

# 1

## Film and Video: History and Technical Aspects



## 2 Digital Filmmaking for Beginners

**T**he technology behind modern video dates back to when film was the only viable method of capturing and presenting the moving image. Many people today refer to video as a film while, in fact, there is a vast difference between actual photographic motion picture film and the modern video. Suffice it to say that the older terminology has been adopted to suit our modern methods. But I believe it's important to know the actual differences between these two very different methods of presenting motion images.

### Film vs. Video: The Differences

Video production technology is part of a history that harkens back to long before the introduction of full-color digital video with dazzling high-fidelity surround sound and spectacular visual effects. It goes back further than motion picture film, and even back further than photography itself. So, let me quickly bring you up to date.

#### The Birth of Photography

If we go back several hundred years, we could say that the art form has its roots in the live performances of puppet shows performed behind a backlit screen where stories were told in black-and-white shadow images to the audience viewing the front of the screen. This form of theater is still practiced in some countries, such as Indonesia, as a cultural art form and has been used for centuries to pass down religious teachings as well as for entertainment.

To liken these “shadow shows” to today’s motion pictures may seem a bit of a stretch, but once you understand the basic theory behind motion pictures as they are projected on a theater screen, you will realize just how alike they really are.

Joseph Neipce (Figure 1-1) is credited with creating the first permanent photographic image in 1824. Neipce, a chemist and inventor, had been experimenting with silver as a light-sensitive compound for capturing an image, but turned eventually to bitumen for his early experiments.

In 1829 he partnered with Louis Daguerre (Figure 1-2) to develop improved photographic processes. When Neipce died in 1833, Daguerre continued to improve the process and eventually introduced the “daguerreotype,” a photograph captured on a metal plate

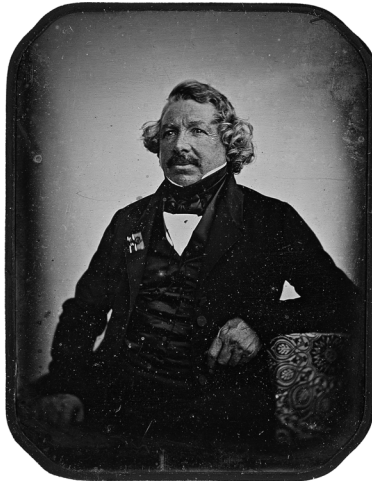
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**FIGURE 1-1** Joseph Neipce

coated with a silver halide compound. Silver has been the main component of photographic chemistry ever since.

Photography flourished from this point, and many improvements were made over the next 175 years, including the introduction of paper prints from a plastic negative—and the inventive contrivance of motion picture technology.

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**FIGURE 1-2** Louis Daguerre

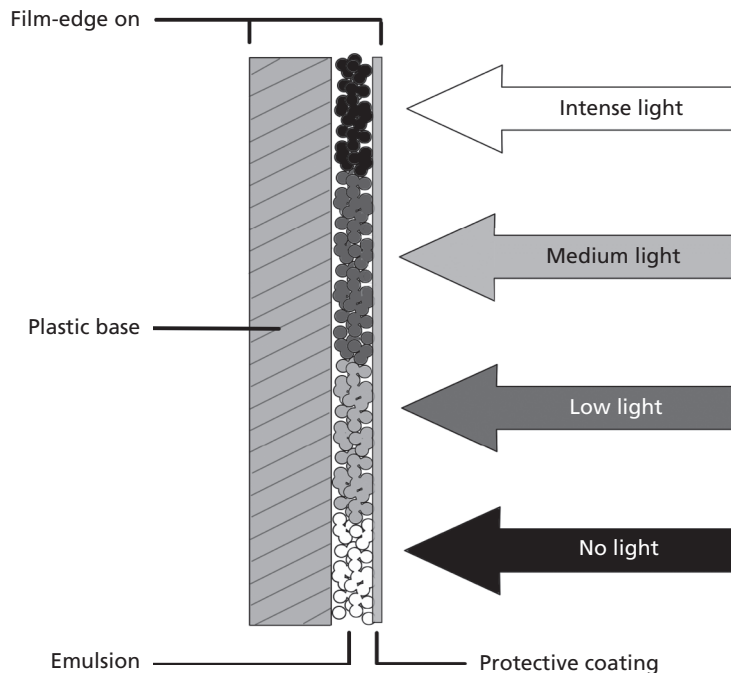
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### How Photography Works

