Art and Technology

Every art is shaped not only by the politics, philosophy, and economics of society, but also by its technology. The relationship isn't always clear: sometimes technological development leads to a change in the esthetic system of the art; sometimes esthetic requirements call for a new technology; often the development of the technology itself is the result of a combination of ideological and economic factors. But until artistic impulses can be expressed through some kind of technology, there is no artifact.

Usually the relationships are broad: the novel never could have come into being without the printing press, but the recent rapid increases in the technology of printing (discussed briefly in Chapter 6) have had little discernible effect on the esthetic development of the novel. What esthetic changes have occurred in its three-hundred-year history find their root causes in other historical factors, mainly the social uses of the art.

Stage drama was radically altered when new lighting techniques allowed it to be brought indoors and sheltered behind the proscenium arch, but the twentieth-century reversion to the thrust stage was mainly due not to developments in technology but to ideological factors. Bach played on the harpsichord of his own day sounds quite different from Bach performed on the modern "well-tempered clavier," but Bach is still Bach. The invention of oil paint provided painters with a medium of wonderful versatility, but if oil paint had never been invented, painters would have painted anyway.

In short, although there has been a communion between art and technology that consists of more than an occasional genius like Leonardo da Vinci combining

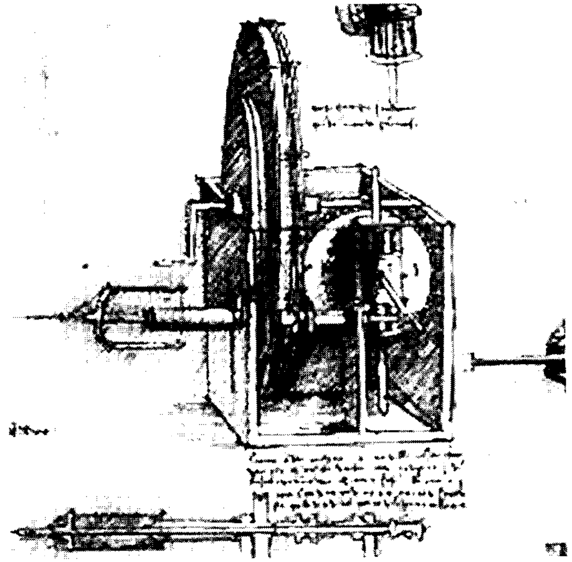


Figure 2-1. This da Vinci drawing suggests the bond between visualization and invention, art and technology.

good work in both fields, a communion that belies the modern conception of the two fields as mutually antagonistic, nevertheless one can study the history of painting without ever having gained any knowledge of how oils differ from acrylics, and students of literature can certainly succeed in mastering the basic history of literature without having studied the operation of the Linotype or the offset press.

This is not the case with film. The great artistic contribution of the industrial age, the recording arts—film, sound recording, and photography—are inherently dependent on a complex, ingenious, and ever more sophisticated technology. No one can ever hope to comprehend fully the way their effects are accomplished without a basic understanding of the technology that makes them possible, as well as its underlying science.

Image Technology

The invention of photography in the early nineteenth century marks an important line of division between the pretechnological era and the present. The basic artistic impulses that drive us to mimic nature were essentially the same both before and after that time, but the augmented technical capacity to record and reproduce sounds and images of the twentieth century presents us with an exciting new set of choices.

Previously we were limited by our own physical abilities: the musician created sounds by blowing or strumming or singing; the painter who captured real images depended entirely on his own eye to perceive them; the novelist and the

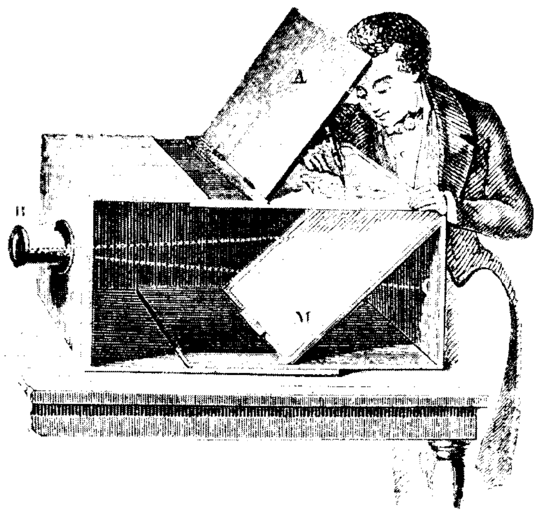


Figure 2-3. This version of the camera obscura reflected the incoming light to a screen at the top of the box so that an artist could trace the image. If the pinhole is sufficiently small, an image will be projected. The optical principle is described in Figure 2-9. (*International Museum of Photography, George Eastman House.*)

poet, not engaged physically in their art, were limited in describing events or characters by their own powers of observation. Recording technology now offers us the opportunity of capturing a representation of sounds, images, and events and transmitting them directly to the observer without the necessary interposition of the artist's personality and talents. A new channel of communication has been opened, equal in importance to written language.

Although the camera did not come into practical use until the early nineteenth century, efforts to create such a magical tool, which would record reality directly, dated from much earlier. The camera obscura (Figure 2-3), the grandfather of the photographic camera, dates from the Renaissance. Da Vinci had described the principle, and the first published account of the usefulness of the invention dates from 1558, the year in which Giovanni Battista della Porta published his book *Natural Magic*. There are even references dating back as far as the tenth-century Arabic astronomer Al Hazen. The camera obscura (literally "dark room") is based on a simple optical rule, but it includes all the elements of the basic contemporary photographic camera except one: film, the medium on which the projected image is recorded.

Louis Daguerre is usually credited with the first practical development of such a medium in 1839, but his colleague Joseph Nièpce had done much valuable work before he died in 1833, and may be credited, as Beaumont Newhall has

Figure 2-4. The camera lucida consisted of a lens arrangement that enabled the artist to view subject and drawing paper in the same "frame," and thus simply outline the image that appeared to be projected on the paper. (*International Museum of Photography, George Eastman House.*)

noted, with the first "successful experiment to fix the image of nature" in 1827. William Henry Fox Talbot was working simultaneously along similar lines: modern photography has developed from his system of negative recording and positive reproduction. Daguerre, whose recording photographic plate was positive and therefore not reproducible (except through being photographed itself), had reached a deadend; the daguerreotype marked the end of a line of technological development, not the beginning of one. But Fox Talbot's negative permitted infinite reproductions. The paper negative was soon replaced by the flexible collodion film negative, which not only marked a distinct improvement in the quality of the image but also suggested a line of development for the recording of motion pictures.

Like the still camera, the motion picture camera was not without its antecedents. The Magic Lantern, capable of projecting an image onto a screen, dates from the seventeenth century and was quickly adapted to photographic use in the 1850s. The production of the illusion of motion was made possible in a very crude way by the so-called Magic Discs of the 1830s and the more sophisticated Zoetrope (Figure 2-6), patented in 1834 by William Horner (although precursors of the Zoetrope may date to antiquity). In the 1870s Eadweard Muybridge, working in California, and Étienne Jules Marey, in France, began their experiments in making photographic records of movement. Émile Reynaud's Praxinoscope

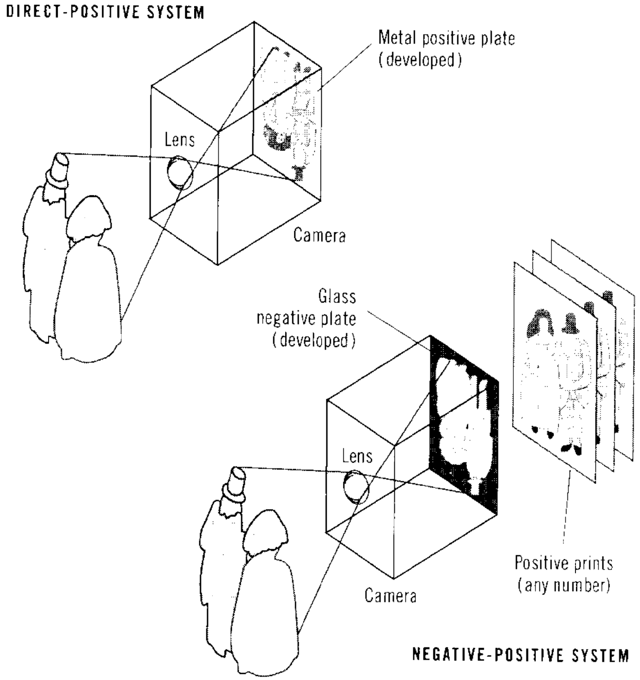


Figure 2-5. PHOTOGRAPHIC SYSTEMS. The negative–positive system (right) of the Talbot-type, Collotype, and modern photography permits infinite reproduction of the image. The direct positive system of the early Daguerreotype (left) creates a single, iconic image. Contemporary "instant photograph" systems such as Polaroid also produce direct positives and are therefore comparable to the Daguerreotype.

(1877) was the first practicable device for projecting successive images on a screen. In 1889 George Eastman applied for a patent on his flexible photographic film, developed for the roll camera, and the last basic element of cinematography was in place.

By 1895 all these elements had been combined, and movies were born.

Sound Technology

The technology of sound recording developed more rapidly. Edison's phonograph, which does for sounds what the camera/projector system does for images, dates from 1877. In many ways it is a more extraordinary invention than cinematography, since it has no antecedents to speak of. The desire to capture and reproduce still pictures predated the development of moving pictures by many years, but there is no such thing as a "still" sound, so the development of sound recording, of necessity, took place all at once.

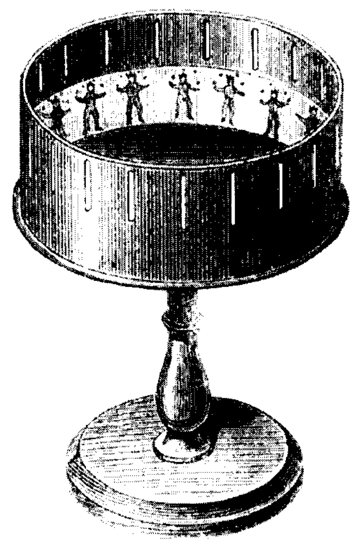


Figure 2-6. THE ZOETROPE. The cylinder was spun; the images on the inside of the drum were viewed through the slots opposite them, creating the illusion of motion. (*International Museum of Photography, George Eastman House.*)

Equally as important as the phonograph, although not often mentioned in histories of the recording arts, is Bell's telephone (1876). It presages the regular transmission of sounds and images whose technology provided us with radio and television but, more important, Bell's invention also shows how electrical signals can be made to serve the purposes of sound recording.

Edison's original phonograph was an entirely physical-mechanical invention, which gave it the virtue of simplicity but also seriously delayed technological progress in the field. In a sense, the purely mechanical phonograph, like Daguerre's positive photograph, was technically a deadend. It was not until the mid-1920s that Bell's theories of the electrical transmission of sound were united with the technology of the mechanical phonograph. At almost precisely the same time, sound recordings were united with image recordings to produce the cinema as we know it today.

It is interesting to conjecture whether there would have been any period of silent cinema at all had Edison not invented a mechanical phonograph: in that case it's quite possible that Edison (or another inventor) would have turned to Bell's telephone as a model for the phonograph and the electrical system of recording sound would have developed much earlier, more than likely in time to be of service to the first filmmakers.

