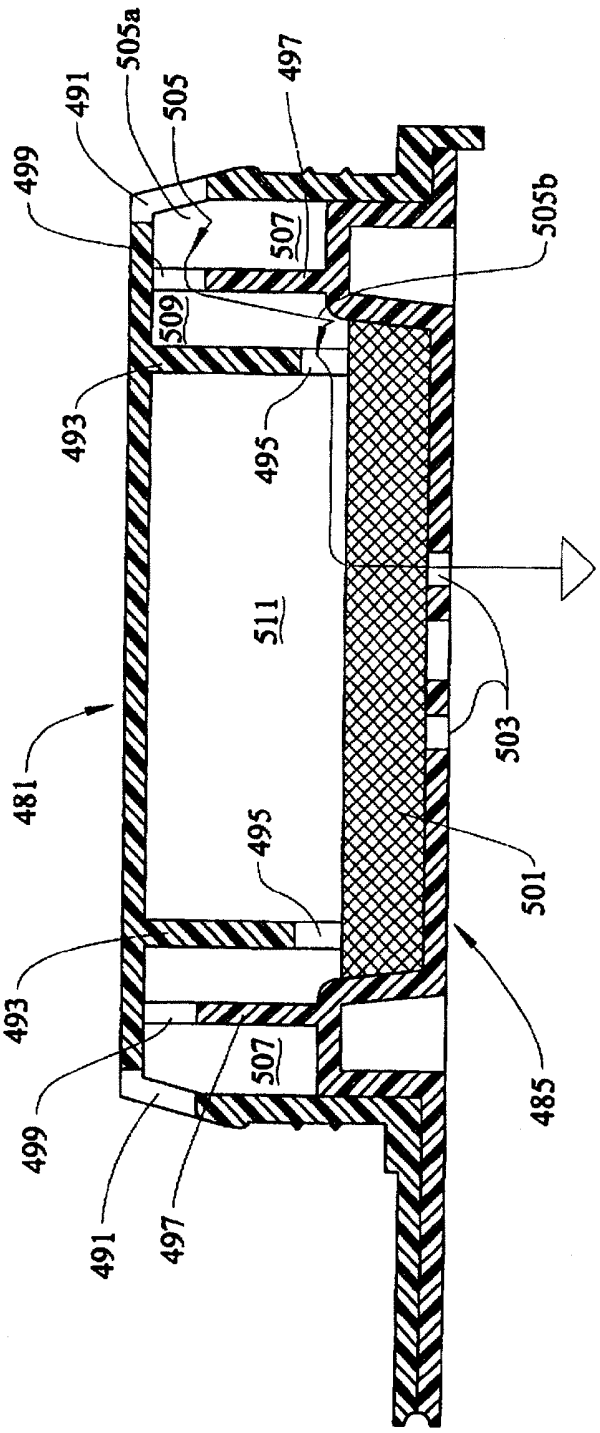

FIG. 25

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VENTING PLUG IN TONER CARTRIDGE

CROSS-REFERENCE TO RELATED APPLICATIONS

The following United States patent applications are directed to subject matter. disclosed or incorporated in the disclosure of this application Ser. No. 08/602,648. filed Feb. 16. 1996. now U.S. Pat No. 5,634,169 entitled "Multiple Function Encoder Wheel for Cartridges Utilized in an Electrophotographic Output Device; five utility applications filed the same day as this application entitled "Toner Cartridge with External Planar Installation Guides. Ser. No. 08/770, 327;" "Toner Cartridge with Locating on Photoconductor Shaft. Ser. No. 08/770,326; " "Toner Cartridge with Hopper Exit Agitator. Ser. No. 08/770,328;" "Toner Cartridge with Housing and Pin Construction. Ser. No. 08/770,330;" and "Toner Cartridge with Heat Shield Shutter Ser. No. 08/770. 334; " and one ornamental design application filed the same day as this application entitled "Toner Cartridge for Laser Printer, Ser. No. 29/066,775.".

TECHNICAL FIELD

This invention relates to electrophotographic development and, more particularly, relates to a plug for a toner cartridge which relieves pressure in the cartridge.

BACKGROUND OF THE INVENTION

The assignee of this invention has manufactured and sold commercially toner cartridges of two different general designs. For its larger laser printers the cartridge has contained a pump to meter toner of the kind disclosed in U.S. Pat. Nos. 5,012,289 to Aldrich et al. and 5,101,237 to Molloy, while the external structure of the cartridge is as disclosed in U.S. Pat. No. 5,136,333 to Craft et al. Details of other elements in the cartridge have varied. These cartridges have a toner adder roller rotating against the rotating movement of a developer roller. and have experienced internal pressure. Later forms employed an internal channel leading from the developing area to the top area of the cartridge, but not to the outside of the cartridge.

For a smaller, light emitting diode printer, the cartridge is as disclosed in U.S. Pat. No. 5,337,032 to Baker et al., which has a toner hopper extending well below a level having the toner adder roller and which has independent driven systems for the photoconductor roller and for the developer roller system as disclosed in U.S. Pat. No. 5,331,378 to Baker et al. This cartridge also has a toner adder roller rotating against the rotating movement of a developer roller, as does the cartridge disclosed of this invention. That cartridge operated at relatively moderate speed and it had no venting to relieve internal pressure.

Internal pressure can cause toner leaks. The leaks often, but not exclusively, occur immediately after the cartridge becomes inactive. Internal pressure in the hopper is created by ingesting air with toner carried by the developer roller past the lower developer roller seal. The toner adder roller pulls this air/toner mixture away from the developer roller which creates a pressure increase in the hopper until an equilibrium pressure is reached.

This invention is to a plug to outside which allows air to pass while blocking the toner, thus relieving internal pressure while not passing toner through the plug.

DISCLOSURE OF THE INVENTION

The plug of this invention may be located in a hole in the side of the toner hopper through which the hopper is filled with toner. At that location the plug is adjacent the hopper. where pressure tends to increase during operation of the cartridge. To avoid toner leaks from such pressure increases. the plug has multiple walls with multiple. spaced openings. with the plug having a series of outside openings which communicate with the inside of the hopper. Air passing through the outside holes enters a first chamber which is closed immediately in front of the outside holes. but which has opposing second holes on each side. Air passing through these second holes enters a second chamber which is closed immediately in front of the second holes. but has opposing third holes on each side at the opposite end of the second chamber from the second holes. Air passing through the second holes enters a central chamber. the bottom of which has a mat filter which does not pass toner. leading to central holes through the cover.

Preferably, the plug is formed in two mating parts of yieldable plastic which are connected by an aligning feature. The mat filter is inserted in the middle and the two parts are pressed together by a press-fit formed by the outer part being slightly smaller than the inner part.

