

Laser printer

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A **laser printer** is a common type of computer printer that rapidly produces high quality text and graphics on plain paper. As with digital photocopiers and multifunction printers (MFPs), laser printers employ a xerographic printing process but differ from analog photocopiers in that the image is produced by the direct scanning of a laser beam across the printer's photoreceptor.

Overview

A laser beam projects an image of the page to be printed onto an electrically charged rotating drum coated with selenium. Photoconductivity removes charge from the areas exposed to light. Dry ink (toner) particles are then electrostatically picked up by the drum's charged areas. The drum then prints the image onto paper by direct contact and heat, which fuses the ink to the paper.

Laser printers have many significant advantages over other types of printers. Unlike impact printers, laser printer speed can vary widely, and depends on many factors, including the graphic intensity of the job being processed. The fastest models can print over 200 monochrome pages per minute (12,000 pages per hour). The fastest color laser printers can print over 100 pages per minute (6000 pages per hour). Very high-speed laser printers are used for mass mailings of personalized documents, such as credit card or utility bills, and are competing with lithography in some commercial applications.

The cost of this technology depends on a combination of factors, including the cost of paper, toner, and infrequent drum replacement, as well as the replacement of other consumables such as the fuser assembly and transfer assembly. Often printers with soft plastic drums can have a very high cost of ownership that does not become apparent until the drum requires replacement.

A duplexing printer (one that prints on both sides of the paper) can halve paper costs and reduce filing volumes. Formerly only available



HP LaserJet 4200 series printer



HP LaserJet 1200 printer

Part of the series on the
History of printing

Woodblock printing	200
Movable type	1040
Intaglio	1430

on high-end printers, duplexers are now common on mid-range office printers, though not all printers can accommodate a duplexing unit. Duplexing can also give a slower page-printing speed, because of the longer paper path.

In comparison with the laser printer, most inkjet printers and dot-matrix printers simply take an incoming stream of data and directly imprint it in a slow lurching process that may include pauses as the printer waits for more data. A laser printer is unable to work this way because such a large amount of data needs to output to the printing device in a rapid, continuous process. The printer cannot stop the mechanism precisely enough to wait until more data arrives, without creating a visible gap or misalignment of the dots on the printed page.

Instead the image data is built up and stored in a large bank of memory capable of representing every dot on the page. The requirement to store all dots in memory before printing has traditionally limited laser printers to small fixed paper sizes such as letter or A4. Most laser printers are unable to print continuous banners spanning a sheet of paper two meters long, because there is not enough memory available in the printer to store such a large image before printing begins.

Printing press	1454
Lithography	1796
Chromolithography	1837
Rotary press	1843
Flexography	1873
Mimeograph	1876
Hot metal typesetting	1886
Offset press	1903
Screen-printing	1907
Dye-sublimation	1957
Phototypesetting	1960s
Photocopier	1960s
Pad printing	1960s
Dot matrix printer	1964
Laser printer	1969
Thermal printer	1970s
Inkjet printer	1976
3D printing	1986
Stereolithography	1986
Digital press	1993

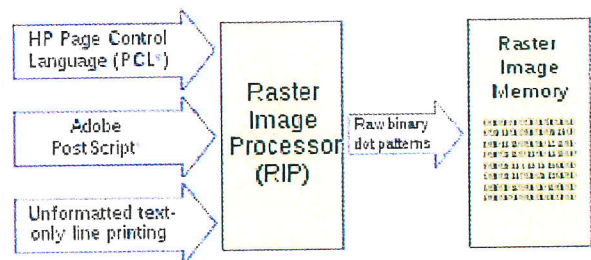
How it works

Main article: Xerography

There are typically seven steps involved in the laser printing process:

Raster image processing

Each horizontal strip of dots across the page is known as a raster line or scan line. Creating the image to be printed is done by a Raster Image Processor (RIP), typically built into the laser printer. The source material may be encoded in any number of special page description languages such as Adobe PostScript (PS), HP Printer Command Language (PCL), or Microsoft XML Page Specification (XPS), as well as unformatted text-only data. The RIP uses the page description language to generate a bitmap of the final page in the raster memory. Once the entire page has been rendered in raster memory, the printer is ready to begin the process of sending the rasterized stream of dots to the paper in a continuous stream.



