

Magnet-less Removable Toner Cartridge for Single-Component and Dual Component Development Systems

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Abstract

The low-end color laser printer market has expanded rapidly in recent years. The design of small light-weight, high image quality, and low-cost color laser printers has been an issue. Authors have described a patented, magnet-less, removable toner cartridge in this article. This add-on low-cost cartridge can be designed such that it can be easily removed and replaced by a casual non-trained operator. Also, the replacement of the carrier in a dual-component development system can be easily accomplished in this way. These magnet-less cartridges can also be cost-effectively used in a single-component or a dual-component xerographic black & white printing, copying or faxing equipment. The architecture of color xerographic systems will be greatly simplified resulting in cost-savings and efficiency.

At this stage, we have demonstrated the feasibility of the magnetic brush and the magnet-less cartridge concepts. Our commercialization strategy calls for licensing the patents and additional knowledge of the office equipment manufacturers.

Introduction

With the advent of color laser printing, the need for a higher performance development system that enables a low cost per copy has become even more critical. This invention provides a cost-effective solution for both color and monochrome laser printers, copiers, duplicators and facsimile machines. It is also applicable to the range of machines from low-speed to very high-speed copiers, printers, and duplicators.

The magnet-less cartridge concept is described in detail in the U.S. Patent # 5,839,027 and the Self-Propelled Switchable Magnetic Brush (SSMB) is described in U.S. Patent # 5,715,504. Both of these patents are assigned to Ravi & Associates.

The current dry-toner cartridges for monochrome and color machines suffer from the following disadvantages:

(a) High cartridge cost – many parts
(b) Not environment-friendly – many disposable parts in the cartridge
(c) Requires lot of space around the circumference of the photoreceptor - not suitable for color machines
(d) Development system not high-quality for color
(e) Development system not easily switchable for color
(f) Carrier/developer can not be easily replaced

For the low-end machines, the current HP LaserJet "All-in-one" toner cartridges contain an imaging photoreceptor, development (magnet) roll, toner, and related mechanisms together.

Other vendors, as for example, Brother, Sharp and Xerox deploy a two-cartridge approach instead of HP's "All-in-one" approach in which photoreceptors are unbundled from the development system.

In current high-speed copiers, printers and duplicators, which currently employ a dual-component development, copy quality maintainenance and periodic replacement of carriers is an expensive issue. To solve the carrier replacement problem, Fuji Xerox has proposed the "Trickle Development System" and many high-end machines have complicated auger mechanism to purge the developer. This problem can be easily solved with this magnet-less cartridge idea.

In prior-art, both active (contact) and non- interactive (non-contact) development systems have been designed with magnetic brush systems. Non-interactive development is most useful in color systems. The highly agitative magnetic brush has been a related issue in color laser printers to develop high-quality images. We propose the Self-Propelled Switchable Magnetic Brush (SSMB) in conjunction with the magnet-less cartridge to enable new and efficient color laser machines from low to high-speed.

Accordingly, several advantages of the proposed Magnet-less Cartridge and Self-Propelled Switchable Magnetic Brush (SSMB) are:

a) Low cost cartridge – magnet-less, with recyclable or bio-degradable plastic parts
b) Dirt-free Operator removal and replacement of carrier and toner
c) Highly reliable novel switchable magnetic brush (SSMB) capable of dynamically varying the speed and direction of the magnetic brush

d) Simplified color printer/copier architecture - less space, fewer parts, lower manufacturing, and maintenance cost.
e) Excellent Developer Agitation
f) Excellent image quality

In our opinion, this novel cartridge concept can enable compact and highly reliable future color or monochrome machines. Our idea is that the magnetic development roller remains a permanent part of the equipment with a removable cartridge that fits on top of the magnet. This fact allows for better tolerances between the magnetic brush and the photoreceptor; which results in better image quality. Kodak's high-speed printers and duplicators (DigiSource 9110 and Nexpress 2100) have demonstrated that excellent image quality can be achieved with the rotating magnetic brush development apparatus. The SSMB device is an improved magnetic brush apparatus with an internal electromagnetic propelling mechanism instead of an external motor-driven mechanism.

