

Optimizing Your Computer Screen for Health and Happiness

MOST OF US USE COMPUTERS regularly these days, and many of us spend several hours a day sitting in front of the screen of a computer. An improperly adjusted screen can cause a lot of eye-strain, fatigue, and discomfort by the end of a typical working day. This essay describes ways in which you can optimize the settings of your computer screen to maximize your comfort during the time that you spend working on your computer.

Some Basic Concepts

The thing that sits on your desk and displays information from your computer is usually called a *monitor*. The flattened window on which the information appears at the front of the monitor is called the *screen* or *display*. However, these are not hard and fast rules, and these terms are often used somewhat interchangeably.

The monitor is connected to your computer by a *video cable*, and it also has a *power cord* that you plug into the wall. Inside your computer, there's a device called a *video adapter* that sends signals to your monitor to control what is displayed on the screen. The video adapter, in turn, is controlled by the computer itself. The video cable from the monitor is plugged into a socket in the video adapter, on the back of the computer.

Computer monitors look very much like television sets, and this is no coincidence, since they are used for similar purposes and employ similar technologies. However, the screen of a computer monitor is usually much sharper and clearer than the screen of a television set, which is one reason why monitors generally cost more than television sets. The additional clarity and sharpness of the monitor is needed in order to display information from a computer neatly enough to make it readable.

Monitor Types

There are two types of monitor in common use these days, called *cathode-ray tubes* and *flat panels*. These two types of monitor use very different technologies to display information on the monitor screen.

Cathode-Ray Tubes

A cathode-ray tube, or CRT, is essentially a big vacuum tube, and a CRT monitor is simply a box that contains such a tube.

A vacuum tube is a electronic device that resembles a clear glass light bulb with various metal wires and plates sealed inside. Vacuum tubes were invented a hundred years ago and used to be common in electronic equipment, but in the 1950s they were replaced for most applications by tiny transistors.

CRTs are among the last remaining vacuum tubes in common use. Unlike most vacuum tubes, a CRT is flattened at one end to form a screen that can be made to glow. The screen that you view when using the monitor is the flattened, glowing end of the CRT inside.

CRTs have survived long after the demise of other vacuum tubes because they do their jobs very well, and they are inexpensive. Furthermore, until recently they had no serious competition. A good CRT monitor provides a very vivid and sharp image, with excellent brightness, contrast, and clarity, and rich colors. For decades CRTs have been the standard for both computer monitors and television sets.

The advantages of a CRT monitor are low cost and good image quality. The disadvantages are the enormous weight and bulk of the monitor (because of the massive vacuum tube inside), their power consumption, and the heat they generate. Indeed, CRT monitors may be larger, heavier, and more

hungry for electricity than the computers to which they are attached. Worse yet, since they are essentially a kind of light bulb, the images they produce have a tendency to become blurry, dim, and distorted as the CRTs age.

Flat Panels

A flat panel is just what the name implies: a sort of monitor that is very thin and flat, with a large screen on the front. Flat-panel monitors don't contain any vacuum tubes. They consist of a simple, rectangular white light called a *backlight*, behind a perfectly flat glass screen that is covered with transparent grid of extremely tiny filters. The filters can block and/or tint the light from the backlight in very precise patterns to form images.

Flat panels have been around for decades, but until very recently they were too temperamental and expensive to use in any but the most specialized applications. Recent advances in flat-panel technology and manufacture have made flat panels serious competitors to the traditional CRT for use in computer monitors.

The advantages of flat panels are their light weight, small size, and low power consumption, along with their extremely sharp, clear images and their tendency to maintain image quality throughout their life cycles. The disadvantages of flat panels are their high cost, the occasional defects that occur in the screens (so-called *hot* or *dead pixels*), their somewhat more limited contrast and color saturation for all but the most expensive models, and their fixed "native" resolutions, which means that they can only display images sharply with one level of detail (CRTs can display images sharply at any level of detail, up to a fairly high limit).