It is worth noting that Thomas Edison himself conceived of his Kinetograph as an adjunct to the phonograph. As he put it in 1894:

> In the year 1887, the idea occurred to me that it was possible to devise an instrument which should do for the eye what the phonograph does for

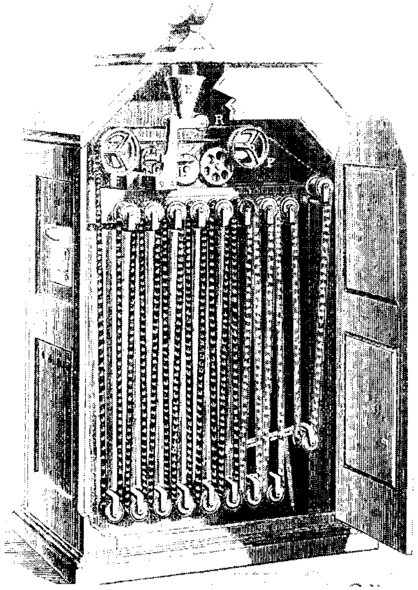


Figure 2-7. Edison's Kinetoscope was a private viewing machine. The film was formed in a continuous loop running around rollers in the base of the machine: no need to rewind before the next showing! (*MOMA/FSA.*)

the ear, and that by a combination of the two all motion and sound could be recorded and reproduced simultaneously.*

William Kennedy Laurie Dickson, an English assistant to Edison who did much of the development work, describes Edison's first conception of the Kinetograph as parallel in structure and conception with his successful phonograph:

> Edison's idea ... was to combine the phonograph cylinder or record with a similar or larger drum on the same shaft, which drum was to be covered with pin-point microphotographs which of course must synchronize with the phonograph record.

This configuration, of course, did not succeed, but the ideal union of sound and image was suggested. Indeed, after Dickson had turned to the new perforated Eastman continuous roll film, he continued to think of the moving pictures as necessarily joined with the sound record; his first demonstration of his success to Edison on October 6, 1889, was a "talkie." Dickson called this device a "Kineto-phone." Edison had just returned from a trip abroad. Dickson ushered him into

* Quoted in W. K. L. Dickson, "A Brief History of the Kinetograph, the Kinetoscope, and the Kineto-Phonograph," in Raymond Fielding's *A Technological History of Motion Pictures and Television*, p.9.

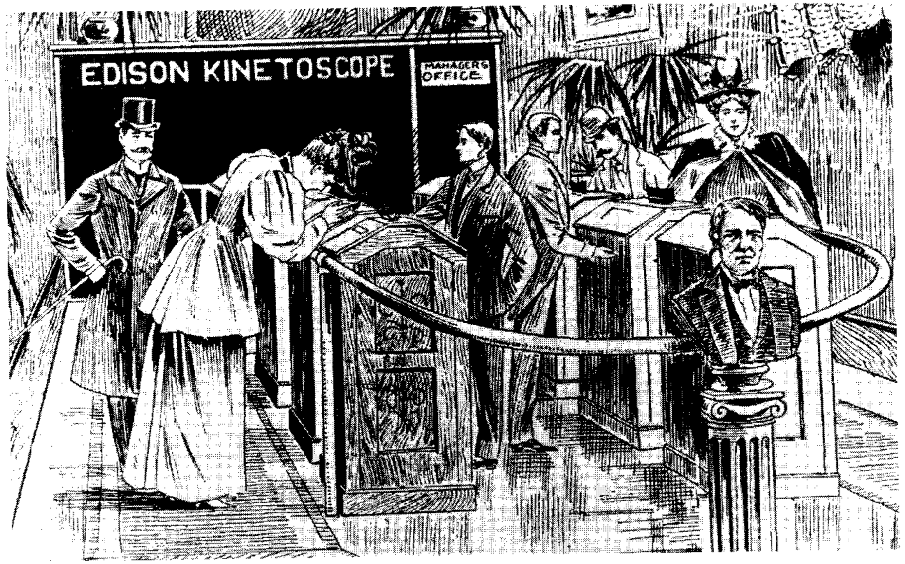


Figure 2-8. Ladies and gentlemen amusing themselves at the Kinetoscope parlor at 28th Street and Broadway, circa 1895. That's a bust of the modest inventor, prominent in the foreground. (*MOMA/FSA.*)

the projecting room and started the machine. He appeared on the small screen, walked forward, raised his hat, smiled, and spoke directly to his audience:

> "Good morning, Mr. Edison, glad to see you back. Hope you like the Kinetophone. To show the synchronization I will lift my hand and count up to ten."

These words, less well known, should certainly rank with Bell's telephonic "Mr. Watson, come here, I want to see you" and Morse's telegraphic "What hath God wrought?"

Because of the technical problems posed by Edison's mechanical recording system—mainly synchronization—the effective marriage of sound and image did not occur until thirty years later, but the desire to reproduce sound and image in concert existed from the earliest days of film history.

By 1900, all the basic tools of the new technological arts had been invented: the painter had the alternative of the still camera; the musician the alternative of the phonograph; and novelists and theater folk were contemplating the exciting possibilities of motion pictures. Each of these records could be reproduced in large quantities and therefore reach large numbers of people. Although the technology of broadcasting was still a few years in the future, workable methods of instantaneous communication had been demonstrated by the telephone and the telegraph; in fact, we are now realizing, as cable technology develops, that wired transmission offers quite a few advantages over radio wave broadcasting, not least of which is addressability. Despite the saturation of the radio spectrum, there is much life left in radio wave broadcasting, as the development of cellular phone systems showed in the 1980s. From now on, however, broadcast and wired transmission must be considered as part of the same industry. The competition between the two technologies will provide much business-page drama in the early years of the twenty-first century.

This flowchart indicates the various stages of the process of film:

VISUAL:	lens →	camera →	filmstock →	editing laboratory →	projection

AURAL:	micro-phone →	recorder →	tape, film, or recorder →	editing & mixing →	playback

Diagram E

At any one of these stages variables can be introduced to give an artist more control over the process. Within each area of the chart there is a large number of factors, each of which has a discernible effect on the finished product, and these factors interact with each other, and between areas, to create an excitingly complex technology. Indeed, no small part of the appreciation of the activity of filmmaking as well as the product lies in an understanding of the technical challenges that filmmakers must surmount.

The Lens

The earliest of cameras, the camera obscura, consisted of a light-tight box with a pinhole in one side. Contemporary cameras, both still and motion picture, operate on the same principle: the box is more precisely machined; photosensitive, flexible film has replaced the drawing paper as the "screen" upon which the image falls; but the greatest changes have taken place in the pinhole. That crude optical device has evolved into a complex system of great technical sophistication. So much depends upon the glass eye of the lens through which we all eventually view a photograph or a film that it must be regarded as the heart of photographic art.

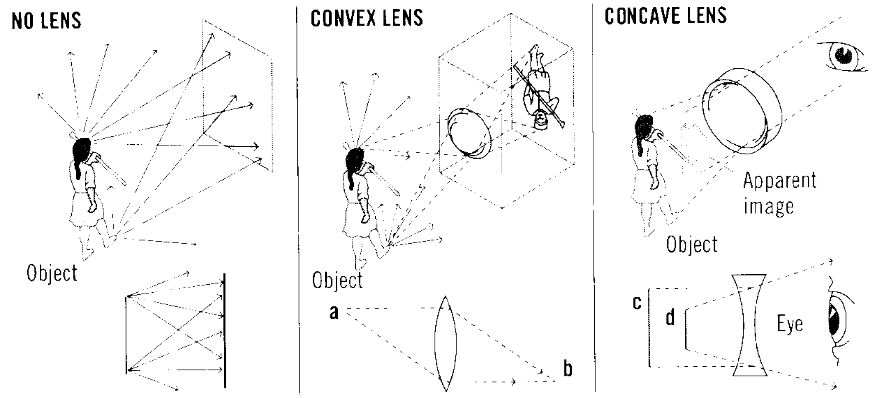


Figure 2-9. LENSES. If there is no lens to focus the rays of light coming from the subject, no image will be produced (left): all rays from all points will strike all parts of the photosensitive plate or film. The convex lens (center) bends the rays from each single point so that they converge on the "focus plane" a certain distance behind it. The image created is reversed right to left and top to bottom. (A transparent negative can then be turned to create the proper left-right orientation in the print.) A pinhole, if it is small enough, will act like a convex lens to give a rough focus. This is the elementary principle which led to the invention of the Camera Obscura (see Figure 2-3). The concave lens (right) causes the rays to diverge in such a way that an observer perceives an "apparent," or "virtual," image which seems smaller than the actual object. The diagrams below the drawings schematically indicate the principles.

Here is the basic idea of the technology of optics: Because light travels at different speeds in different mediums, light rays bend when they pass from one medium to another. Lenses made out of glass or other transparent materials can then focus those rays. While the lens of the human eye is continuously variable, changing in shape each time we unconsciously refocus from one object to another, photographic lenses can only perform the specific tasks for which they are painstakingly designed.

A photographer has three basic types of lenses available to him. These three general categories of lenses are usually classified according to their focal length: the distance from the plane of the film to the surface of the lens. Although a lens is usually chosen specifically for the subject it must photograph, there are various ancillary characteristics to each lens that have become valuable esthetic tools for the photographer. For cameras that use 35 mm film, the "normal" lens has a focal length roughly between 35 and 50 mm. This lens is the most common choice for the photographer because it distorts least and therefore most closely mimics the way the human eye perceives reality.

The wide-angle lens, as its name indicates, photographs a wide angle of view. A photographer finding himself in a cramped location would naturally use this lens in order to photograph as much of the subject as possible. However, the wide-angle lens has the added effect of greatly emphasizing our perception of depth and often distorting linear perception. The fish-eye lens, an extremely wide-angle lens, photographs an angle of view approaching 180°, with corresponding distortion of both linear and depth perception. Generally, for 35 mm photography, any lens shorter than 35 mm in focal length is considered a wide-angle lens.

The telephoto or long lens acts like a telescope to magnify distant objects, and this, of course, is its most obvious use. Although the long lens does not distort linear perception, it does have the sometimes useful effect of suppressing depth perception. It has a relatively narrow angle of view. Normally, any lens longer than 60 mm is considered a telephoto lens, the effective upper limit being about 1200 mm. If greater magnification were desired, the camera would simply be attached to a standard telescope or microscope.

It should be noted that these lenses are not simply solid pieces of glass, as they were in the eighteenth century, but rather mathematically sophisticated combinations of elements designed to admit the most amount of light to the camera with the least amount of distortion.

Since the 1960s, when they came into general use, zoom lenses, in which these elements and groups of elements are adjustable, have gained considerable popularity. The zoom lens has a variable focal length, ranging from wide-angle to telephoto, which allows a photographer to change focal lengths quickly between shots and, more important cinematographically, also to change focal lengths during a shot. This device has added a whole new set of effects to the vocabulary of the shot. Normal zoom lenses (which can have a focal length range from 10 to 100 mm) naturally affect the size of the field photographed as focal length is shifted (since longer lenses have a narrower angle of view than do shorter lenses), and this effect permits the zoom shot to compete with the tracking shot (see Figure 3-59).

Thanks to computer-aided design and manufacturing techniques and advances in the chemistry of optics, the photographic lens is now an instrument of considerable flexibility; we have reached a point where it has become possible to control individually most of the formerly interrelated effects of a lens. In 1975, for example, optics specialists at the Canon company developed their "Macro zoom lens" in which elements of the Macro lens (which allows closeup photography at extreme short ranges), combined with a zoom configuration, allow zooms that range in focus from 1 mm to infinity.

Only one major problem in lens technology remains to be solved. Wide-angle and telephoto lenses differ not only in angle of view (and therefore magnification) but also in their effect on depth perception. No one has yet been able to construct a lens in which these two variables can be controlled separately.

