should be close to the dot or other marking for the standard position on the focus adjustment.

CARE OF THE LENS

hen possible, remove lenses from the camera when shipping, and pack them ted, foam-lined cases. Shocks, prolonged vibration, and extreme heat can n a lens element. Keep the lens mount clean. Both camera and lens mating must be free of dirt and dust to ensure proper seating of the lens, especially and wide-angle lenses. If necessary, clean the mount with a soft cloth.

hen a lens is not in use, cover the front element with a lens cap to protect it dust and fingerprints. Use a rear element cap when the lens is not on the cam- ome people like to keep a clear, daylight filter in place at all times to protect ont element (see Chapter 8).

ust on the Lens

ust on the lens lowers contrast. It may be blown off with a rubber syringe able at any pharmacy) or with small containers of compressed air (like Dust- Avoid compressed air that may have oil droplets in the spray. Tip the lens when blowing dust off. Some cinematographers use their breath to remove but take care not to blow saliva on the element, since it is harder to remove dust.

air doesn't remove all the dust, use a clean camelhair brush, reserved for the urpose of lens cleaning. Avoid touching the bristles, since oil from the hand ransfer to and remain on them. An alternate method is to fold photographic issue over itself several times, tear off an edge and lightly brush the element he torn edge. Do not rub a dry element with the lens tissue; you may damage ns coating.

ingerprints on the Lens

l and fingerprints are more difficult to remove and, if left on the lens, can etch selves into the coating; remove them as soon as possible. First, remove dust the lens as described above. Use photographic tissue—not eyeglass or sili- coated tissue, which may damage the coating. Never rub tissue on a dry lens. he on the lens to cause condensation. Rub the tissue as gently as possible, a circular motion combined with a rolling motion to lift any dirt off the ele- To avoid grinding grit into the coating, continually use a clean portion of the . Whenever the condensation evaporates, breathe on the lens again.

r particularly stubborn fingerprints, apply a drop of lens-cleaning solution to ssue (not directly to the lens). Take care that the solution does not come into ct with the area where the element meets the barrel, as it may loosen the ele- After moistening the element, use a dry tissue as described above (rubbing moistened lens).

CHAPTER 5

The Video Image

This chapter provides more technical information about video recording in production and postproduction. For the basics of video formats, cameras and editing, see Chapters 1, 2, 3, and 14.

FORMING THE VIDEO IMAGE

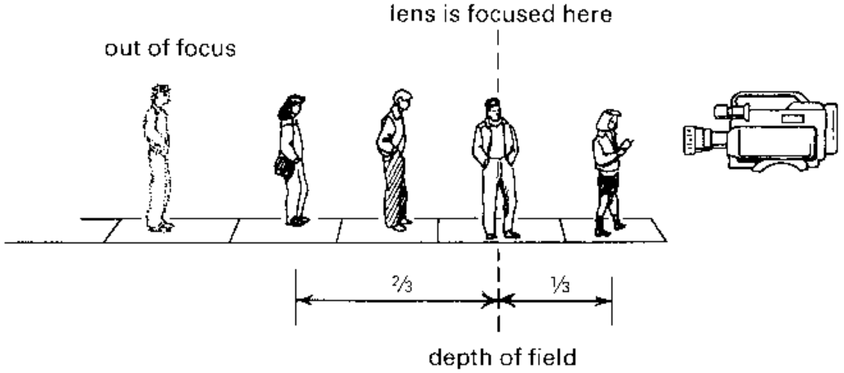
THE VIDEO CAMERA'S RESPONSE TO LIGHT

On p. 84 you'll find simplified instructions for setting the exposure of a video camera when shooting. Let's look more closely at how the camera responds to light so you'll have a better understanding of exposure and how to achieve the look you want from your images.

The camera's sensor can be thought of as a device for converting light into a electrical signal (see p. 4). Generally speaking, the more light that strikes the sensor, the higher the voltage of the signal. But to look more closely at the relationship between light and the resulting video signal, we can draw a simplified graph like the one in Fig. 5-1. The amount of light striking the sensor increases as we move from left to right.[1] Look at the line marked "A." Note that below a certain amount of light (the far left side of the graph), the system doesn't respond at all—this is the *black clip* level. Then, as the exposure increases, there is a corresponding increase in the signal. Above a certain amount of exposure, the system again stops responding. This is the *white clip* level. You can keep adding light, but the signal won't get any stronger.