The disadvantages of flat panels are diminishing, with the current downward trend in prices for flat-panel monitors and improvements in the technology. As a result, it's likely that flat-panel monitors will more or less completely replace CRT monitors over the next few years. Then again, industry "experts" have been predicting this for many years, and CRTs are still around.

Monitor Sizes

Monitors are manufactured with screens in a very wide variety of sizes, from the very tiny screens of

mobile telephones to the gigantic screens used at rock concerts and in football stadiums.

The size of a monitor screen is usually expressed as the distance between opposite corners of the screen, measured diagonally. Most screens have a 4:3 aspect ratio, meaning that they are one third wider than they are high. A screen that measures 16 inches wide by 12 inches high will measure 20 inches from corner to corner, and will thus be referred to as a 20-inch screen.

Desktop computers are usually equipped with monitors that have screens varying in size from 13 to 24 inches. The ideal size for a monitor screen depends on the distance from which it will be viewed, and on the resolution set for the monitor (which we will explain shortly). In general, the larger the screen, the more expensive the monitor. CRT monitors in large sizes can be extraordinarily heavy (well over 100 lbs or 50 kg) and bulky. Extremely small screens are almost always flat-panel screens, because it is difficult to manufacture CRTs in such small sizes.

Monitor Resolution

Resolution is the characteristic of a monitor that controls how much detail or information it can display on the screen. A given monitor will usually have a range of resolutions that it can display. CRT monitors can usually support any resolution up to a fixed maximum. Flat-panel monitors work similarly, except that they also have a "native" resolution for which the screen is designed, which provides a much clearer image than any other resolution setting.

In order to understand resolution, you have to understand the way a computer displays information on a monitor. Computers divide the screen of the monitor into a large rectangular array of extremely small dots, called *picture elements*, or *pixels* for short. The array of dots is called a *raster*. The number of rows and columns of pixels in the raster is referred to as its *resolution*. A typical computer monitor today may have a resolution of 1024 vertical columns of pixels arranged in 768 horizontal rows.

The pixels in the raster are so small and numerous that they tend to blend together when they are

viewed by a human being, such that human beings don't see the individual pixels but instead see patterns in the pixels. Ideally, the resolution of the monitor should be set so that the size of an individual pixel is just barely big enough to see. If the pixels are much larger than this, the screen will look like a mosaic of boxes or dots instead of a smooth collection of text and images; and if the pixels are much smaller than this, the detail they provide is wasted, since the tiniest details will be too small for human beings to see.

The computer to which the monitor is connected can control the brightness and color of each pixel on the screen individually, and it displays information on the screen by selectively setting these characteristics for groups of pixels in order to form patterns. For example, a computer can "draw" a vertical black line on the screen by setting all the pixels in a given column of the raster to black, while leaving the surrounding pixels white.

The resolution of the screen of a monitor is determined by the computer to which it is connected, but a given monitor usually cannot handle a resolution higher than a certain limit. The computer must be set to produce a resolution at or below this limit. In addition, if the screen of the monitor is a flat panel, there is usually a "native" resolution for which the screen is designed, and at which the image looks particularly sharp and clear. The resolution of flat-panel monitors should be set to this native resolution whenever possible. Finally, the video adapters of some computers have a maximum resolution that they cannot exceed, and the computer setting must be at or below this resolution, no matter what the monitor's limits might be.

At the time of this writing, the most common resolution for computer monitors is 1024x768 pixels, but many other resolutions are possible. Given that the best resolution is usually the one that makes individual pixels just barely large enough to see when a human user sits at a normal viewing distance from the screen, a resolution of 1024x768 works out just about right for a 15-inch screen viewed from a distance of two feet. If the screen size is larger, or if it is viewed from a closer distance, the resolution should be increased; and if it is smaller, or if it is viewed from further away, the

resolution should be decreased. Resolution should also be set lower if viewing conditions are poor, and it should be set somewhat higher for critical work with top-quality monitors, such as photo retouching.