Traditional photography, unlike digital photography, is a chemistry-based medium. Both Neipce and Daguerre realized the potential of silver as a light-sensitive element that could be used to re-create a live scene. By the time plastic negatives were invented, the process was refined to the point it is at today. Here is the recipe:

1. Take a very fine powder of silver salts and suspend it in gelatin to keep it from falling off the plastic base. This is called photographic emulsion.
2. Expose the emulsion to light, focused through a lens, reflecting from a subject (see Figure 1-3). The more light exposure there is, the more the silver salts react by tarnishing.
3. Then, in a darkened room, subject the negative to various chemical baths to wash away the silver emulsion that is unexposed (the dark parts of the scene

**FIGURE 1-3** The more light, the more the silver salts react by tarnishing



from which no light reflected into the lens). Don't forget to save the silver that disengages from the plastic. It is silver, after all, and is valuable.

4. Fix the remaining exposed silver permanently to the plastic base with another chemical bath.
5. Next, as we have only a negative image, shine a light through this plastic negative, through a focusing lens, and onto a piece of light-sensitive paper or another piece of plastic film coated with silver salts emulsion. Where there is a dense buildup of emulsion (the dark or opaque part), the light will not be able to pass through. Where the plastic is void of silver (the clear part), the light can shine through to expose the paper or film. When chemically processed, this "print" will be a positive representation of your scene.

While still images are usually printed on paper, some are printed onto new film to create a positive image in the form of a slide.

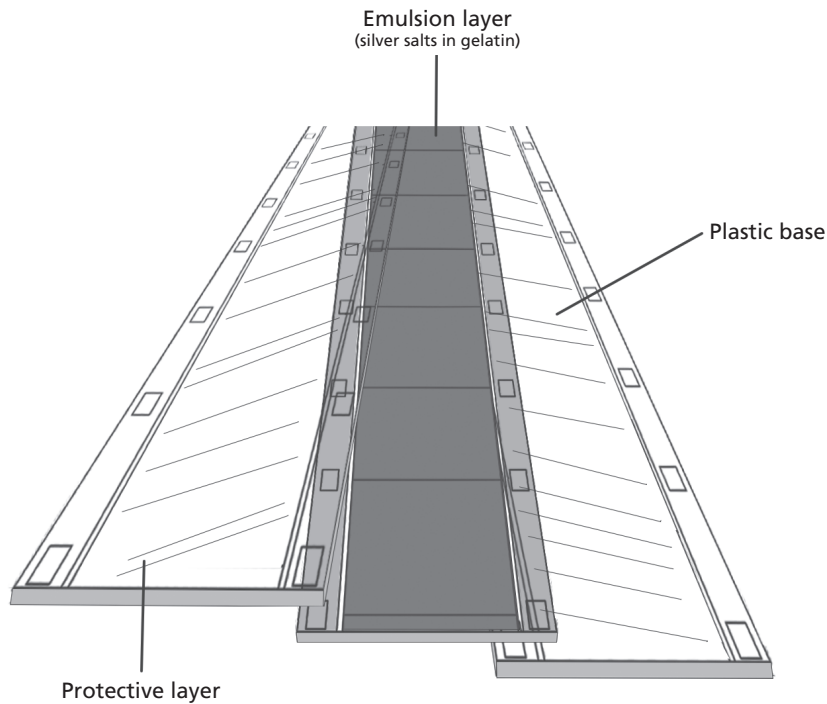
Motion pictures are printed to a new strip of emulsion-treated, celluloid plastic film. This film is perceived as a long strip of celluloid with many small images on it—each image slightly advanced in motion from the one preceding it. And indeed it is, in its finished form. But, the raw, unexposed film is really just a long strip of plastic with a silver emulsion applied (see Figure 1-4), just like the film for still pictures but much longer.

When the film is pulled through the camera by virtue of the sprocket holes on the edges, it stops for a fraction of a second so that the camera's shutter can quickly open and then close while the film is being held still to record one frame (picture) on the film. Then the film advances to the next frame and stops again so the process can repeat. This is called the intermittent action of the camera, and is why the frames are all so precisely placed and the images are not blurred by the motion of the film.

Now, imagine you are in a theater. The lights go down, the curtains open, and the film begins rolling through the projector. The same intermittent action allows the shutter to open and project a still image through a focusing lens and onto the screen. Then the shutter closes, plunging the theater into darkness, and the film is pulled down one frame, held perfectly still, and the shutter opens again to project the next frame.

