Camera Description and Development

A camera is a device that directs an image focused by a lens or other optical system onto a photosensitive surface housed in a lighttight enclosure. In this very basic sense, these components perform the same function today that they did when photography was invented nearly 150 years ago.

In simple cameras the lens is generally of the fixed-focus variety: no provision is made to focus on objects at varying distances from the camera. More complicated cameras have a system to achieve good focus that is manually or automatically actuated, in order to vary the lens-to-focal-plane distance. (The focal plane is the point behind the lens where the image comes to focus.)

The photographic surface used in modern cameras is almost exclusively light-sensitive film. Flexible roll film may be housed in a cassette or on a paper-backed spool. A gear mechanism built into the camera advances the film between exposures. On professional, large-format cameras the film is a fairly stiff sheet that is carried in a holder to be inserted into the focal-plane area after the image has been focused.

Cameras are manufactured in a variety of types and sizes. Miniature instruments producing incredibly small images are used in medical research. Commercial portrait studios may use large-format view cameras that produce a film image as large as 11 x 14 inches.

The electronics revolution has had an immense impact on camera design, making possible instruments of remarkable sophistication in almost every price range.

Camera Development

Centuries before the invention of the first practical photographic process, artists had been using a device called Camera Obscura, literally a dark chamber, as an aid in rendering proper perspective or tracing a scene. Originally, in fact, it was a dark room, with a small opening in an outside wall. An image of an illuminated object outside the room passed through the hole and was reproduced, upside down and in small scale, on an opposite wall. Later, a lighttight box replaced the room, and a simple lens was inserted in the hole. In 1839 the pioneer inventor Louis J. M. Daguerre developed the light-sensitive Daguerreotype, a photographic plate on which a camera obscura image could be held and fixed permanently. That same year, a French firm began production of the world's first commercial camera. In basic design, this instrument was remarkably like a camera obscura. The surface on which an artist sketched the projected image became a removable piece of ground glass, onto which the image could be brought into focus. After the photographer focused the image, the ground glass was replaced by a special wooden frame, which held the light-sensitive plate. Moving a simple, manually operated slide, or simply removing the lens cap for a time, made the exposure. Even after the early processes were speeded up sufficiently to make portraiture possible, exposures of 10 to 15 seconds were not uncommon. The absence of a film-exposure mechanism (shutter) continued throughout the entire wet-plate.

The development of the gelatin dry plate in the 1870's began a revolution in camera design that was accelerated by the invention of flexible film. These dry, sensitized materials allowed designers to make very compact instruments that were much more convenient to operate.

The introduction of the Kodak camera in 1888 brought about massive, permanent changes in the world of photography. The Kodak was preloaded at the factory with sufficient film for 100 exposures. When the roll was finished, the entire camera was returned to the factory in Rochester, NY, where the film was developed and printed and the camera reloaded. In a single stroke, George Eastman had created the class of amateur photographers, those who wanted to take pictures but were unwilling to deal with the darkroom machines of the photographic process. The sales motto "You press the button, we do the rest" accurately summed up the new system. In 1900 the marketing of Eastman's Kodak Brownie #1 popularized photography even further. At a cost of $1.00 for the camera and 10 cents per roll of film, the Brownie put a basic photographic system within reach of virtually everyone.

The continuing improvements of sensitized film products were paralleled by the development of more sophisticated cameras. The first optical rangefinder became available in 1916, and a very high-speed lens, the Ernostar, which had an effective aperture of f/20, appeared on a compact camera in 1924, marking the beginning of the era of natural-light candid photography.

With the introduction in 1938 of the Super Kodak 620, complete automation of camera exposure systems moved a step closer to realization. A very costly snapshot camera, the Kodak 620 was the first to incorporate a completely automated method of exposure control. Only a few of these cameras were made before World War II stopped production, but the Super Kodak 620 indicated what was possible. After the war, miniaturized electronic components made automatic exposure systems commonplace on even the most inexpensive cameras. The process of automating most camera functions was completed in the late 1970's, when the first of what have come to be known as "point and shoot" cameras appeared on the market. These cameras, so simple to use that even beginners can take satisfactory pictures, now dominate the amateur market.