Aspect Ratio

Every screen has an *aspect ratio*, which is the ratio of the screen's height to its width. A perfectly square screen would be just as high as it is wide, and would have an aspect ratio of 1:1. Most real-world monitor screens for computers, however, have an aspect ratio of 4:3; that is, if the screen is four inches wide, it is three inches high. This aspect ratio was inherited from traditional television sets. A few high-end and special-purpose monitors have other aspect ratios, but 4:3 is still the most common for most screen sizes.

It's important to set the resolution of a screen to match its aspect ratio. For example, with a screen that has the standard 4:3 aspect ratio, the number of pixels horizontally should be 1/3 greater than the number of pixels vertically. This ensures that pixels are square, which in turn ensures that shapes such as squares and circles do not appear distorted on the screen. If the resolution set for the screen does not match its aspect ratio, circles may look like ovals, and squares will not be perfectly square.

Virtually all of the standard resolution settings that computers offer in their video settings are designed for a standard 4:3 aspect ratio. The one exception is 1280x1024 pixels, which is present for historical reasons. If you set this resolution on a standard 4:3 monitor, it will generally work, but you may see some slight distortion of shapes on the screen. Despite this, some people prefer it.

Note that the native resolution of a flat-panel monitor always matches the aspect ratio of the monitor. In other words, a flat-panel monitor with a native resolution of 1024x768 will have physical dimensions that match an aspect ratio of 4:3, and a flat panel with a native resolution of 1280x1024 will have physical dimensions that match an aspect ratio of 5:4. As long as you set the monitor to the native resolution, there will never be any distortion on the screen.

Color Depth

In addition to resolution, monitors can also handle various *color depths*. Color depth is the maximum number of individual colors that can be displayed on the screen of a monitor at one time. Color depth was once a significant issue for computer monitors, but it is much less so today, thanks to advances in technology.

In the world of computers, there is no such thing as infinitely variable color. All the pixels on the screen of a monitor are set to one of a fixed number of colors. The total set of colors available at a given color depth is called the *palette* of that color depth. Color depth is sometimes also identified in bits, such as 8-bit color, 16-bit color, and so on. Technically speaking, the number of colors in the palette is equal to two raised to the power of the number of bits; thus, 16-bit color refers to a palette of 2^{16} colors, or 65,536, and 8-bit color refers to 2^8 colors, or 256.

The simplest color depth and palette is called *monochrome* (or sometimes *single-bit*) color. The palette contains just two colors, light and dark, and all pixels on the screen must be set to one of these two colors. A more common name for this is simply *black and white*, although the “white” is usually some shade of bright green or amber, depending on the monitor. Monochrome monitors were fairly common in the earliest days of desktop computing, but today they are practically unknown, since it is very difficult to use a computer today if the monitor cannot display things in color.

Today’s color monitors can generally accept any color given to them by the video adapter of the computer, and so the limiting factor (if any) is usually the video adapter. Even video adapters have advanced, however, such that most adapter/monitor combinations provide color depths of millions of colors—more than enough to display even full-color photographs. A typical desktop computer today will support at least 24-bit color (more than 16 million colors), and many will support 32-bit color (more than 4 *billion* colors).

Some inexpensive video adapters limit color depth as a function of the resolution setting. In other words, the higher the resolution, the lower the available color depth. A video adapter might sup-

port 32-bit color at a resolution of 1024x768, but only 8-bit color at a resolution of 1600x1200. Video adapters like this are becoming increasingly rare, as technological progress makes it possible to support even a very large number of colors at a very low price.