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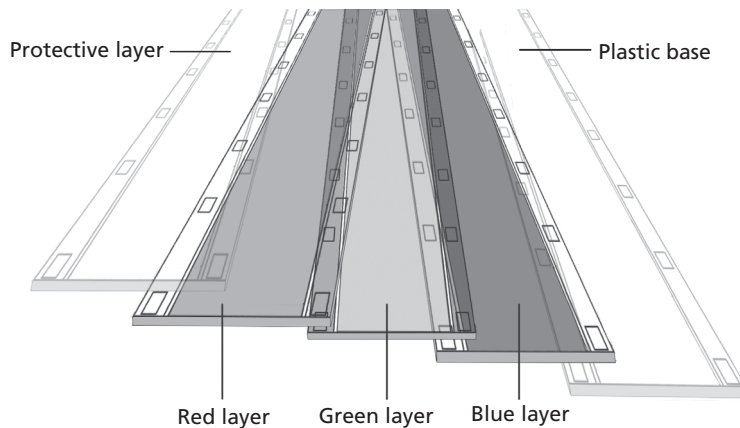
**FIGURE 1-4** The three main components of black and white film



Because this happens 24 times each second and the shutter is closed for only a fraction of a second each time, you aren't aware of the dark between the frames. The light is what activates your vision, and each frame or picture stays on your retina while the theater is in darkness. This human phenomenon is known as persistence of vision, or image retention. You are not able to "see the dark parts" between projected frames. The brain seamlessly transitions from one frame to the next to give you the perception of motion on the screen. Pretty neat, eh?

Now, if you stop to think about it, how different is that from the shadow shows mentioned earlier in this chapter? The light is shining through the clear areas of the film and is blocked by those parts that are dense with emulsion particles. The density of the emulsion determines the darkness of the image. An old black-and-white Humphrey Bogart film would show a close-up of Bogey as a shadow. Not a silhouette, but as a detailed shadow in shades of grey.

**FIGURE 1-5** The different components of color film.



That's all very well for black-and-white movies, but what about color film?

Color film works exactly the same way as black and white, except that color film has three layers of emulsion (see Figure 1-5). One is chemically screened to record only light of the red frequencies, one for blue, and one for green. These are the three primary colors of light—red, blue, and green (RGB). When these colors are mixed together in their varying shades and hues, they can create any color in the visible spectrum. It's the same as three-color printing, where the paper is passed through the printer three times, once for each primary color (although the primary colors for inks, dyes, and paints are red, blue, and yellow instead of red, blue, and green...go figure!).

Now we have a shadow show in full color! Things have come a long way.

## On to Video

Like most technologies, modern video systems did not just spring into existence fully formed. However, it has enjoyed very rapid development.

## The History

Television technology was slowly developed by many people in many countries, but the first truly electronic television system (both the camera and the television receiver)

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**FIGURE 1-6** Philo Farnsworth



is credited to American inventor Philo Farnsworth (Figure 1-6), who developed the system between 1926 and 1939 when he sold the rights to RCA Victor.

Television's public debut was the broadcast of several events at the 1939 World's Fair in New York. Later, Mr. Farnsworth was quoted as saying, "There's nothing on it [television] worthwhile, and we're not going to watch it in this household, and I don't want it in your intellectual diet." True story!

Oh well, we watch it anyway (sorry, Philo). And because we watch so much and demand the ability to see programs again and again at different times, the television industry needed a device capable of recording and playing back programs (and, of course, commercials).

### Enter the Videotape Recorder

The earliest experiments to produce a viable videotape recorder/player utilized modified audiotape recorders that ran quarter-inch tape at speeds up to 360 inches per second to create a linear video track. The pictures were of a very poor quality, and the fast running speed meant that they could only record a few minutes of programming.

Charles P. Ginsburg was the leader of the research team at the Ampex Corporation that invented the first practical videotape recorder (VTR) in 1951. That first machine sold for \$50,000 in 1956.



While there were still signal quality and program length considerations, further advancements in technologies, such as quad recording (recording by scanning the tape across its width) and finally helical scanning (recording in diagonal stripes), which is in use today and discussed below, finally made VTRs a staple for every broadcast and video production company.

