

# How Inkjet Printers Work

by [Jeff Tyson](#)

No matter where you are reading this article from, you most likely have a printer nearby. And there's a very good chance that it is an **inkjet printer**. Since their introduction in the latter half of the 1980s, inkjet printers have grown in popularity and performance while dropping significantly in price.



**An inexpensive color inkjet printer made by Hewlett Packard**

An **inkjet** printer is any printer that places extremely small droplets of ink onto paper to create an image. If you ever look at a piece of paper that has come out of an inkjet printer, you know that:

- The dots are extremely small (usually between 50 and 60 microns in diameter), so small that they are tinier than the diameter of a human hair (70 microns)!
- The dots are positioned very precisely, with resolutions of up to 1440x720 dots per inch (dpi).
- The dots can have different colors combined together to create photo-quality images.

In this edition of [HowStuffWorks](#), you will learn about the various parts of an inkjet printer and how these parts work together to create an image. You will also learn about the ink cartridges and the special paper some inkjet printers use.

First, let's take a quick look at the various printer technologies.

## Impact vs. Non-impact

There are several major printer technologies available. These technologies can be broken down into two main categories with several types in each:

- **Impact** - These printers have a mechanism that touches the paper in order to create an image. There are two main impact technologies:
  - **Dot matrix** printers use a series of small pins to strike a ribbon coated with ink, causing the ink to transfer to the paper at the point of impact.
  - **Character** printers are basically computerized typewriters. They have a ball or series of bars with actual characters (letters and numbers) embossed on the surface. The appropriate character is struck against the ink ribbon, transferring the character's image to the paper. Character printers are fast and sharp for basic

text, but very limited for other use.

- **Non-impact** - These printers do not touch the paper when creating an image. Inkjet printers are part of this group, which includes:
  - **Inkjet** printers, which are described in this article, use a series of nozzles to spray drops of ink directly on the paper.
  - **Laser** printers, covered in-depth in [How Laser Printers Work](#), use dry ink (toner), static electricity, and heat to place and bond the ink onto the paper.



**A Hewlett Packard LaserJet 4050T**

- **Solid ink** printers contain sticks of wax-like ink that are melted and applied to the paper. The ink then hardens in place.
- **Dye-sublimation** printers have a long roll of transparent film that resembles sheets of red-, blue-, yellow- and gray-colored cellophane stuck together end to end. Embedded in this film are solid dyes corresponding to the four basic colors used in printing: cyan, magenta, yellow and black (CMYK). The print head uses a heating element that varies in temperature, depending on the amount of a particular color that needs to be applied. The dyes vaporize and permeate the glossy surface of the paper before they return to solid form. The printer does a complete pass over the paper for each of the basic colors, gradually building the image.
- **Thermal wax** printers are something of a hybrid of dye-sublimation and solid ink technologies. They use a ribbon with alternating CMYK color bands. The ribbon passes in front of a print head that has a series of tiny heated pins. The pins cause the wax to melt and adhere to the paper, where it hardens in place.
- **Thermal autochrome** printers have the color in the paper instead of in the printer. There are three layers (cyan, magenta and yellow) in the paper, and each layer is activated by the application of a specific amount of heat. The print head has a heating element that can vary in temperature. The print head passes over the paper three times, providing the appropriate temperature for each color layer as needed.

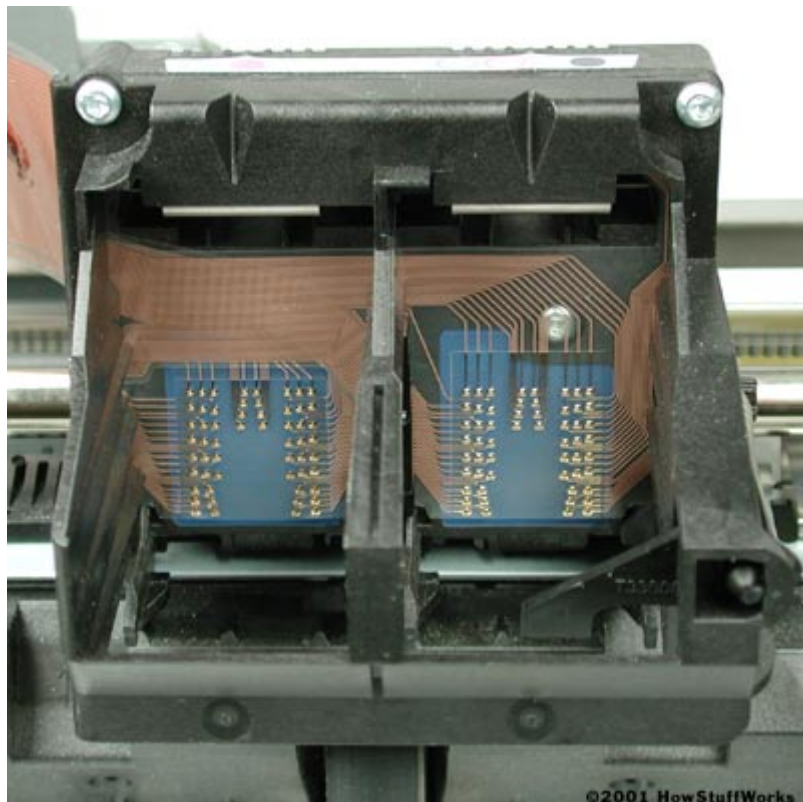
Out of all of these incredible technologies, inkjet printers are by far the most popular. In fact, the only technology that comes close today is laser printers.

