Christopher James, Rockets, Mexico, 1992
(Diana plastic camera negative—platinum print)
(Courtesy of the author)
The Pinhole

OVERVIEW AND EXPECTATIONS

Because “The Pinhole” is the first chapter, it is a fine time to introduce you to my book’s personality and to give you an idea of what you can expect from it. My students consider my writing style conversational and friendly, and I have done my best to keep it that way.

In this chapter you’ll get a compressed overview of early photographic history and the myriad scientific, social, and artistic connections that led to the pinhole camera. Not all of photography’s fascinating days-of-yore reside in this first chapter. This is the first “A Little History” section, and although it may appear to be extensive, it is this prehistory that sets the stage for a great deal of what follows in the book. You’ll find “A Little History” beginning nearly every chapter, and I have done my best to fill it with salient historical references as well as the odd and ironic things that always permeate most human endeavors.

You’ll also get a little science that briefly explains how the pinhole camera works and instructions on how to make one. You’ll learn how to test your pinhole and how to use it. Also included are easy solutions for those of you who are “handmade” impaired and directions to resources, images, and Web sites for more information on this wonderful and idiosyncratic way of making images.

A LITTLE HISTORY: CONCEPTION AND CONNECTIONS

The Conception

First the rumors. It is reported that the earliest writing regarding the camera obscura (“dark room” in Latin) occurred in the fifth century B.C. diaries of Chinese philosopher Mo Tzu (also referred to in various histories as Mo Ti or Lo Ti). In his journals, Mo Tzu contemplated the effects and nature of light and the reflection presented by an inverted image when light, and the image carried in it, passed through a small hole and landed on an opposing flat surface. Much later, somewhere in the neighborhood of 350 B.C., Aristotle (384–322 B.C.) witnessed a corresponding phenomena during an eclipse and included the concept of a camera obscura in his curriculum.
Figure 1–1

Christopher James, *Foot of the Pyramid, 1992*

This cyanotype print’s negative was made from a pinhole camera outfitted with a 4" × 5" Polaroid back loaded with Polaroid Type 55 Positive/Negative Film. It provides a pretty decent example of the pinhole’s extraordinary depth of field. The camera, a few inches from the foot, defines the blades of grass to the volleyball net 50 yards away. The only reason her face isn’t defined sharply is because she needed to breathe during the exposure.

(Courtesy of the author)
Evidently, the next time someone thought the optical magic of the camera obscura was worthy of note was nearly 1,300 years later when the renowned Arabian mathematician and physicist Ibn al-Haitam (c. 965–1040) used a pinhole aperture, as his hero Aristotle had, to view an eclipse. Ibn al-Haitam (also known as Ibn al-Haytham, al-Hazen, al-Basri, and al-Misri) was a big fan of Aristotle, and it was Aristotle's writing that persuaded al-Haitam to abandon his dedicated religious studies in order to adopt a life in pursuit of scientific veracity. Al-Haitam is reputed to have penned nearly 100 works, of which only 52 are known today, explaining diverse inquiries into such subjects as optics, the linearity of light, and the squaring of a circle. In his experiments with candles and paper screens with small apertures, he described the linear qualities of light and how a light image, travelling through his paper apertures, became more focused as the aperture was made smaller. Al-Haitam expressed his amazement and explained the optical experience in his book *On the Form of an Eclipse* in 1038. The dissemination of this work may have led to the following rumor regarding the practical applications of the camera obscura. Then again, it may have been the other way around.

A very long time ago, nomads in the deserts of the Middle East were fully aware of the light (fotizo) writing (graphi) image. In the beginning, so the story goes, these travelers would rest during the intense heat of the day and travel at night when the conditions were less demanding. In their tents, protected from the sun, they could relax and gaze out of the front flaps, scanning the horizon for any possible problems, or perhaps relatives, that might come from that general direction. Occasionally, they would take a glance at a shimmering, inverted, “shadow picture” of the view from the other direction—the one behind the tent. This image was projected on the front flap wall.

To make this upside-down image they would poke a small hole (the aperture) into the wall of the tent that was at their back. The landscape of that view, illuminated by the intense reflections of sun and sand, would, as in a camera, invert and project an upside-down version of that scene on the tent wall opposite the hole. Lots of holes, lots of views, and the resting nomad could relax knowing that he was alone and free of company. Thus, the basic principles of photographic optics were initiated for purely practical reasons. Perhaps this was the knowledge that launched al-Haitam’s inspiration.