This is somewhat like a characteristic curve for film (see Fig. 7-4). When the exposure for any part of the scene falls below the black clip level, that area in the image will be undifferentiated black shadows. Anything above the white clip will be bright and washed-out white. For objects in the scene to be rendered with some detail, they need to be exposed between the two.

1. By the "amount of light" we mean *exposure*, which is determined by the amount of light in the scene, the setting of the lens iris, filters being used, and the setting of the electronic shutter.



g. 4-12. Split focus. Depth of field extends about twice as far behind the plane at which e lens is focused as in front. (Robert Brun)

For a shot in which the camera and/or the actors' movements are planned ocked out), you should rehearse focus changes (*follow focus*). A camera assistant focus puller often changes (*pulls*) focus during the shot. Follow-focus devices ometimes remotely controlled) are available to make it easier to pull focus and reat moves precisely (see Fig. 4-13). Place tape or make chalk marks on the floor to e the actors or the focus puller. Put tape on the lens distance scale and mark setgs with a Sharpie for a homemade follow-focus device.

TAPE FOCUS. On some productions, and for some shots, an assistant meares distances with a 50-foot tape or electronic measuring device. The distance is easured from the film plane (marked on many cameras by an engraved Φ on the mera housing) to the chosen plane of critical focus. Measurements can also be ade to the near and far points that must be in focus; then, if there is adequate pth of field, calculate the split focus distance and set the focus accordingly. For de-angle lenses, tape focusing is often more accurate than eye focus. Cinematogphy Electronics makes the "cine tape measure" that gauges distance to the subt ultrasonically and gives a digital readout at the camera. Tape focus doesn't work your lens doesn't have distance markings, and the lens must be properly collinted for the focusing scale to be accurate (see Depth of Focus, p. 173).

FOCUS IN THE VIEWFINDER. In many shooting situations, focusing by e through the viewfinder is preferable to tape focus. With small crews or when action is uncontrolled, it may be impossible to use a tape. Eye focus is often ter and is usually more accurate with long focal length lenses or in other situans where depth of field is shallow.

Be sure the viewfinder's diopter is adjusted properly to your vision before focus- g either a video camera (see Chapter 3) or a film camera (see Chapter 6). To focus camera lens, rotate the focus ring or other focus control until the subject is ought into sharpest focus. If the camera is not running, "go through" focus once twice—that is, rotate the focus ring past the point where the image is sharpest, op and then rotate back to the point of sharpest focus.

Many camcorders allow you to increase the detail or peaking in the viewfinder,

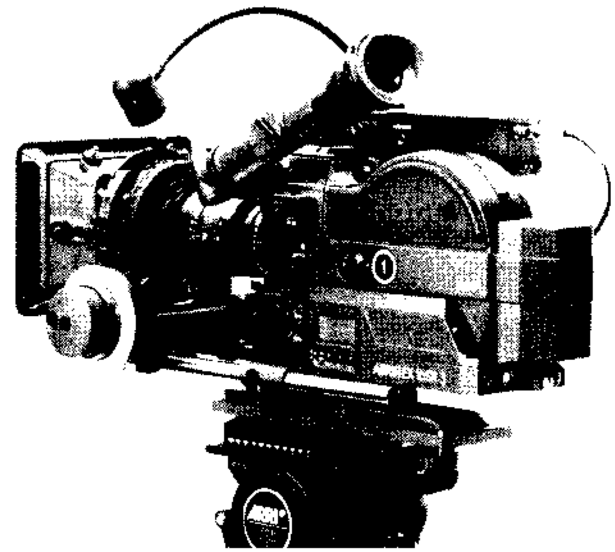


Fig. 4-13. Arriflex 16SR 3 equipped with follow focus knob, matte box, extended viewfinder for tripod or dolly work, and video assist. (Arriflex Corporation)

or to magnify portions of it, which can be a big help in seeing focus (see p. 112). You may also want to use the camera's autofocus to find focus (but don't leave it on auto; see p. 120).