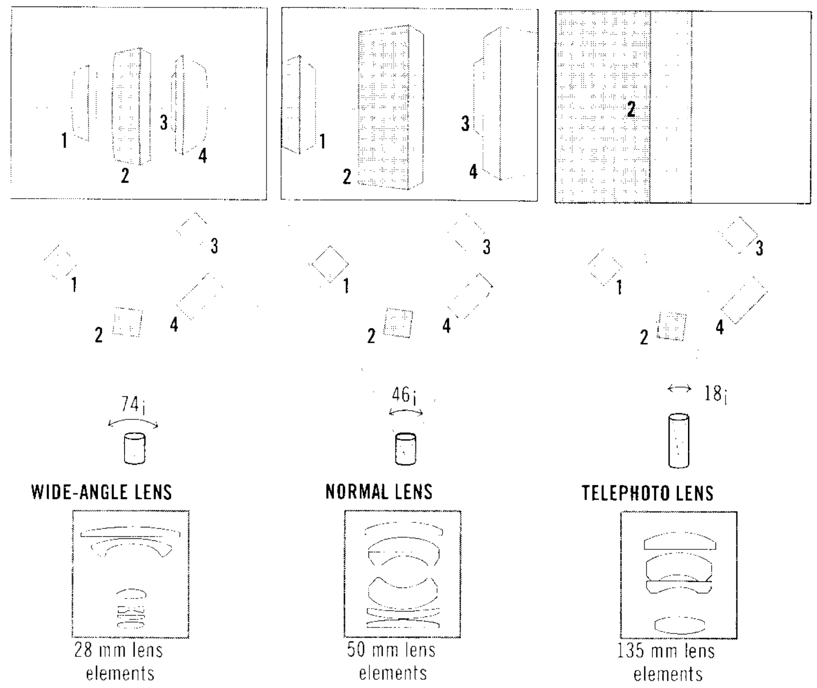


Figure 2-10. WIDE-ANGLE, "NORMAL," AND TELEPHOTO LENSES. Nearly all modern photographic lenses are more complicated than the simple lenses shown in Figure 2-9. Most are composed of sets of elements, such as those which are schematized at the bottom of this diagram. The 28 mm, 50 mm, and 135 mm lenses are common wide-angle, "normal," and "telephoto" lenses in 35 mm photography, whether motion picture or still. Each of the three lenses is seeing the same arrangement of four columns from the same distance and perspective. The frames at the top are exact visualizations of the various images of the scene each lens produces. The wide-angle lens image appears to be taken from a greater distance; the telephoto image is greatly magnified. Notice the slight linear distortion in the wide-angle image and the "flat" quality of the telephoto image. In 35 mm photography, the 50 mm lens is considered "normal" because it best approximates the way the naked eye perceives a scene. (Compare Figure 3-59.)

Alfred Hitchcock spent decades working on this problem before he finally solved it in the famous tower shot from *Vertigo* (1958) by using a carefully controlled zoom combined with a track and models. Hitchcock laid the model stairwell on its side. The camera with zoom lens was mounted on a track looking "down" the stairwell. The shot began with the camera at the far end of the track and the zoom lens set at a moderate telephoto focal length. As the camera tracked in toward the stairwell, the zoom was adjusted backwards, eventually winding up at a wide-angle setting. The track and zoom were carefully coordinated so that the size of the image appeared not to change. (As the track moved in on the center of

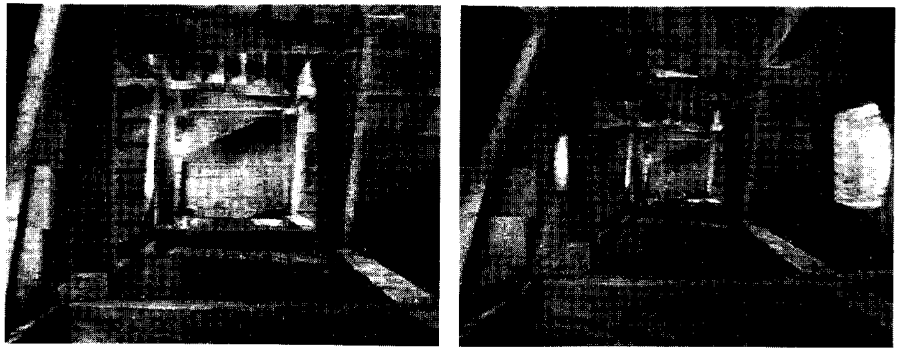


Figure 2-11. Providing an ultimate emblem for Hitchcock's life and work, the tower scene from *Vertigo* forged a union of technology and psychology. The camera tracks in and zooms out to distort our perception of depth without changing the range of the frame. (*Frame enlargements.*)

the image, the zoom moved out to correct for the narrowing field.) The effect relayed on the screen was that the shot began with normal depth perception which then became quickly exaggerated, mimicking the psychological feeling of vertigo. Hitchcock's shot cost $19,000 for a few seconds of film time.

Steven Spielberg used a similar combined track-and-zoom in *Jaws* (1975) to add to the sense of apprehension. Perhaps the most interesting application of this unusual technique was in the diner scene from *Goodfellas* (1990). Director Martin Scorsese used it through the tense scene between Robert De Niro and Ray Liotta to heighten the audience's sense of dread.

To summarize: the shorter the lens, the wider the angle of view (the larger the field of view), the more exaggerated the perception of depth, the greater the linear distortion; the longer the lens, the narrower the angle of view, the shallower the depth perception.

Standard lenses are variable in two ways: the photographer adjusts the focus of the lens (by varying the relationship between its elements), and he controls the amount of light entering the lens.

There are three ways to vary the amount of light that enters the camera and strikes the film:

- the photographer can interpose light-absorbing material in the path of the light rays (filters do this and are generally attached in front of the lens),
- he can change exposure time (the shutter controls this),
- or he can change the aperture, the size of the hole through which the light passes (the diaphragm controls this aspect).

Figure 2-12. WIDE-ANGLE DISTORTION. Anna Karina in Jean-Luc Godard's *Pierrot le fou* (1965). (*l'Avant-Scène. Frame enlargement.*)

Filters are generally used to alter the quality of the light entering the camera, not its quantity, and are therefore a minor factor in this equation. Aperture and exposure time are the main factors, closely related to each other and to focus.

The diaphragm works exactly like the iris of the human eye. Since film, more so than the retina of the eye, has a limited range of sensitivity, it is crucial to be able to control the amount of light striking the film. The size of the aperture is measured in f-stops, numbers derived by dividing the focal length of a particular lens by its effective aperture (the ratio of the length of a lens to its width, in other words). The result of this mechanical formula is a series of standard numbers whose relationship, at first, seems arbitrary:

*f*1	*f*1.4	*f*2	*f*2.8	*f*4	*f*5.6	*f*8	*f*11	*f*16	*f*22

Diagram F1

These numbers were chosen because each successive f-stop in this series will admit half the amount of light of its predecessor; that is, an f1 aperture is twice as "large" as an f1.4 aperture, and f2.8 admits four times as much light as f5.6. The numbers have been rounded off to a single decimal place; the multiplication factor is approximately 1.4, the square root of 2.

The speed of a lens is rated by its widest effective aperture. A lens 50 mm long that was also 50 mm wide would, then, be rated as an f1 lens; that is, a very "fast" lens that at its widest opening would admit twice as much light as an f1.4 lens and four times as much light as an f2 lens. When Stanley Kubrick decided that he wanted to shoot much of *Barry Lyndon* (1975) by the light of a few eighteenth-century candles, it was necessary that he adapt to movie use a special lens the

Figure 2-13. TELEPHOTO DISTORTION. A shot from Robert Altman's *Buffalo Bill and the Indians* (1976). Bill's posse is at least a half mile from the camera.

Zeiss company had developed for NASA for space photography. The lens was rated at f0.9, while the fastest lenses then in general use in cinematography were f1.2s. The small difference between the two numbers (0.3) is deceiving for, in fact, Kubrick's NASA lens admitted nearly twice as much light as the standard f1.2 lens.

Since the development of these ultrafast lenses filmmakers have had powerful new tools at their command, although only knowledgeable filmgoers might notice the new effects that are possible. Fast lenses are also important economically, since lighting is one of the most time-consuming and therefore expensive parts of filmmaking. Modern amateur cinematographers expect their Camcorders to record a decent image no matter what the light, and most do; only the professionals know how remarkable a technical feat this is. A contemporary CCD ("charge-coupled device") Camcorder is so effective at amplifying the light the lens transmits that it can serve as a night-vision scope, more efficient than the human eye.

The concept of the f-number is misleading, not only because the series of numbers that results doesn't vividly indicate the differences among various apertures, but also because, being a ratio of physical sizes, the f-number is not necessarily an accurate index of the actual amount of light entering the camera. The surfaces of

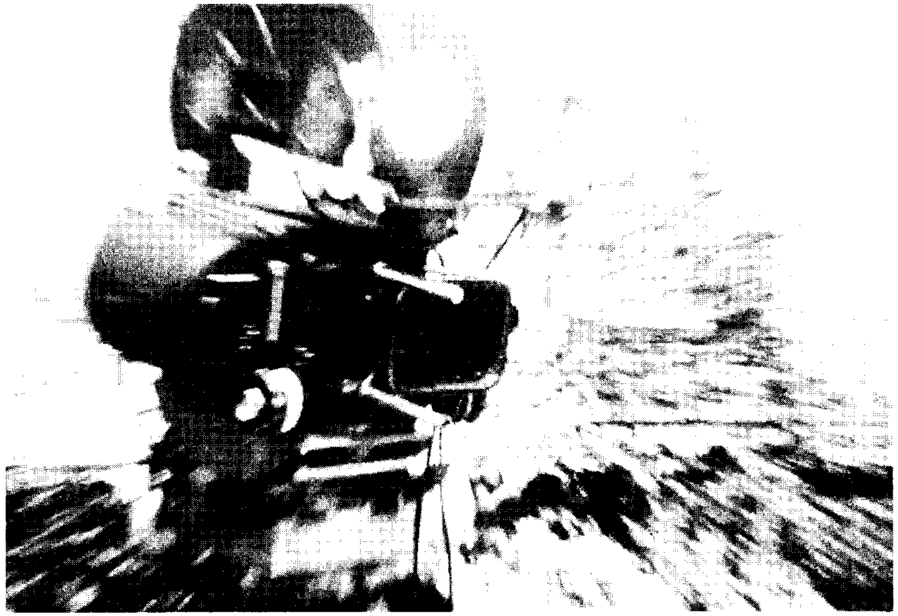


Figure 2-14. This frame enlargement from Godard's "Camera-Eye" (1967) clearly shows the effect of rapid zooming during the shot. The blurred lines aim toward the center of the image. Most zooms do not occur quickly enough to blur individual frames like this. (*l'Avant-Scène. Frame enlargement.*)

lens elements reflect small amounts of light, the elements themselves absorb small quantities; in complex multi-element lenses (especially zoom lenses) these differences can add up to a considerable amount. To correct for this, the concept of "T-number" was developed. The T-number is a precise electronic measurement of the amount of light actually striking the film.

Changing the size of the diaphragm—"stopping down"—because it effectively changes the diameter of the lens also changes the depth of field: the smaller the diameter of the lens opening, the greater the precision of focus. The result is that the more light there is available, the greater the depth of field. The phrase "depth of field" is used to indicate the range of distances in front of the lens that will appear satisfactorily in focus. If we were to measure depth of field with scientific accuracy, a lens would only truly be in focus for one single plane in front of the camera, the focus plane. But a photographer is interested not in scientific reality but in psychological reality, and there is always a range of distances both in front of and behind the focus plane that will appear to be in focus.

We should also note at this point that various types of lenses have various depth-of-field characteristics: a wide-angle lens has a very deep depth of field, while a telephoto lens has a rather shallow depth of field. Remember, too, that as

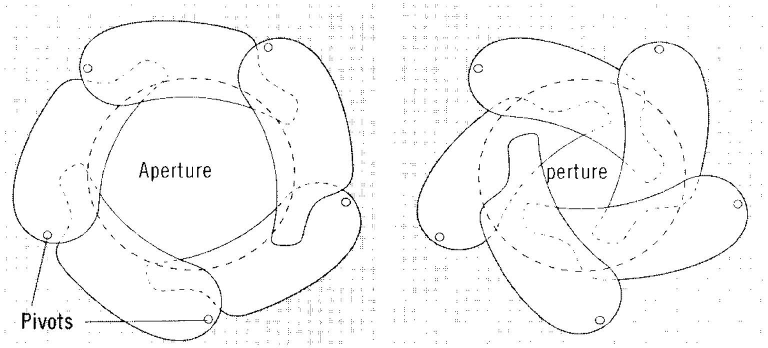


Figure 2-15. THE DIAPHRAGM. One of the simplest elements of the photographic system, as well as one of the most important, the diaphragm is constructed of wafer-thin, spring-loaded metal leaves usually five or six in number—which overlap each other so that the size of the aperture can be accurately adjusted.

each particular lens is stopped down, as the aperture is narrowed, the effective depth of field increases.