BRIEF DESCRIPTION OF THE DRAWING

The details of this invention will be described in connection with the accompanying drawing. in which

FIG. **1** is a perspective view of the toner cartridge from above and left rear. where left is determined facing the printer from its front side where cartridge insertion is made;

FIG. **2** is a perspective view from above and left front of the cartridge sectioned near the top;

FIG. **3** is a top right front view of the cartridge with further cover elements removed;

FIG. **4** is a top right rear view of the cartridge with cover elements removed;

FIG. **5** is a top left rear view of the cartridge with cover elements removed;

FIG. **6** is a top right rear view of the cartridge sectioned similarly to the sectioning of FIG. 2;

FIG. **7** is a bottom left front view of the cartridge;

FIG. **8** is a bottom right rear view of the cartridge;

FIG. **9** is a front right perspective view of the hopper housing member;

FIG. **10** is a left front view of the inside of a printer in which cartridge 1 is installed;

FIG. **11** is a partially sectioned right side view showing more detail of parts shown in FIG. **10** with the cartridge installed;

FIG. **12** is a perspective view showing the inside one end member of the hopper;

FIG. **13** is a perspective view showing the inside of the other end member of the hopper;

FIG. **14** is a perspective view of the gear plate;

FIG. **15** is a perspective view of a readily removable bushing;

FIG. **16** is a perspective view showing the removable bushing installed;

FIG. **17** is a right rear view showing detail of a shutter;

FIG. **18** is a perspective view of an extended hub inserted in the photoconductor drum;

FIG. **19** is a right perspective view showing elements inside the cover of the cartridge;

FIG. **20** is a left bottom perspective view showing elements inside the cover of the cartridge;

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FIG. **21** is a right perspective view showing parts of the cartridge installed in a printer; and

FIG. **22** shows the inside of the cover of the cartridge where it receives an extension from the hopper;

FIG. **23** shows elements of the hopper plug prior to assembly;

FIG. **24** shows the assembled hopper plug alone; and

FIG. **25** shows a staggered crosssection of the hopper plug to illustrate air flow.

BEST MODE FOR CARRYING OUT THE INVENTION

The self-contained, removable printer cartridge **1** is shown in FIG. **1** in a perspective view from above and left rear (the hand grips **3***a* and **3***b* being considered the front and the side having the pivoted upper shutter **5** being the upper side).

For purposes of illustration, FIG. **1** shows the upper shutter **5** pivoted downward to its open position and lower shutter **7** pivoted rearward and upward to its open position. In actual operation, these positions are reached by interaction with the printer or other device in which cartridge **1** is installed as will be explained below.

To facilitate and guide insertion of cartridge **1** into the printer, cartridge **1** has a left guide wing **9***a* and a right guide wing **9***b*. Guide wings **9***a* and **9***b* are thin planes formed as arcs of a relatively large circle, except near the front, where the bottom **9***aa* is enlarged downward. Guide wings **9***a* and **9***b* are mirror images of each other except that, in this particular embodiment described, the left guide wing **9***a* is wider (extends further laterally) than the right guide wing **9***b* simply to accommodate the width provided by a particular printer in which the exemplar cartridge **1** is to be installed.

In the embodiment herein described, bottom shutter **7** is pivoted from left-rear cover **31***a* on a left top actuator link arm **11***a* and from rear cover (not shown) on a right top actuator link arm **11***b*, located on opposite sides of shutter **7**. Each link arm **11***a*, and **11***b* is integral with an actuator **13***a*, and **13***b*, respectively, each of which has a rectangular actuator surface **13***aa* and **13***bb*, respectively, which extends over the respective guide wings **9***a*, **9***b*.

A pivoted lower shutter link **15***a* and a side of the lower shutter **17***a*, pivoted to lower link **15***a* and upper actuator link **11***a* complete a conventional four bar linkage to provide rotation of shutter **7** in response to rotation of actuator **13***a*. The rear end of coil spring **19***a* connects to a lower hook **11***aa* in link arm **11***a* to bias shutter **7** closed when the cartridge is not inserted in a printer or other device. The front end of coil spring **19***a* connects to an upper hole **31***aa* under actuator **13***a*. A mirror image of these parts (see FIG. **3**) exists on the opposite side, the corresponding part of which will be designated by the same number with "b" letters.

When cartridge **1** is installed in the printer, actuator surfaces **13***aa* and **13***bb* are pushed downward by the mating surfaces of the printer to the positions above wings **9***a*, **9***b* respectively, as shown in FIG. **1**.

Cartridge **1** is inserted by a human operator grasping grips **3***a*, **3***b* through holes **3***aa*, **3***bb* and moving cartridge **1** in the direction of shutter **5** and toward the rear of the printer (**291**, FIG. **10**) in which it is being installed. A series of upwardly extending ribs **21** spaced along the width of cartridge **1** under grips **3***a*, **3***b*, except at holes **3***aa* and **3***bb*, provide strength while holes **3***aa* and **3***bb* provide room for the fingers of a person to grasp grips **3***a*, **3***b*. On the left side is a relatively wide, upwardly extending tab **23**. In a preferred combination of the embodiment of the invention described herein and an exemplary printer the top of tab **23** interacts with a physical sensing switch in the printer to detect that a cartridge **1** has been installed.

Front cover **25**, on which grips **3***a*, **3***b*, ribs **21** and tab **23** are integrally formed, is above a separated toner hopper, as will be described. The top cover of cleaner chamber **27** is rearward of shutter **5**.

Immediately inside wings **9***a* and **9***b* are raised, elongated locator surfaces **29***a*, **29***b* to which pressure is applied by a printer to firmly position the toning mechanisms of cartridge **1** when cartridge **1** is installed. Locator surfaces **29***a* and **29***b*, wings **9***a* and **9***b*, as well as rear cover **31** under wing **9***a*, are formed integral with cleaner housing **27**. Also integral with these elements is front cover **25**, having grips **3***a*, **3***b* and an outer cover **33** on the left side and generally coextensive in length with the length of front cover **25**. Cover **33** has a U-shaped housing **35** at its top. Housing **35** traps spacer stud **37***a* as will be explained and an assembly hole **39***a* near the upper front of cover **33** and a spring-holding hole **39***b* near the lower front of cover **33**.

A coupler **41** receives a drive element from a printer which contains an Oldham coupler to rotatably drive the developer roller **43** (not shown in FIG. **1**) and toner adder roller **45** (not shown in FIG. **1**). To the rear of coupler **41** is the shaft **47** of photoconductor drum **49** (drum not shown in FIG. **1**).

FIG. **2** is a perspective view from above and left front of cartridge **1** sectioned near the top to show internal elements. At the immediate front is a large, cylindrical toner hopper **61**, having a paddle **63**, which, during operation, is rotated clockwise as seen in FIG. **2**. Paddle **63** has an outer toner moving bar **63***a*, which extends across the width of hopper **61** except for a far left section **63***aa* which is inset as will be explained. The rear wall **61***a* of hopper **61** when cartridge **1** is installed for operation in a printer terminates at about one-third of the total height of hopper **61** as a flat surface **61***aa* (specifically, hopper **61** has a 106 mm diameter and the distance vertically from the lowest point of hopper **61** to the horizontal plane coinciding with the highest point surface **61***aa* of rear wall **61***a* is 35.3 mm). The upper surface **61***aa* of rear wall **61***a* is thin and flat with a slight downward angle from hopper **61** to facilitate removal of the molded part from its mold. An extension **65***a* from an agitator bar **65** has a depending tab **65***b* (see FIG. **9**) which rests on upper wall **61***aa* thereby positioning bar **65** slightly above upper wall **61***aa*. Extension **65***a* extends past upper wall **61***aa* to a location at which bar **63***a* of paddle **63** encounters extension **65***a* as it rotates. The surface **61***aaa* opposite surface **61***aa* from which toner exits is flat and at approximately 50 degrees from vertical (best seen in FIG. **9**) when cartridge **1** is installed for operation in a printer.

Vertical ribs **67** located immediately rearward of rear wall **61***a* are stiffeners for top wall **69** formed about one-third down from the top of hopper **61**. The toner moving bar **63***a* of paddle **63** is closely adjacent to the sides of hopper **61** except where the top of rear wall **61***a* and the start of top wall **69** form an opening for toner to be delivered rearward from hopper **61** to the toning mechanisms of cartridge **1**. This is best shown in FIG. **9**.