Generating the raster image data

Charging

A corona wire (in older printers) or a primary charge roller projects an electrostatic charge onto the photoreceptor (otherwise named the photoconductor unit), a revolving photosensitive drum or belt, which is capable of holding an electrostatic charge on its surface while it is in the dark.

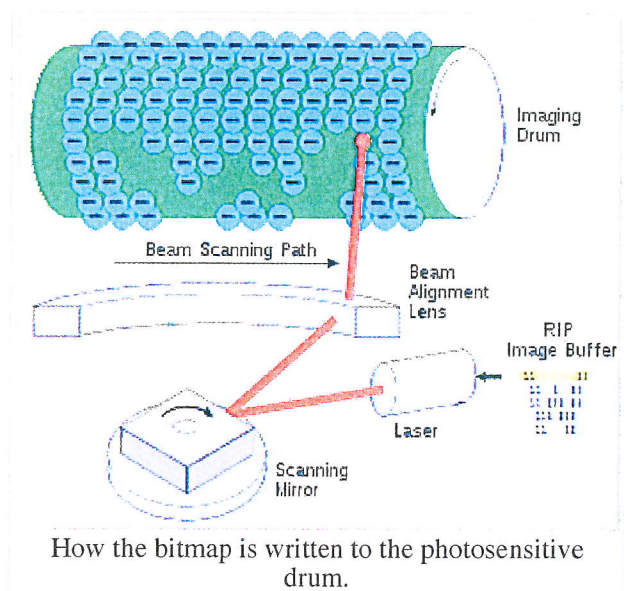
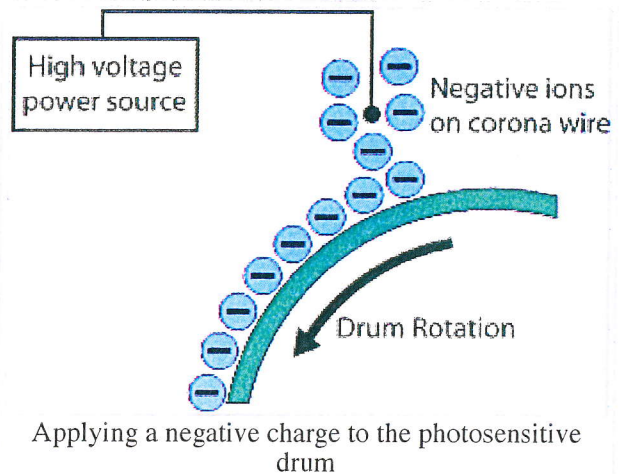
An AC bias is applied to the primary charge roller to remove any residual charges left by previous images. The roller will also apply a DC bias on the drum surface to ensure a uniform negative potential. The desired print density is modulated by this DC bias. [4]

Numerous patents describe the photosensitive drum coating as a silicon sandwich with a photocharging layer, a charge leakage barrier layer, as well as a surface layer. One version uses amorphous silicon containing hydrogen as the light receiving layer, Boron nitride as a charge leakage barrier layer, as well as a surface layer of doped silicon, notably silicon with oxygen or nitrogen which at sufficient concentration resembles machining silicon nitride; the effect is that of a light chargeable diode with minimal leakage and a resistance to scuffing.

Exposing

The laser is aimed at a rotating polygonal mirror, which directs the laser beam through a system of lenses and mirrors onto the photoreceptor. The beam sweeps across the photoreceptor at an angle to make the sweep straight across the page; the cylinder continues to rotate during the sweep and the angle of sweep compensates for this motion. The stream of rasterized data held in memory turns the laser on and off to form the dots on the cylinder. (Some printers switch an array of light emitting diodes spanning the width of the page, but these devices are not "Laser Printers".) Lasers are used because they generate a narrow beam over great distances. The laser beam neutralizes (or reverses) the charge on the white parts of the image, leaving a static electric negative image on the photoreceptor surface to lift the toner particles.

A beam detect (BD) sensor is used to synchronize the laser sweeping process at the end of each sweep cycle. [4]



Developing

The surface with the latent image is exposed to toner, fine particles of dry plastic powder mixed with carbon black or coloring agents. The charged toner particles are given a negative charge, and are electrostatically attracted to the photoreceptor's latent image, the areas touched by the laser. Because like charges repel, the negatively charged toner will not touch the drum where the negative charge remains.