Filmmakers and photographers are thus presented with a complex set of choices regarding lenses. The style of photography that strives for sharp focus over the whole range of action is called deep focus photography. While there are a number of exceptions, deep focus is generally closely associated with theories of realism in film while shallow focus photography, which welcomes the limitations of depth of field as a useful artistic tool, is more often utilized by expressionist filmmakers, since it offers still another technique that can be used to direct the viewer's attention. A director can change focus during a shot either to maintain focus on a subject moving away from or toward the camera (in which case the term is follow focus) or to direct the viewer to shift attention from one subject to another (which is called rack focus).

The Camera

The camera provides a mechanical environment for the lens, which accepts and controls light, and the film, which records light. The heart of this mechanical device is the shutter, which provides the second means available to the photographer for controlling the amount of light that strikes the film. Here, for the first time, we find a significant difference between still and movie photography. For still photographers, shutter speed is invariably closely linked with aperture size. If

Figure 2-16. Ten candles provided all the light for this scene from Kubrick's *Barry Lyndon* (1975). Murray Melvin and Marisa Berenson. (*Frame enlargement.*)

they want to photograph fast action, still photographers will probably decide first to use a fast shutter speed to "freeze" the action, and will compensate for the short exposure time by opening up the aperture to a lower f-stop (which will have the effect of narrowing the depth of field). If, however, they desire the effect of deep focus, still photographers will narrow the aperture ("stop down"), which will then require a relatively long exposure time (which will in turn mean that any rapid action within the frame might be blurred). Shutter speeds are measured in fractions of a second and in still photography are closely linked with corresponding apertures. For instance, the following linked pairs of shutter speeds and apertures will allow the same amount of light to enter the camera:

F-STOP:	*f*1	*f*1.4	*f*2	*f*2.8	*f*4	*f*5.6	*f*8	*f*11	*f*16
SHUTTER SPEED	1/1000	1/500	1/250	1/125	1/60*	1/30	1/15	1/8*	1/4

Diagram F2 (* approximately)

In motion picture photography, however, the speed of the shutter is determined by the agreed-upon standard twenty-four frames per second necessary to synchronize camera and projector speed. Cinematographers, therefore, are strictly limited in their choice of shutter speeds, although they can control exposure time

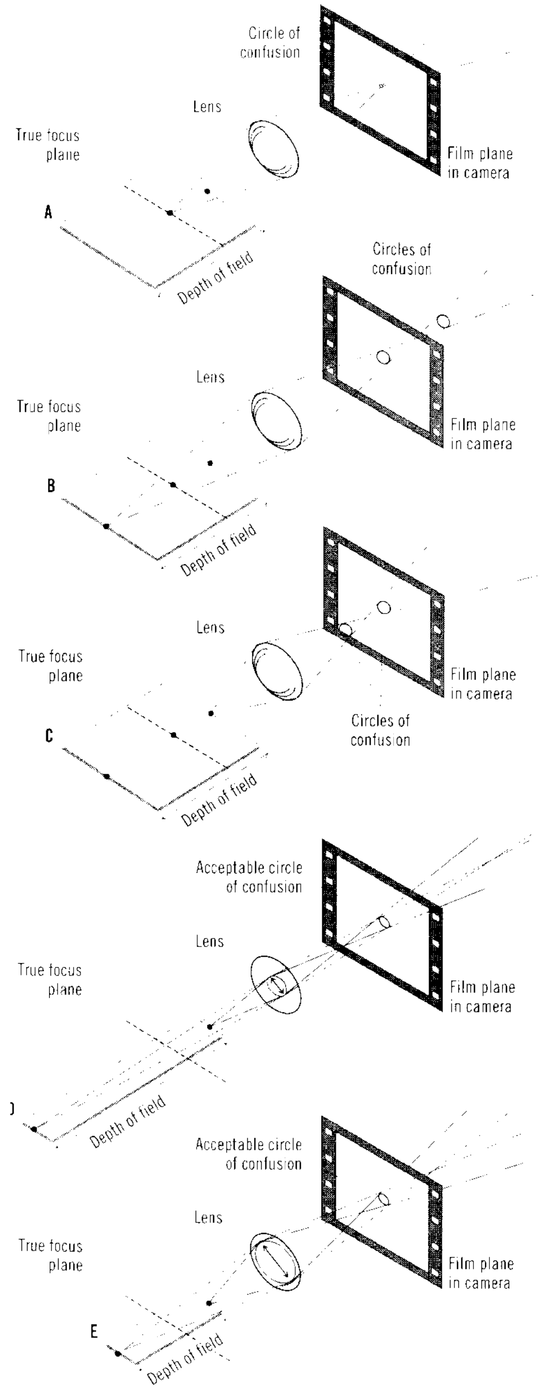


Figure 2-17. FOCUS AND DEPTH OF FIELD. Lenses bend light rays in such a way that only one plane in front of the lens is truly and accurately in focus. The dotted line in these five drawings represents that true focus plane. However, psychologically, a certain range of distances in front and in back of the focus plane will appear satisfactorily in focus. This "depth of field" is represented here by the shaded areas.

In A, an object point on the precise focus plane produces the narrowest "circle of confusion" on the film plane behind the lens. In B, an object point at the far end of the range of depth of field produces the largest acceptable circle of confusion. For objects beyond this point, the circle of confusion is such that the eye and brain read the image as being "out of focus." In C, an object point at the near boundary of depth of field produces a similarly acceptable circle of confusion. Objects nearer to the lens than this will produce an out-of-focus circle of confusion.

D and E illustrate the effect of aperture size (or diaphragm setting) on depth of field. The narrower aperture in D yields a greater depth of field, while the larger aperture in E limits the depth of field. In both illustrations, points at the near and far end of the depth of field range produce equal, acceptable circles of confusion.

In all five drawings depth of field has been slightly reduced for illustrative purposes. The calculation of the depth of field of a particular lens and aperture is a simple matter of geometry. Generally, depth of field extends toward infinity. It is much more critical in the near range than the far.

Figure 2-18. SHALLOW FOCUS. Characters are sharply in focus, background is blurred in this shot from Kubrick's *Paths of Glory* (1957). (*MOMA/FSA.*)

within narrow limits by using a variable shutter, which controls not the time the shutter is open, but rather the size of the opening. Clearly, the effective upper limit in cinematography is 1/24 second. Since the film must travel through the projector at that speed, there is no way in normal cinematography of increasing exposure time beyond that limit. This means that cinematographers are effectively deprived of one of the most useful tools of still photography: there are no "time exposures" in normal movies.

Focal length, linear distortion, distortion of depth perspective, angle of view, focus, aperture, depth of field, and exposure time: these are the basic factors of photography, both movie and still.

A large number of variables are linked together, and each of them has more than one effect. The result is, for example, that when a photographer wants deep focus he decreases the size of the aperture, but that means that less light will enter the camera so that he must add artificial light to illuminate the subject sufficiently, but that might produce undesirable side effects, so, to compensate, he will increase exposure time, but this means that it will be more difficult to obtain a clear, sharp image if either the camera or the subject is moving, so he may decide

Figure 2-19. DEEP FOCUS. One of the more extraordinary deep-focus shots photographed by Gregg Toland for Orson Welles's *Citizen Kane* (1941). The focus reaches from the ice sculptures in the near foreground to the furniture piled up behind the table at the rear. (*MOMA/FSA.*)

to switch to a wider-angle lens in order to include more area in the frame, but this might mean that he will lose the composition he was trying to achieve in the first place. In photography, many decisions have to be made consciously that the human eye and brain make instantly and unconsciously.

In movies, the camera becomes involved in two variables that do not exist in still photography: it moves the film, and it itself moves. The transport of the film might seem to be a simple matter, yet this was the last of the multiple problems to be solved before motion pictures became feasible. The mechanism that moves the film properly through the camera is known as the "pull-down mechanism" or "intermittent motion mechanism." The problem is that film, unlike audiotape or videotape, cannot run continuously through the camera at a constant speed. Films are series of still pictures, twenty-four per second, and the intermittent motion mechanism must move the film into position for the exposure of a frame, hold it in position rock steady for almost 1/24 second, then move the next frame into position. It must do this twenty-four times each second, and it must accomplish this mechanical task in strict synchronization with the revolving shutter that actually exposes the film.

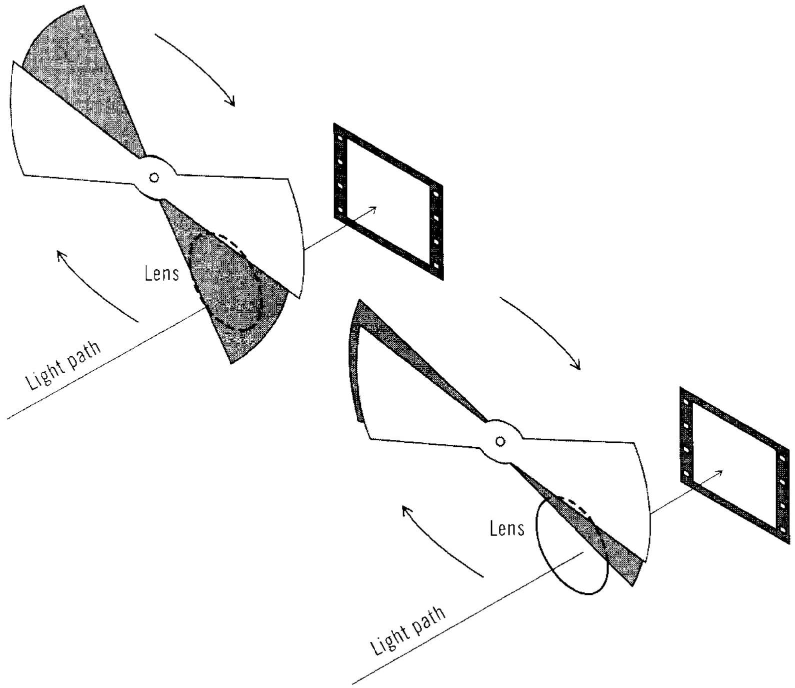


Figure 2-20. THE VARIABLE SHUTTER. In still photography, the shutter is simply a spring-loaded metal plate or fabric screen. In motion-picture photography, however, the time of exposure is limited by the 24-frame-per-second standard speed. The variable shutter allows some leeway in exposure time. Although it revolves always at the same 24 fps speed, the size of the "hole" and therefore the time of the exposure can be varied by adjusting the overlapping plates.

In the U.S., Thomas Armat is usually credited with inventing the first workable pull-down mechanism in 1895. In Europe, other inventors—notably the Lumière brothers—developed similar devices. The pull-down mechanism is literally the heart of cinema, since it pumps film through the camera or projector. The key to the success of this system of recording and projecting a series of still images that give the appearance of continuous movement lies in what Ingmar Bergman calls a certain "defect" in human sight: "persistence of vision." The brain holds an image for a short period of time after it has disappeared, so it is possible to construct a machine that can project a series of still images quickly enough so that they merge psychologically and the illusion of motion is maintained. Al Hazen had investigated this phenomenon in his book *Optical Elements*, as early as the tenth century. Nineteenth-century scientists such as Peter Mark Roget and Michael Faraday did valuable work on the theory as early as the 1820s. During

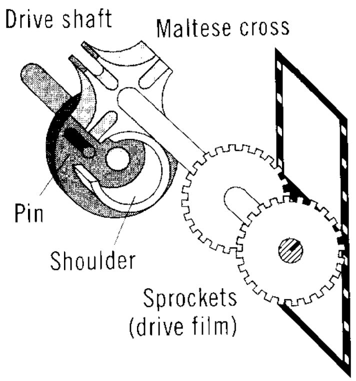
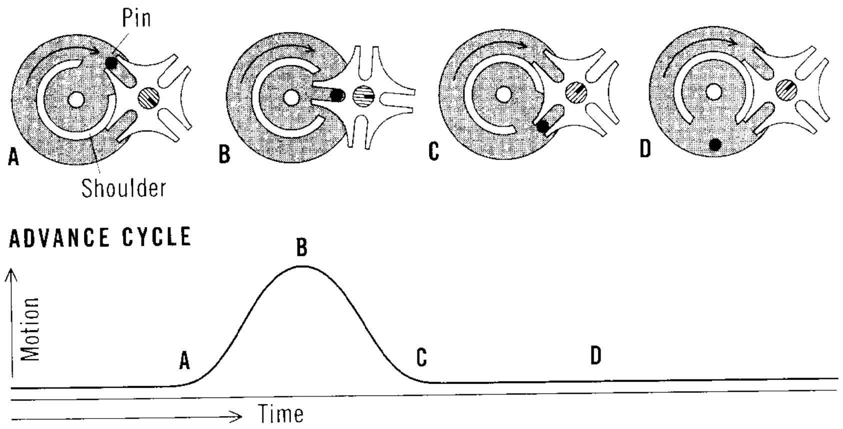


Figure 2-21.
THE MALTESE CROSS MECHANISM. The drive shaft rotates at constant speed. At the beginning of the cycle (A), the pin engages the Maltese cross gear which is connected by a shaft to the sprockets which drive the film. So long as the pin is engaged in the Maltese Cross (A,B,C), the film is moving. Through most of the cycle, the pin is not engaged and the shoulder holds the cross (and the film) steady (D). The graph describes cross and film movement throughout the full cycle.



the early years of this century Gestalt psychologists further refined this concept, giving it the name "Phi-phenomenon."