In FIG. **2**, a small part of developer roller **43** to which coupler **41** is directly attached, is seen past ribs **67**. Developer roller **43** is parallel to and in contact with photoconductor drum **49**. Cleaner chamber **27** has spaced, vertical internal baffles **71**, which are strengthening members, as well as members which limit unbalanced accumulation of

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toner in chamber **27**. Toner which is not transferred during development is scraped from photoconductor drum **49** by cleaning blade **73**, which is mounted to a vertical panel **73***a*, having a horizontal gusset **73***aa* to increase strength. As best seen in FIG. **3**, panel **73***a* is mounted to supporting member **75**, which has vertical columns **75***a* (FIG. **2**), **75***b* on opposite sides. Panel **73***a* is mounted to the vertical columns **75***a*, **75***b* by a screw **77***a* to panel **75***a* and a screw **77***b* to panel **75***b*.

FIG. **3** is a top right side view with further cover elements removed and part of the cleaner removed to illustrate the internal configuration of cartridge **1**. A solid, steel-bar doctor blade **91** extends parallel with and in pressure contact with developer roller **43**. Blade **91** contacts roller **43** at about 20 degrees from the vertical toward toner adder roller **45**. Also shown in FIG. **3** are metal electrical contact **93** to doctor blade **91**, metal electrical contact **95** to toner adder roller **45** and metal electrical contact **97** to developer roller **43**. The outer ends **93***a*, **95***a*, **97***a* of the contacts bear against metal contacts in the printer when cartridge **1** is installed and thereby make electrical contact to receive electrical potentials from the printer.

The developing system of cartridge **1** is essentially very similar to that of the Optra brand family of printers sold by the assignee of this invention. As in that family of printers, toner adder roller **45** is a conductive sponge material attached to a steel shaft and developer roller **43** is semiconductive material attached to a steel shaft. When cartridge **1** is installed for operation in a printer, cartridge **1** is oriented generally as shown in FIG. **3** and the horizontal plane containing the lowest surface of toner adder roller **45** is 22.6 mm above the lowest point of hopper **61**.

Toner adder roller **45** and developer roller **43** are journaled in the rearward extensions **99***a* and **101** a (FIG. **4**) of the end members **99** and **101** (FIG. **4**) of hopper **61**. Agitator **65** has a bent portion **65***aa* to become parallel to extension **99***a* where it is pivoted to extension **99***a* on pin **103***a*. As paddle **63** rotates, bar **63***a* contacts extension **65***a*, thereby rotating agitator **65** around pin **103***a* upward. Agitator **65** then returns to near rear wall **61***a* under the force of gravity to dislodge toner, which otherwise tends to accumulate on exit surface **61***aaa* (see FIG. **9**).

FIG. **4** is a top right rear view with cover elements removed showing more fully the end members **99** and **101** of hopper **61** and their extensions **99***a* and **101***a*. Integral with end member **101** is spacer stud **37***b*. Under and to the front of stud **37***b* is spring mounting post **131***b*, which mounts one end of spring **132***b*, the other end of which is mounted on hole **242** (best seen in FIG. **20**).

Also integral with end member **101** is perpendicular shield wall **133**, which extends downward and rearward to present a barrier to physically protect encoder wheel **135**. The bottom portion of wall **133** forms a flat contact surface **133***a* to receive a locating roller from the printer when cartridge **1** is installed. Encoder wheel **135** is linked to paddle **63** through a paddle gear assembly **163** having a torsional yield member (FIG. **5**) so as to provide information as to the amount of toner in hopper **61** to the printer on which cartridge **1** is installed by the sensing of the location of windows **135***a*. Additionally, other windows **135***b* provide other information, while wider window **135***c* provides a home location reference. Light blocking selected labels **136** are located between windows **135***b* and **135***c* and block windows of a series of windows **135***b* to thereby customize information onto wheel **135**. The details and operation of encoder wheel **135** are described in U.S. patent application Ser. No. 08/602,648, filed Feb. 16, 1996, now U.S. Pat. No. 5,634,169, entitled "Multiple Function Encoder Wheel for Cartridges Utilized in an Electrophotographic Output Device" and form no contribution to the invention of this specification.

FIG. **4** also shows electrical contacts **93**, **95** and **97** as they are supported by floor **137** which extends perpendicularly from hopper extension **101***a*. Vertical ribs **139** extend from floor **137** between contacts **93**, **95** and **97** to strengthen the floor **137**.

Mounting roller **141***a* is journaled to hopper extension **99***a* and symmetrical mounting roller **141***b* is mounted to hopper extension **101***a*. Rollers **141***a* and **141***b* contact inside surfaces of the cover of cartridge **1**, as will be described. Surfaces **133***a* and **161***a* (FIG. **5**) of hopper **61** rests on rollers in the printer as will be further described.

Hopper end member **101** has an opening receiving a closely-fitting, resilient, cylindrical plug **143**. Prior to installing plug **143**, toner is loaded into hopper **61** through the open hole, then plug **143** seals the hole.

Photoconductor roller **49** has at its right end a transfer roller drive gear **145**, which drives a roller in the printer when cartridge **1** is installed in the printer.

FIG. **5** is a top left rear view with cover elements removed showing more fully the outside of members **99** and **99***a* of hopper **61**. Integral with end member **99** is spacer stud **37***a*. Under and to the front of stud **37***a* is spring mounting post **131***a*, which mounts one end of spring **132***a*, the other end of which is mounted in a hole in member **431** (FIG. **19**), which is an inner extension of cover **33** (FIG. **2**).

Also integral with end member **99** is perpendicular shield wall **161**, which extends downward and rearward to a barrier to physically protect torsional paddle gear assembly **163**. The bottom portion of wall **161** forms a flat contact surface **161***a* to receive a locating roller from the printer when cartridge **1** is installed. The details of paddle gear assembly **163** are not part of this invention and are more fully disclosed in the above-mentioned patent application Ser. No. 08/602,648, now U.S. Pat. No. 5,634,169.

Gear **49***a*, integral with the end of photoconductor drum **49**, receives power from a meshing gear in the printer when cartridge **1** is installed in the printer. Coupler **41** is integral with developer roller **43** and drives idler gear **165**, which drives toner adder roller **45** (FIG. **3**) by being meshed with gear **167**, which is integral with toner adder roller **45**. Coupler **41** receives power from a driver in the printer which is separate from the drive to drum **49**, although preferably from a single motor in the printer.

Gear **167** drives the large gear of compound gear **169**. Gear **169** drives the large gear of compound gear **171**, and gear **171** drives paddle gear **163**. A gear plate **173**, mounting gears **165** and **169**, is mounted on hopper extension **99***a* by mounting screw **175**.

FIG. **5** shows the end of agitator **65** opposite that shown in FIG. **3**. That end has a bent portion **65***bb* to become parallel to extension **101***a* of end member **101** when it is pivoted to extension **101***a* on a pin **103***b*.

Continuing the detailed description of the cartridge incorporating a preferred embodiment of the present invention, FIG. **6** is a top right rear view sectioned near the top similar to the sectioning of FIG. **2**. FIG. **6** illustrates more clearly the mounting of doctor blade **91** mounted to press on developer roller **43** under the bias of leaf spring **191**. Blade **91** is located on the left rear by tab **361** (best seen in FIG. **14**), and on the rear by extension **196***a* (FIG. **12**) of hopper end

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member **99** which form front and back barriers for holding the left side of doctor blade **91**. Similarly, on the right side, two surfaces from **101***a*, including a rear extension **365** (best seen in FIG. **13**) and a front extension **366** (FIG. **13**) form front and back holding the right side of doctor blade **91**, symmetric to the cage holding the left side of doctor blade **91**. The top of blade **91** is held by spring **191**. An adhesive tape **192** across the top of the doctor blade **91** bridges over the adjoining horizontal edge of wall **69** (FIG. **2**) for sealing, as is conventional.