Officially, academic historians give the credit to the remarkable Greek mentor-philosopher, Aristotle, who noticed that light rays converged in order to pass through small holes in opaque objects. Aristotle also noted that these same light rays diverted on the backside of the opaque plane exactly the same way they went through the front—in straight lines. As a result, the image illuminated was seen upside down and in proportion to the original. Aristotle’s experiments also demonstrated that the shape and proportions of the camera obscura had a direct relationship to the way the image was seen on the final projection surface. What Aristotle could never figure out, however, is why the image from a geometrically squared aperture would result in a circular image—a question that he was never able to answer. In any event, there was no concept of saving the image; it was just interesting to look at and trace.
In the early 1400s two Italian gentlemen began to influence the way artists could observe and record three-dimensional objects and space on a flat two-dimensional plane such as paper, canvas, or a wall. In the first decade of the 1400s, Italian architect Filippo Brunelleschi (1377–1446) was a major player in the European one-point perspective craze in painting. Brunelleschi’s odd, photographically rendered architectural tracings from the camera obscura solidly support this historical impression. It was Brunelleschi, by the way, who won a major architectural competition to design the prominent dome of Florence’s Santo Maria del Fiore. Coincidentally, the famed Italian astronomer Paolo Toscanelli (1397–1482), installed a bronze plate with a pinhole aperture in a window of Santo Maria del Fiore, and on sunny days a projected image of the sun can clearly be seen on the floor of the church, functioning as a notation of time.

The second gentleman was Leon Batistta Alberti (1404–1472), the “point-man” for the illumination of Renaissance artistic theory. Alberti, the dashing prototype for the universal “Renaissance man,” academically described how the perspective “thing” worked in his 1435 treatise (dedicated to Brunelleschi) entitled De Pictura (“On Painting”). In his writing, Alberti illustrated the concept of the theoretical, and real, window of the camera obscura and what possibilities that optical instrument offered to the artist on its glass-tracing surface. Alberti called the drawings that came from his own camera obscura miracles.
In 1490, Leonardo da Vinci (1452–1519) supposedly made the first recorded drawing of a camera obscura and its operation in his Codex atlanticus. Presumably he was aware of how an artist could use this contraption in order to chronicle real life by means of drawing the camera obscura's projection. However, because da Vinci wrote with his less dominant hand, and backwards, it took about 300 years before anyone could decode his inspirations and confer proper credit for them.

Shortly thereafter, in 1558, Giambattista della Porta (c.1535–1615) began writing about the focusing abilities of different shaped pieces of glass in what would eventually become his published four-volume *Magia Naturalis*, a major work that he began to write at the age of 15. The problem with the della Porta attribution is that no one ever was able to specifically verify that the idea was originally his. This is due to della Porta's politically inspired habit of assigning credit for his discoveries to those who held titled rank. In the case of his work on the telescope he gave credit to Federico Cesi, the president and founder of the Academy of Lynxes, an association for the advancement of science, that both della Porta and Galileo belonged to.

The first person to actually be credited with placing a lens on a camera obscura, with the intention of focus, was the infamous mathematician Girolamo Cardano (1501–1576) in 1550. Cardano was a brilliant individual but had a reckless weakness for gambling and socially questionable nightlife activities. His extensive analysis on the “theory of probability” greatly assisted his gambling addiction but got him into an incredible amount of personal trouble with his family and associates. Cardano’s brainstorm was described quite clearly in 1568 by the Venetian Daniele Barbaro (1513–1570) in his book *La practica della perspettiva* and gave inspiration to the ideas that led to moveable lens parts and a more flexible focusing system in a camera obscura from a fixed position. Barbaro wrote of “the magic, clouds, water twinkling and flying birds,” and noticed that one could actually record this magical life by means of tracing as long as the camera’s user moved the tracing paper toward and away from the lens in order to achieve focus. Other historical accounts give credit for the first lens, in 1583, to Giovanni Benedetti, curtly describing his invention as a solid hunk of nonmoveable glass on the camera obscura.

Honestly, though, giving credit for such wonders as moveable lens focus is pretty difficult to do because no one is absolutely sure of the facts. This is also true when attempting to attribute first discovery to other scientifically related inventions. A good example of this, if I may offer a short detour in the chapter, is the invention of the telescope, the microscope, and Heliocentric Theory.