So, let's take a closer look at what's inside an inkjet printer.

## Inside an Inkjet Printer

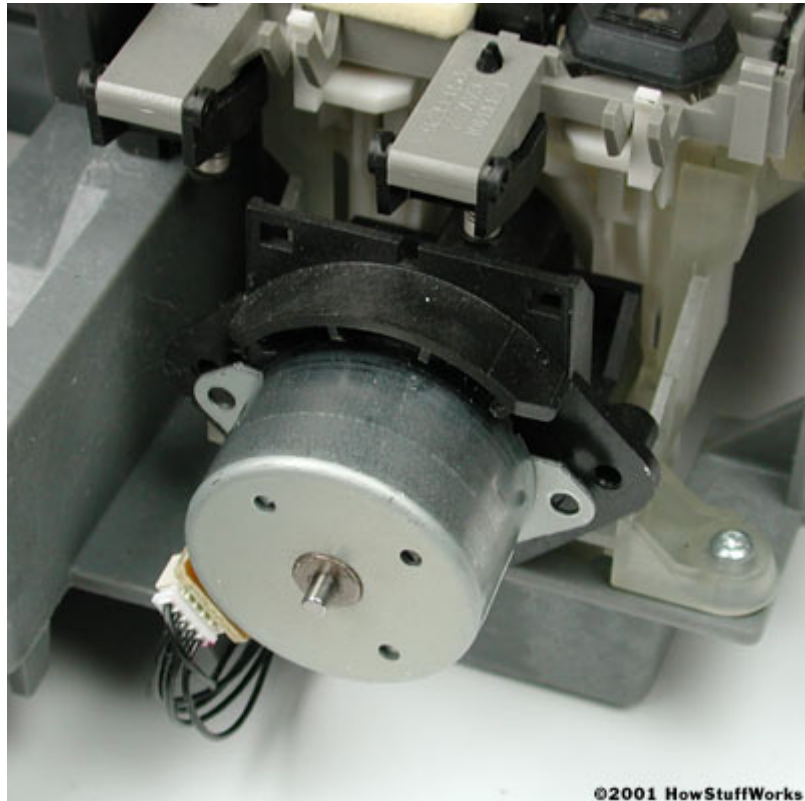
Parts of a typical inkjet printer include:

- **Print head assembly**
  - **Print head** - The core of an inkjet printer, the print head contains a series of nozzles that are used to spray drops of ink.



**The print head assembly**

- **Ink cartridges** - Depending on the manufacturer and model of the printer, ink cartridges come in various combinations, such as separate black and color cartridges, color and black in a single cartridge or even a cartridge for each ink color. The cartridges of some inkjet printers include the print head itself.
- **Print head stepper motor** - A [stepper motor](#) moves the print head assembly (print head and ink cartridges) back and forth across the paper. Some printers have another stepper motor to **park** the print head assembly when the printer is not in use. Parking means that the print head assembly is restricted from accidentally moving, like a [parking brake](#) on a car.



Stepper motors like this one control the movement of most parts of an inkjet printer.