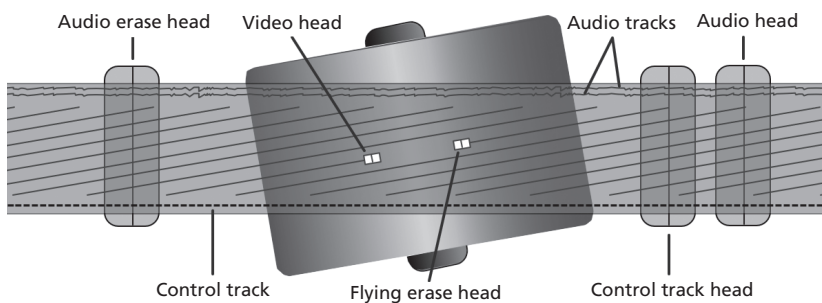
## The Technical Bit

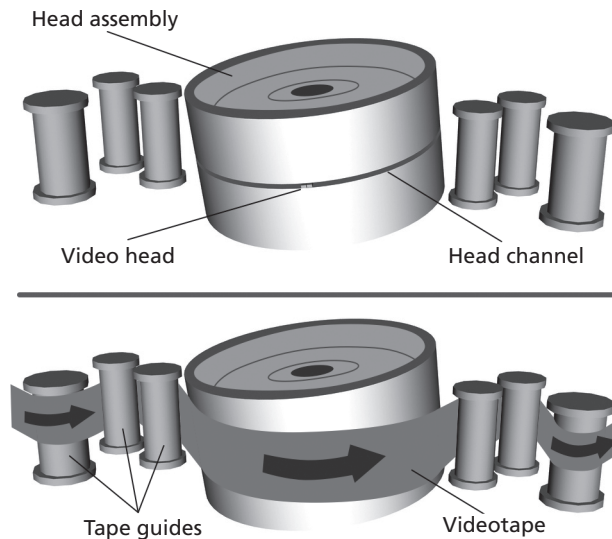
The way in which the picture information is striped onto the tape in long, diagonal scans is an efficient way of maximizing the amount of video information that can be recorded on a given length of tape. This is called a Helical scan. In Figure 1-7, notice the two linear audio tracks at the top of the tape and the control track on the bottom. The control track is a timing track that ensures that the playback heads synchronize with the video stripes that were laid down during recording.

The video record/playback heads and the erase heads are rapidly spinning within a gap in the head drum assembly. In the figure, the gap is not shown so that it won't be confused with the indication of the recorded track. As you can see, the head drum is tilted to create the diagonal signals to be recorded onto the magnetic oxide of the recording tape.

In Figure 1-8, you can see the U-Matic threading pattern, which allows a maximum amount of tape to be recorded at once (longer diagonal stripes than would be possible with a "flat" pass across the heads).

**FIGURE 1-7** Magnetic recording and the Helical scan



**FIGURE 1-8** Videotape threading path

While there are static record/playback and erase heads for the linear sound tracks, we've left them off this diagram to demonstrate the rollers that guide the threading path. There are usually two heads in a stack that create and play back the channel 1 and channel 2 linear sound tracks. There will also be a general erase head that can erase all information on the tape prior to being rerecorded on so that there is no chance of technical difficulties resulting from old information conflicting with new information as it is recorded. There is also a static head, which will record and play back the control track that synchronizes the video playback heads with the diagonal video stripes.

Within the head drum assembly resides either two or four record/playback heads for picture (depending on format and recorder size), one flying erase head to ensure stable edits of the picture track when new picture material is inserted on an editing recorder (or when the recorder within a camera system stops and starts to make multiple shots), and perhaps an audio head to record high-fidelity audio, which is recorded on the same part of the tape as the picture tracks, but embedded deeper in the oxide.

This is the way video cassettes have worked since analog times. Even digital recording uses this same method for recording data. The main difference between analog and

digital recordings is that because digital uses the same technology that allows computer hard drives to store information, there is more redundancy in the signal, which ensures a clearer, more artifact-free image that can be manipulated in the digital realm.

## A Word about Analog vs. Digital Video

Okay, this is a tough one. The intention of this book is to help you understand and practice the “hands-on” of producing videos. It is *not* a reference book for electronics technicians. As such, this section on what is analog and what is digital will be brief on the technical information and will focus on how the new digital technology helps the producer to make videos. Aren’t you glad?

I have read definitions of analog and digital signals in manuals and reference books written by the technical geniuses who design video production and post-production gear, and I don’t think that even they understand what they’ve written sometimes.

Suffice it to say analog systems are the old, original way of doing things electronically. In analog, video signals are laid down by recording modulating pulses (see Figure 1-9). How yucky is that?

Digital is the new and (for the most part) better way. Digital signals are made up of signals that are analogous to the ones and zeros used in the binary language of computers (see Figure 1-10).

In the early days of video, everything was analog. As we progressed into the digital age, brought on by the need for smaller, faster computers, it became obvious that the lower-quality picture and sound transmitted by an analog signal was just not going to cut the mustard in the new digital age.