As it happens, a speed of at least twelve or fifteen pictures per second is necessary, and a rate of about forty pictures per second is much more effective. Early experimenters—W. K. L. Dickson for one—shot at speeds approaching forty-eight frames per second to eliminate the "flicker" effect common at slower speeds. It quickly became evident, however, that the flicker could be avoided by the use of a double-bladed projection shutter, and this has been in common use since the early days of film. The effect is that, while the film is shot at twenty-four frames per second, it is shown in such a way that the projection of each frame is interrupted once, producing a frequency of forty-eight "frames" per second and thus eliminating flicker. Each frame is actually projected twice.

During the silent period—especially during the earliest years when both cameras and projectors were hand-cranked—variable speeds were common: both the cameraman and the projectionist thus had a degree of control over the speed of

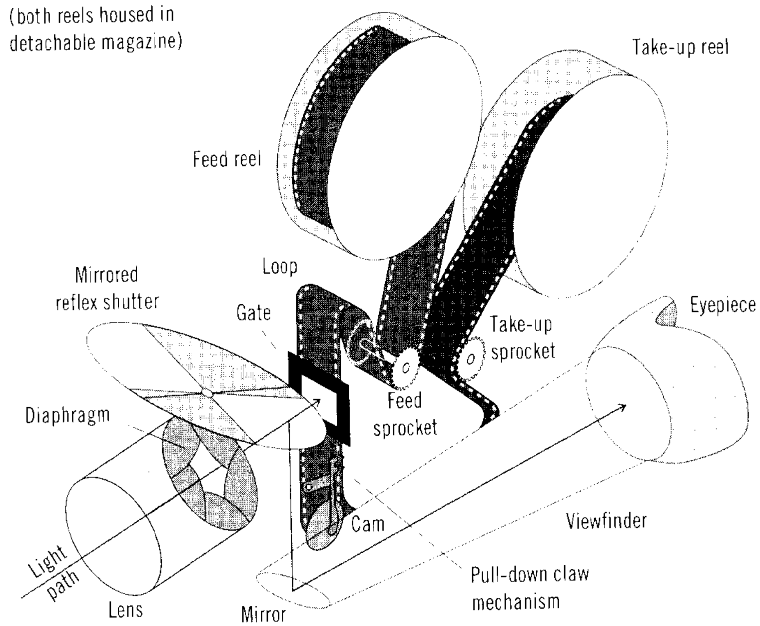


Figure 2-22. THE REFLEX CAMERA. The feed and take-up reels are housed in a separate magazine which can be changed easily and quickly. The feed and take-up sprockets run continuously. Intermittent motion in this machine is provided by a cam-mounted claw mechanism rather than the more complicated Maltese cross system illustrated in Figure 2-21. The heart of the reflex camera is the mirrored shutter. Tilted at a 45° angle to the light path, this ingenious device permits the camera operator to see precisely the same scene through the viewfinder that the film "sees." When the shutter is open, all light strikes the film. When the shutter is closed, all light is redirected into the viewfinder. The reflex camera has almost entirely replaced earlier systems with separate viewfinders, both in still and motion picture photography.

the action. The average silent speed was between sixteen and eighteen frames per second, gradually increasing over the years to twenty and twenty-two frames per second. Twenty-four frames per second did not become an immutable standard until 1927 (although even now it is not entirely universal: European television films are shot at twenty-five frames per second in order to synchronize with the European television system, whose frequency is twenty-five frames per second). When silent films are projected at "sound speed," as they often are nowadays, the effect is to make the speeded-up action appear even more comical than it was originally.

The effect of frequency is not to be underestimated. Because we grow up inundated with motion-picture and television images in the 24 fps to 30 fps range (or 48 fps to 60 fps projected), we learn to accept this moving-picture quality as standard, when it is in fact just adequate. One of the most effective ways to increase image quality is to increase frequency, which you can prove to yourself by visiting a Showscan or Imax installation. Both of these proprietary technologies for museum and theme park shows use higher frequencies. (Imax also uses wider stock.) When the U.S. standard for HDTV (high-definition television) was adopted in 1994, increased frequency was a major element of the prescription.

The genius of the device Armat invented is that it alternately moves the film and holds it steady for exposure in such a way that there is a high ratio between the amount of time the film is held still and the amount of time it is in motion. Obviously, the time during which the frame is in motion is wasted time, photographically. The sequence of operations is described in Figure 2-21. Considering the smallness of the frame, the fragility of the film, and the tremendous forces to which the tiny sprocket holes are subjected, the motion picture camera and projector are formidable mechanisms indeed. The Maltese Cross gear itself is an eloquent emblem of nineteenth-century mechanical technology.

The speed of the camera introduces another set of variables that can be useful to filmmakers, and it is in this area that cinema finds its most important scientific applications. By varying the speed of the camera (assuming the projector speed remains constant), we can make use of the invaluable techniques of slow motion, fast motion, and time-lapse (extreme fast motion) photography.

Film, then, is a tool that can be applied to time in the same ways that the telescope and the microscope are applied to space, revealing natural phenomena that are invisible to the human eye. Slow motion, fast motion, and time-lapse photography make comprehensible events that happen either too quickly or too slowly for us to perceive them, just as the microscope and the telescope reveal phenomena that are either too small or too far away for us to perceive them. As a scientific tool, cinematography has had great significance, not only because it allows us to analyze a large range of time phenomena but also as an objective record of reality. The sciences of anthropology, ethnography, psychology, sociology, natural studies, zoology—even botany—have been revolutionized by the invention of cinematography. Moreover, filmstocks can be made that are sensitive to areas of the spectrum outside that very limited range of frequencies, known as "colors," that our eyes perceive. Infrared and other similar types of photography reveal "visual" data that have hitherto been beyond our powers of perception.

The terms "slow motion" and "fast motion" are fairly self-explanatory, but it may nevertheless be useful to describe exactly what happens in the camera. If we can adjust the speed of the pull-down mechanism so that, for example, it shoots 240 frames per second instead of the standard 24, then each second of recording time will stretch out over ten seconds of projected time, revealing details of motion that would be imperceptible in real time. Conversely, if the camera takes, say, three frames per second, projected time will "happen" eight times more

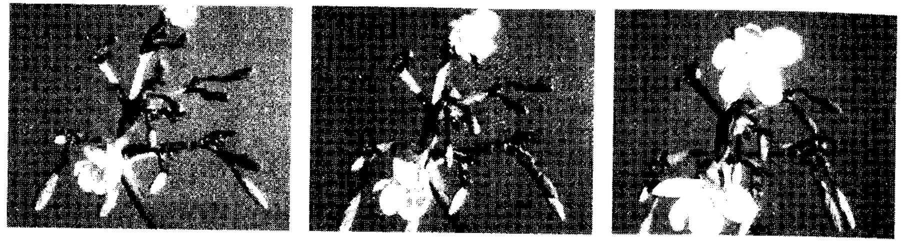


Figure 2-23. TIME-LAPSE PHOTOGRAPHY. Because film can compress (and expand) time, as a scientific tool it serves purposes similar to the microscope and telescope. (*Courtesy Archive Films. Frame enlargements.*)

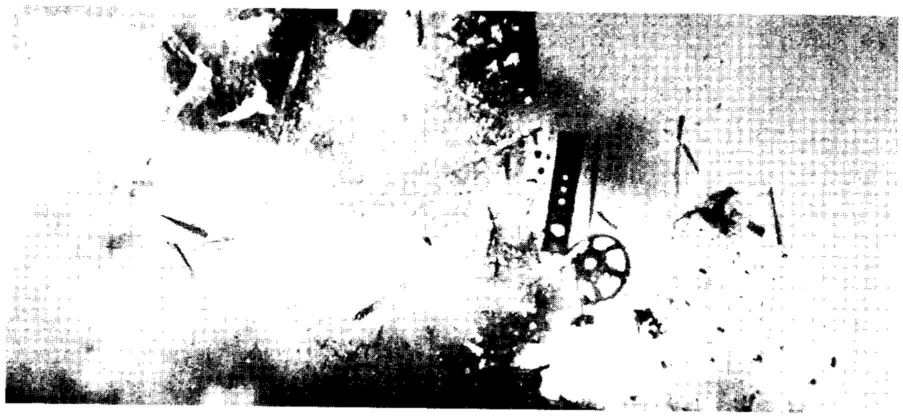


Figure 2-24. Slow motion is occasionally useful in narrative films, as well. This frame from the sequence in extreme slow motion that climaxes Michelangelo Antonioni's *Zabriskie Point* (1969) captures some of the ironic, lyrical freedom of the explosion fantasy. (*Sight and Sound. Frame enlargement.*)

quickly than real time. The term "time lapse" is used simply to refer to extremely fast motion photography in which the camera operates intermittently rather than continuously—at a rate of one frame every minute, for example. Time-lapse photography is especially useful in the natural sciences, revealing details about phenomena like phototropism, for example, that no other laboratory technique could show.

It doesn't take many viewings of slow- and fast-motion films made with primarily scientific purposes in mind before it becomes obvious that the variable speed of the motion picture camera reveals poetic truths as well as scientific ones. If the slow-motion love scene has become one of the hoariest clichés of contemporary cinema while the comedic value of fast-motion early silent movies has become a truism, it is also true that explosions in extreme slow motion (for example, the final sequence of Antonioni's *Zabriskie Point*, 1969) become symphonic celebrations of the material world, and time-lapse sequences of flowers in which a day's time is compressed into thirty seconds of screen time reveal a natural choreography that is stunning, as the flower stretches and searches for the life-giving rays of the sun.

The camera itself moves, as well as the film, and it is in this area that cinema has discovered some of its most private truths, for the control over the viewer's perspective that a filmmaker enjoys is one of the most salient differences between film and stage.

There are two basic types of camera movement: the camera can revolve around one of the three imaginary axes that intersect in the camera; or it can move itself from one point to another in space. Each of these two types of motion implies an essentially different relationship between camera and subject.

In pans and tilts, the camera follows the subject as the subject moves (or changes); in rolls, the subject doesn't change but its orientation within the frame is altered; in tracks (also known as "dollies") and crane shots, the camera moves along a vertical or horizontal line (or a vector of some sort) and the subject may be either stationary or mobile. Because these assorted movements and their various combinations have such an important effect on the relationship between the subject and the camera (and therefore the viewer), camera movement has great significance as a determinant of the meaning of film.

The mechanical devices that make camera movement possible are all fairly simple in design: the tripod panning/tilting head is a matter of carefully machined plates and ball-bearings; tracking (or traveling) shots are accomplished simply by either laying down tracks (very much like railroad tracks) to control the movement of the camera on its mount, or using a rubber-tired dolly, which allows a bit more freedom; the camera crane that allows a cinematographer to raise and lower the camera smoothly is merely a counterweighted version of the "cherry-pickers" that telephone company linesmen use to reach the tops of poles. (See Figure 3-60.)