In general, thanks to continuing advances in monitor and video technology, color depth is no longer the important issue it once was. If you do choose to set color depth on your computer, keep in mind that 8-bit color (256 colors) is a minimum for most desktop computers today, and you’ll need at least 16-bit color (65,536 colors) to display photographs with any realism. Higher color depths are always preferable. If your computer is old or extremely inexpensive, there might be limitations on color depth at the highest resolutions, in which case you’ll have to find a compromise between resolution and color depth that you find acceptable.

Refresh Rates

Computer monitors do not actually display moving images, even though images on the screen may appear to move. Instead, they display a series of individual, stationary images in rapid succession (many images per second). Human vision tends to blend the images together to form a continuous image that seems to move. The rate at which individual images are displayed on the monitor is called the *refresh rate*.

Generally speaking, there’s a minimum refresh rate that you need in order to comfortably view a monitor, and anything above that is sufficient for just about any purpose. A refresh rate below 60 images per second may produce an impression of flickering for some individuals, especially when the monitor is seen out of the corner of the eye—but individual sensitivity to flicker varies a great deal, and a refresh rate that irritates one person may be more than sufficient for another.

Brightness affects the potential for flicker in a monitor: the brighter the image, the higher the refresh rate must be in order to avoid the impression of flickering.

Monitors have maximum refresh rates that depend on resolution settings. The higher the resolution setting, the lower the maximum refresh rate

that can be used. Video adapters also have maximum refresh rates for any given combination of color and resolution settings. The overall maximum refresh rate you can use is the lower of the monitor maximum or the video-adaptor maximum for the color depth and resolution you've chosen.

Since flicker is highly subjective, you should choose refresh rates that suit you personally. If the monitor seems to flicker unacceptably, increase the refresh rate (you may have to reduce the resolution or color depth in order to increase it, however). The impression of flicker is not unusual at refresh rates below 60 images per second, and quite a few people begin to notice it at 30 images per second. Beyond 80 images per second, almost no one sees any trace of flicker. Set the refresh rate to the lowest level that you find comfortable—setting extremely high rates just puts an unnecessary load on your video adapter, making it run hotter than necessary (high-performance video adapters can become quite hot).

Flat-panel monitors are far less prone to visible flickering no matter what refresh rate is used. On a flat-panel monitor, each image displayed remains on the screen for a small fraction of a second, until the next image comes along. On a CRT, the image is displayed only very briefly, and then the screen mostly goes dark until the next image arrives. Because of this, for any given refresh rate, a CRT is more likely to show perceptible flickering than a flat-panel. This is one more advantage of flat-panel monitors. However, it can also be a disadvantage for activities such as video games or watching movies, because the latency of the flat panel might produce a visible “smearing” of images that move very rapidly.

Frame Rates

Under normal conditions, a computer can update the contents of the screen faster than the monitor and video adapter can refresh it. In other words, the computer might be able to completely change the contents of the screen, say, 100 times per second, whereas the refresh rate might be only 60 images per second. This is fine: it simply means that the computer is fast enough to keep images moving at full speed.

However, in some cases, notably when a game is running on the computer or when something like video is being displayed, the computer may not be able to update the screen as quickly as the monitor refreshes it. The monitor might have the refresh rate set to 60 images per second, but the computer might only be able to update the screen completely at a rate of 10 images per second. In this case, the image will not flicker, but it will appear to move in stop-motion because the computer cannot update the screen quickly enough to maintain the illusion of smooth movement.

The speed at which the computer can update the screen is called the *frame rate*. When it is higher than the refresh rate, there's no problem. When it is lower than the refresh rate, it may produce jerky motion on the screen of the monitor, if there are objects moving on the screen. The frame rate produced by the computer is not settable; instead, it varies with the program that the computer is running. Complex programs that generate a lot of movement—particularly video games—require so much computer power that some computers may not be able to provide an acceptable frame rate, and the movement generated by such programs will not be smooth. If your computer cannot generate an acceptable frame rate for a given program, your only options are to stop using the program, upgrade to a faster computer, or simply put up with the jerky motion on the screen.

