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Apple Color Printer: How It Implements the CMYK Color System

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TOPIC ----------

Scanners and displays typically use an RGB (red, green, blue) color system. Most printers function in the CMYK (cyan, magenta, yellow, black) color system. This article describes how the Apple Color Printer uses the CMYK color system.

DISCUSSION ----------

CMYK Compared to RGB

Light-emitting color devices generally use RGB, which is known as an additive color system. Fully combining saturated red, blue, and green achieves the absolute white point of an RGB device. Reflective media (like paper) generally use CMYK, which is known as a subtractive color system.

Fully combining saturated cyan, magenta, and yellow creates black (absorbs or subtracts all light, and reflects nothing). Saturation refers to a pure hue or a perceived pure color. A pure hue is 100% saturated. Adding white to a hue decreases the percentage of saturation.

The Apple Color Printer uses the CMYK color system to attain millions of colors. Mixing various combinations of cyan, magenta, and yellow creates any color. Mixing fully saturated cyan, magenta, and yellow creates black. To attain blacker blacks and conserve the ink supplies of the color cartridges, the Apple Color Printer uses a black ink cartridge in any situation where it needs black.

The Print Head

The Apple Color Printer uses a four-part print head with a separate set of 64 nozzles for each primary color: cyan, magenta, yellow, and black. The

nozzles are placed 1/360th of an inch apart. The separate color heads are placed 0.5 inches apart on the print head. The optimum operating temperature for the ink jet heads is about 36° C (84° F). The printer activates the nozzle heater when it detects a temperature less than 36° C. This keeps the nozzles at the optimum operating temperature. Each color operates in a manner similar to the single print head of the StyleWriter.

Ink is heated within a nozzle until a bubble forms within the nozzle. The ink within the nozzle heats enough to cause the bubble to explode, ejecting ink from the nozzle at a speed of 12 meters/second. When the ink is ejected, a vacuum is created within the nozzle. The vacuum draws ink from the head subtank to refill the nozzle (the subtank is prefilled from the cartridge).

The head prints when the carriage moves from left to right, with colors output in the order black, cyan, magenta, yellow. It creates colors other than cyan, magenta, yellow, and black by mixing colors on the paper. The inks aren't physically mixed. Because the dots are so small (1/360 inch), placing a cyan and yellow dot next to each other gives the appearance of a green dot. Colors nearby affect the appearance of another color, even when the samples are large and obvious. When the sample size is 1/360 inch, the eye sees a different color.

Generating Colors from CMYK

If the three colors were physically mixed, the printer could theoretically create 16.7 million colors. Because color differences are what the human eye perceives, it attains substantially less than 16.7 million discernibly different colors. The eye can realistically perceive about 3 million color differences when the colors are placed next to each other. Keeping the color samples apart from each other drops the number of discernible colors to about 7000.

Because it's impossible to perfectly mix the three primary colors in 1/360-inch dots, patterns or halftoning produces the effect of mixed color.

Addressing Individual Nozzles

The four logical print heads (one for each color) are physically located on the same print head. Each print head's 64 nozzles are addressed in four groups of sixteen. Heat group 1 controls every fourth nozzle on all four heads, as does Heat group 2, and so on.

There's a delay when addressing each of the heads, due to their physical separation of 0.5 inch. This same delay is necessary when addressing individual nozzles between the color heads. If it needs a magenta dot just below a cyan dot, the cyan nozzle must fire one timing cycle before the magenta head fires, to account for the 0.5 inch the print head must travel between the two actions.

A serial signal arrives at the print head for each color (that is, a specific color value for cyan). It then converts the signal to a parallel signal that addresses each of the color's 64 nozzles (actually only those nozzles that need to be fired for a certain color). That parallel signal

is then matrixed with the head heat signal, causing the proper nozzles to heat and fire.

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