As a result, until relatively recently, technical advances in this area were few. Two stand out. First, in the late 1950s, the Arriflex company developed a 35 mm movie camera that was considerably lighter in weight and smaller in dimension than the standard Mitchell behemoths that had become the favored instruments of Hollywood cinematographers. The Arriflex could be hand-held, and this allowed new freedom and fluidity in camera movement. The camera was now free of mechanical supports and consequently a more personal instrument. The French New Wave, in the early sixties, was noted for the creation of a new vocabulary of hand-held camera movements, and the lightweight camera made possible the style of cinéma-vérité Documentary invented during the sixties and still common today. Indeed, one of the cinematographic clichés that most identified

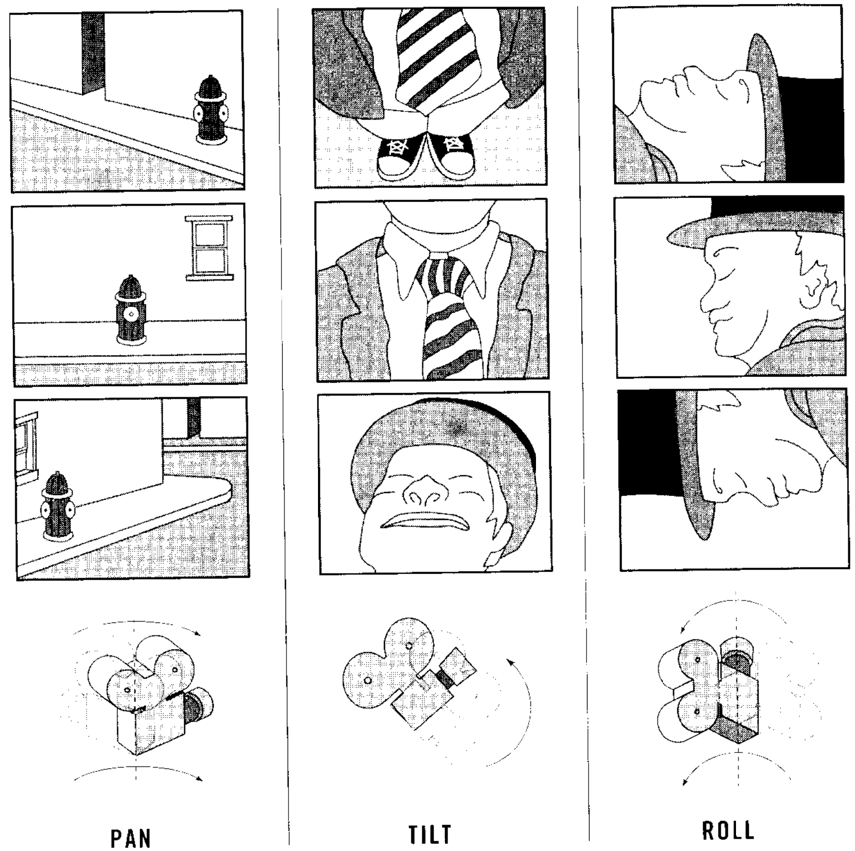


Figure 2-25. PAN, TILT, AND ROLL. The pan is by far the most common of these three elementary movements. The roll, since it disorients and doesn't provide any new information, is least common.

the 1990s was the quick-cut, jittery, hand-held exaggeration exploited in so many television commercials. The more things change, the more they remain the same.

For nearly fifteen years, hand-held shots, while inexpensive and popular, were also obvious. Shaky camera work became a cliché of the sixties. Then, in the early seventies, a cameraman named Garrett Brown developed the system called "Steadicam" working in conjunction with engineers from Cinema Products, Inc. Since then, this method of filming has gained wide popularity and has significantly streamlined the filmmaking process. In terms of economic utility, it ranks right up there with ultrafast lenses, since laying tracks is the second most time-consuming activity in film production (and the Steadicam eliminates them).

In the Steadicam system, a vest is used to redistribute the weight of the camera to the hips of the camera operator. A spring-loaded arm damps the motion of the

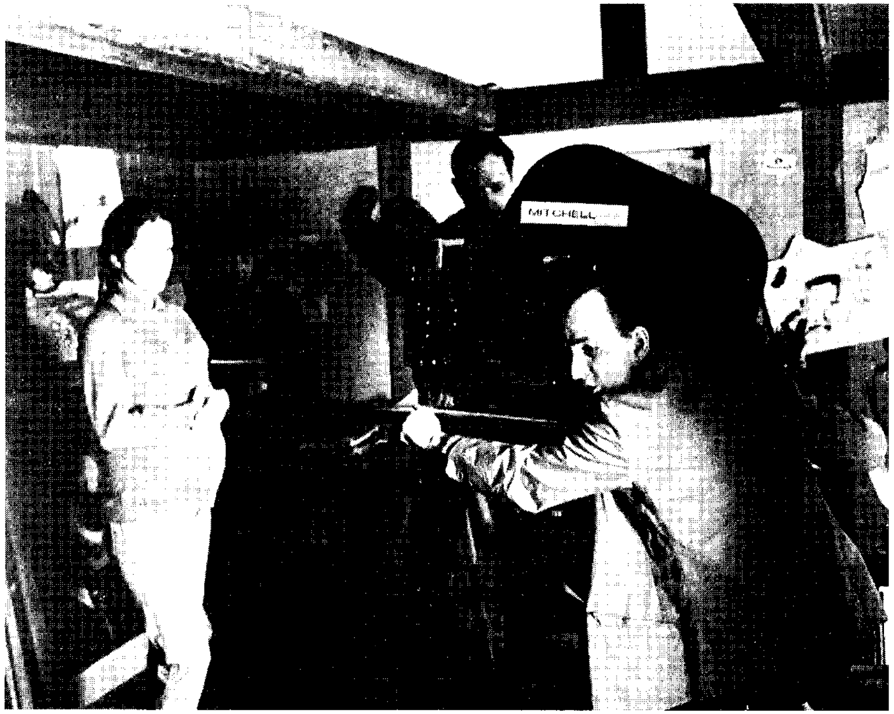


Figure 2-26. Ingmar Bergman with bulky Mitchell camera on the set of *Hour of the Wolf* (1966), Liv Ullmann to the left.

Figure 2-27. Stanley Kubrick "hand-holding" a small Arriflex: the rape scene from *A Clockwork Orange* (1971). Malcolm McDowell wears the nose.

camera, providing an image steadiness comparable to much more elaborate (and expensive) tracking and dolly shots. Finally, a video monitor frees the camera operator from the eyepiece, further increasing control of the hand-held walking shot. Steadicam operators are among the unsung artistic heroes of the film profession. Most are trained athletes; the work they do is a prodigious combination of weightlifting and ballet. Ironically, the better they do it, the less you notice.

Even a lightweight camera is a bulky device when placed on a standard crane. In the mid-seventies, French filmmakers Jean-Marie Lavalou and Alain Masseron constructed a device they called a "Louma." Essentially a lightweight crane very much like a microphone boom, it allows full advantage to be taken of lightweight cameras. The Louma, precisely controlled by servo-motors, enables the camera to be moved into positions that were impossible before and frees it from the presence of the camera operator by transmitting a video image of the scene from the viewfinder to the cinematographer's location, which can be simply outside a cramped room, or miles away, if necessary.

Devices such as the Kenworthy snorkel permit even more minute control of the camera. As the Louma frees the camera from the bulk of the operator, so the snorkel frees the lens from the bulk of the camera. There are now a number of devices that follow the Louma and Kenworthy principles—and one that represents a quantum leap for the freedom of the camera. Not satisfied with having liberated the camera from tracks and dollies, Garrett Brown developed his "Skycam" system in the mid-1980s.

With hindsight, the Skycam is an obvious offspring of the Steadicam and the Louma. The system suspends a lightweight camera via wires and pulleys from four posts erected at the four corners of the set or location. The operator sits offset, viewing the action on a monitor and controlling the movement of the camera through controls that communicate with the cable system via computer programs. Like the Steadicam before it, the Skycam is often most effective when it is least obvious. But on occasion, especially covering sports events, the Skycam provides exhilarating images that are otherwise impossible. Peter Pan never had it so good.

With the advent of these devices, most of the constraints imposed on cinematography by the size of the necessary machinery have been eliminated, and the camera approaches the ideal condition of a free-floating, perfectly controllable

Figure 2-28.
THE STEADICAM.
Springs damp the motion of the camera. The harness provides cantilevered balance.

artificial eye. The perfection of fiber optics technology extended this freedom to the microscopic level; the travels through the various channels of the human body that were science fiction when they were created by means of special effects in 1967 for the film *Fantastic Voyage* could, by the mid-seventies, be filmed "on location" for the documentary *The Incredible Machine*.

Syntax

Film has no grammar. There are, however, some vaguely defined rules of usage in cinematic language, and the syntax of film—its systematic arrangement—orders these rules and indicates relationships among them. As with written and spoken languages, it is important to remember that the syntax of film is a result of its usage, not a determinant of it. There is nothing preordained about film syntax. Rather, it evolved naturally as certain devices were found in practice to be both workable and useful. Like the syntax of written and spoken language, the syntax of film is an organic development, descriptive rather than prescriptive, and it has changed considerably over the years. The "Hollywood Grammar" described below may sound laughable now, but during the thirties, forties, and early fifties it was an accurate model of the way Hollywood films were constructed.

In written/spoken language systems, syntax deals only with what we might call the linear aspect of construction: that is, the ways in which words are put together in a chain to form phrases and sentences, what in film we call the syntagmatic category. In film, however, syntax can also include spatial composition, for which there is no parallel in language systems like English and French—we can't say or write several things at the same time.

So film syntax must include both development in time and development in space. In film criticism, generally, the modification of space is referred to as "mise-en-scène." The French phrase literally means "putting in the scene." The modification of time is called "montage" (from the French for "putting together"). As we shall see in Chapter 4, the tension between these twin concepts of mise-en-scène and montage has been the engine of film esthetics ever since the Lumières and Méliès first explored the practical possibilities of each at the turn of the century.

Over the years, theories of mise-en-scène have tended to be closely associated with film realism, while montage has been seen as essentially expressionistic, yet these pairings are deceptive. Certainly it would seem that mise-en-scène would indicate a high regard for the subject in front of the camera, while montage would give the filmmaker more control over the manipulation of the subject, but despite these natural tendencies, there are many occasions when montage can be the more realistic of the two alternatives, and mise-en-scène the more expressionistic.

Take, for example, the problem of choosing between a pan from one subject to another and a cut. Most people would say that the cut is more manipulative, that it interrupts and remodels reality, and that therefore the pan is the more realistic of the two alternatives, since it preserves the integrity of the space. Yet, in fact, the reverse is true if we judge panning and cutting from the point of view of the observer. When we redirect our attention from one subject to another we seldom actually pan. Psychologically, the cut is the truer approximation of our natural

Figure 3-17. TROPE. An ant-covered hand from Dali and Buñuel's surrealist classic *Un Chien Andalou* (1928). Another very complex image, not easily analyzed. Iconic, Indexical, and Symbolic values are all present: the image is striking for its own sake; it is a measure of the infestation of the soul of the owner of the hand; it is certainly symbolic of a more general malaise, as well. It is metonymic, because the ants are an "associated detail"; it is also synecdochic, because the hand is a part that stands for the whole. Finally, the source of the image seems to be a trope: a verbal pun on the French idiom, "avoir des fourmis dans les mains," "to have ants in the hand," an expression equivalent to the English "my hand is asleep." By illustrating the turn of phrase literally, Dali and Buñuel extended the trope so that a common experience is turned into a striking sign of decay. (I am indebted to David Bombyk for this analysis.) (*MOMA/FSA.*)

perception. First one subject has our attention, then the other; we are seldom interested in the intervening space, yet the cinematic pan draws our attention to just that.*

It was André Bazin, the influential French critic of the 1950s, who more than anyone developed the connections between mise-en-scène and realism on the one hand, and montage and expressionism on the other. At about the same time, in the middle fifties, Jean-Luc Godard was working out a synthesis of the twin notions of mise-en-scène and montage that was considerably more sophisticated than Bazin's binary opposition. For Godard, mise-en-scène and montage were divested of ethical and esthetic connotations: montage simply did in time what

* It has been suggested that the zip pan, in which the camera moves so quickly that the image in between the original subject and its successor is blurred, would be the most verisimilitudinous handling of the problem. But even this alternative draws attention to itself, which is precisely what does not happen in normal perception. Perhaps the perfect analogue with reality would be the direct cut in which the two shots were separated by a single black frame (or better yet, a neutral gray frame), which would duplicate the time (approximately 1/20 of a second) each saccadic movement of the eye takes!