Frame rates are usually an issue only for the complex games and video programs mentioned above (and of these two categories, games are by far the more likely to have problems). For all other uses of the computer, the frame rates are likely to be so sky-high that they will never be the source of any difficulties.

Sometimes frame rates can be improved by lowering the resolution and/or color depth of the monitor. This diminishes the amount of work the computer must do for each frame and will raise the frame rate, which may or may not be enough of an improvement to solve the problem. However, it also makes the image on the screen less detailed.

A classic example of low frame rates can be seen when a computer with relatively little power is used to run something like an aircraft simulation

program. Normally, when the computer can maintain a high frame rate, movement in the aircraft simulation on the monitor screen is completely smooth and realistic. When the computer cannot maintain an adequate frame rate, though, the movement becomes very jerky, and starts to look more like a quick series of stationary slides than smooth motion—which can destroy the simulation experience.

Given all this, it's not surprising that the computer users who require the most powerful computers are those who regularly play games on them. On much more rare occasions, video playback or editing programs can have problems with frame rates on slower computers. For more routine office and home work (e-mail, text editing, surfing the Web, etc.), even modest computers can maintain extremely high frame rates, making this a non-issue for almost everyone but gamers and video producers.

Brightness and Contrast

Brightness is good in a monitor. A bright image is usually easier on the eyes than a dim image, since the typical surroundings of a computer—a well-lit office, a room lit by daylight, etc.—are likely to be bright as well. Most monitors are capable of producing very bright images when new; as they age, however, the image can dim considerably, especially with CRT monitors in their old age.

Contrast is also a good thing in monitors. The higher the maximum contrast of the monitor, the easier it is to see things on the screen, and the more life-like photographs will appear. Flat-panel monitors will often maintain fairly constant contrast throughout their lives; CRT monitors tend to lose contrast significantly as they age.

Most monitors have brightness and contrast controls directly on the monitor. These controls are completely independent of the computer and video adapter, and can be adjusted to taste.

To set brightness and contrast for good comfort, have the computer display an image containing areas of pure white and pure black. Set the brightness all the way up, then lower it until the black areas on the screen appear to be completely black (on CRT monitors, you can compare them to the

dark area of the screen surrounding the image—if this area matches the black parts of the displayed image, the brightness is set correctly). Once this is done, set the contrast all the way up, then lower it until the brightest areas of the image look comfortably white to you (not glaringly bright, and not dull gray). Often this corresponds to a setting just below the maximum contrast.

You should wait 30 minutes after turning the monitor on before adjusting contrast and brightness, in order to make sure that the monitor has fully warmed up. This is especially true with CRT monitors, which have to warm up in a literal sense.

As the monitor ages, you may have to periodically adjust the brightness and contrast, particularly the former. And here again, this particularly applies to CRT monitors.

You can extend the life of your monitor somewhat by keeping brightness and contrast below the maximums, within the limits of your visual comfort. This is especially true for flat panels.

Selecting a Color Scheme

Desktop computers allow you to select colors for various parts of the screen, such as window borders, title bars, the desktop itself (that is, the image that you see on the screen when you close all windows), and so on. Setting colors is purely a matter of taste, but a few considerations should be kept in mind when choosing personalized color schemes.

In most cases, black text on a bright background is easiest on the eyes, especially in office and home environments where you are required to look at documents printed on paper in black on white. People with certain types of vision impairments may find bright text on a black background to be more readable. However, most computers these days assume dark text on a light background and it may be difficult to set the opposite.

Very bright or clashing colors can produce eye-strain. Bright red and blue in close proximity can be particularly tiring. If you are doing critical photo or video retouching work, it may be best to set most of the colors on the screen to gray, so that bright colors do not cause you to misjudge the color balance in the photos or videos that you are retouching. Using a neutral gray for things like

window borders and the desktop also helps you to judge neutral gray in photos and graphics.