Spring **191** has blunt ends **191** a and **191** b, spaced from the center, which contact blade **91** to bias it downward on to developer roller **43**. A central ledge **197**, integral with ribs **67**, forms a cavity receiving the center of spring **191**. Horizontal ledges **199***a* and **199***b*, opposite central parts of spring **191**, formed integral with ribs **67**, are horizontal barriers to prevent spring **191** from moving toward the front. Preferably, so as to permit rough handling of cartridge **1** which might occur during shipment, solid upper stop members (not shown) are attached by double sided adhesive on each side between ledges **199***a* and **199***b* and the sides **99***a* and **101***a*, respectively. These are spaced 0.18 mm above the top of blade **91** and, therefore, contact blade **91** only during rough handling.

FIG. **6** also illustrates posts **141***aa* and **141***bb*, which are molded as extensions of members **99***a* and **101***a*, respectively, and supporting mounting rollers **141***a* and **141***b*, respectively (FIG. **5**).

FIG. **7** is a bottom left front depiction of cartridge **1** viewed externally. A series of horizontal depressions **221** along the back of hopper **61** provide a roughened surface for thumbs when fingers grasp the cartridge through opening **3***aa* and **3***bb*. A series of relatively long vertical ribs **223** integral with the bottom of hopper **61** serve as paper and other media guides, while a series of shorter ribs **225**, located rearward of the start of ribs **223** and between ribs **223**, prevent media snags as media encounter photoconductor drum **49**, located immediately after ribs **223** and **225**. Past drum **49**, media encounter further media guide ribs **227** located on the bottom of shutter **7**. FIG. **7** also affords a clear view of idler gear **165** and gear **167**.

FIG. **8** is a bottom right rear depiction of cartridge **1** viewed externally. This shows the full right guide wing **9***b* with enlarged front part **9***bb*. FIG. **8** shows the right cover elements which were deleted in FIG. **6**. A front lower cover section **241** is over much of the encoder wheel **135** and has an access hole **243** for ease of assembly and has an access opening **244** (best seen in FIG. **20**). Cover section **241** is stepped outward a small amount to provide room for spring **132***b* (FIG. **20**) to extend between post **131***b* (FIG. **4**) and hole **242** (best seen in FIG. **20**). Generally, above and forward of and integral with cover section **241** is cover section **245**, which is over the remaining upper front of cartridge **1**. Section **245** has a U-shaped housing **247** at its top which traps spacer stud **37***b*. In the rearward part of section **245** opposite the area above photoconductor drum **49**, are located rectangular channels **249** with the second rectangular channel **249***a* and the last rectangular channel **249***b* being open to pass air for cooling photoconductor drum **49** during operation of cartridge **1**.

The far rear portion **251** of this particular embodiment of the invention herein described mounts links **11***b* and **17***b* to shutter **7**. A bottom section **253** of the cover located under and forward of passages **249***a* and **249***b* mounts the shaft **47** of photoconductor drum **49** and has two upper symmetrical vent holes **255***a* and **255***b* to pass air for cooling drum **49**.

FIG. **9** is a front right perspective view of the molded plastic member housing **271** which forms the central portion and central extension of hopper **61** with end member **99** attached and agitator **65** installed. It is seen to form a cylindrical chamber with an exit opening formed between wall **69** and wall **61***a*. An inset **273** at the bottom rear of hopper **61** provides space for rollers in the printer. As best seen in FIG. **2**, paddle bar **63***a* has an inset far left section **63***aa* to clear inset **273**.

Member **271** has a slot **275** around its right side. A directly similar slot is around the left side. End member **101** has a mating ridge **321** (FIG. **13**). During manufacture slot **275** is mated with ridge **321** in end member **101** and the two are welded together with ultrasonically created heat. Member **99** is welded to the left side of member **271** in the same manner with ridge **322** (FIG. **12**) inserted in a mating slot (not shown) on the left side of member **271**.

A notch **277** above agitator extension **65***a* allows for sufficient rotation of agitator **65** to allow paddle arm **63***a* to pass beyond extension **65***a* while preventing a full turn-over of agitator **65**.

Developer Assembly

The housing **271** and its attached end members **99** and **101**, form toner hopper **61**. Extension **101***a* journals toner adder roller **45** and developer roller **43**. Gear plate **173**, which is attached to extension **99***a* by screw **175**, journals the opposite ends of toner adder roller **45** and developer roller **43**. Accordingly, a single unitary assembly is formed of the hopper **61** rearward to and including developer roller **43**.

Photoconductor and Cover Assembly

Front cover **25** grips **3***a*, **3***b*, left outer cover **33**, rear wall **31**, (FIG. **1**) right cover sections **241**, **245**, and **251**, (FIG. **8**) wings **9***a*, **9***b* and cleaning chamber **27** are a single molded part. Photoconductor **49** is journaled in this part with its shaft **47** extending past the covers on opposite sides. Shutter **7** is movably supported to left cover **31** and right rear cover **251**. Accordingly, a single unitary assembly is formed of the cover members, the photoconductor drum **49** and the shutter **7**.

In use, springs **132***a* and **132***b* pull the developer roller **43** against the photoconductor drum **49** at a predetermined tension. When cartridge **1** is picked up, the developer assembly and the photoconductor and cover assembly rotate under gravity until stud **37***a* (FIG. **1**) contacts housing **35** and stud **37***b* (FIG. **8**) contacts housing **247**, thereby holding the two assemblies together.

Lower Shutter as Heat Barrier

Lower shutter **7**, when open, covers all of the lower surface of the cleaner chamber. The material of shutter **7** is polycarbonate, a material which deflects heat from the fixing operation which occurs after paper is moved rearward from contact with the photoconductive drum **49**. The material of the body of the photoconductor and cover assembly, the hopper **61**, end members **99** and **101**, and shutter **5** are polystyrene which is lower in cost than polycarbonate would be. The added cost of shutter **7** being polycarbonate is justified by shutter **7** providing heat protection to the cleaner **27** which allows that member to be polystyrene.

Agitator Bar System

The toner of cartridge **1** is monocomponent, which can become stagnant and cohesive when left undisturbed for a

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time. This stagnation and settling of toner may be aggravated by the slight vibrations generated by the printer motor and gear train in a laser printer.

Failure to deliver toner from wall **61***a* via sloped exit surface **61***aaa* is the consequence of the settling, stagnation, and cohesive nature of the monocomponent toner in hopper **61**. The angle of repose of the settled toner (i.e., the angle of tilt of a surface on which the settled toner rests before it "falls" under its own weight) can reach or exceed 90 degrees The exiting surface **61***aaa* is tilted upward at approximately 50 degrees from vertical during operation (angle A, FIG. **9**), allowing the toner to stagnate into a pile that does not reach the toner adder roller **45**. This leads to premature failure to print, termed "starvation," as would result using an empty cartridge. Experimentally, as much as 230 grams of the 465 gram capacity of hopper **61** of toner have been found in the hopper **61** of a cartridge **1** when starvation has occurred due to existence of a stagnant pile of toner preventing toner delivery to toner adder roller **45**.

Agitator bar **65** overcomes toner stagnation and failure to deliver toner to toner adder roller **45**. The primary function of agitator bar **65** is to prevent toner stagnation and to deliver toner from the entrance of the developer sump to the toner adder roller thus preventing premature failure to print.

As the hopper paddle **63** rotates counter-clockwise (FIG. **3**), it reaches a point in its rotation where it begins to contact extension **65***a* and lift agitator bar **65**. Paddle **63** continues to lift agitator bar **65** until it loses engagement with extension **65***a*. At this point, the agitator bar **65** falls back via gravity to the resting position, carrying toner from the entry of the developer chamber to the toner adder roller. (Although not useful on the disclosed embodiment, an alternative is a pad on extension **65***a* or on upper wall **61***aa* which will cushion the fall. Such a pad would also serve as a spacer to control the position of the agitator in the down position and eliminate tab **65***b*).