The evolution of camera design in the professional market tends to be a more gradual process. Professional models are available with automatic exposure-control systems, and several advanced professional cameras offer automatic focusing.

The Parts of the Camera

Lens

The lens is the image-forming device on a camera. It may be composed of from one to as many as 10 or 12 elements. The first cameras were fitted with a single-element meniscus lens (a lens with one concave and one convex surface). In addition to its very low speed, this type of lens suffered from a number of inherent optical defects and it was soon replaced with greatly improved, more complicated designs. The single-element lens remained in use on inexpensive cameras, however, and within limits was capable of producing very acceptable results.

The three basic types of lenses are normal, wide angle, and telephoto. The lens's focal length—the point at which light rays converge, or focus, through the lens—determines the size of the image that will be produced on the film. With a normal lens, the viewing field is approximately 50 degrees. The objects photographed appear normal in size and shape, relative to the picture's background. A camera that uses a 35-mm film will usually have a 50-mm lens for normal coverage; on a medium-format 2 1/4" x 2 1/4" camera, the same coverage is obtained with an 80-mm lens. Many photographers use the diagonal of the negative image to determine the best focal length for a "normal" shot.

In a wide-angle lens, the field of view is much wider: about 90 degrees. These lenses are used where the distance between camera and subject is limited, as in interior photography. The wide-angle lens is also used to make smaller objects look larger (to give a spacious impression of a small room, for instance), or to photograph large objects from close up. Telephoto, or long-focus lenses, have a smaller field of view than a normal lens, and show an enlarged detail of the image over the same film area. Interchangeable-lens cameras offer the photographer the opportunity to select a focal length that is optimum for any given situation. In recent years, variable-focal-length, or "zoom," lenses, have become very popular. A single lens of this type can replace many individual lenses, and offers a great convenience to the photographer.

The speed, or light-gathering power, of a lens is indicated by the *f/*number, called the aperture. The lower the *f/*number, the faster the lens—that is, the more light it lets through. A fast lens has an aperture of at least *f/*2.0. As the speed increases, the cost of the lens tends to increase, since it is more costly to maintain high standards of optical correction at very high apertures.

Diaphragm–The Camera "Valve"

One of the two factors that determines correct film exposure is the amount of light allowed to pass through the lens.

Mechanically reducing the aperture improves optical performance, particularly toward the edge of the picture, and increases the depth of field, which is the zone of good focus.

Older camera used fixed aperture sizes, often no more than a round hold in a metal mask. Some had adjustable apertures via the use of interchangeable metal masks with different sized holds. One popular system was one known as "Waterhouse" stops.

Today, however, most cameras use an iris-type diaphragm, which consists of a number of very thin metal blades. They are so mounted that by rotating a ring or moving a lever, the size of the lens opening can be varied. On automatic cameras the diaphragm is adjusted by a built-in mechanism to produce the optimum exposure over a wide range of lighting conditions.

The various openings of the diaphragm—called *f*-stops—are stamped on the lens mounting. Each change of diaphragm opening changes the amount of light passing through the lens by a factor of 2. For example, the amount of light allowed through the lens at a setting of 2 is twice the amount allowed through the lens at a setting of 2.8. The standard diaphragm settings found on most lenses are 2, 2.8, 4, 5.6, 8, 11, 16, 22, and so on. The smallest lens opening on a lens whose *f*-stops end in 22 is, in fact, 22.

Shutter–The Camera "Switch"

The second exposure control factor is the shutter, a mechanical device that acts as a gate, controlling the duration of time that light is allowed to pass through the lens and fall on the film. Two types of shutters are in general use. The leaf type, like the diaphragm, is made up of a number of thin metal blades that are opened and closed either by a spring-driven clockwork mechanism, or—in many recent models—by an electromechanical device. Shutters of this type usually have a maximum speed of 1/500th of a second.

The focal-plane shutter in modern cameras usually consists of two pieces of rubberized fabric that move across the focal plane. The spacing between the fabric edges and the speed of transit determine the effective shutter speed. Some recent models use ultrathin pieces of titanium instead of fabric. Shutters of this type are capable of very high speeds, in some cases 1/4,000th of a second. The entire shutter mechanism is independent of the optical system, and it is therefore ideal for cameras with interchangeable lenses.