With film cameras, focus with the lens iris at the widest aperture to keep the viewfinder bright, to minimize depth of field, and to see the image pop in and out of focus better. With video cameras, opening the iris beyond normal exposure will not help.

When focusing a zoom lens, remember that depth of field will be minimized at the longest focal length (zoomed in). To focus the lens, zoom all the way in, set focus, then zoom out to whatever focal length you like. If you focus instead at a wider focal length (where depth of field is greater), the subject will usually go out of focus when you zoom in. (Sometimes when the subject is very close to the camera, this method doesn't work because when you zoom in, the depth of field can no longer accommodate the subject.)

If, while shooting, the image is sharp at wide angle but goes out of focus when zoomed in, it probably means you didn't focus at long focal length as you should have. If the image becomes seriously out of focus when zooming out from long focal length to wide angle, it may mean the lens is not properly seated (see The Lens Mount, p. 171).

When pulling focus during a shot, you obviously shouldn't open the iris or do too much "going through" focus as described above. If an unrehearsed focus pull must be done while the camera is rolling, documentary filmmakers often zoom in quickly, refocus and zoom back to the selected focal length. This "focusing zoom" is generally edited out.

With some video cameras and digitally controlled zooms, you can preprogram zoom and focus and exposure settings and have the camera automatically transition m one to the other for very fluid moves, including very slow moves that are hard do manually.

Whenever you're shooting, always have a general idea of how much depth of ld you're working with. For example, if you're using a wide-angle lens stopped wn to a high *f*-number, you know you have a lot of depth of field, so focusing is s critical. Using the hyperfocal distance (see below) can help you estimate when ocusing is necessary.

Because of the increased sharpness of HD compared to SD, focus is particularly tical when shooting HD. When shooting with video cameras, focus and depth of ld can be judged in the viewfinder or monitor (and a large, sharp monitor can lp a lot). When using film cameras, some viewfinders provide a better sense of cus and depth of field than others (see Chapter 6). Ground-glass or fiber-optics lex viewfinders give a rough idea of the depth of field; aerial image finders give nost none. In general, any small film or video viewfinder image tends to exagger- depth of field. If something looks out of focus in the viewfinder, it will be out of cus when recorded on film or video. But a sharp viewfinder image is not a guaran- that the picture will look sharp on screen.

Depth of Field Charts

Depth of field charts (see Appendix C) and calculators give an estimate of the pth of field. For a given focal length lens, you cross-reference the distance the ns is focused at, the lens aperture (*f*-stop) and the circle of confusion to find e near and far extent of depth of field.

Charts and calculators are designed for a "generic" reading of depth of field, but particulars of your lens, the film or video format, or individual shots can result actual depth of field that is as much as 15 to 20 percent different. Depth of field lculations are properly made from the front nodal point of the lens, which varies th lens design. Typical charts and calculators don't take into account individual ns variations, possibly throwing off readings at close focusing distances (the lens anufacturer's charts, however, should compensate for this). Some lenses have ugh depth of field guides engraved opposite the *f*-stop ring. Use only *f*-stops, and t T-stops, in depth of field calculations.

To provide a reference point for sharpness, a permissible *maximum* circle of nfusion is chosen for different formats (sometimes called the *circle of least confu- n*). To use a depth of field chart, you need to choose what circle of confusion you nt to work with; see Appendix C. For example. in 16mm a permissible circle of nfusion of 1/1000-inch or 1/2000-inch is often used.

As noted above, don't think of depth of field—or DOF charts—as an absolute. here are always variables like the recording format (in a high resolution film or leo format, depth of field is reduced, since the eye has a sharp reference point at makes areas that are out of focus more obviously soft) and the distribution for- at (theatrical projection calls for a smaller circle of confusion than small-screen V broadcast).

The Hyperfocal Distance

For any lens at a particular focal length and *f*-stop, the closest distance setting ch that the far limit of depth of field extends to infinity is called the *hyperfocal*

distance (see Appendix D). When the lens is set at the hyperfocal distance, depth of field extends from half that distance to infinity (infinity may be written ∞ on lenses and charts). For example, a 25mm lens at *f*/8 has a hyperfocal distance of 10 feet (based on a 1/1000-inch circle of confusion). When the lens is focused at 10 feet, the depth of field extends from 5 feet to infinity. The hyperfocal distance is also the near limit of depth of field when the lens is focused at infinity.