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**FIGURE 1-9** An analog signal



**FIGURE 1-10** A digital signal

**10010101110100001110010101110100001101011**

One disadvantage of analog becomes apparent when compositing a multiimage picture. An example might be a background image with a live action, picture-in-picture box in one corner, a graphic logo in another corner, and a text graphic overlay in the center of the frame—all originally separate images. This might have taken four passes of the background image, three passes of the logo image, two passes of the picture-in-picture image, and a final pass to complete the full image with the text overlay. Depending on the quality of each original image and the format you might be working in (two-inch videotape at a high-end production studio versus half-inch video in a home editing suite), your background images might begin to look “noisy” or “grainy” after a few passes.

Another example of the horrors of analog can be seen if you duplicate videotape A onto videotape B and then use videotape B to copy onto videotape C and then use videotape C to copy... you get the idea. In the analog days, your picture and sound would suffer noticeably after the second duplication, and be trash by the fourth (see Figure 1-11).

## Enter Digital Video

With digital, you can layer virtually as many images as you like with no noticeable degradation of quality. Cool! Now we can do all of those fancy, juicy special effects and graphics builds formerly only afforded by Hollywood production companies and big television networks. We can also make duplications from duplications from duplications as long as we like. Well, not really. There is a point at which even a digital signal will become corrupted and lose quality, or begin to “pixilate,” but that’s so far down the duplicating line that most of us will never be bothered with it.

**FIGURE 1-11** As analog video is copied over and over, picture and sound degradation is readily apparent.



Old VHS videotapes would eventually fall prey to “dropouts.” This is where the metallic oxide particles that are bound to the plastic surface of the tape and hold the magnetic information would fall off in small chunks. The symptom of this is quick flashes or streaks in the picture. Digital videotapes don’t fall victim to this problem because of the amount of redundant signal backup that can be fit onto the tape. If the zeros and ones become corrupted on one microscopic part of the tape, they will likely be readable from another area on the tape nearby. Of course, too much damage to the tape will eventually cause digital breakup of the picture and sound. Nothing’s perfect (yet).

As the next chapter explains, we will eventually be recording all data on static memory cards. For video, this is already beginning and when it permeates, the whole production industry—from camera recording to post-production and archiving—will have achieved a technological nirvana at an affordable price that will cause many video producers to quote that famous old saying, “I musta done died and gone to heaven!”

Digital technology isn’t perfect, but it’s pretty darn close!

## DVDs

So far we’ve been talking about formats for capturing video with a camera as well as playing it back for the audience. It seems reasonable at this point to mention DVDs because they are a popular method for playing back prerecorded material. I would like to make it clear, though, that DVDs are not great as an original camera-capture format, as the images are at once compressed to mpeg-2 (see the compression formats near the end of this chapter). While this is okay for consumer cameras, as long as the user is not considering complex editing of their footage, it is not of a quality that professionals require to capture the best possible original footage. As a method of playing back a finished program, however, DVDs and Blu-ray rock!

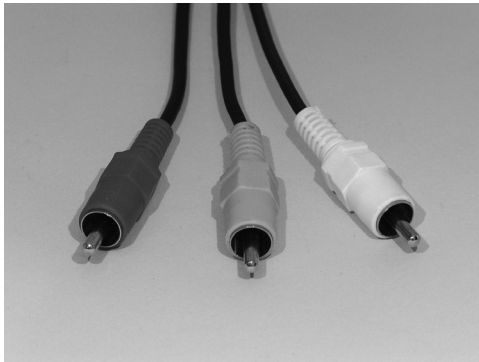
## Plugs and Connectors

In Figures 1-12 through 1-25, I’ve depicted some of the common connectors, both analog and digital, that you’ll encounter in video work. These connectors include the following:

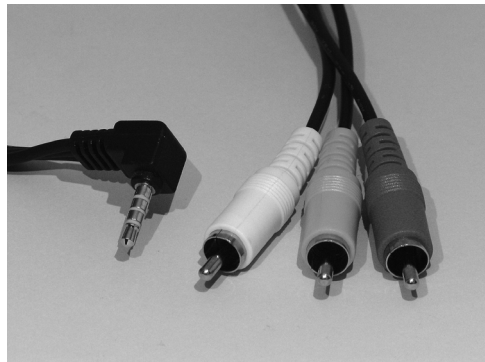
- **Phono plugs (male)** These are used for patching audio and analog video signals. The yellow one is always video, and the other two are left and right audio (see Figure 1-12).