Exposure Control

Many professional photographers still use exposure meters, which are instruments that measure light intensity, indicated what aperture and shutter speed are appropriate to the film type used, under prevailing light conditions. Completely automatic exposure control, however, is now virtually standard on all snapshot cameras, although many new professional instruments offer an automatic system that permits the photographer to retain a great deal of individual control.

On nonreflex instruments, a selenium cell mounted adjacent to the lens measures the incoming light and selects a combination of lens aperture and shutter speed that will produce a negative of good quality. Single-lens reflex cameras almost without exception are fitted with through-the-lens metering systems (TTLs) that offer the ultimate in automated control of exposure. A light-sensing cell is located in the optical path inside the camera and gives an extremely accurate reading of the prevailing light conditions. The information is processed by an electronic circuit built into the camera, and the aperture and shutter speed are set accordingly.

The newest 35-mm cameras can use film cassettes that are magnetically or optically encoded with numbers that tell the camera what type of film is in the cassette, and then adjust the camera speed accordingly.

The Viewfinder

For the photographer, the viewfinder defines the area covered by whatever lens is in use on the camera. The most primitive type is a simple wire frame mounted just over the lens. Proper eye position is determined by a vertical post mounted at the rear of the camera. The view seen through the frame with the post in the center is equal to the area covered by the lens.

The type of viewfinder in most frequent use today is actually a reversed telescope on all cameras except single and twin-lens reflex instruments. On a typical high-grade 35-mm camera with interchangeable lenses, a bright line in the viewfinder outlines the area covered by the lens in use, and changes size automatically to correspond with the lenses of different focal lengths. In a single-lens reflex camera the image focused by the camera lens is reflected by a mirror onto a ground-glass screen, usually through a special prism arrangement. Twin-lens reflex cameras have two coupled lenses; one of them acts as a viewfinder and, like the single-lens reflex, reflects the image it sees on a ground-glass screen.

Focusing Methods

On adjustable-lens cameras, a sharp picture requires accurate positioning of the lens system. Although its use has declined sharply, the optical-coupled rangefinder is one of the best methods of achieving good focus quickly. If the camera is out of focus, the user sees a double image in a portion of the viewfinder field. Focusing the lens brings the two images together, until—as the lens moves into focus—they are perfectly aligned.

In the single- and twin-lens reflex cameras, the image is visually focused on the ground glass in the viewfinder. Ground glass is used, whether or not the camera is fitted with a prism system for eye-level viewing. Because of the very slight distance between the picture-taking lens and the viewfinder lens in a twin-lens reflex camera, in close-ups the view seen by the photographer does not precisely match the view focused on the film. This very slight difference is called “parallax,” and there are various devices available to correct for it.

Many modern cameras used by the casual user are fitted with automatic focusing systems. There are two general types, active and passive. In the active system, a circuit so elaborate that it is actually a complete miniature computer sends out an infrared beam. This beam bounces off the photographic subject and is reflected back to the camera. By electronically measuring the angle of the beam, the distance to the subject can be determined. A servomotor than adjusts the lens appropriately.

The passive system works on the principle that an in-focus subject will show more contrast than an out-of-focus subject. A CCD (Charge-Coupled Device) light mounted behind the lens will search out the point of greatest contrast and set the lens. Single-lens reflex cameras often use this type of automatic focusing.

TYPES OF CAMERAS

For more than several decades the box camera was the instrument of choice for the casual amateur photographer. Inexpensive and simple, it was, nevertheless, capable of excellent results under many conditions. Box cameras were normally fitted with a single-element lens, a limited range of aperture control, and a single-speed leaf shutter.

The Folding-Roll Film Camera

Second in popularity only to the box camera, the folding camera was manufactured in a variety of formats. Basically, though, it was a box camera whose lens was incorporated into a movable bellows that could slide back and forth on a rail, allowing the lens to change focus. Lenses and shutters were often one-piece units. More elaborate models were first-rate instruments with high-quality optical systems and precision shutters. Many were fitted with coupled rangefinders. The most significant advantage they have over the box camera, however, was their compact design when folded, which made them easier to pack and transport.