The hyperfocal distance setting is quite handy when focusing is difficult. If you set the lens at the hyperfocal distance, you don't need to worry about focus unless the subject comes closer than one half the hyperfocal distance. Of course, the remarks about depth of field not being an absolute apply here as well, and to use the hyperfocal distance chart you must choose an appropriate circle of confusion for your work.

Some very wide-angle lenses (and some very cheap lenses) have no provisions for focusing. These lenses are usually prefocused at the hyperfocal distance of the widest aperture. Consult the manufacturer's data sheet to find the closest focusing distances at the various *f*-stops.

CHOOSING A ZOOM LENS

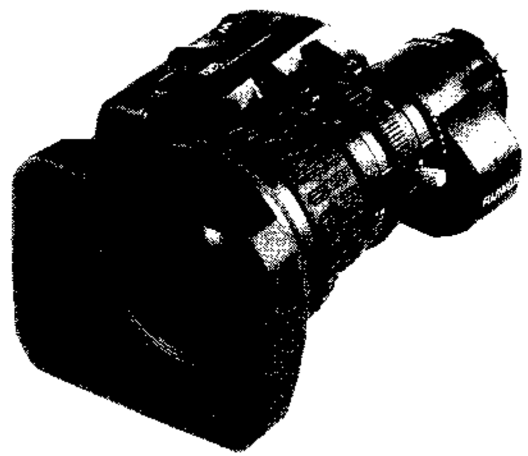
The *zoom lens* offers various focal lengths in one lens. Focal length may be changed during a shot (*zooming*) or between shots. Zoom lenses are larger, heavier, more delicate and more prone to flare and distortion than fixed focal length (prime) lenses. Zoom designs have improved to the point that some high-quality zoom lenses are as sharp as primes. This section is about choices in zoom lenses. For techniques of shooting with zooms, see p. 355.

The zoom is sometimes the only lens used on a production, so the choice of which one you use is important. With video cameras that have permanently mounted lenses, you may choose the camera in part for its lens. When selecting a lens (or camera/lens combination) there are various criteria to take into account.

Zoom Range

Zoom lenses vary in their range of focal lengths. Zooms are designated by their zoom range (for example 10–100mm) or the widest focal length times a magnification factor (for example, 10 x 9.5 is the same as 9.5 95mm). Because the angle of view afforded by any particular focal length lens depends on the film or video format you're shooting, you need to know what gauge film or what size video sensor your camera has in order to evaluate what the range of focal lengths really means visually (see Focal Length and Format, p. 148). Sometimes consumer video lenses indicate only a magnification factor (10X) and you can't easily tell exactly what the range is.

Having a good wide-angle lens can make a big difference in many shooting situations, particularly in documentary work or whenever you're shooting in close quarters or want to capture wide vistas or deep focus shots. To take the example of a 16mm film camera (or a video camera with a 2/3-inch chip), having a lens that goes to less than 9mm opens up a whole range of possible shots (and ways that the



4-14. Fujinon video-style lens with attached zoom motor. Standard definition 20 x 6.4 which means a generous zoom range from 6.4 to 128mm or (with built-in 2x range ex- er) from 12.8 to 256mm. (Fujinon, Inc.)

era can interact with the film subjects) that can't be done if your lens reaches only)mm or 12mm. Shooting people in cars or around a dinner table often requires a y wide lens (even 5.5mm or 6mm can be helpful). A difference of a couple of mil- ters at long focal lengths is trivial, but at short focal lengths is very noticeable (a nm lens is about 25 percent wider than a 12mm). Many consumer and prosumer o cameras are really deficient in the short focal lengths and need to be used with a -angle adaptor (see below).

.ong focal lengths allow you pture small details in the land- e or create shots with highly pressed perspective. Shooting ng focal lengths requires that camera be very steady on a od (see Telephoto Lenses, p. . Having both long and short l lengths in one lens gives you nendous flexibility and allows xtreme zoom shots that range n a tight closeup to a distant, view in one shot. Some video eras have a *digital zoom* feature magnifies the image beyond range of what the lens does cally. This is like enlarging the is using a digital video effect. wers the resolution and should erally be avoided.