What Is A Magnet-Less Cartridge?

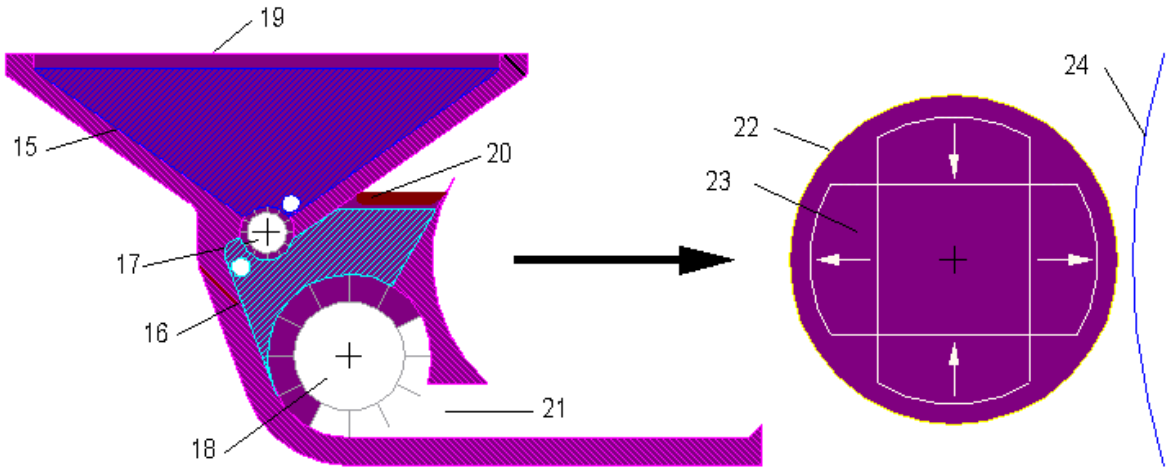
The magnet-less cartridge will be loaded such that the cartridge will fit snugly on the development roller sleeve of the magnetic brush system.

The operation of changing these magnet-less cartridges is easy and dirt-free. These cartridges are very environmentally safe because the magnet roll is not thrown away with the cartridge. These toner cartridges are relatively simple, less expensive and can be made of recyclable or bio-degradable materials.

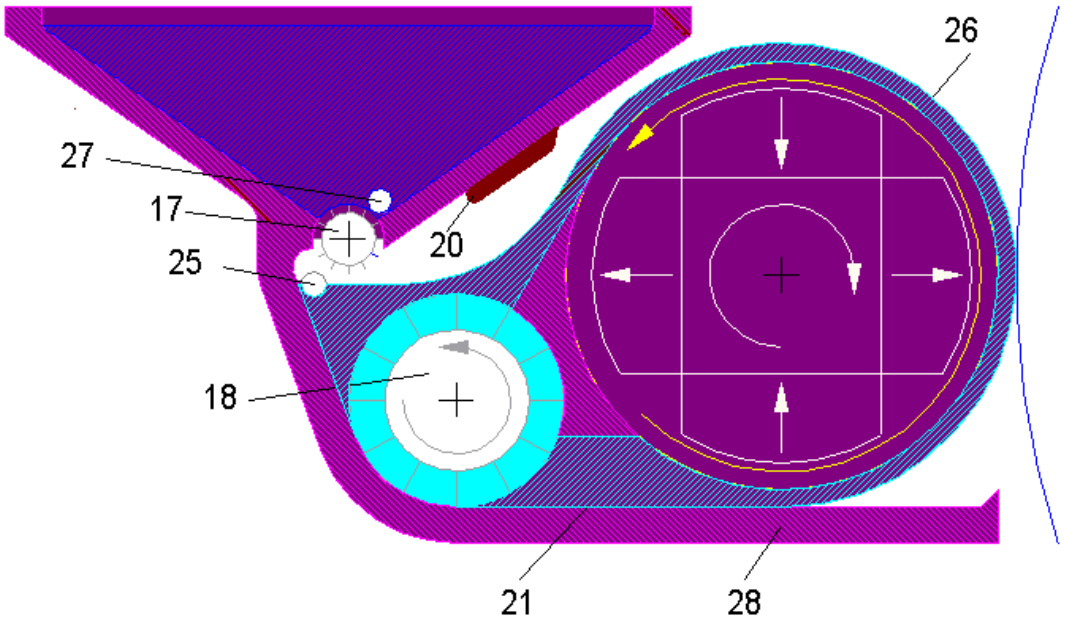
The magnet-less cartridge assembly (19) which is shown below can be filled with black magnetic toner only in single component development systems or can be filled with magnetic carrier (16) mixed with non-magnetic black or cyan,. Magenta, or yellow toners (15) for dual component development systems The toner dispensing wheel (17) and the mixer paddle wheel (18) are independently driven by an external gear mechanism.