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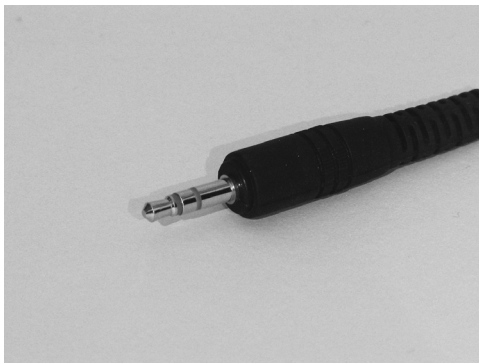
**FIGURE 1-12** Phono plugs (male)



**FIGURE 1-13** AV cord (male)



**FIGURE 1-14** Stereo headphone jack (male)

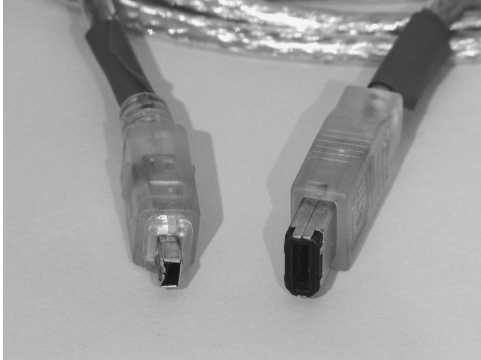


**FIGURE 1-15** 1/4" phone plug and XLR plug (male)

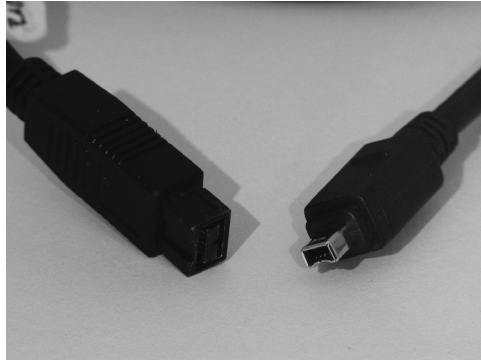


- **AV cord (male)** This is used for patching audio and analog video signals. The camera end is a multiconnection, 1/8" phone plug (see Figure 1-13).
- **Stereo headphone jack (male)** You'll find either a 1/8" or a 1/4" plug on the cord from your headphones (see Figure 1-14).
- **1/4" phone plug and XLR plug (male)** These are microphone plugs. A high-impedance mic will have a phone plug, and a low-impedance mic (or mic cable) will sport the XLR (see Figure 1-15).
- **FireWire connector, large and small (male)** These are used mainly for connecting your camera to your computer to capture your footage onto your computer's hard drive (see Figure 1-16).

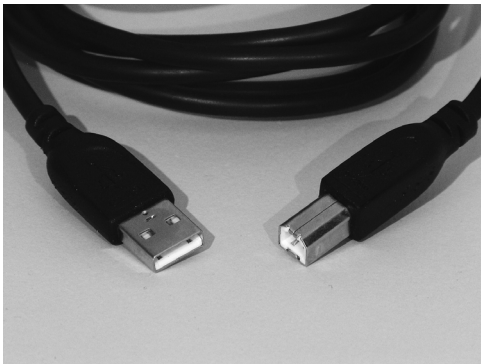
**FIGURE 1-16** FireWire connector, large and small (male)



**FIGURE 1-17** FireWire 800 and 400 connectors (male)



**FIGURE 1-18** USB connectors (male)



**FIGURE 1-19** BNC connector (male)



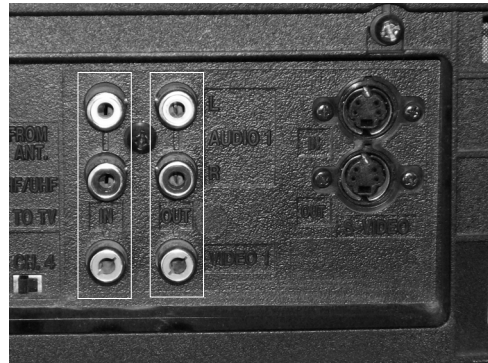
- **FireWire 800 and 400 connectors (male)** The 800 provides faster transfer speeds (see Figure 1-17).
- **USB connectors (male)** There are two sizes of USB connectors. This cord has both. As with FireWire, the small one accommodates the camera (see Figure 1-18).
- **BNC connector (male)** This carries an analog video signal (no audio) and is found on professional cameras (see Figure 1-19).
- **S-video plug (male)** This separates chrominance from luminance in an analog video signal for better picture quality (see Figure 1-20).