Connections

Credit for the telescope had been demanded by several gentlemen, including Hans Lippershey (1570–1619), an eyeglass maker in Holland who, in 1608, came up with the idea of a telescope by watching two children play with discarded convex and concave lenses in his shop. Concurrently, Jacob Metius, of Belgium, filed for his own patent rights to the telescope. Although Metius’s extensive work with convex and concave optics was well known, his proprietary rights over Lippershey could not be established, and for political and financial reasons Metius decreed that all of his notes and tools be destroyed upon his death.

A corresponding story from 1609 described a tale in which Galileo Galilei (1564–1642) got wind of Lippershey’s optical invention and how Hans was on his way to Italy to show, tell, and sell his new telescope to the Venetians. Galileo quickly reasoned that his appropriation of Lippershey’s wonderful idea might be a perfect way to extricate himself from his chronic state of debt. Within days, Galileo made up a telescope, presumably using della Porta’s *Magia Naturalis*’s book on Refraction as a guide, and beat Lippershey to Venice; a deception that, historically and personally, proved to be a lousy idea. Here’s why:

Galileo was a disciple of Polish astronomer Nicolaus Copernicus’s (1473–1543) *Heliocentric Theory*. The Book of Alternative Photographic Processes
sun, centric = center), which had determined that the sun, and not the Earth, was at the center of all planetary movement. Copernican theory was counter to the ancient and accepted theological view defined by the Greek astronomer Ptolemy (127–151 A.D.) that placed the Earth at the center of the universe. Ptolemy had created a system where all heavenly bodies could be tracked through an indecipherable application of cycles. Better still, Ptolemy had actually determined the latitude and longitude of all “1,022” stars in the sky. It is interesting to note that Copernicus’s idea about the heavens was originally that of Aristarchus of Samos (310–230 B.C.), who had attempted to figure out the distances between the sun, moon, and Earth with his good friend Eratosthenes of Cyrene (276–195 B.C.).

In 1632 the Catholic Church decided that it had had enough of the Copernican nonsense and reacted poorly when Galileo aimed his telescope at the heavens and publicly proclaimed, 2,100 years after Aristarchus and Eratosthenes, and 118 years after Copernicus, that the Earth did indeed move around the sun. The church, never an institution to adapt quickly to scientific revelations concerning the heavens, officially proclaimed Galileo’s announcement as heresy, incarcerated him, and remained adamant about their decision until 1992 when it decided to forgive and forget. As an aside, Galileo is often given credit, along with Antony van Leeuwenhoek (1632–1723) and Robert Hooke (1635–1703), for discovering the microscope, in the simplest sense a telescope pointing in the opposite direction. Leeuwenhoek constructed and used single lens microscopes and made the landmark discovery of bacteria by bravely examining plaque in the mouth of an old man who, in his entire life, had never cleaned his teeth.

Figure 1–6
Galileo Galilei (1564–1642)

Figure 1–7
John A. Whipple, Daguerreotype of the Moon, 1852
This image by John Whipple (1822–1891) is reputed to be the first Daguerreotype of the moon although there is some evidence that Jean Claudet made the first in 1845. The image was exposed at the 15-inch refractor of the Harvard College Observatory, Cambridge, Massachusetts, February 26, 1852. Prints were made with Whipple’s glass plate, albumen sensitized, Crystalotype Process, and glued into the world’s first photography magazine, The Photographic Art-Journal, 1853.
(Courtesy of Harvard College Observatory, Cambridge, Massachusetts)
Also, Hooke constructed a lens that he called a “compound” microscope and wrote the book *Micrographia* in 1665, one of the most influential biology texts in history. None of these distinguished scientists were, in fact, responsible. The actual inventors of the microscope were the father and son collaboration of Hans and Zacharias Jansen, of Middleburg, Holland, who, in 1595, crafted a small working instrument that they christened “The Royal Jansen.”

With the advent of the telescope, and the ability to craft and work glass into tools of magnification, scientists placed multiple, and multishaped, lenses on their small camera obscura holes. They then noticed that, depending on the focal length (the distance between the aperture and the plane where the image landed), they could focus and alter the effects of the image.

In 1604, mathematician and the father of modern optics Johannes Kepler (1571–1630) worked out a formal relationship between mirrors, lenses, and vision. Shortly thereafter, in 1609, Kepler wrote a book entitled *Astronomia Nova* that had a profound influence on the way scientists thought about light, because he was the first to describe the ray theory of light as a means to explain vision. One of the strongest reactions to Kepler’s work was seen in the research of Issac Newton (1643–1727), who hypothesized in 1675 that white light wasn’t really white at all and that the white appearance was actually an entire spectrum of colors. It was Kepler, by the way, who is given credit for being first to use the words camera obscura.