There has been something of a minor renaissance in folding-roll film cameras in recent years, with appearance of several new professional instruments. They are appreciated for their large negative size and compact design.

Twin-Lens Reflex Cameras

A medium-format camera—one that uses film larger than 35-mm—the twin-lens reflex was immensely popular after World War II. It is fitted with two lenses of identical focal length, one mounted atop the other. The lower, or taking, lens focuses its image directly on the film, while the image produced by the upper viewing lens is reflected through 90 degrees by a mirror, and brought to focus on a horizontal ground-glass focusing screen. The light paths to the film plane and the focusing screen are equal, so that if the photographer brings the scene on the focusing screen to sharp focus, the image on the film plane will be equally sharp.

Single-Lens Reflex Cameras

One of the most popular designs available today, the single-lens reflex (SLR) both views and photographs through one lens. Light passing through the lens is reflected by a mirror and brought to focus on a ground glass. The mirror causes a reversal of the image seen on the ground glass, but the addition of a pentaprism mounted over the ground glass allows the camera to be used at eye level, with the image seen upright and in proper left/right orientation. An instant before the exposure is made, the mirror swings upward, and the shutter is activated. A single control cocks the shutter for the next exposure, advances the film, and returns the mirror to focusing position.

This design of a single-lens reflex camera allows the photographer to see the exact image that will be recorded on the film. Light entering the camera through the lens is reflected into the viewfinder by a mirror, focusing screen, and pentaprism. When the shutter release is pressed, the mirror flips up and incoming light strikes the exposed film. Other manual controls include the film-advance lever, film-speed dial, and rewind knob. In some modern cameras the film is advanced and rewound automatically.

Viewing Cameras and Technical Cameras

Cameras in this category are used almost exclusively by professional photographers. The most common film formats are 4 x 5 or 8 x 10 inches, the latter often used in the very large cameras found in portrait studios. Film for these cameras is loaded in the darkroom into two-sided holders, which are inserted at the back of the camera. Both the camera's back and front can be tilted in various positions, to permit the photographer to make certain types of corrections in the image. By raising the lens in relation to the film plane, when photographing a tall building, for example, the tendency for parallel lines to look as if they converge is eliminated.

Instant Cameras

An instant camera will produce a finished print in from 20 seconds to about 4 minutes. The film, after exposure, is passed between two stainless steel rollers inside the camera. These rupture a chemical pod on the film and spread developing agent evenly over the film's surface. In the original Polaroid system it was necessary for the user to peel the finished print from the base material. Professional Polaroid films, both color and black and white, are still developed in this manner.

Beginning in 1972 with the all new model, the SX-70, Polaroid Instant Cameras eject the developing picture from the camera, and the film reaches its final development in full daylight. The process is completed in about 4 minutes. The Spectra, introduced in 1986, employs this type of technology and a more advanced type of electronic exposure control and automatic focusing system. Like the later SX-70 models, it employs an ultra-high-frequency sound emitter. An electronic circuit in the camera measures the time required for the sound to be reflected back from the object photographed. This time measurement is converted into a measurement of distance, and an electrical mechanism coupled to the focusing circuit sets the lens for the proper exposure.

Disc Cameras

Since its introduction in the 1980's, flexible film has usually been rolled onto a spool or loaded into a cassette. In 1980 the Eastman Kodak Company introduced a new format for mass-market cameras. Fifteen images, each 5/16 x 3/8 inches, can be photographed on a piece of circular film about 2 1/2 inches in diameter, which is housed in a thin, lighttight film disc. Disc cameras are exceptionally compact, and most are fitted with an electronic flash and a motor that advances the disc after each exposure.

The system has quickly abandoned due to the extremely small negative image captures on the disc and the limited size of quality enlargements which can be obtained from them.

Electronic Imaging

Over the past decade, a revolution has shaken the imaging industry through the adoption of digital imaging techniques.

In the early 1980's, Sony Corporation introduced the world's first commercial electronic digital still camera called the Mavicia. The significance of the technology was not missed by the other competitive companies. Nearly everyone began a race to perfect an electronic camera of their own.

