PowerBook 165c Display: Technical Details (2/93)

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TOPIC ----------

This article provides technical details about the new color display in the Macintosh PowerBook 165c.

DISCUSSION ----------

Overview

Apple has worked hard to provide the best quality color passive-matrix display in the industry. The PowerBook 165c uses a passive-matrix 256-color flat panel display (FPD) with good color saturation, high contrast, and a quick response time. Ghosting and shimmering, which are often found on passive-matrix displays, has been reduced on the PowerBook 165c screen.

To make the best passive-matrix display required a number of changes over the existing PowerBook displays. We now have two Cold Cathode Fluorescent Lamps (CCFL), to increase the brightness of the screen for the color display, mounted at the top and bottom of the screen. Because of the addition of color pigment and higher quality polarizers on the display glass, additional light is needed to create a bright, vivid display. This display will distinguish the PowerBook 165c from the passive-matrix competition in a side-by-side comparison. The displays used on other passive-matrix color systems support only 16 colors, but the PowerBook 165c can support 256 different colors on the screen.

Some other color displays suffer from washout: that is, uneven brightness and color across the screen. To reduce washout, the PowerBook 165c display uses a new type of liquid crystal material. The reflector and light pipe on the back of the screen have been optimized to provide even light distribution across the entire display. This means that colors will appear more vivid and true.

The sharper contrast or color quality and the increased viewing angle are improved over the competition, thanks to a new polarizer that increases the contrast ratio.

PowerBook Display and Dimming

When the backlight is off, the screen turns black. The additional filter and

color pigments used in the display don't allow enough light to enter the display for the user to see the image on the screen without the backlight. This is different from the grayscale displays on the PowerBook 160 and 180, which still allow the user to read the display with the backlight off. This is a problem because the machine will look like it is in sleep state and the user may accidentally turn the unit off or just close the lid and carry it away (draining the battery in the process).

Liquid Crystal Displays

Liquid crystal displays are nonemissive, in that they do not create their own light, but pass or block light. The display in the PowerBook 165c uses a backlight to send the image to the user. The display consists of a reflector, light pipe, rear polarizer, back glass, liquid crystal material, front glass, and front polarizer.

The liquid crystal material is a liquid with rod-shaped molecules inside. These modules can form a twisting helix (staircase) pattern that "bends" light entering the display. The two polarizers are shifted and will only allow light that is bent by the liquid crystal material to be seen by the user. When a current is applied, the rods straighten out and no longer bend the light.

Each pixel in a color display contains three subpixels: one for red, one for green, and one for blue. A red, green, and blue color pigment is applied to the glass at each subpixel of the display. These color pigments line up with the electrodes that run down the glass and the liquid crystal material inside the display. The display can twist each subpixel up to 64 times per cycle. This controls the amount of red, green, and blue that is seen by the user. The display controller twists the blue and green liquid crystals 64 times, and the red liquid crystal 0 times, to get the brightest red possible. To get a darker red, it starts to twist the red liquid crystal.

Passive Matrix

In a passive-matrix display, the top glass contains very fine thin wires, or electrodes, that are aligned vertically down the screen. The bottom glass contains wires that cross the display horizontally. When a current is passed from the top glass electrode to the bottom glass electrode, the liquid crystal rod stops twisting. Because the light is not bent, the polarizer stops the user from seeing the light passed from the back of the display. Because all the pixels in a given row or column use the same wire, you can have crosstalk on the display. If a large number of pixels in a row are on (as in a menu bar), the other pixels in that row may twist. This is seen as a slight line that passes across the screen. Crosstalk has been reduced on the PowerBook 165c display and should be less of a problem compared to the PowerBook 160 display.

Active Matrix

An active-matrix display has a transistor at each pixel to activate the liquid crystal material. The top or bottom layer of glass contains the transistors, and wires that provide individual control over each subpixel. This individual control over each pixel allows the display to provide higher contrast, larger viewing angle, faster response, and a brighter display. The problem with this

type of display is its production cost. The screen is like a 9-inch memory chip with 768,000 transistors. If any of the wires leading to the transistor are bad, or the transistor etched into the glass fails, the pixel does not work. This causes a large number of displays to be rejected because too many pixels do not work -- and this increases the cost of this type of display.

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