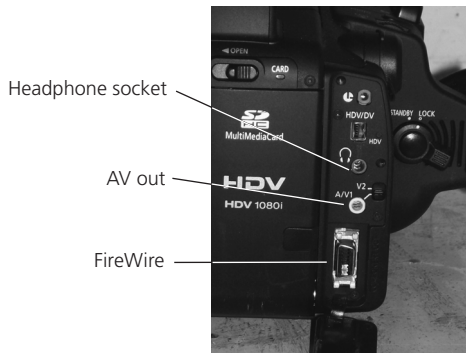
**FIGURE 1-20** S-video plug (male)



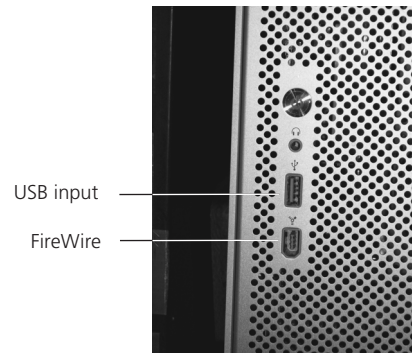
**FIGURE 1-21** RCA and S-video plugs (female)



**FIGURE 1-22** HDV FireWire and RCA phono (female)



**FIGURE 1-23** USB and FireWire inputs (female).



- **RCA and S-video plugs (female)** On the left are the RCA phono ins and outs for a stereo VCR, and on the right are the S-video sockets (see Figure 1-21).
- **HDV FireWire and RCA phono (female)** The back of my camera shows the AV (analog) video/audio output, headphone socket, and FireWire in (see Figure 1-22).
- **USB and FireWire inputs (female)** On the computer are the receptacles for the USB and FireWire inputs (see Figure 1-23).
- **BNC connector (female)** Analog video (only) output on many professional cameras (see Figure 1-24).
- **XLR microphone inputs (female)** For professional, low-impedance microphones (see Figure 1-25).



**FIGURE 1-24** BNC connector (female)**FIGURE 1-25** XLR microphone inputs (female)

## High-Definition and Aspect Ratios

While digital video has given us much better quality and more capabilities in special effects, it has also brought along a number of issues that need to be understood because some of them are potentially confusing. First, let's look at aspect ratios. The aspect ratio of a picture is its measurement ratio of width to height. Old-style TV screens (from the 1940s on up to about the early 2000s) had an aspect ratio of 4:3 (actually, 1.33:1, which is usually just called a 4 to 3 ratio) (see Figure 1-26). No matter the size of the screen, the ratio between width and height was always 4:3. Today, when you buy a new TV you will likely purchase a 16:9 screen (1.78:1, usually referred to as a 16 to 9 ratio) (see Figure 1-27).

**FIGURE 1-26** Old-style 4:3 TV. Notice the sides are cropped.

**FIGURE 1-27** Newer-style 16:9 TV with the full image shown



On a movie theater screen, you will usually see a movie in 1.85:1, or perhaps 2.39:1. This can explain why you often see movies on your high-definition television that have black bars at the top and bottom of the picture. The movie format being shown is a widescreen theatrical release print and must be “letter boxed” to fit the whole image on the screen at once (see Figure 1-28).

**FIGURE 1-28** The “letter box” format displays the movie as it appeared on the movie theater screen.



**FIGURE 1-29** This movie has been recropped for television.



If the movie has been recropped for television, it will fill your TV screen, but the left and right sides will be somewhat cropped. This television version of the movie will use electronic panning or will simply cut to a composition that allows the right or left side to be seen when appropriate (see Figure 1-29).

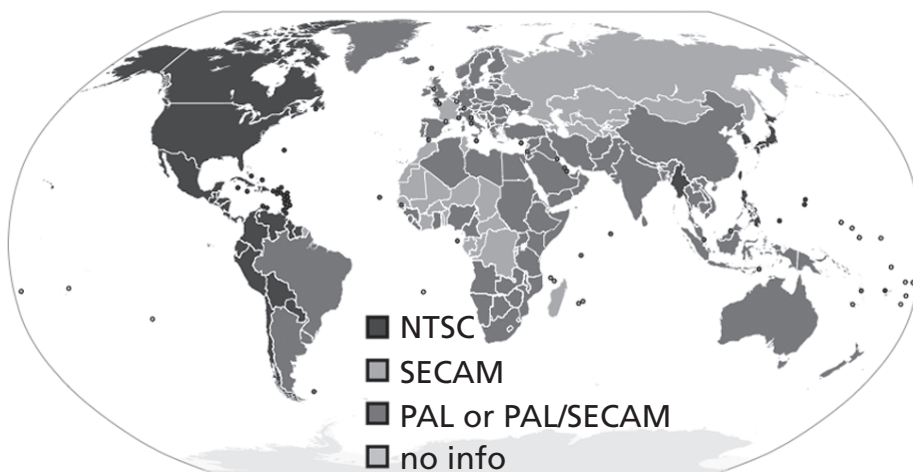
Most people don't mind the letter box option so they can see the movie as it was meant to be seen.