The overall darkness of the printed image is controlled by the high voltage charge applied to the supply toner. Once the charged toner has jumped the gap to the surface of the drum, the negative charge on the toner itself repels the supply toner and prevents more toner from jumping to the drum. If the voltage is low, only a thin coat of toner is needed to stop more toner from transferring. If the voltage is high, then a thin coating on the drum is too weak to stop more toner from transferring to the drum. More supply toner will continue to jump to the drum until the charges on the drum are again high enough to repel the supply toner. At the darkest settings the supply toner voltage is high enough that it will also start coating the drum where the initial unwritten drum charge is still present, and will give the entire page a dark shadow.

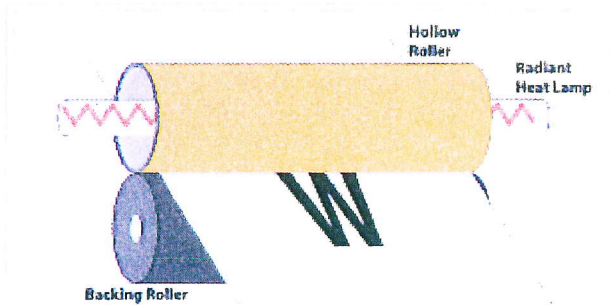
Transferring

The photoreceptor is pressed or rolled over paper, transferring the image. Higher-end machines use a positively charged transfer roller on the back side of the paper to pull the toner from the photoreceptor to the paper.

Fusing

The paper passes through rollers in the fuser assembly where heat (up to 200 Celsius) and pressure bond the plastic powder to the paper.

One roller is usually a hollow tube (heat roller) and the other is a rubber backing roller (pressure roller). A radiant heat lamp is suspended in the center of the hollow tube, and its infrared energy uniformly heats the roller from the inside. For proper bonding of the toner, the fuser roller must be uniformly hot.



Melting toner onto paper using heat and pressure.

The fuser accounts for up to 90% of a printer's power usage. The heat from the fuser assembly can damage other parts of the printer, so it is often ventilated by fans to move the heat away from the interior. The primary power saving feature of most copiers and laser printers is to turn off the fuser and let it cool. Resuming normal operation requires waiting for the fuser to return to operating temperature before printing can begin.

Some printers use a very thin flexible metal fuser roller, so there is less mass to be heated and the fuser can more quickly reach operating temperature. This both speeds printing from an idle state and permits the fuser to turn off more frequently to conserve power.

If paper moves through the fuser more slowly, there is more roller contact time for the toner to melt, and the fuser can operate at a lower temperature. Smaller, inexpensive laser printers typically print slowly,

due to this energy-saving design, compared to large high speed printers where paper moves more rapidly through a high-temperature fuser with a very short contact time.

Cleaning

When the print is complete, an electrically neutral soft plastic blade cleans any excess toner from the photoreceptor and deposits it into a waste reservoir, and a discharge lamp removes the remaining charge from the photoreceptor.

Toner may occasionally be left on the photoreceptor when unexpected events such as a paper jam occur. The toner is on the photoconductor ready to apply, but the operation failed before it could be applied. The toner must be wiped off and the process restarted.

Waste toner cannot be reused for printing because it can be contaminated with dust and paper fibers. A quality printed image requires pure, clean toner. Reusing contaminated toner can result in splotchy printed areas or poor fusing of the toner into the paper. There are some exceptions however, most notably some Brother and Toshiba laser printers, which use a patented method to clean and recycle the waste toner.^{[5][6]}

Color laser printers

Color laser printers use colored toner (dry ink), typically cyan, magenta, yellow, and black (CMYK).

While monochrome printers only use one laser scanner assembly, color printers often have two or more scanner assemblies.

Color printing adds complexity to the printing process because very slight misalignments known as registration errors can occur between printing each color, causing unintended color fringing, blurring, or light/dark streaking along the edges of colored regions. To permit a high registration accuracy, some color laser printers use a large rotating belt called a "transfer belt". The transfer belt passes in front of all the toner cartridges and each of the toner layers are precisely applied to the belt. The combined layers are then applied to the paper in a uniform single step.