On many monitors, displayed items that are in white will appear smoother than items displayed in bright red, green, or blue (that is, you'll be less likely to notice individual pixels on the screen). However, items displayed in these latter colors may look somewhat sharper on the screen.

Adjustments Specific to CRTs

CRT monitors have some specific adjustments that you can make that don't exist for flat-panel displays.

A CRT monitor does not display pixels in fixed positions on the screen. The position of the raster containing the pixels can be adjusted in size, shape, and position. All of the adjustments are on the monitor itself. Many of them are properly adjusted at the factory (except for brightness and contrast, which you may wish to modify yourself), but they will probably require adjustment as the monitor ages. The more expensive the monitor, the greater the range of adjustments that you can make; very inexpensive monitors may offer nothing other than brightness and contrast controls.

The size of the image should be adjusted so that it leaves a thin black border between the image itself and the edges of the screen. The border should be of the same width on all sides of the screen. On older monitors, the image may become distorted as its size is increased; try to find a balance between the amount of distortion you're willing to tolerate and the size of the overall image.

The shape of the image should be adjusted so that it matches the aspect ratio used by the video adapter. In other words, if the computer is set to a resolution of 1024x768 pixels, that's four pixels horizontally for three vertically (a 4:3 ratio), and so the shape of the image should be adjusted so that it is exactly 1/3 wider than it is tall. This prevents items on the screen from looking distorted. If the shape is not properly adjusted, circles displayed on the screen may look like ovals, and squares may be of unequal dimensions. Some monitors have a specific control for image shape; others allow shape adjustment through the use of separate size controls for vertical and horizontal dimensions.

Inexpensive monitors may have no controls at all for this.

Some monitors allow the adjustment of *geometry*. Geometry adjustments allow you to make sure that the image is truly rectangular on the screen, with true right angles at the corners and sides that are not curved. If the edges of the image appear to be bent inward or outward, you can use the geometry adjustment(s) to make them reasonably straight.

Monitors may also have a *rotation* adjustment. The magnetic field of the Earth can cause the image on the monitor to rotate very slightly (yes, really!); adjusting the rotation of the image allows you to make sure that the image is straight up and down. This adjustment rarely has to be made, since the influence of the Earth's magnetic field is quite small. Very expensive, high-resolution CRT monitors may show this on close examination, however.

Sometimes there is a *convergence* adjustment on the monitor. This adjustment allows you to eliminate any small color fringes on items displayed on the screen. If you see tiny blue or red fringes around objects on the screen, especially in the corners of the screen, you may need to adjust the convergence. Inexpensive monitors may not have convergence adjustments, or it may be impossible to get the convergence perfect for every part of the screen. Expensive monitors may adjust their own convergence, and they are less likely to require convergence adjustment, anyway (ironically, they are more likely to include convergence controls, even though they are less likely to need them).

Degaussing means removing the effects of the Earth's magnetic field from the screen. Over time this magnetic field can magnetize parts of the screen and produce unpleasant color fringing or color shifts from one part of the screen to another. Most CRT monitors automatically degauss (demagnetize) the screen each time the power is applied (this is why CRT monitors often make a "thunk" sound when they are turned on). If you leave the monitor on 24 hours a day, it might be a good idea to turn it off and on again occasionally to let the monitor degauss itself. Some monitors have a special button or control that allows you to degauss them without turning them off and on.

A very few CRT monitors include *focus* controls, that let you control the sharpness of the image. If yours has such a control, you can adjust it periodically to ensure that the image is as sharp as possible on the screen.

When you examine the image on the screen while making adjustments, always look at both the center of the image and the corners and sides. In some cases, particularly with older monitors, you may not be able to adjust the center of the image to perfection without slightly degrading the periphery of the image, or *vice versa*. In these cases, you'll have to find a compromise that you can live with.