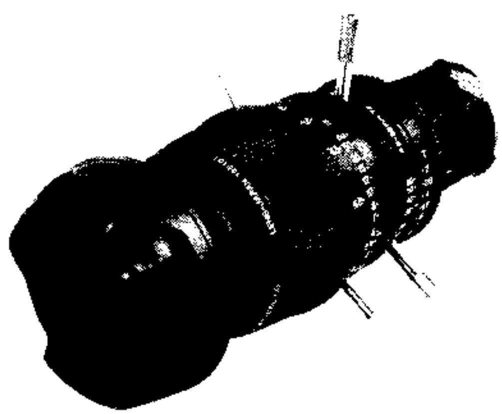


Fig. 4-15. Fujinon cine-style digital cinema lens. Wide-angle zoom, 13 x 4.5, which means a wider angle but more limited 4.5–59mm range compared to the lens in Fig. 4-14. Cine lenses typically have larger gear teeth for items like zoom motors and follow focus attachments, and better markings for zoom and focus. (Fujinon, Inc.)

CHANGING THE ZOOM RANGE. Some zoom lenses can be fitted with a wide-angle attachment to convert to a zoom range of shorter focal lengths. A .8X wide-angle converter could be used with a 12–120mm lens to make it 9.6-96mm. As a rule, these attachments don't affect aperture or focus settings and may not significantly impair the image (converters that require you to refocus when you zoom are lighter and more compact but are much less useful).

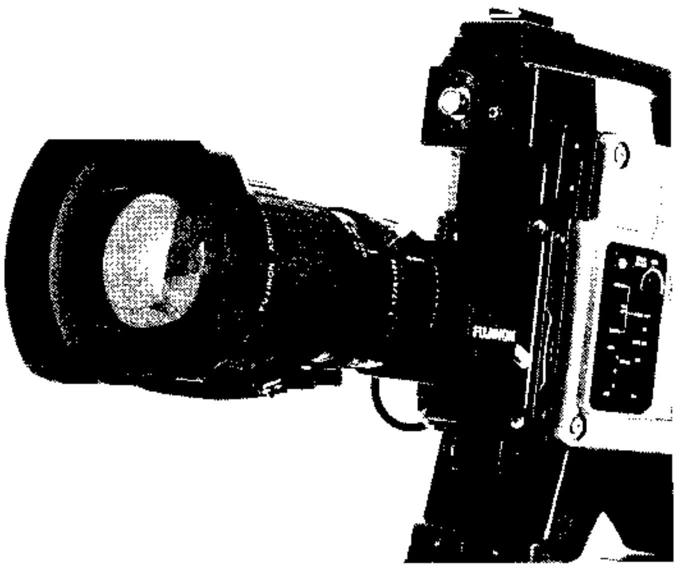


Fig. 4-16. Century Double Aspheric .6X wide-angle adaptor mounts on the front of lens. With this adaptor, you can't zoom during shots, but there are other Century adaptors that permit full zooming. (Fletcher Chicago/Schneider Optics)

Rear-mounted lens attachments, such as *range extenders*, change the relative aperture and reduce the speed of the lens. For example, a 2X range extender converts a 12–120mm zoom range to a 24–240mm and changes an *f*/2.2 aperture to an *f*/4.4. Aberrations are also magnified and may make the image unacceptable. Stopping down does minimize most of the aberrations, but stopping down to *f*/8 is the equivalent of *f*/16 when using a 2X extender.

Many video lenses have a built-in 1.5X or 2X range extender that can be set by switching a lever. Doing so provides longer focal lengths, but sacrifices some image quality and lens speed. Front-mounted range extenders don't change relative aperture, but sometimes they vignette at the shorter focal lengths. Range extenders are also used with prime lenses.

g. 4-8. Depth of field. The lens is focused on the man in both photographs. (left) The pth of field is not adequate to make the foreground and background appear sharp. (right) he lens has been stopped down, and the entire picture now appears sharp. (Ted Spagna)

Depth of field is not an absolute. There is no clear demarcation between parts the image that are sharp and those that are blurry and out of focus. Instead, there a gradual transition between the two. Even the idea of "acceptable sharpness" is lative. It depends on many factors, including the film or video format, the type of m, lens filters, and lighting. For more on how depth of field varies with different m and video formats, see p. 148.