At the top of its travel the agitator bar **65** is out of the way of the main sump paddle **63** and approaches a notch **277** in the hopper housing **271** (FIG. **9**). Notch **277** provides space for the agitator bar **65** to clear the end of hopper paddle **63**, and prevents overtravel of the agitator arm **65**, which could cause locking into an up position when the cartridge is shipped, stored, or handled outside of the machine.

In the up position, the agitator bar **65** forms a nearly vertical wall over hopper wall **61***a*. The initial opening above wall **61***a* is about 26.7 mm, while the height of bar **65** facing that opening is 7 mm. This allows room for toner from the main sump to flow between the agitator **65** and sloped wall **61***aaa*. It also serves as a temporary barrier to prevent the delivery of excessive amounts of toner from the hopper **61** to the toner adder roller **45**. As the agitator bar **65** falls to its resting position, both newly delivered toner and any stagnant toner resting on wall **61***aaa* are pushed toward the toner adder roll **45**. The motion of the agitator **65** also stirs toner in the area above and toward developer roll to doctor blade nip **91**, helping to prevent packing and stagnation of toner in this volume.

The agitator **65**, preferably can be implemented by stamping (or laser cutting) and can be formed from sheet metal with spring characteristics that maintain agitator shape during assembly and operation. The entire part comprising bar **65**, extension **65***a* and bent portions **65***aa* and **65***bb* preferably can be made by stamping out all features in one operation. As envisioned for the preferred embodiment; illustrated herein, bar **65** may have a length approximately equal to the toner adder roller length, which may be, for example, 220 mm; and have an exemplary height of approximately 7 mm; a thickness of 1.3 mm, chosen to give an agitator mass of the entire part stamped of, for example, approximately 20 grams. Since agitator bar **65** is driven by gravity, the mass is chosen to provide a driving force sufficient to push stagnant toner along wall **61***aaa* to toner adding roll **45**, but the mass is limited so as not to affect the torque sensing function of the hopper paddle **63**.

Hinge segments **65***aa* and **65***bb* and the associated distance from pins **103***a* and **103***b* to agitator bar **65** determine the arc swept by bar **65** as it falls from the up position to the down position. In the present preferred embodiment, pivot distance of 13.5 mm, for example, allows the paddle to sweep from an up position which leaves a gap of 3 mm between the bottom of the bar **65** and the wall **61***aa*, to a down position 3 mm above the toner adder roller **45**. With this design, the weight of the paddle is effectively applied to move toner over the distance swept by the arc. A shorter pivot distance would result in insufficient travel to capture and deliver toner; and would require a heavier paddle to exert the same force on the toner over the distance swept through the arc. Pins **103***a* and **103***b* are smaller in diameter (1 mm, for example) than their holes in which they fit in portions **65***aa* and **65***bb* to prevent binding due to toner buildup.

Extension **65***a* is long enough to engage the active segment of paddle **63**. Additionally, the length of extension **65***a* is long enough to overlap the active segment of paddle **63** when extension **65***a* first engages the paddle **63** to prevent scraping of the paddle surface. A small radius (0.5 mm, for example) is placed on the bottom tip of extension **65***a* to prevent scraping of paddle **63** as it releases extension **65***a*.

The overall length and elasticity of the agitator **65** allows assembly over pins **103***a* and **103***b* by simply deflecting the part.

Accordingly, this agitator design functions to overcome toner stagnation and to deliver toner from the entry of the hopper **61** to the toner adder roller **45** active area. The agitator **65** and its extensions **65***a*, **65***aa* and **65***bb* are a single part. Agitator bar **65** is driven internally, with no external gearing, cams, or seals as would be required by an externally driven agitator. Thus gear cost and complexity, seals, friction, and toner leaks are eliminated as problem areas. Agitator **65** is activated frequently enough to move toner and prevent stagnation without adding excessive stirring or damage to the toner. This design enhances first-in, first-out toner delivery from hopper **61** to the smaller area containing the toner adder roller **45** by preventing excessive toner delivery in the raised position and discouraging return toner from the area of the toner adder roller **45** to the hopper **61**.

Dimensions

With the cartridge installed for operation, the location of the nip of toner adder roller **45** with developer roller **43** is at 105 degrees from vertical. The nip angle of the photoconductor drum **49** to the developer roller **43** is 95 degrees from vertical. As previously stated, the doctor blade nip is at 20 degrees from the vertical.

The length from the bottom of hopper **61** to the horizontal plane coinciding with the edge of top surface **69** near hopper **61** is 61.96 mm, creating an initial opening of about 26.7 mm (as indicated previously, bottom surface **61***aa* is at 35.3 mm). Top surface **69** has a slight upward angle to a tallest point of 64.34 mm.

The diameter of toner adder roller **45** is 14 mm and it is located with its circumference 1 mm above the bottom of

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hopper body **271** immediately below it. The diameter of developer roller **43** is 20.11 mm and it is located with its circumference 2 mm above the bottom of hopper body **271** immediately below it. The length from the bottom of hopper **61** to the horizontal plane coinciding with the bottom of developer roller **43** is 23.7 mm, and the corresponding length to the bottom of the toner adder roller **45** is 22.6 mm. The diameter of photoconductor drum **49** is 30 mm.

The bottom of body **271** under rollers **43** and **45** is at a 6 degree upward angle to provide sufficient room for guide ribs **225** on the outside of body **271**.

Installing the Cartridge

FIG. **10** is a left front view of the inside of a printer with which the inventive cartridge herein described by way of an exemplary preferred embodiment may be used. The cartridge **1** is installed in a printer **291** (FIG. **10**) from the front to a final position well within the printer **291**. To achieve this, guide wings **9***a* and **9***b* are initially guided by a lower track **293** over a curved track, which guides cartridge **1** under the laser printhead (not shown) and over paper feed elements **295**.

The path is downward, which utilizes gravity while inserting cartridge **1**, thereby easing insertion. The guide **293** (and a guide not shown, which is a mirror image of guide **293** on the opposite side of printer **291**) has the same curvature as wings **9***a*, **9***b* so that the wings **9***a*, **9***b* can follow guide **293** and its opposite guide.

Upper guide **297** is parallel to guide **293**. Guide **297** extends further into the printer than guide **293**. A guide (not shown), which is a mirror image of guide **297**, is on the opposite side of printer **291**. Guide **297** encounters actuator surface **13***bb* early during the insertion of cartridge **1**. As cartridge **1** is moved rearward, actuator surface **13***bb* is rotated to open shutter **7** (as is surface **13***aa* rotated by encountering a mirror image of guide **297** on the left side of the printer). This early movement of shutter **7** is very advantageous in that it eliminates the need for space and mechanism which would be required if actuation occurred at the end of insertion of cartridge **1**.

Also shown in FIG. **10** is the right reference position roller **299** on which contact surface **133***a* rests when the cartridge is inserted. Contact surface **161***a* will rest on an identical roller (not shown) on the opposite side of printer **291**. Rearward of roller **299** is V-block **301**, shown more clearly in FIG. **11**, and an associated electrical contact **302**. Further rearward is an upstanding lug **303**, which will contact shutter **7** to hold it open as will be described.