As outlined in the SSMB Patent # 5,715,504 noted above, the multi-pole magnet (23) inside the sleeve (22) will be made to rotate through the electromagnetic (self-propelled) action. When the SSMB device (23) is energized by a poly-phase alternating or pulsating current, the magnet structure rotates and the developer/toner mixture self-propels on the circumference of the outer sleeve (23). The outer sleeve is rotated at a fraction of the speed (1/6th to 1/10th) of the inside rotating magnet with a gear mechanism.

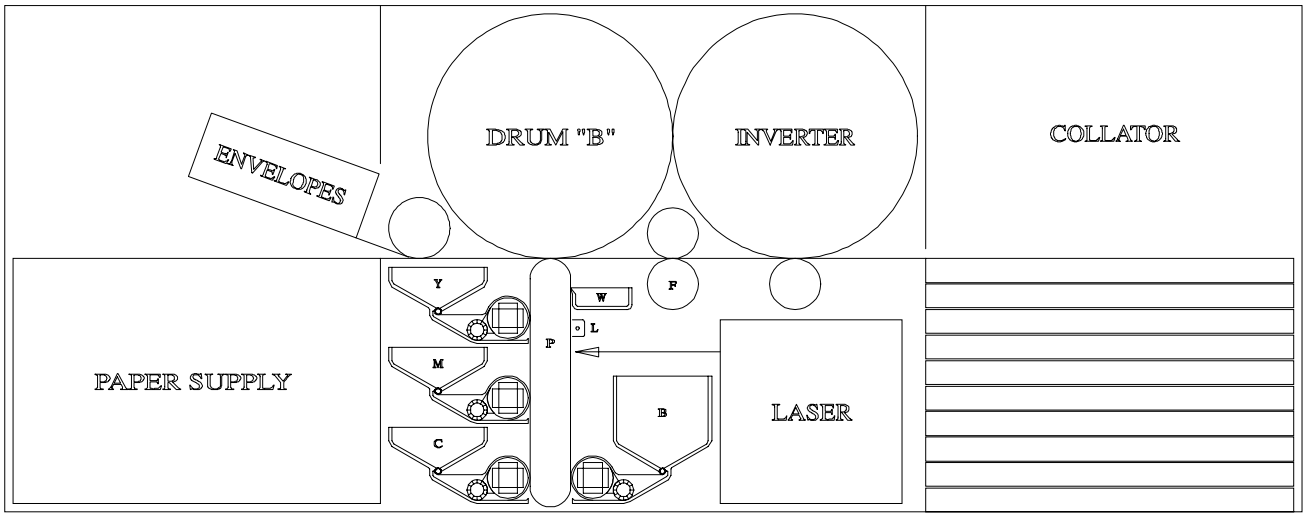
By controlling the frequency or the sequence of the supplied voltage, the speed and the direction of the rotating magnetic structure (23) can be easily changed. The brush formed on the surface of the sleeve (23) is brought in proximity with the charged electrostatic image on the photoreceptor (24).



NEW CARTRIDGE



INSTALLED CARTRIDGE



Due to the skewed magnetic poles inside the magnet structure, the developer powder also moves in the axial direction providing the desired tumbling motion for a better image development.