What "In Focus" Means

To understand depth of field, it helps to understand what being "in focus" or ut of focus" actually means. A point in the subject or scene is considered in *critical us* when it registers as a point on film or video (see Fig. 4-9). All of the points in e subject that are in critical focus make up the *plane of critical focus* (also called the *ne of primary focus*). Any point that is nearer or farther from the camera than this ane registers as a circle instead of a point in the image. This circle is the *circle of fusion*.

When circles are sufficiently small or far enough away, they appear to the eye as ints (you can check this by making a circle on a piece of paper and viewing it om a distance). The depth of field is determined by the region on either side of e plane of critical focus where points in the subject are circles so small that they pear to the viewer as points (and thus appear to be in sharp focus).

We use depth of field to define what parts of the subject are acceptably sharp, but noted above, "acceptable sharpness" depends on many things. In part, the eye perives sharpness in a relative way. For example, if you shoot with a low-resolution rmat (or use a diffusion filter to soften the image), the apparent depth of field is eater since *nothing* is particularly sharp. High definition video formats tend to ve less depth of field than standard definition formats because they are capable of oducing a very sharp image.

One of the key considerations in focusing and depth of field is how much the age is magnified (points start to look like circles when you enlarge them.) Someng that looks sharp on a small TV screen may look out of focus when the same age is projected on a large theater screen. Depth of field will seem smaller on the screen.

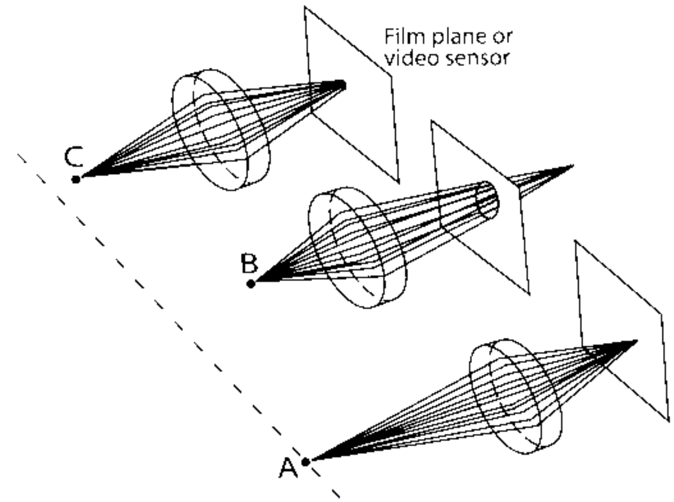


Fig. 4-9. Depth of field. All three lenses are focused at the dashed line. (right) Point A is on the line and the rays of light converge to a point at the film plane. This is in sharp focus. (middle) Point B is closer to the lens so the rays of light form a circle (*circle of confusion*) where they hit the film. This is out of focus. (left) The rays of light from point C also form a circle, but it's small enough to appear as a point to the eye. This seems in focus to the viewer and thus C is within the depth of field. The same principle applies for a video camera; substitute the sensor for the film in the description above.

Fig. 4-10. Out of focus and in focus. Point sources of light appear as circles when they're out of focus.

In general, the more you magnify an image, the softer (less sharp) it looks (see Fig. 1-9).

Controlling Depth of Field

There are two ways to control depth of field: change the size an object appears in the image (*image reproduction ratio*) or change the *f*-stop.[4] The larger an object is

4. With some consumer or prosumer camcorders there aren't *f*-stop markings on the iris, but adjusting the iris still means changing the *f*-stop.

d are called *one-piece* units. Some camcorders are *dockable*, which means the and recorder can be separated if necessary (handy if one part breaks down). o settings, instead of camcorders, several cameras can be used with one or parate VTRs. Regardless of the physical package the camera and recording ism are in, all camera/recorders share certain elements:

The lens. Forms an image of the scene on the camera's sensor(s). Most lenses have controls for the focus of the image, the brightness of the image (using the *iris diaphragm*), and the magnification of the image (using the zoom to change focal length). On some cameras the lens is built into the camera; on others it is detachable and different lenses can be used.