As cartridge **1** is inserted, wings **9***a*, **9***b* are guided by guides **293** and **297** and the mirror image guide (not shown) on the opposite side of printer **291**. As insertion continues, the wings **9***a*, **9***b* fall off the lower guide **293** (and its mirror image guide) and the shaft **47** of photoconductor drum **49** drops into V-block **301** and a mirror image V-block (not shown) on the opposite side of printer **291**. A depending thin metal sheet **302** (FIG. **11**, shown in side view) is contacted and bent somewhat by shaft **47** as it is guided by V-block **301**. This creates a connection for operating potential to shaft **47**. When cartridge **1** falls into V-block **301**, lug **303** contacts shutter **7** to hold shutter **7** open. Prior to that the longer length of upper guide **297** was sufficient to hold shutter **7** open.

In this final position cartridge **1** is more precisely located with respect to functional elements. Cartridge **1** is held in printer **291** as described below under the heading "Reference Surfaces."

To remove the cartridge, it is grasped by grips **3***a*, **3***b* and pulled sharply upward and forward. Wings **9***a* and **9***b* again enter between guides **293** and **297**, and the cartridge can be pulled free.

Manufacture of Cartridge

All molded parts follow the technical dictate (to avoid distortion on cooling) of keeping adjoining surfaces the same thickness. Accordingly, molded studs seen from the rear (shown, for example, in FIG. **13**) appear as holes in the part. Circles in the drawings with bowed lines crossing indicate the gate where molten resin was received into the mold (shown, for example, also in FIG. **13**).

Assembly of cartridge **1** begins with the joining of hopper body **271** to its end members **99** and **101** with paddle **63** installed. The inside of end member **99** is shown in FIG. **12** and the inside of member **101** is shown in FIG. **13**. Both are molded parts of polystyrene resin. Each of the members **99** and **101** is mated to its corresponding side of body **271** (FIG. **9**). Ridge **321** of member **101** enters slot **275** on the right edge of member **271**. Ridge **322** of member **99** enters slot (not shown) on the left edge of member **271** mating ridge **322**. Those parts are held tightly in a fixture and ultrasonically welded, with paddle **63** inserted before the last of the two end members is welded. Then a bushing (not shown) is press fit into the central hole **325** of member **101** around the shaft of paddle **63** and a second bushing (not shown) is similarly press fit around the shaft of paddle **63** in central hole **329**.

Agitator bar **65** (FIG. **9**) is then flexed and installed by mounting end portion **65***aa* on pin **103***a* and end portion **65***bb* on pin **103***b*.

Toner adder roller **45** with low friction washers on each end is then installed by angling its shaft through hole **333** (FIG. **12**) in member **99**, straightening, and then moving roller **45** laterally to bring its shaft through a press fit bushing (not shown) in hole **335** in member **101**.

Prior to installing toner adder roller **45** and gear plate **173**, a sickle-shaped seal member having a semicircular central body (not shown) is installed on each side of the location of developer roller **43**. Such a seal is illustrated in IBM Technical Disclosure Bulletin, Vol. 33, No. 3B, August 1990, pp. 29–30, entitled "Toner Seal for Printer." The location of this seal on the right side is labeled surface **383** in FIG. **13**. This is essentially standard as putty is first applied on each end of the location for the seal and the ends of the compliant elongated seal are pressed into the putty. The seal has ridges directed slightly toward the center. A seal system such as this is essentially the same as previous cartridges.

Doctor blade **91** (best seen in FIG. **6**) is then installed by bringing it vertically upward behind ridge **365** (FIG. **13**) on the right. In the completed cartridge **1** blade **91** is held on the bottom by contact with developer roller **43**. Developer roller **43** with low friction washers on each end is installed by positioning the left end of its shaft past end member **99** (FIG. **12**) and threading the right end of its shaft through the central hole of the bushing **375**, shown in FIG. **15**.

Gear plate **173** is shown alone in FIG. **14**. It has a hole **351** to receive the shaft of toner adder roller **45** and hole **359** for shaft of developer roller **43**. A central hole **353** is to receive screw **175** but hole **353** is significantly larger than the shaft of screw **175**. Gear plate **173** has a shaft **355**, a shaft **357**, and a rightwardly extending tab **361**.

Gear plate **173** is brought toward member **99** while the shafts of toner adder roller **45** and developer roller **43** are

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positioned through holes **351** and hole **359** respectively. Gear plate **173** is rotated until tab **361** abuts the edge of doctor blade **91**. This serves as a locator for gear plate **173** and doctor blade **91**. Screw **175** is then tightened in hole **353** to fix plate **173** in that position.

Gears **169**, **165** and **171** are pressed on shafts **355**, **357** and **363** (FIG. **5**, on member **99**). (As is shown in FIG. **14**, such shafts have an enlarged head with a gap so as to be yieldable when receiving a press-on force.) A gear **167** is also pressed on the shaft toner adder roller **45**. Paddle gear assembly **163** is pressed onto the shaft of paddle **63**. These gears and drive coupler **41** are keyed to their shafts by the two having matching "D" cross sections.

Bushing **375** has a flat outside segment **377** which permits bushing **375** to enter opening **379** (FIG. **13**) in member **101** since opening **379** is circular with an open less-than-one-half circle segment in which bushing **375** can fit at one orientation. Bushing **375** is then rotated in a direction to rotate lower tab **381** downward, which removes the orientation at which bushing **375** can fit through the incomplete segment of **379** and locks bushing **375** into place. Bushing **375** installed is shown in FIG. **16**. In operation, developer roller **43** rotates in a direction to rotate tab **381** downward. The advantage of bushing **375** is that it provides for relatively easy installation and change of developer roller **43** in the event that a member requires replacement during subsequent tests.

Drive coupler **41** is then press fit on the left end of the shaft of developer roller **43** using a locating shim to space coupler **41** slightly from cover **31**. Mounting rollers **141***a* and **141***b* are previously applied by press fit during completion of the hopper **61**. An adhesive tape is applied across the top of doctor blade **91**. Spring **191** is then flexed into place to bias doctor blade **91** downward. After toner is installed and leak tested, the previously mentioned upper stop members on each side of ledges **199***a* and **199***b* are applied individually and remain in place, held by their back adhesive layer. Also encoder wheel **135** is installed by press fit.

With rollers **43** and **45** and doctor blade **91** in place, metal contact **93** is inserted between ribs **139**. Contact **93** has arrowhead sides to bind into ribs **139**, and extends upward and over two posts **385** (FIG. **4**) in member **101***a* and extends to a bent end which presses against doctor blade **91**. Contacts **95** and **97** similarly have arrowhead sides which dig into ribs **139** and terminate in short bent ends **387**, **389**, respectively, which press against the shafts of roller **45** and **43**, respectively. Contact grease is added to contacts and shafts.

The foregoing all are part of the developer assembly. The photoconductor and cover assembly is separately assembled. The cleaner blade panel **73***a* (see FIG. **3**) is installed using screws **77***a* and **77***b*. Link arms **11***a*, **11***b*, **17***a*, **17***b* and **15***a*, **15***b* are assembled in a known manner by studs having extensions which enter matching holes in adjoining arms. The arms are then are rotated to operating positions in which the extensions find no opening and therefore lock the members together while leaving them free to rotate. Links **13***a* to **11***a* and **13***b* to **11***b* are held by a pin **401** with latch, as shown in FIG. **17**.

Pin **401** has a circular flexible arm **403** and latches **11***a* and **11***b* have a matching ledge **405***b* (the ledge on the opposite side not shown). Pin **401** is inserted through the holes of member **13***a* and **11***a* and another pin **401** is inserted through the holes of members **13***b* and **11***b*. The pins **401** are then rotated until their arms **403** flex around ledge **405***b* and the ledge on the opposite side, respectively, and then recover to latch under ledge **405***b* and the ledge on the opposite side, respectively. This holds both four bar linkages in place. Pin **401** has a shaft **407** (best seen in FIG. **4**), which extends into a groove (not shown) on each side of cleaner **27** for added stability of each four bar linkage.