The sleeve (22) and the magnetic structure (23) are fixed and permanent part of the machine. The removable magnet-less cartridge assembly is shown in the upper diagram. The lower diagram shows the cartridge properly mounted inside the machine for the imaging operation on the sleeve (22), which is non-removable from the machine.

By closing the shutter/scrapper knife (20) and accelerating the rotational speed of the magnetic structure (23), the toner material on the sleeve (22), which makes contact with the photoreceptor is moved back into the cartridge with the help of the paddle wheel (18). The sleeve (22) is now clean from the toner or carrier material and the glove-less operation of loading and unloading the cartridge can be accomplished in this position.

By using the Magnet-less Cartridge and Self-Propelled Switchable Magnetic Brush, scalable, simple and cost-

effective architectures can be created for non-contact or contact development systems as shown above.

The principle of simple architecture is applicable to both. monochrome or color development systems As shown in the picture above, the marking engine can be very small and compact. The marking engine contains a vertically stacked developing system for three colors, Cyan, Magenta, and Yellow on the left side and Black on the right side of the photoreceptor.

An example of a straight paper path has been shown but it can be varied to suit the requirements. As for example, the Transfer Drum"B" can be replaced by an IBT (Intermediate Belt Transfer) system and the duplex inverter can be replaced with other mechanisms.

An intrinsic feature of this architecture is the SSMB developing system, which is smoothly switchable and can work with both active and non-interactive brush development systems. Due to its easy and smooth switchability, different color developers, as for example, Cyan, Magneta, Yellow, Black, can be engaged or disengaged easily and simply.

In contrast, color machines of today require a carousel system for developer switching, which is a bulky and expensive electromechanical system. The developer or carrier replacement in a carousel system usually requires trained technician since it can not be easily accomplished by a casual operator.

Test Results

We developed a bench prototype to demonstrate the Switchable Self-Propelled Magnetic Brush idea as claimed in Patent # 5, 715,504.

With the help of the prototype, we have demonstrated that the SSMB device is feasible, cost-effective and runs without causing any noticeable heat dissipation. We have demonstrated that a small portion of the multi-pole magnetic structure can be used for self-propelling action and the remainder can be used for creating an agitative magnetic brush. In our experiments, we found that the magnetic brush can be changed to move faster or slower in speed by changing the frequency of the supply voltage. The direction of the brush can be easily changed by reversing the polarity of the poly-phase supply. We also demonstrated that the brush can be easily switched with the aid of a scrapper knife. On the same bench, we also demonstrated the feasibility of a magnet-less cartridge.

We have also performed a parts count, preliminary manufacturing cost analysis, and reliability analysis. Furthermore, we have created printer architectures for color and monochrome systems that are modular, scalable, productive, and highly maintainable.

Conclusions

We believe that small, light-weight, high-image quality, low-cost monochrome and color laser printers can be designed with the SSMB and Magnet-less cartridge concepts.

Reducing the number of removable or recyclable parts in the magnet-less cartridge should bring the cost per copy to a lower level compared to the current approaches.

Since the magnet roll remains part of the machine and is not removable with the cartridge, reliability and image quality can be maintained at a high level for both contact and non-contact development systems.

This approach is extensible to high-end copiers and printers because these design concepts are applicable to dual component development systems. Operator-friendly replacement of carrier/developer is a very desirable feature, especially for the high-end systems.

References

Development of trickle developing system and applying to Color Laser Wind 3310 by Yoshifumi, Katumi, Takeshi and Toshio – Fuji Xerox Technical Report No. 12, 1998

Biography

Ravi Sahay has extensive experience as a management consultant in the areas of electronic imaging, printing, publishing and document management. He holds a master's degree in Electrical Engineering as well as master's degree in Business Administration.

Ravi has worked for Xerox Corporation as a Systems Engineer, Strategic Planner and New Product Development Manager. He holds seven U.S. patents on Xerographic machines and two patents are pending.

Henry L. Alioth has extensive experience in Magnetics and is the founder of Swiss Magnet Inc., a Las Vegas based company. Henry completed his degree in Electrical Engineering from ETH Zuerich, Switzerland in 1957 and he holds three U.S. Patents.