Digital cameras generally use a cluster of light-sensitive electronic Charge-Coupled Devices (CCD's), of Chemical Metal Oxide (CMOs) sensors instead of film, at the focal plane. Each light sensor on devices is called a pixel. The pixel converts light into an electronic signal, which is recorded as part of a digital file which is stored on (usually) removable solid state memory device.

Among the more popular digital media formats on the market today are Smart Media, Digital Film and Sony's Memory Stick, MultiMedia Cards, IBM's MicroDrive and several others.

Regardless of the storage medium, the more dense the grouping of sensing devices, the sharper the resulting picture, which is recorded in full color. Increased pixels have spurred the development of larger and larger solid state storage units. Some are not larger than 1 gigabyte.

No matter what storage medium is used, once recorded, the image can be viewed on a television set or a computer screen by downloading the information on the storage device, resulting in a still video image, a paper print from a high quality desktop printer or a photographic quality dye sublimation printer.

Usually, with desktop printers, the quality of the image, while not quite as fine as that on the photographic print paper, approaches that of true photo images. These output processes have continuously improved to the point that the causal user finds them quite acceptable. In high-end professional equipment the quality achieved parallels that of conventional film and prints.

For a number of years, these digital camera systems were used primarily by photojournalists, who could afford the equipment and who had a legitimate need to be able to transmit their picture information over ordinary telephone lines by using a computer modem. A picture taken in Los Angeles could be viewed in full color a few minutes later in New York City. This time savings and elimination of the conventional photographic chemical processes made a significant reduction in photographic costs and easily justified any initial investments.

Massive research efforts and increased production have now lowered the cost of all-electronic still systems. By 2000, the cost of a high resolution camera had dropped below $900 while intermediate quality suitable for the average user had dropped to several hundred dollars.

In 2003, 4-6 megapixel cameras were being marketed for less than five hundred dollars. This development represented a 4X increase in photographic resolution more than 70% reduction in camera equipment costs.

In 2000 it was forecast that this trend toward lower prices, more and better features, and higher quality will result in a significant reduction of conventional photographic processes by 2003. This has easily proven the case.

For the first time, digital camera photography represents a larger market share of photographic print processing than conventional film--mainly through the aggressive marketing of product by the film companies through the use of kiosks and point of sale counters in a wide variety of alternative stores such as supermarkets.

In 2003 the market projections indicate that, for the first time, digital cameras will outsell conventional 35mm and point and shoot cameras, discounting disposable one-use cameras.

The digital still camera revolution was initially impacted slightly by digital *video* cameras which directly captured still digital images. Now, in some respects, the tables have been reversed.

In the beginning of the digital photography revolution, output of digital "stills" from video cameras surpassed the relatively low resolution of most reasonably priced digital still cameras in the consumer market. This is no longer the case.

Typical digital cameras now have MPG encoding build in and can take short videos, with sound, and record them on the storage card, similar to still photos.

Because of their requirement for higher resolution to enable photographic prints to be made they can, in some instances, actually outperform a video camera in capturing scene details. The obvious downside is their limited recording time due to the limited memory.

The rapid deployment of "mega pixel" (1,000,000 pixel) cameras have changed the equation significantly.

It is generally conceded that a camera must have (at a minimum) one million pixels of data to be sufficient to produce up to a 5" x 7" photo print.

In 1999, Olympus introduced the first consumer "Mega pixel" cameras at a price of about $1500. Almost immediately numerous other vendors did the same. Prices dropped and now cameras in excess of 5,000,000 pixels are in the market at about $500-600.

These cameras can accurately record sufficient data to produce prints up to 30" x 40" and more than meet the criteria for professional-level performance.

Within the span of the past two years the equivalent of the $50,000 studio cameras capabilities have migrated to the consumer.

While these high-end professional studio devices still are manufactured and sold to professional studios, their claim to being the only equipment capable of "professional" quality has waned.

For general professional use, the capability, quality and ease of use customarily associated with conventional 35 mm cameras has become a reality in the digital photographic systems and equipment costs are generally close to medium prices consumer market.