Shutter **7** is installed by flexing shutter **7** and locating pins **431***b* (FIG. **1**) and a pin on the opposite side (not shown) and inserting pin **431***b* and the pin on the opposite side in holes in the sides of locator surface **29***a*, **29***b*, respectively. Pin **431***b* has a coil compression spring **433** wrapped around it which is tensioned to bias cover **7** upward.

As best seen in FIG. **19**, one end of spring **132***a* is attached through a hole of connector tab **431** of cover **33** on one side and the opposite end of spring **132***a* is temporarily attached to hole **39***a* of cover **33**. As seen in FIG. **20**, spring **132***b* is attached through a hole of connector tab **242** of cover **241** on one side and the opposite end of spring **132***b* is temporarily attached to hole **243** of cover **241**.

The photoconductor drum **49** is installed into the cleaner housing assembly by placing the drum and the two gears **49***a* and **145** (see FIGS. **4** and **5**) in position with a thin washer, (not shown) on the left side and inserting shaft **47** through that assembly and the housings **31** (FIG. **2**) and **253** (FIG. **8**). Standard E-clips are installed on each end of shaft **47** to hold the drum and shaft from lateral movement. As shown in FIG. **18**, an extending hub **145***a* of gear **145**, has an internal copper sheet **421** with three sharp points **421***a*. Copper sheet **421** also has an elongated member **421***b* extending to over the central hole. Hub **145***a* is inserted inside drum **49**. Points **421***a* dig into the aluminum cylinder which forms the inside of drum **49**, creating both physical and electrical connection. Shaft **47** is then threaded through gear **145**, drum **49** and then through gear **49***a*. This bends elongated member **421***b* so that it presses against shaft **47** and makes electrical contact.

The developer assembly is then placed before the photoconductor and cover assembly and the two are moved together. Covers **33** and **241**, **245** flex outward and then close into the final position. Springs **132***a* and **132***b* are removed from holes **39***a* and **243** and manually attached to studs **131***a* and **131***b* respectively. This completes the cartridge **1**.

It will be readily understood that any joint where toner is contained must be sealed. Immediately inside the bearings of toner paddle **63** and toner adder roller **45** synthetic rubber end seals are located. FIG. **13** shows a socket **335** having upper and lower tabs which receive such a seal, the seal having matching extensions which fit in the tabs to prevent rotation of the seal. The ends of the chamber of cleaner **27** have foam walls with outer adhesive to secure their positioning. As is previously known, other extended joints have a plastic (polyethylene terephthalate) tape with one side carrying pressure sensitive adhesive applied along them by the adhesive. As is also previously known, developer roller **43** is sealed with a tape which is cantilevered up from the bottom of body **271** to be located in front of the roller **43**. A second adhesive strip seals the far rear edge of body **271**. Such sealing is basically standard and forms no part of this invention.

Toner

In a preferred embodiment cartridge **1** employs monocomponent electrophotographic toner which may be basically conventional. The amount of toner in hopper **61** is limited by pressure impairing print quality and sensing of toner level by toner resistance on paddle **63**. When cartridge **1** is in the installed position, a typical top level of toner will be **10** mm above the upper barrier wall **61***aa*. The presence

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of toner at that typical highest level is indicated in FIG. **9** by surface lines **425**, but the toner is shown otherwise as transparent for clarity. The actual toner is, of course, an opaque, dry powder. During use, the toner is depleted to lower levels and it is moved by paddle **63**. As is conventional, developer roller **43** applies toner **425** to photoconductor drum **49** to develop electrostatic images on photoconductor drum **49**.

Reference Surfaces

FIG. **19** shows just the roller **141***a* of the hopper assembly as finally installed and, therefore, located on a flat surface **441** which is an extension of the cover **33**. Similarly, FIG. **20** shows just the roller **141***b* of the hopper assembly as finally installed and therefore located on a flat surface **443** which is an extension of cover **241**. Such positioning of an assembly with the photoconductor roller and an assembly with the developer roller for lateral adjustment for rollers is essentially the same as in prior cartridges.

However, in the described embodiment of the present cartridge, cartridge **1** has flat surfaces **133***a* and **161***a* and the printer **291** has the second set of rollers (roller **299**, FIG. **10** and its mirror image), on which flat surfaces **133***a* and **161***a*, respectively, rest. In the prior cartridges a second set of rollers was part of the cartridge. As in the prior cartridges the two sets of rollers **141***a*, **141***b*, **299**, and the mirror roller image of **299**, define a plane of movement to guide the developer roller **43** into the intended contact with photoconductor drum **49**.

FIG. **19** shows tab **23**, which is an extension of cover **33** and, when the cartridge **1** is installed in a printer as shown in FIG. **19**, is generally above a flat surface **445** of the frame of the printer. Similarly, as shown in FIG. **20**, a top flat ledge **447** is an extension of cover **241** and, when cartridge **1** is installed in a printer, is above a flat surface (**448** of FIG. **10**) of the frame of the printer.

A flat bottom surface **449** (FIG. **19**) is under tab **23** of cover **33**, and a flat bottom surface **451** (FIG. **20**) of cover **245** is under ledge **447**. Bottom surfaces **449** and **451** are locator surfaces which rest on frame surfaces **445** and **448**, respectively.

FIG. **21** shows the right side of cartridge I installed in a printer with emphasis on cantilevered roller **461** pressing down on locator surface **29***b*. A second cantilevered roller (not shown), which is a mirror image of roller **461** exists and presses down on locator surface **29***a*. Roller **461** and its mirror image roller are attached to the frame of the printer. They are firmly biased downward by a coil spring **463** for roller **461** and a mirror image coil spring for the mirror image roller. As the cartridge **1** is inserted in the printer by movement of wing **9***a* in guides **293**, **297** and wing **9***b* in corresponding mirror image guides, locator surface **29***b* encounters cantilevered roller **461** and locator surface **29***a* encounters a corresponding mirror image cantilevered roller; and the locator surfaces **29***a*, **29***b* rotate those rollers upward as the cartridge **1** continues to move.

When wing **9***a* falls off of guide **293** and is finally positioned by shaft **47** settling in V-block **301**, cantilevered roller **461** fully contacts surface **29***b*, as shown in FIG. **21**. When the top cover of the printer is closed, a downwardly positioned leaf spring on the printer cover contacts tab **23** on the left front of cover **33** and a second downwardly positioned spring on the printer cover contacts surface **447** on right cover **241**. Such interaction of a cartridge with a printer lid is generally conventional, as illustrated by U.S. Pat. No. 5,365,315 to Baker et al.

As the printer lid is closed, a charge roller mechanism is moved to shutter **5** and then continues to move downward to open shutter **5** by pushing it downward and to bring a charge roller in contact with photoconductor **49**. A laser beam for discharging drum **49** is also directed through the opening left after shutter **5** is pivoted down, as is shown on U.S. Pat. No. 5,526,097 to Ream.

In summary, the photoconductor and cover assembly is located downwardly by front surfaces **449** and **451**, is located downwardly by shaft **47** in V-block **301** and in the mirror image V-block and is held in the downward location by cantilevered roller **461** on surface **29***b* and the mirror image cantilevered roller on surface **29***a*. The developer assembly is located laterally by springs **132***a* and **132***b* moving the assembly so that developer roller **43** contacts the photoconductor **49**, and is located downwardly by ledge **133***a* resting on roller **299** and ledge **161***a* resting on the mirror image roller to roller **299**. The developer assembly requires no upward locator as it has sufficient weight not to displace upward.