Color printers usually have a higher "cents-per-page" production cost than monochrome printers.

The following two pages are from the manual for an HP2605 color laser printer. They show the four cartridges for red, cyan, yellow, and black with their drums inside, and a laser scanning system for creating the image on the drums. The ETB belt picks the images off the four drums and delivers them in almost perfect register to the paper, after which the toner is fused on. A miraculous piece of engineering for a few hundred dollars.



Fuji Xerox colour laser printer C1110B

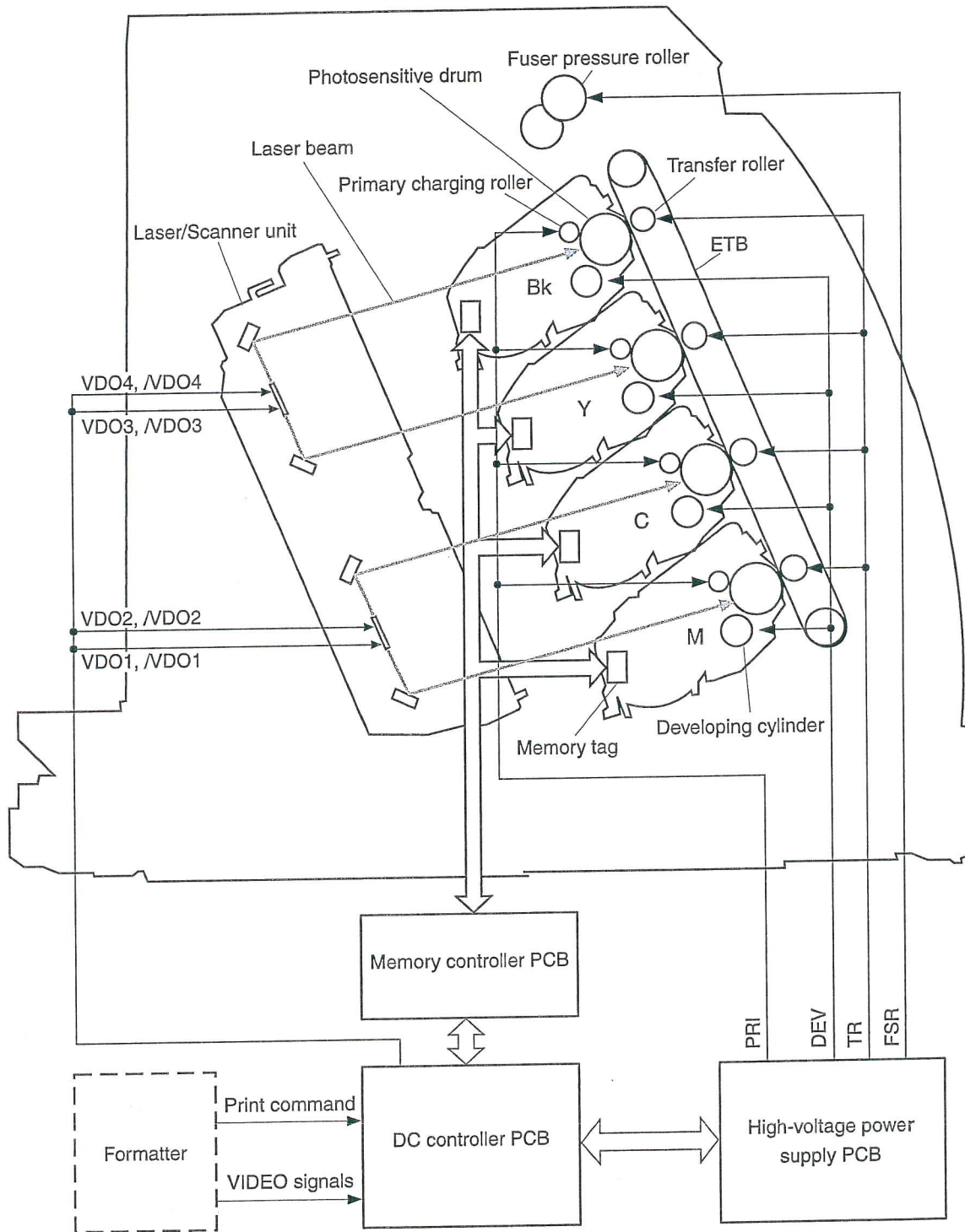


Figure 4-2 Image formation system

Image formation process

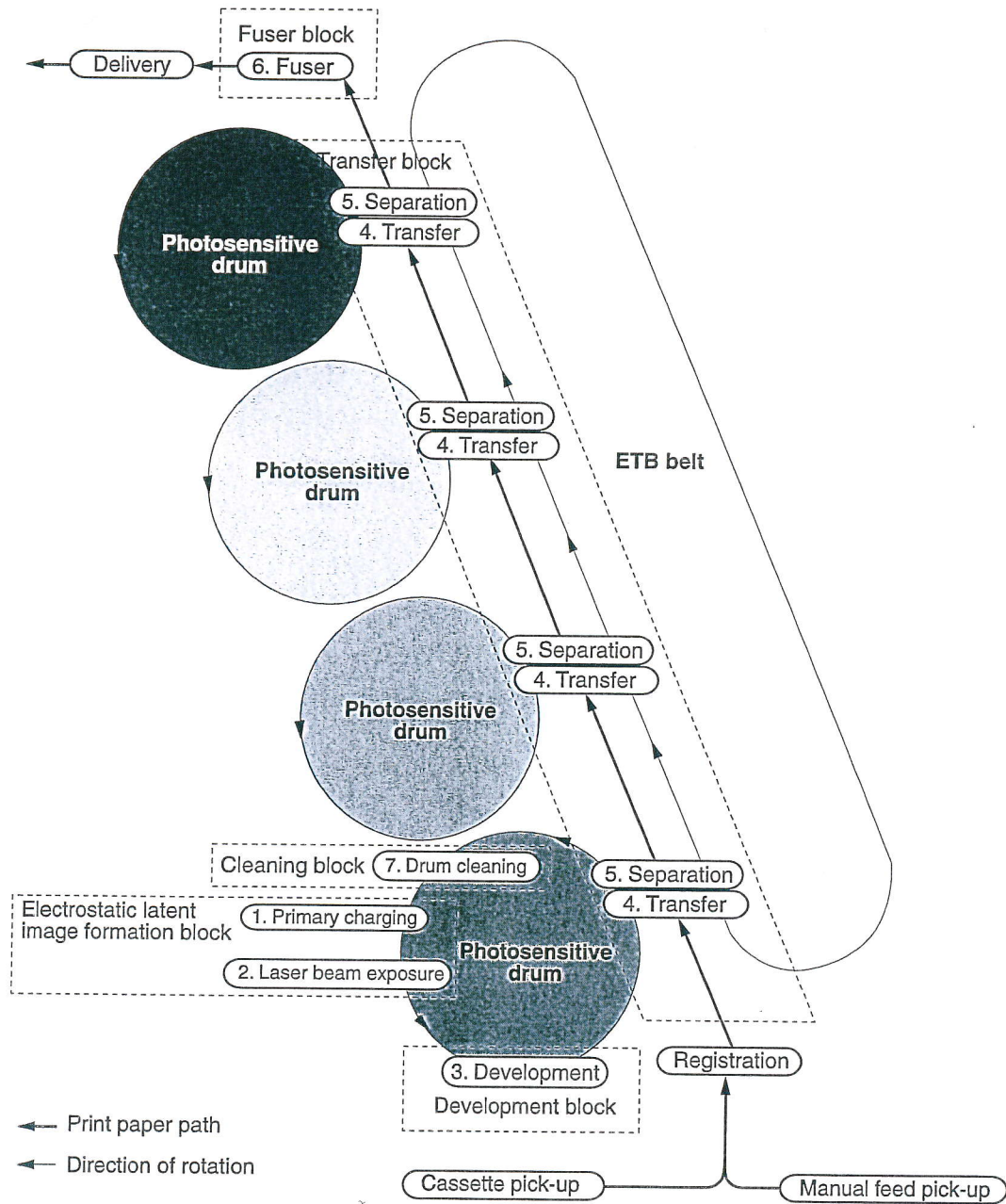


Figure 4-3 Image formation process