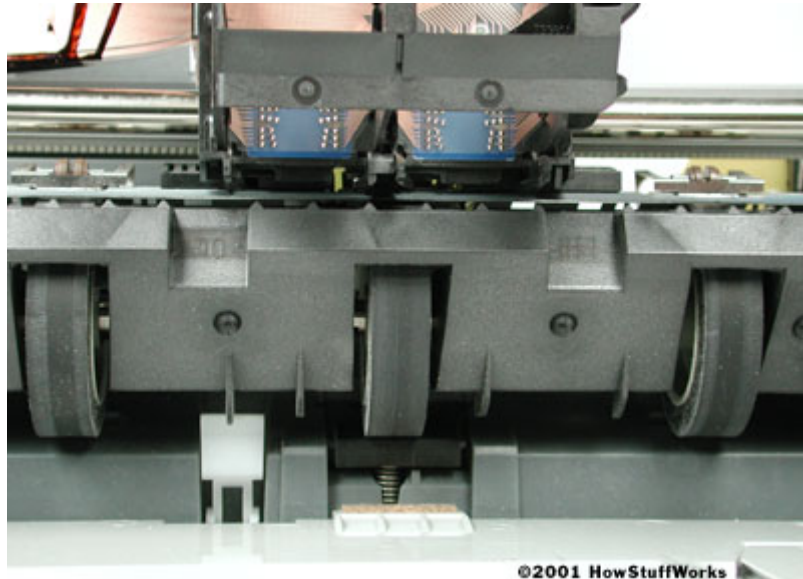
- **Belt** - A belt is used to attach the print head assembly to the stepper motor.
- **Stabilizer bar** - The print head assembly uses a stabilizer bar to ensure that movement is precise and controlled.



Here you can see the stabilizer bar and belt.

- **Paper feed assembly**

- **Paper tray/feeder** - Most inkjet printers have a tray that you load the paper into. Some printers dispense with the standard tray for a **feeder** instead. The feeder typically snaps open at an angle on the back of the printer, allowing you to place paper in it. Feeders generally do not hold as much paper as a traditional paper tray.
- **Rollers** - A set of rollers pull the paper in from the tray or feeder and advance the paper when the print head assembly is ready for another pass.



The rollers move the paper through the printer.

- **Paper feed stepper motor** - This stepper motor powers the rollers to move the paper in the exact increment needed to ensure a continuous image is printed.
- **Power supply** - While earlier printers often had an external [transformer](#), most printers sold today use a standard [power supply](#) that is incorporated into the printer itself.
- **Control circuitry** - A small but sophisticated amount of circuitry is built into the printer to control all the mechanical aspects of operation, as well as decode the information sent to the printer from the computer.





The mechanical operation of the printer is controlled by a small circuit board containing a microprocessor and memory.

- **Interface port(s)** - The [parallel port](#) is still used by many printers, but most newer printers use the [USB port](#). A few printers connect using a [serial port](#) or small computer system interface ([SCSI](#)) port.



While USB taking over, many printers still use a parallel port.

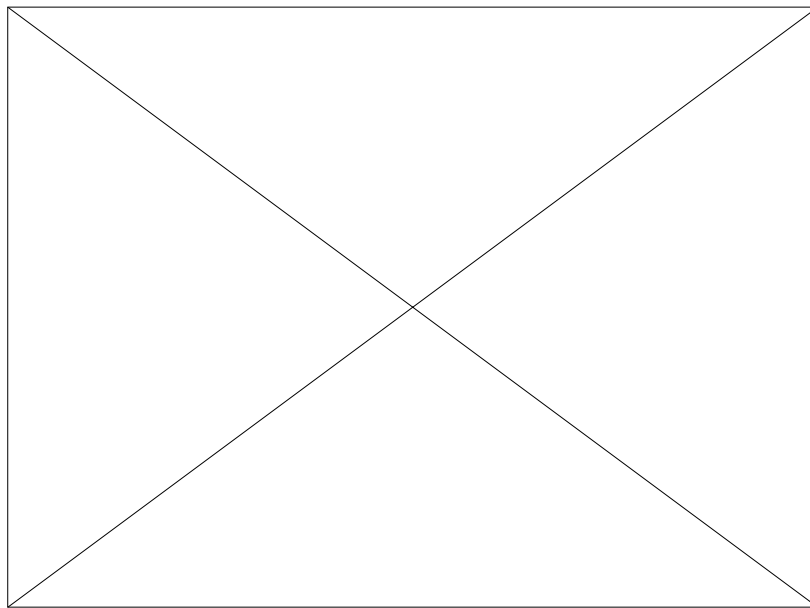
## Heat vs. Vibration

Different types of inkjet printers form their droplets of ink in different ways. There are two main inkjet technologies currently used by printer manufacturers:



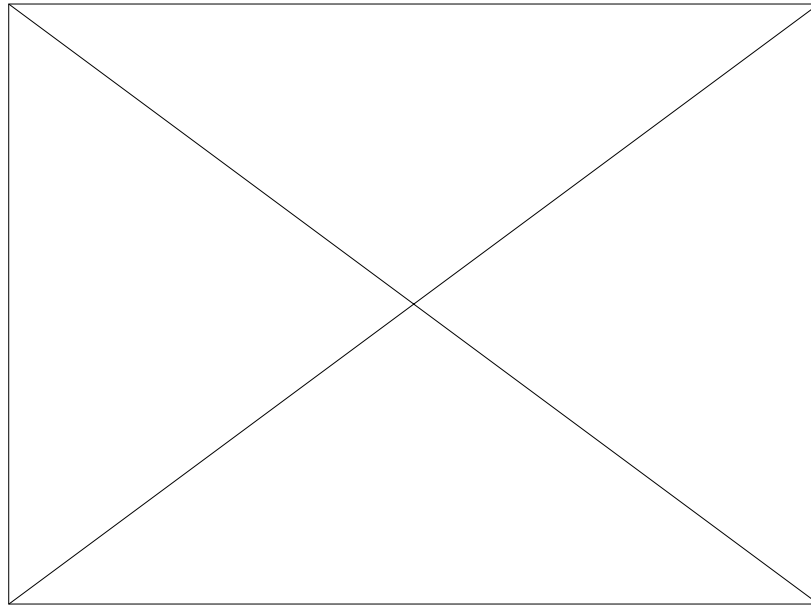
**View of the nozzles on a thermal bubble inkjet print head**

- **Thermal bubble** - Used by manufacturers such as [Canon](#) and [Hewlett Packard](#), this method is commonly referred to as **bubble jet**. In a thermal inkjet printer, tiny resistors create heat, and this heat vaporizes ink to create a bubble. As the bubble expands, some of the ink is pushed out of a nozzle onto the paper. When the bubble "pops" (collapses), a vacuum is created. This pulls more ink into the print head from the cartridge. A typical bubble jet print head has 300 or 600 tiny nozzles, and all of them can fire a droplet simultaneously.



**Click the button to see how a thermal bubble inkjet printer works.**

- **Piezoelectric** - [Patented by Epson](#), this technology uses **piezo crystals**. A crystal is located at the back of the ink reservoir of each nozzle. The crystal receives a tiny electric charge that causes it to vibrate. When the crystal vibrates inward, it forces a tiny amount of ink out of the nozzle. When it vibrates out, it pulls some more ink into the reservoir to replace the ink sprayed out.



**Click on the button to see how a piezoelectric inkjet printer works.**

Let's walk through the printing process to see just what happens.

## Click "OK" to Print

When you click on a button to print, there is a sequence of events that take place:

1. The software application you are using sends the data to be printed to the printer [driver](#).
2. The driver translates the data into a format that the printer can understand and checks to see that the printer is online and available to print.
3. The data is sent by the driver from the computer to the printer via the connection interface ([parallel](#), [USB](#), etc.).
4. The printer receives the data from the computer. It stores a certain amount of data in a [buffer](#). The buffer can range from 512 KB random access memory ([RAM](#)) to 16 MB RAM, depending on the model. Buffers are useful because they allow the computer to finish with the printing process quickly, instead of having to wait for the actual page to print. A large buffer can hold a complex document or several basic documents.
5. If the printer has been idle for a period of time, it will normally go through a short clean cycle to make sure that the print head(s) are clean. Once the clean cycle is complete, the printer is ready to begin printing.
6. The control circuitry activates the paper feed stepper motor. This engages the rollers, which feed a sheet of paper from the paper tray/feeder into the printer. A small trigger mechanism in the tray/feeder is depressed when there is paper in the tray or feeder. If the trigger is not depressed, the printer lights up the "Out of Paper" [LED](#) and sends an alert to the computer.
7. Once the paper is fed into the printer and positioned at the start of the page, the print head stepper motor uses the belt to move the print head assembly across the page. The motor pauses for the merest fraction of a second each time that the print head sprays dots of ink on the page and then moves a tiny bit before stopping again. This stepping happens so fast that it seems like a continuous motion.
8. Multiple dots are made at each stop. It sprays the CMYK colors in precise amounts to make any other color imaginable.
9. At the end of each complete pass, the paper feed stepper motor advances the paper a fraction of an inch. Depending on the inkjet model, the print head is reset to the beginning side of the page, or, in most cases, simply reverses direction and begins to move back across the page as it prints.
10. This process continues until the page is printed. The time it takes to print a page can vary widely from printer to printer. It will also vary based on the complexity of the page and



size of any images on the page. For example, a printer may be able to print 16 **pages per minute** (PPM) of black text but take a couple of minutes to print one, full-color, page-sized image.