Figure 3-18. METONYMIC GESTURE. Max von Sydow suffers in Ingmar Bergman's *Hour of the Wolf* (1967)...

mise-en-scène did in space. Both are principles of organization, and to say that mise-en-scène (space) is more "realistic" than montage (time) is illogical, according to Godard. In his essay "Montage, mon beau souci" (1956) Godard redefined montage as an integral part of mise-en-scène.

Setting up a scene is as much an organizing of time as of space. The aim of this is to discover in film a psychological reality that transcends physical, plastic reality. There are two corollaries to Godard's synthesis: first, mise-en-scène can therefore be every bit as expressionistic as montage when a filmmaker uses it to distort reality; second, psychological reality (as opposed to verisimilitude) may be better served by a strategy that allows montage to play a central role. (See Chapter 5.)

In addition to the psychological complexities that enter into a comparison of montage and mise-en-scène, there is a perceptual factor that complicates matters. We have already noted that montage can be mimicked within the shot. Likewise, montage can mimic mise-en-scène. Hitchcock's notorious shower murder sequence in *Psycho* is an outstanding example of this phenomenon. Seventy separate shots in less than a minute of screen time are fused together psychologically into a continuous experience: a frightening and graphic knife attack. The whole is greater than the sum of its parts (see Figure 3-21).

Figure 3-69. Gregory Peck drowns his interlocutor in a glass of milk—and we share the viewpoint and the experience—in this memorable pov shot from Hitchcock's *Spellbound*. (*Frame enlargements.*)

The two continuous channels themselves communicate in distinctly separate ways. We "read" images by directing our attention; we do not read sound, at least not in the same conscious way. Sound is not only omnipresent but also omnidirectional. Because it is so pervasive, we tend to discount it. Images can be manipulated in many different ways, and the manipulation is relatively obvious; with sound, even the limited manipulation that does occur is vague and tends to be ignored.

It is the pervasiveness of sound that is its most attractive quality. It acts to realize both space and time. It is essential to the creation of a locale; the "room tone," based on the reverberation time, harmonics, and so forth of a particular location, is its signature. A still image comes alive when a soundtrack is added that can create a sense of the passage of time. In a utilitarian sense, sound shows its value by creating a ground base of continuity to support the images, which usually receive more conscious attention. Speech and music naturally receive attention because they have specific meaning. But the "noise" of the soundtrack—"sound effects"—is paramount. This is where the real construction of the sound environment takes place.

But "noise" and "effects" are poor labels indeed for a worthy art. Possibly we could term this aspect of the soundtrack "environmental sound." The influence of environmental sound has been felt—and noticed—in contemporary music, especially in that movement known as "musique concrète." Even recorded speech has been affected by this new ability. In the great days of radio, "sound effects" were limited to those that could be produced physically. The advent of synthesizers, multitrack recording, and now computer-manipulated digitized sound has made it possible for the sound effects technicians, or "Foley artists," as they are now called, to recreate an infinite range of both natural and entirely new artificial sounds. Much of the best modern sound drama (which has appeared mainly on records, and public interest radio stations) has recognized the extraordinary

Sound

While the fact of the image is a disadvantage of a kind in terms of point of view in film narrative, the fact of sound—its ever-presence—is a distinct advantage. Christian Metz identifies five channels of information in film: (1) the visual image; (2) print and other graphics; (3) speech; (4) music; and (5) noise (sound effects). Interestingly, the majority of these channels are auditory rather than visual. Examining these channels with regard to the manner in which they communicate, we discover that only two of them are continuous—the first and the fifth. The other three are intermittent—they are switched on and off—and it is easy to conceive of a film without either print, speech, or music.

potential of what used to be known simply as sound effects. Contemporary music also celebrates this formerly pedestrian art.

Film, too, has recognized sound's new maturity. In the early days of the sound film, musicals, for instance, were extraordinary elaborate visually. Busby Berkeley conceived intricate visual representations of musical ideas to hold an audience's interest. Now, however, the most powerful film musical form is the simple concert. The soundtrack carries the film; the images are dominated by it.

We can conceive of nonmusical cinema in this vein as well. In England, where radio drama lasted longer than in the U.S., a tradition of aural drama was maintained from the *Goon Shows* of the 1950s through *Monty Python's Flying Circus* of the 1970s.

In the U. S. much of the best comedy has been almost exclusively aural since the days of vaudeville: beginning with the masters Jack Benny, George Burns, and Fred Allen, this exuberant if unsung tradition has given us Nichols and May, Mel Brooks, and Bill Cosby; the complex "cinematic" constructions of the Firesign Theatre and Albert Brooks; and the "new commentary" of Billy Crystal, Whoopi Goldberg, Jerry Seinfeld, and Steven Wright. Much of this recent comedy extends the boundaries of the old vaudeville tradition: aural artists have moved into more complex modes.

In cinema, Francis Ford Coppola's fascinating *The Conversation* (1974) did for the aural image what *Blow-up* (1966) had done for the pictorial image eight years earlier. While the soundtrack can certainly support greater emphasis than it has been given, it cannot easily be divorced from images. Much of the language we employ to discuss the codes of soundtracks deals with the relationship between sound and image. Siegfried Kracauer suggests the differentiation between "actual" sound, which logically connects with the image, and "commentative" sound, which does not. Dialogue of people in the scene is actual, dialogue of people not in the scene is commentative. (A filmmaker sophisticated in sound, such as Richard Lester, often used commentative dialogue of people who were in the shot, but not part of the action of the scene.)

Director and theorist Karel Reisz used slightly different terminology. For Reisz, who wrote a standard text on editing, all sound is divided into "synchronous" and "asynchronous." Synchronous sound has its source within the frame (the editor must work to synchronize it). Asynchronous sound comes from outside the frame.

Combining these two continuums, we get a third,* whose poles are "parallel" sound and "contrapuntal" sound. Parallel sound is actual, synchronous, and connected with the image. Contrapuntal sound is commentative, asynchronous, and opposed to or in counterpoint with the image. It makes no difference whether we are dealing with speech, music, or environmental sound: all three are at times variously parallel or contrapuntal, actual or commentative, synchronous or asynchronous.

The differentiation between parallel and contrapuntal sound is perhaps the controlling factor. This conception of the soundtrack as working logically either with or against the image provides the basic esthetic dialectic of sound. The Hollywood sound style is strongly parallel. The programmatic music of thirties movies nudged, underlined, emphasized, characterized, and qualified even the simplest scenes so that the dullest images as well as the most striking were thoroughly pervaded by the emotions designed by the composers of the nearly continuous music track. Erich Wolfgang Korngold and Max Steiner were the two best-known composers of these emotionally dominating scores.

In the experimental 1960s and 1970s, contrapuntal sound gave an ironic edge to the style of film music. Often the soundtrack was seen as equal, but different from, the image. Marguerite Duras, for example, experimented with commentative soundtracks completely separate from the image, as in *India Song* (1975). In the 1980s, Hollywood returned to programmatic music. John Williams, composer of the soundtracks for many of the blockbusters of the late 1970s and 1980s from

* I am indebted to Win Sharples Jr, "The Aesthetics of Film Sound," *Filmmakers Newsletter* 8:5, for this synthesis.

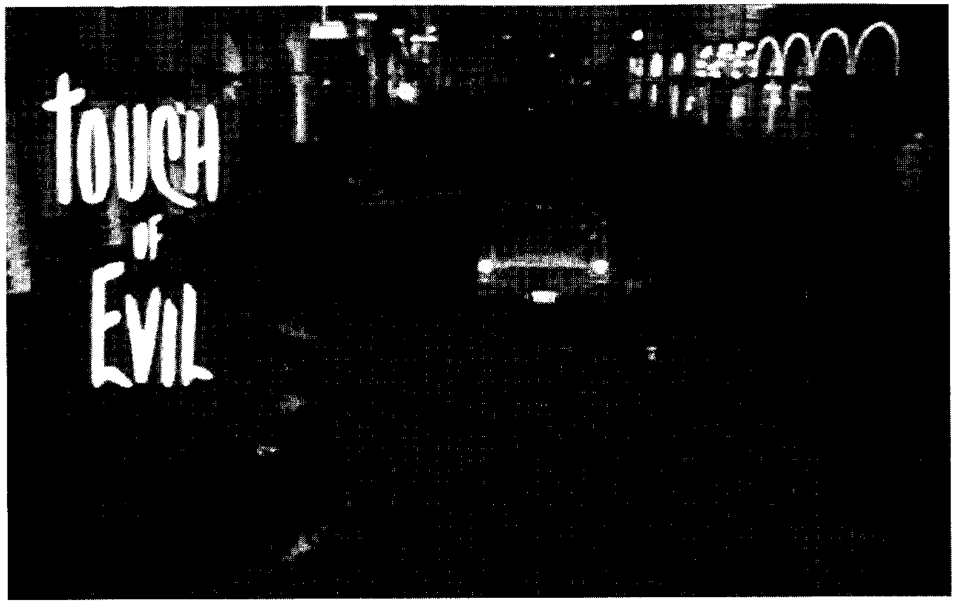


Figure 3-70. The title frame from Orson Welles's tour de force establishing track at the beginning of *Touch of Evil* (1958). In a few minutes, we know all that we need to know. (*Frame enlargement.*)

Jaws (1975) and *Star Wars* (1977) to *Home Alone* (1990) and *Jurassic Park* (1993), has defined the musical themes of a generation, just as his notable predecessors had done. But music is still used commentatively as well. Rock, for example, offers filmmakers a repertoire of instant keys to modern ideas and feelings, as George Lucas's *American Graffiti* (1973), Lawrence Kasdan's *The Big Chill* (1983), or any of the films of John Hughes demonstrated clearly.

Ironically, music—which used to be the most powerfully asynchronous and commentative element of the soundtrack—has now become so pervasive in real life that a filmmaker can maintain strict synchronicity of actual sound and still produce a complete music track. The ubiquitous Walkman radio and Boom Box have made life a musical.

Montage

In the U.S., the word for the work of putting together the shots of a film is "cutting" or "editing," while in Europe the term is "montage." The American words suggest a trimming process, in which unwanted material is eliminated. Michelangelo once described sculpture similarly as paring away unneeded stone to discover the natural shape of the sculpture in a block of marble. One edits or cuts raw material down. "Montage," however, suggests a building action, working up from the raw material. Indeed, the classic style of Hollywood editing of the thirties and forties, revived in part in the eighties—what the French call découpage classique—was in fact marked by its smoothness, fluidity, and leanness. And European montage, ever since the German Expressionists and Eisenstein in the twenties, has been characterized by a process of synthesis: a film is seen as being constructed rather than edited. The two terms for the action express the two basic attitudes toward it.

Whereas mise-en-scène is marked by a fusion of complexities, montage is surprisingly simple, at least on the physical level. There are only two ways to put two pieces of film together: one can overlap them (double exposure, dissolves, multiple images), or one can put them end to end. For images, the second alternative dominates almost exclusively, while sounds lend themselves much more readily to the first, so much so that this activity has its own name: mixing.

In general parlance, "montage" is used in three different ways. While maintaining its basic meaning, it also has the more specific usages of:

- a dialectical process that creates a third meaning out of the original two meanings of the adjacent shots; and
- a process in which a number of short shots are woven together to communicate a great deal of information in a short time.