The sensor. Light-sensitive electronic chip that converts the light coming through the lens into electric charges. Either a CCD (charge coupled device) or CMOS (complementary metal oxide semiconductor) type of imager. A CCD outputs analog signal voltages, a CMOS usually outputs signals already converted to digital bits. See Fig. 2-14.

DSP. Digital Signal Processors convert the signal from the sensor to digital form if it isn't digital already. Other tasks: adjust color and tonal reproduction; set frame rate and the length of exposure (using the *shutter*); adjust the sensitivity of the sensor (using the *gain* control); manage and store a range of complex parameters.

The viewfinder. A small monitor (TV screen) that allows you to see what you're shooting or playing back. Some cameras have both a viewfinder and a separate fold-out video screen.

The recording system. Stores the video signal on tape, hard drive, or other media.

Audio recording. Most camcorders have built-in or attached microphones and provisions to plug in external mics. The recording level (volume) of the sound must be adjusted before shooting (see Chapters 10 and 11).

The power supply. Cameras can be run on rechargeable batteries or by plugging into an AC power supply.

Timecode. Critical for many aspects of postproduction (see p. 203). Most modern cameras have timecode capability.

ny consumer camcorders are designed for the "point and shoot" user and are automated. Some won't even let you adjust key settings. Since control of exposure, and color is part of the creative process of shooting, it's often not antage to have these things set automatically. Professional camcorders are lly not so automatic or at least provide manual overrides. If you hope to capigh-quality images and sound, it's important to know which automatic setan be trusted, and when you need to make adjustments manually.

PICTURE CONTROLS

Viewfinders and Monitors

To look at the video image, we use a *monitor*.[1] The viewfinder is a small monitor mounted on the camera that allows you to see the image you're shooting. Professionals often work with a larger, separate monitor as well, which permits others to watch too. For years, camcorders were equipped with black-and-white CRT viewfinders (see p. 198); these used to be the sharpest but newer color LCD (liquid crystal display) viewfinders can be very sharp. Many camcorders have both eyepiece-style viewfinders and fold-out LCD screens (see Fig. 3-1). Fold-out screens have advantages and disadvantages. They allow you to hold the camera away from your face and in positions that would be difficult with a standard viewfinder. They also make viewing playback easier, especially when more than one person want to watch. But they can drain the battery faster and may be hard to see in bright daylight. They are also a poor tool to use to judge focus or exposure. Newer fold-out LCDs may also have touch-sensitive camera controls instead of mechanical buttons and switches on the camera body.

Viewfinders and other types of monitors are essential for checking how the shot is framed and if the focus, exposure, and color are correct. However, it takes experience to learn when you can trust the picture and when you should take what you're seeing in the viewfinder with a grain of salt. Some examples:

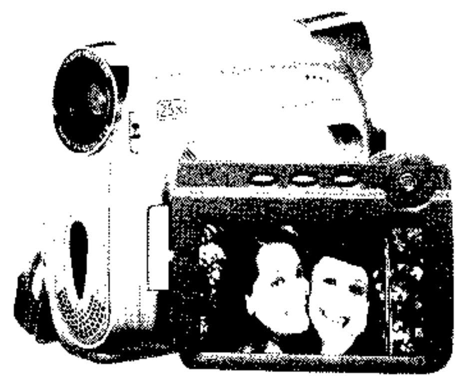


Fig. 3-2. Consumer DV camcorder showing LCD. (Canon U.S.A., Inc.)

- When you're shooting, viewfinders and monitors show you the video as it comes out of the camera, but they don't tell you what is actually being recorded. So if there are problems with the tape or recording device, you'll find out only when you stop recording and watch playback.
- The edges of the frame that you see in the viewfinder or monitor may be different than what the audience will see. See p. 331 for discussion of TV cutoff and p. 87 for aspect ratio.
- Exposure, color, and contrast may look quite different in the viewfinder than what is actually being recorded.

1. What's the difference between a monitor and a TV? A TV usually has a built-in *tuner* that allows you to receive broadcast television channels over the air or through a cable. Monitors allow you to input video directly from a camera or deck and usually have no tuner. These days, most TVs also have direct video inputs. For more on different types of monitors, see p. 197.