Ledges **133***a* and **161***a* resting on roller **299** and a mirror image roller respectively permit the developer assembly to adjust laterally. In prior cartridges, both sets of rollers were in tracks in the cartridge. This required difficult tolerances to locate the bottom of the cartridge within the printer. In the subject cartridge, ledges **133***a* and **161***a* have no linked parts to the media guide ribs **223** and **225**, which are in the same molded part as ledges **133***a* and **161***a*.

FIG. **22** shows an extension of side member **99** held in a slot **471** in the bottom of the cover **25**. This provides lateral location between the hopper assembly and the cover **25**. Generally similar lateral location structure is in previous cartridges. If desirable, the upper parts of end members **99** and **101** and have an upward ridge or bump, which will strike cover **25** during rough handling and thereby limit relative upward movement of the hopper assembly with respect to cover **25**.

When installed in the printer, frame members contact left cover **31** and right cover **241** to assure they do not contact the hopper assembly and interfere with its free movement over roller **299** and its mirror image roller on ledges **133***a* and **161***a* respectively.

Venting By Plug

Plug **143** (FIG. **24**) in a preferred form is a venting element which allows air to escape cartridge **1** while blocking toner. Cartridge **1** in the embodiment disclosed is designed to operate at high speed to print from 8 to 24 or more standard pages per minute. This operation generates a potentially detrimental internal pressure level during operation, which contributes to leaks of toner from cartridge **1**. To relieve such pressure, plug **143** is a labyrinth design ending in a felt filter.

The leaks often, but not exclusively, occur immediately after the cartridge becomes inactive. Internal pressure in hopper **61** is created by ingesting air with toner **425** carried by the developer roller **43** past a seal (not shown) under the developer roller **43**. The toner adder roller **45** pulls this air/toner mixture away from the developer roller which creates a pressure increase in hopper **61** until an equilibrium pressure is reached. As shown in FIG. **23**, plug **143** is formed from a single molded part **481** having a circular base member **483** and a circular cap member **485** separated by a thin connecting arm **487**, which has a central notch **489** to permit bending as a solid hinge.

Base **483** has a series of equally separated external holes **491** around the entire bottom circumference of base **483**. Extending from the bottom of base **483** and located inward is a circular wall **493** having spaced rectangular openings **495** at the outer end of wall **493** equally spaced around the entire circumference of wall **493**.

Similarly, cap **485** has a circular wall **497** extending from the top of cap **485** having spaced rectangular openings **499**

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at the outer end of wall **497** equally spaced around the entire circumference of wall **497**. A disk **501** of standard F3 felt is pressed into the center of cap **485** where it contacts the inside of holes **503** (FIG. **24**) in the center of cap **485**.

To complete plug **143** as shown in FIG. **24**, cap **485** and base **483** are intermeshed by folding arm **487** at hinge point **489**. In this position no part of openings **499** is opposite external holes **491** and no part of openings **495** is opposite holes **499**. FIG. **25** is a staggered cross section view of FIG. **24** which shows all of the holes **495** and **499** and indicates the staggered path by the angles **505***a* and **505***b* in discussion arrow **505**.

As shown in FIG. **25**, the plug is held together by a press fit in which the bottom circumference of base **483** is slightly smaller than the circumference of cap **485**. In operation, when pressure increases in cartridge **1**, air, potentially containing toner particles, enters openings **491** which are inside of hopper **61**. That air enters circular chamber **507**, as illustrated by arrow **505**, and is blocked by wall **497** immediately opposite hole **491** and, therefore, must move right or left, as illustrated by bent arrow **505***a*, to reach openings **499**. The air then enters chamber **509**. That air is blocked by wall **493** and also must move right or left, as illustrated by bent arrow **505***b*, to reach openings **495**, which are on the opposite end of chamber **509**. Upon passing through openings **495**, as shown by arrow **505**, the air enters central chamber **511** and passes through felt filter **501** and then out of cartridge **1** through holes **503**. (FIG. **23** shows four central flanges **513***a*–**513***d*, which divide chamber **511** into four equal parts. However, flanges **513***a*–**513***d* are for structural support of felt disk **501** and, functionally, chamber **511** can be a single chamber.)

The labyrinth configuration of this construction of plug **143** results in continuing operation as an air vent with only minor accumulation of toner inside of the plug **143**. The internal chambers **507**, **509** and **511** are concentric circles.

We claim:

1. A toner cartridge subject to increases in pressure in internal regions containing toner during operation,

said cartridge having an opening in the side of said cartridge and a removable plug which fits in and closes said opening in said cartridge,

said plug having openings into said cartridge communicating with a labyrinth of chambers reached by staggered paths,

said labyrinth communicating with holes in said plug leading to the outside of said cartridge,

and a filter located in said plug between said openings into said cartridge and the outside of said cartridge which blocks toner from passing through said holes leading to the outside.

2. The toner cartridge as in claim **1** in which said plug has a central chamber communicating with said labyrinth and said filter is located between said central chamber and said holes leading to the outside.

3. The toner cartridge as in claim **2** in which said labyrinth comprises

a first chamber communicating with said cartridge through said openings into said cartridge, and

a second chamber having openings, said openings of said second chamber communicating with said first chamber and not facing said openings into said cartridge,

said central chamber communicating with said second chamber, said openings of said central chamber being on the opposite side of said second chamber from said openings of said second chambers and not facing said openings of said second chamber.

4. The toner cartridge as in claim **3** in which said cartridge contains electrophotographic toner for developing electrostatic imaging.

5. The toner cartridge as in claim **2** in which said cartridge contains electrophotographic toner for developing electrostatic imaging.

6. The toner cartridge as in claim **1** in which said labyrinth comprises

a first chamber communicating with said cartridge through said openings into said cartridge,

a second chamber having openings, said openings of said second chamber communicating with said first chamber and not facing said openings into said cartridge, and

a third chamber having openings communicating with said second chamber, said openings of said third chamber being on opposite side of said second chamber from said openings of said second chamber and not facing said openings of said second chamber.

7. The toner cartridge as in claim **6** in which said cartridge contains electrophotographic toner for developing electrostatic imaging.

8. The toner cartridge as in claim **1** in which said cartridge contains electrophotographic toner for developing electrostatic imaging.

9. A venting plug for an electrophotographic toner cartridge comprising

a first chamber having openings on the outside of said plug for insertion into an electrophotographic cartridge,

a second chamber having openings, said openings of said second chamber communicating with said first chamber and not facing said openings for insertion into an electrophotographic cartridge,

a third chamber having first openings communicating with said second chamber, said first openings of said third chamber not facing said openings of said second chamber, said third chamber also having second openings located generally on the opposite side of said plug from said openings for inserting into an electrophotographic cartridge, and

a filter located in said plug between said openings for insertion into an electrophotographic cartridge and the outside of said plug which blocks toner from passing through said second chamber.

10. The venting plug as in claim **9** in which said third chamber is in the center of said plug and said filter is located between said third chamber and said second openings.

11. The venting plug as in claim **10** in which said first openings of said third chamber are on the opposite end of said second chamber from said openings of said second chamber.

12. The venting plug as in claim **11** in which said first chamber, said second chamber, and said third chamber are concentric circles.

13. The venting plug as in claim **10** in which said first chamber, said second chamber, and said third chamber are concentric circles.

14. The venting plug as in claim **9** in which said first openings of said third chamber are on the opposite end of said second chamber from said openings of said second chamber.

15. The venting plug as in claim **14** in which said first chamber, said second chamber, and said third chamber are concentric circles.

16. The venting plug as in claim **9** in which said first chamber, said second chamber, and said third chamber are concentric circles.

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