This last is simply a special case of general montage; the dialectical process is inherent in any montage, conscious or not.

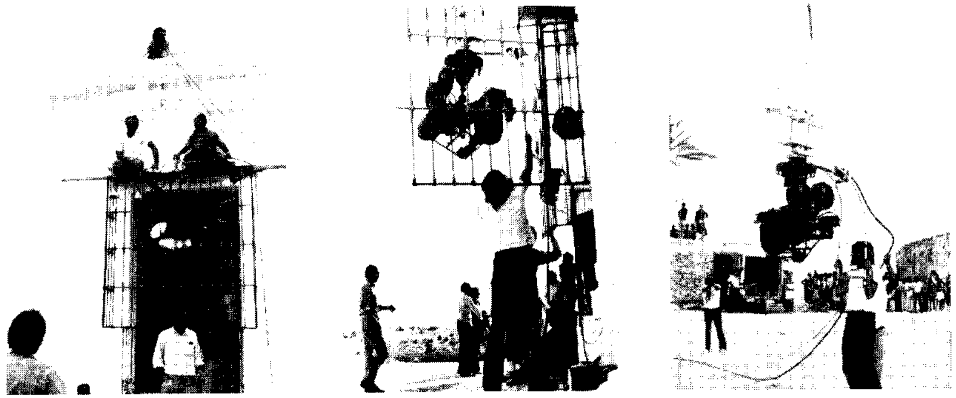


Figure 3-71. To end *The Passenger* with a long, majestic, and mysterious track up to and through a window, Antonioni set up this complex apparatus—sort of a combination of a Steadicam, Skycam, and overhead track. The operator guided the camera, suspended from a crane, up to the window grill, which grips then opened while attaching the camera to the crane so that it could move out into the courtyard.

Découpage classique, the Hollywood style of construction, gradually developed a broad range of rules and regulations: for example, the practice of beginning always with an establishing shot, then narrowing down from the generalization; or, the strict rule of thumb for editing dialogue scenes with master shots and reverse angles. All the editing practices of the Hollywood grammar were designed to permit seamless transitions from shot to shot and to concentrate attention on the action at hand. What helped to maintain immediacy and the flow of the action was good; what did not was bad.

In fact, any kind of montage is in the end defined according to the action it photographs. Still pictures can be put together solely with regard to the rhythm of the succeeding shots. Diachronic shots, inherently active, demand that the movements within the shot be considered in the editing. The jump cut, where the natural movement is interrupted, provides an interesting example of the contrasting ways in which découpage classique and contemporary editing treat a problem.

In Hollywood cinema, "invisible cutting" was the aim, and the jump cut was used as a device to compress dead time. A man enters a large room at one end, for instance, and must walk to a desk at the other end. The jump cut can maintain tempo by eliminating most of the action of traversing the long room, but it must do so unobtrusively. The laws of Hollywood grammar insist that the excess dead time be smoothed over either by cutting away to another element of the scene (the desk itself, someone else in the room) or by changing camera angle sufficiently so that the second shot is clearly from a different camera placement. Simply snipping out the unwanted footage from a single shot from a single angle is not permitted. The effect, according to Hollywood rules, would be disconcerting.

Modern style, however, permits far greater latitude. In *Breathless* (1959), Jean-Luc Godard startled some estheticians by jump cutting in mid-shot. The cuts had no utilitarian value and they were disconcerting. Godard himself seldom returned to this device in later films, but his "ungrammatical" construction was absorbed into general montage stylistics, and jump cuts are now allowed for rhythmic effect. Even the simple utilitarian jump cut has been streamlined: edited from a single shot (single angle), it can be smoothed by a series of quick dissolves.

The lively 1960s films of Richard Lester—especially his musicals *A Hard Day's Night* (1964), *Help!* (1965), and *A Funny Thing Happened on the Way to the Forum* (1966)—popularized jump cuts, rapid and "ungrammatical" cutting. Over time, his brash editorial style became a norm, now celebrated every night around the world in hundreds of music videos on MTV. Because these video images now dominate our lives it's hard to understand how fresh and inventive these techniques seemed in the 1960s. Because this style is now so pervasive in music videos, Lester must be counted as—at least in one sense—the most influential film stylist since D. W. Griffith. Except for morphs, there are few techniques of contemporary music videos that Richard Lester didn't first try in the 1960s. (But then, there isn't much about contemporary music that the Beatles and their colleagues didn't first explore in the 1960s.)

It's important to note that there are actually two processes going on when shots are edited. The first is the joining of the two shots. Also important, however, is determining the length of any individual shot, both as it relates to shots that precede and follow it and as it concerns the action of the shot. Découpage classique demands that a shot be cut so that the editing doesn't interfere with the central action of the shot. If we plot the action of each shot so that we get a rising then a falling curve, Hollywood grammar demands a cut shortly after the climax of the curve. Modern directors like Michelangelo Antonioni, however, reversed the logic, maintaining the shot long after the climax, throughout the period of aftermath. The last shot of *The Passenger* (1975) is an excellent example.

The rhythmic value of editing is probably best seen in the code of "accelerated montage," in which interest in a scene is heightened and brought to a climax through progressively shorter alternations of shots between two subjects (often in chase scenes). Christian Metz pointed to accelerated montage as a uniquely cinematic code (although Charles Ives's antagonistic brass bands provided an illustration of this kind of cross-cutting in music). Accelerated montage points in the direction of a second type of editing.

Montage is used not only to create a continuity between shots in a scene but also to bend the time line of a film. "Parallel" montage allows the filmmaker to alternate between two stories that may or may not be interrelated, cross-cutting between them. (Accelerated montage is a special type of parallel montage.) The flashback and the flash-forward permit digressions and forecasts. "Involuted"

Figure 3-72. Robert Altman's magnificent satire of the film industry, *The Player* (1992), begins with a reel-long tracking shot which is the equal of Murnau's, Welles's, or Godard's: establishing the location, setting up the action, introducing the characters, passing by small incidental dramas, tossing off inside jokes, peering in windows, and, postmodernly talking about its antecedents at the same time that it pays homage to them, even while Altman's own shot surpasses those of his predecessors, distanced with insouciant wit, as if to say, "long tracking shots, like long sentences, separate the players from the rest." (*Frame enlargement.*)

montage allows a sequence to be narrated without particular regard for chronology: an action can be repeated, shots can be edited out of order. Each of these extensions of the montage codes looks toward the creation of something other than simple chronology in the montage itself, a factor very little emphasized in classic découpage continuity cutting.

Possibly the most common dialectic device is the match cut, which links two disparate scenes by the repetition of an action or a form, or the duplication of mise-en-scène. Stanley Kubrick's match cut in *2001: A Space Odyssey* (1968), between a prehistoric bone whirling in the air and a twenty-first-century space station revolving in space, is possibly the most ambitious match cut in history, since it attempts to unite prehistory with the anthropological future at the same time as it creates a special meaning within the cut itself by emphasizing the functions of both bone and space station as tools, extensions of human capabilities.

The codes of montage may not be as obvious as the codes of mise-en-scène, but that doesn't mean that they are necessarily less complex. Few theorists have gone further than differentiating among parallel montage, continuity montage, accelerated montage, flashbacks, and involuted montage. In the 1920s, both V. I. Pudovkin and Sergei Eisenstein extended the theory of montage beyond these ments of film. These must be either autonomous shots—which are entirely independent of what comes before and after them—or what he calls "syntagmas"—units that have meaningful relationships with each other. (We might call these "scenes" or "sequences," but Metz reserves those terms for individual types of syntagma.) At each stage of this binary system, a further differentiation is made: the first bracket differentiates between autonomous shots and related shots, clearly the primary factor in categorizing types of montage. Either a shot is related to its surrounding shots, or it is not.

The second bracket differentiates between syntagmas that operate chronologically and those that do not. In other words, editing either tells a story (or develops an idea) in chronological sequence, or it does not. Now, on the third level, the differentiations branch out. Metz identifies two separate types of achronological syntagmas, the parallel and the bracket. Then he differentiates between two types of chronological syntagmas: either a syntagma describes or it narrates. If it narrates, it can do so either linearly or nonlinearly. If it does so linearly, it is either a scene or a sequence. And finally, if it is a sequence, it is either episodic or ordinary.

The end result is a system of eight types of montage, or eight syntagmas. The autonomous shot (1) is also known as the sequence shot (although Metz also places certain kinds of inserts—short, isolated fragments—here). The parallel syntagma (2) has been discussed above as the well-known phenomenon of parallel editing. The bracket syntagma (3), however, is Metz's own discovery—or invention. He defines it as "a series of very brief scenes representing occurrences that the film gives as typical examples of a same order or reality, without in any way chronologically locating them in relation to each other" [Metz, p. 126].

This is rather like a system of allusions. A good example might be the collection of images with which Godard began *A Married Woman* (1964). They all alluded to modern attitudes toward sex. Indeed, Godard in many of his films seemed to be particularly fond of the bracket syntagma, since it allows film to act something like the literary essay.

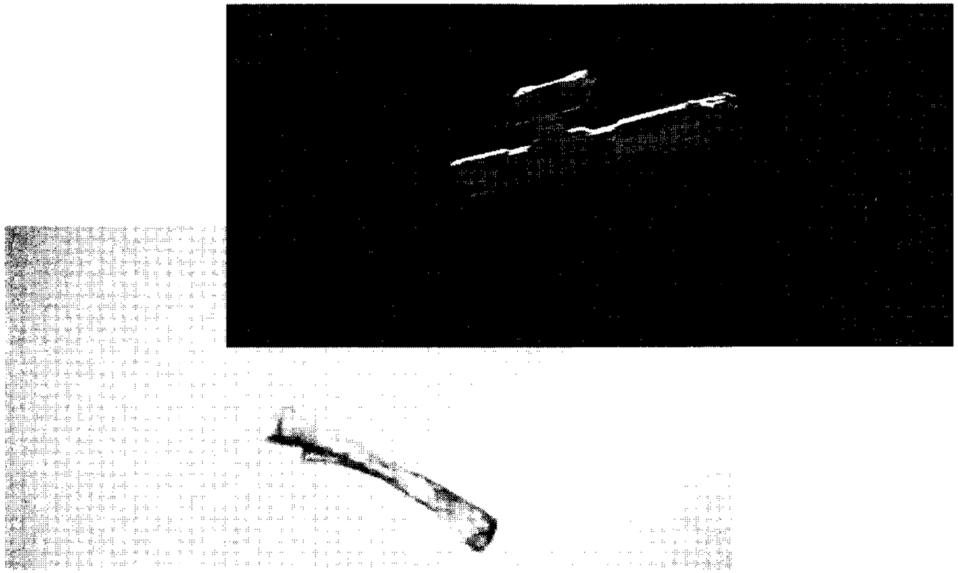


Figure 3-73. Kubrick's transcendent match cut. (*Frame enlargements.*)

essentially practical concerns. Pudovkin identified five basic types of montage: contrast, parallelism, symbolism, simultaneity, and leitmotif. He then developed a theory of the interaction between shots variously called "relational editing" or "linkage." Eisenstein, on the other hand, saw the relationship between shots as a collision rather than a linkage, and further refined the theory to deal with the relationships between elements of individual shots as well as the whole shots themselves. This he called the "montage of attractions." Both theorists are discussed in greater detail in Chapter 5.

In the late sixties, Christian Metz attempted to synthesize all these various theories of montage. He constructed a chart in which he tried to indicate how eight types of montage were connected logically. There are a number of problems with Metz's categories, yet the system does have an elegance all its own and it does describe most of the major patterns of montage. More important, despite its idiosyncrasies and occasional confusions, it remains the only recent attempt to comprehend the complex system of montage.

Note that Metz is interested in narrative elements—syntagmas—that can exist within shots as well as between them, an important refinement since, as we have already indicated, the effects of many types of montage can be accomplished within a shot without actually cutting. If the camera pans, for example, from one scene to another, those two scenes exist in relationship to each other just as they would if they were cut together.

Metz's grand design may seem forbidding at first glance, but it reveals a real and useful logic when studied. He begins by limiting himself to autonomous seg-