11. Once the printing is complete, the print head is parked. The paper feed stepper motor spins the rollers to finish pushing the completed page into the output tray. Most printers today use inks that are very fast-drying, so that you can immediately pick up the sheet without smudging it.

In the next section, you will learn a little more about the ink cartridges and the paper used.

## Paper and Ink

Inkjet printers are fairly inexpensive. They cost less than a typical black-and-white laser printer, and much less than a color laser printer. In fact, quite a few of the manufacturers sell some of their printers at a loss. Quite often, you can find the printer on sale for less than you would pay for a set of the ink cartridges!

Why would they do this? Because they count on the supplies you purchase to provide their profit. This is very similar to the way the [video game](#) business works. The hardware is sold at or below cost. Once you buy a particular brand of hardware, then you must buy the other products that work with that hardware. In other words, you can't buy a printer from Manufacturer A and ink cartridges from Manufacturer B. They will not work together.



**This printer sells for less than \$100.**

Another way that they have reduced costs is by incorporating much of the actual print head into the manufacturers believe that the printer that is most likely time you replace the printer.



**A typical color ink cartridge:**  
This cartridge has cyan, magenta and yellow inks in separate reservoirs.

cartridge itself. The since the print head is the part of to wear out, replacing it every cartridge increases the life of the

The paper you use on an the quality of the image. doesn't provide as crisp and for an inkjet printer. There image quality:

- **Brightness**
- **Absorption**

inkjet printer greatly determines Standard copier paper works, but bright an image as paper made are two main factors that affect

The **brightness** of a paper is normally determined by how rough the surface of the paper is. A course or rough paper will scatter [light](#) in several directions, whereas a smooth paper will reflect more of the light back in the same direction. This makes the paper appear brighter, which in turn makes any image on the paper appear brighter. You can see this yourself by comparing a photo in a newspaper with a photo in a magazine. The smooth paper of the magazine page reflects light back to your eye much better than the rough texture of the newspaper. Any paper that is listed as being *bright* is generally a smoother-than-normal paper.

The other key factor in image quality is **absorption**. When the ink is sprayed onto the paper, it should stay in a tight, symmetrical dot. The ink should not be absorbed too much into the paper. If that happens, the dot will begin to **feather**. This means that it will spread out in an irregular fashion to cover a slightly larger area than the printer expects it to. The result is an page that looks somewhat fuzzy, particularly at the edges of objects and text.



**Imagine that the dot on the left is on coated paper and the dot on the right is on low-grade copier paper. Notice how irregular and larger the right dot is compared to the left one.**

As stated, feathering is caused by the paper absorbing the ink. To combat this, high-quality inkjet paper is **coated** with a waxy film that keeps the ink on the surface of the paper. Coated paper normally yields a dramatically better print than other paper. The low absorption of coated paper is key to the high resolution capabilities of many of today's inkjet printers. For example, a typical Epson inkjet printer can print at a resolution of up to 720x720 dpi on standard paper. With coated paper, the resolution increases to 1440x720 dpi. The reason is that the printer can actually shift the paper slightly and add a second row of dots for every normal row, knowing that the image will not feather and cause the dots to blur together.

Inkjet printers are capable of printing on a variety of media. Commercial inkjet printers sometimes spray directly on an item like the [label on a beer bottle](#). For consumer use, there are a number of specialty papers, ranging from adhesive-backed labels or stickers to business cards and brochures. You can even get iron-on transfers that allow you to create an image and put it on a T-shirt! One thing is for certain, inkjet printers definitely provide an easy and affordable way to unleash your creativity.

#### **Refilling Cartridges**

Because of the expense of inkjet cartridges, a huge business has grown around the idea of refilling them. For most people, refilling makes good sense, but there are a few things to be aware of:

- Make sure the refill kit is for your printer model. As you learned in the previous section, different printers use different technologies for putting the ink on the paper. If the wrong type of ink is used, it can degrade the output or possibly damage the printer. While some commercial inkjets use oil-based inks, virtually all desktop inkjets for home or office use have water-based ink. The exact ink composition varies greatly between manufacturers. For example, thermal bubble inkjets need ink that is stable at higher temperatures than piezoelectric printers.
- Most manufacturers require that you use only their approved ink. Refill kits normally will void your warranty.
- While you can refill cartridges, be very careful of the ones that have the print head built into the cartridge. You do not want to refill these more than two or three times, or the print head will begin to deteriorate and could damage your printer.

Check out [this site](#) for some good links and information about inkjet refills.

For more information on inkjet printers and related topics, check out the links on the next page.