All of the various adjustments of CRT monitors tend to drift with time, and slowly deteriorate over the life of the CRT. Readjusting the monitor periodically can keep the image quality higher for a much longer time. When the image quality drops low enough that it remains unacceptable even after careful adjustment, it's time to replace the monitor.

Burn-In and Other Issues

If a fixed image is left on the screen of a CRT monitor for an extremely long period, it may "burn in," leaving a "ghost" image on the screen even after the image is changed. To prevent this, most desktop computers provide *screensavers* that place a continuously changing image on the screen after the computer has been left alone for some period of time. It's a good idea to set up a screensaver on your computer to protect the screen of your monitor if you must be away from the computer for a long period with the monitor left on. If you always turn the monitor off when you are not using the computer, you don't need a screensaver.

CRT monitors contain a big vacuum tube, as we've previously mentioned, and a vacuum tube is very similar to a light bulb. As time passes, the tube gradually wears out. To lengthen the life of a CRT monitor, it's a good idea to turn it off when you are not using the computer. Most computers also let you set a time limit for automatic shutdown of the monitor. How long you should set this limit is a matter of great debate. Some people prefer to turn the monitor off only when they've finished using the computer for the day; others prefer to turn the monitor off after only a few minutes of inactivity. The trade-off here is that the CRT gradually wears

out whenever it is on, but turning the monitor off and on also puts a lot of wear and tear on the tube and monitor each time it is done. Leaving the monitor on mainly puts wear on the tube; turning the monitor on and off puts wear on both the tube and the internal electronics of the monitor (but the strain lasts only briefly). The setting that works best for you depends on your work patterns with the computer.

CRT monitors generate considerable heat. It's important to never put anything on top of the monitor that might block the vents in the monitor case. These vents allow heat to escape, and if they are blocked, the monitor may overheat and fail.

Because CRTs deteriorate gradually, you may develop eyestrain from a deteriorating monitor before you realize that the monitor is getting old. It's a good idea to periodically take an objective look at the image on the screen and decide whether or not it has become too fuzzy, dim, distorted, or fringed with color for comfortable viewing. Examine the image with a magnifying glass if necessary. If the image is of poor quality and you cannot make it acceptable by adjusting the monitor, the monitor should be replaced.

CRTs generate a great deal of static electricity on the front of the screen (you can hear it crackle if you hold your hand near the screen). This static electricity attracts dust. You should periodically turn the monitor off and gently wipe away the dust with a soft, slightly damp, lintless cloth.

CRT monitors also contain extremely high voltages (20,000 volts or more) inside the case. Never open the case for any reason. Never allow moisture to enter the case. Touching the internal parts of a CRT monitor can produce a severe and potentially lethal electric shock. Allowing foreign materials such as water to enter the case may cause a fire and will almost certainly ruin the monitor.

Adjustments for Flat Panels

If you are using a flat-panel monitor, consider turning on the ClearType option in Windows; this option can make a huge difference in the appearance of text on a flat-panel display. (ClearType usually does not improve text on a CRT, and may even make it look worse.)

Flat-panel monitors are free of most of the adjustment problems of CRTs. Since the image raster is built right into the screen of the monitor, it remains perfect throughout the monitor's life, and no adjustment of size, geometry, shape, etc., is required (or possible). However, this same factory-determined resolution also means that flat panels have a *native resolution* for which they are designed, and the image on the screen will only look truly sharp when the native resolution is used.

For example, a 15-inch or 17-inch flat panel may have a native resolution of 1024x768 pixels. If you adjust your computer to produce an image of 1024x768 pixels, it will be razor sharp on the flat-panel screen. If you choose any other resolution, however, the image may be slightly distorted or fuzzy. This happens because flat panels have the raster installed at the factory, with a fixed number of rows and columns. If the video adapter connected to the monitor is set to the native resolution, the pixels it produces exactly match those installed on the screen at the factory, and all is well. If the video adapter is set to a different resolution, however, the monitor must try to adapt a "foreign" resolution to the resolution for which it was built, and the resulting compromise seriously diminishes image quality.