Standards for still photography, which may affect your video compositions when you are showing photographic stills in your program, include 4:3, 3:2, 16:9, 5:4, 6:7, and 1:1 (square). The 4:3 standard definition, 16:9 standard definition, and 16:9 high definition formats require you to set up all of the parameters in both your camera and your editing software very carefully.

## Television Standards Around the World

Ever since television has existed there have been differences in how it works in various countries. Older style television sets that employ a cathode-ray tube (CRT) work by scanning the television image onto the back of a phosphorous-active screen a line at a time. Standard analog TV in North America is interlaced TV and it works by having a CRT scan lines 1, 3, 5, 7, 9, etc. (all the odd lines) first from top to bottom in 1/60th of a second. Then the gun draws out lines 2, 4, 6, 8, 10, etc. (the even lines), again in 1/60th of a second. This completes one full frame of the moving image in 1/30th of

**FIGURE 1-30** The television standards used in various parts of the world. (This picture is licensed under Creative Commons Attribution ShareAlike 2.0 License.)



a second (1/60th plus 1/60th). In the North American Standard, 525 lines are drawn in this way for each frame. This is called NTSC, which stands for National Television System Committee. As seen in Figure 1-30, this standard is used in North America, some parts of South America, a small part of Africa, and some Asian countries.

Secam (Séquentiel Couleur À Mémoire) is used in France (where it was first created), Russia, Asia, and several countries in Africa. It utilizes 625 lines at a frame rate of 25 frames per second (fps). PAL (Phase Alternation by Line), developed in Germany, is used in that country, as well as in the rest of the other countries in the world. It also uses the 625 line, 25 fps system.

Because of these differences in analog television signals, importing foreign television programs and videos required standards conversions that were often expensive and degrading to the signals. Hopefully, the new age of digital video will solve this problem. Discussions among governing bodies from all countries are still trying to iron out the technical specifications for a universal standard.

## Video Formats

Finally, in this chapter I want to introduce you to several of the many video formats in which you can output your final program after the post-production process. I'm going to try to stay away from influencing you to embrace any particular format as a favorite, as you will likely find uses for many of them. Many formats have very specific uses.

Table 1-1 lists in alphabetical order each format's uses and strengths. Whew! There are dozens and dozens more formats, but these are the most common.

**TABLE 1-1** Common Video Formats

FORMAT	TYPE	POPULARITY	USES AND STRENGTHS
.avi	Audio Video Interleave	Very common	Typically uses less compression than other formats.
.dat	VCD Video	Average	Used to make video CDs.
.avi	Audio Video Interleave	Very common	Typically uses less compression than other formats.
.dat	VCD Video	Average	Used to make video CDs.
.dvr	Div X Video	Average	High-quality video compression. Needs plug-in or Div X player.
.fcp	Final Cut Project	Average	
.flv	Flash Movie File	Very common	
.m2t	High Definition DVD	Average	HDV compression scheme for camcorders. Uses MPEG-2 compression.
.m2ts	Blu-ray High Def. DVD	Average	BD-AV format for Blu-ray disks. High def. based on MPEG-2.
.m2v	MPEG-2 Video	Average	MPEG-2 with video only. No audio. Used for making DVDs.
.m4v	iTunes Video	Common	
.mov	Apple QuickTime	Very common	
.mp4	MPEG-4 Video	Very common	
.mpeg	MPEG Movie	Common	
.mpg	MPEG Video File	Very common	
.mts	AVCHD Video	Common	Used by Sony, Panasonic, and other HD camcorders.
.qt	Apple QuickTime	Common	Cross-platform format for Mac or PC. Good player control capability.
.rm	Real Media	Common	
.swf	Flash Movie	Very common	Used for web movies and animations (can contain vector or raster graphics and text). Best compression for web streaming. Good quality, but small file size.
.vob	DVD Video Recording	Very common	
.wm	Windows Media	Average	Same as Windows Media Video, but simpler. Can contain video and audio.
.wmv	Windows Media Video	Very Common	An .asf file that is encoded using the Windows Media Video codec. Player capability is often restricted.