The better monitors will try to display non-native resolutions acceptably; often the image will be of normal size, but a bit blurry around the edges. Less expensive monitors may simply display a smaller image on the screen, so that a large black border surrounds it. If the video adapter is set to a resolution *higher* than the native resolution of the monitor, the monitor may refuse to work at all, or (in rare cases) it may be damaged.

Because of this limitation, it's important to choose a flat-panel monitor of the size and resolution you want at the time of purchase. You won't be able to change the native resolution thereafter, and if you run the monitor at anything other than the native resolution, image quality will be quite substandard.

Flat-panel monitors have far less of a problem with burn-in than do CRT monitors, but it can still happen occasionally, and so the use of a screen-saver is still a good idea.

Flat-panel monitors consume less power and generate less heat than CRT monitors, and they deteriorate more slowly. This means that you have more flexibility in deciding when to turn the flat-panel monitor on and off than you might with a CRT monitor. However, the same overall guidelines apply: whenever the monitor is on, the screen is (slowly) deteriorating, and whenever the monitor is turned off and then on again, some momentary stress is put on both the screen and the internal electronics of the monitor.

Dead and Hot Pixels

A *dead pixel* is a pixel on the screen of a monitor that is always dark, even when the computer attempts to set it to a different color. A *hot pixel* is a pixel that is always bright. A *stuck pixel* is a pixel that always has the same brightness and color, no matter what the computer attempts to set it to. One of the problems with flat-panel monitors is that there are often dead, hot, or stuck pixels on the monitor right out of the box.

Bad pixels result from defects in the manufacturing process. They are present when you buy the monitor (or appear shortly thereafter) and they cannot be repaired. Very few manufacturers guarantee that all pixels in a flat-panel monitor will work, and some stubbornly refuse to replace monitors with defective pixels. This is one of the major drawbacks to flat-panel monitors today. It will eventually be resolved as manufacturing techniques improve, but, at the time of this writing, it is still a major issue.

CRT monitors never have bad pixels, since the pixel raster is not fixed at the factory.

Monitor Placement

The screen of a monitor should be placed such that the upper edge of the image on the screen is just above eye level when you are seated in front of the monitor and looking straight ahead. In practice, this is often difficult with existing desks and chairs. If the monitor is on an adjustable stand, you may be able to raise it to the necessary level; if not, you might be able to place it on top of large books or sturdy boxes (be careful when doing this for CRT monitors, as they are extremely heavy). Placing the monitor at the correct height can help avoid neck

pain and other discomforts that result from constantly looking downward at a screen.

The viewing distance for the screen is a matter of personal preference, but a good starting point is a distance that is slightly greater than the diagonal of the screen. If the viewing distance is large compared to the size of the screen, lower resolutions should be used for the monitor so that details do not become too small to see. Conversely, if the viewing distance is small compared to the size of the screen, high resolutions can be used to put more information on the screen.

Subdued lighting (but not total darkness) in the area around the monitor is best, although here again, this isn't often possible in modern office environments. If bright lighting is unavoidable, the monitor should at least be positioned so that overhead or other nearby lights do not reflect off the surface of the screen and into your eyes. Areas bril-

liantly lit by daylight should be avoided, if possible. If there are windows behind the monitor, the brightness of daylight may make it difficult to see the image on the monitor; and if there are windows behind you, the reflected light from the windows on the monitor screen may have the same effect. A position that places the screen perpendicular to the windows may be best.

The image on a flat-panel display may look different depending on the angle from which it is viewed; it may look great when viewed straight on, but it may seem dark or oddly colored when viewed from the side. This is a function of the way the monitor is designed, and there is nothing you can do about it short of buying a different monitor. The most recent and expensive flat-panel monitors have this problem to a far lesser degree than older and cheaper flat panels. 