While the physical camera portion of the photographic equation was well documented and working nicely as a drawing aid for painters, the chemical part of the equation was just beginning. In 1727, Johann Heinrich Schulze (1687–1744) observed the darkening action of light on a liquid mixture of silver chloride and chalk and began to make photograms on white leather, using stencils and the sensitized solution. It is interesting to note that Schulze accidentally discovered the darkening effects of light on silver when he mixed a silver contaminated nitric acid with chalk (calcium carbonate), creating silver carbonate.

In 1777 the Swedish chemist Karl Wilhelm Scheele (1742–1786) published the book *Chemical Observations and Experiment on Air and Fire*. In it Scheele worked with his newfound knowledge of how the blue/violet end of the spectrum had a noticeable impact on a compound of silver and chlorine (silver chloride) through the chemical act of reduction, salt to metal. An additional bit of interesting history, Scheele made a lot of discoveries that have had a significant impact on our lives and the medium of photography. Among his revelations are the independent recognition of oxygen (1774) and nitrogen and the isolation of citric, gallic, tartaric, and prussic acids. Unfortunately, neither Schulze nor Scheele had a way of sharing their light-sensitive metal salt discoveries, because fixer had not been invented yet.

The camera obscura, however, was still going strong. Count Francesco Algorotti suggested in his book *Essays on Painting* (1764) that many Italian painters had to be using the “contrivance,” for how else could one explain the real-

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Figure 1–8

Physionotrace of Gilles Louis Christine (1754–1811), Inventor of the Physionotrace, 1792

The physionotrace was an ink on copper plate drawing process where a subject’s likeness was traced by drawing with a stylus that was connected, with levers, to an eyesight. When the drawing had been completed, the copper plate was etched and engraved, allowing the potential for multiple copies of a realistic likeness. They didn’t know it yet, but painters around the world were just about to be freed from a life of painting the faces of wealthy patrons.

(Courtesy of the George Eastman House, Rochester, NY)
ism in their drawings? This realism was especially demanded for portraiture, and in 1786 the use of the camera obscura took its turn at providing the wish for reproducible reality through the invention of the physionotrace by Frenchman Gilles-Louis Chrétien (1754–1811).

Then something really important happened. In London, on the 5th of November, 1794, Mrs. Elizabeth Fulhame self-published a book modestly entitled, An Essay on Combustion, with a View to a New Art of Dying and Painting, wherein the Phlogistic and Antiphlogistic Hypotheses Are Proved Erroneous. This grandiose title described a tedious series of experiments that began in the summer of 1780, because Mrs. Fulhame wanted to devise a way of staining fabric for her dresses with heavy metals such as silver and gold. She hypothesized that this might be possible with the influence of water and light, and her research brought her to the conclusion that water played the major role in catalytic reactions as both the reducing and oxidizing agent. She also noted that after those actions had taken place, the water was always restored to its original state. More than one photographic historian has opined that Mrs. Fulhame's great achievement, the discovery of Catalysis, was the beginning of photography as an art based on scientific and chemical principles. Elizabeth Fulhame's social position as a woman, Dr. Fulhame's compliant wife, and amateur scientist, resulted in her thesis being dismissed by the scientific community. This quasi-official reaction didn't seem to temper her zeal or curiosity. In a response to the situation she wrote, "... censure is perhaps inevitable; for some are so ignorant at the sight of any thing, that bears a semblance of learning, in whatever shape it may appear; and should the spectre appear in the shape of a woman, the pangs which they suffer, are truly dismal."

In 1816, Nicéphore Niépce (1765–1833) attempted the first camera-based images by making silver chloride coated paper negatives. These first experiments by Niépce and his brother Claude utilized a camera obscura and sensitized paper and were designed to be used with a hot air, engine-powered lithography press that the brothers had designed together. Their first results yielded negative images that Niépce was only partially able to fix.

The first successful positive image was made in 1826–1827 by coating pewter plates with a light-sensitive ground of Bitumen of Judea (asphaltum) that was soluble in lavender oil but that became insoluble when it was exposed to light. The principle here is similar to the effect that occurs in the gum bichromate process, when a dichromate is added to a solution of gum arabic, water, and paint, and exposed to ultraviolet (UV) light. Niépce began his process by coating a pewter plate with the Bitumen of Judea and then exposing a translucent engraving, laid on the plate, to sunlight. Following exposure, Niépce bathed the plate in the oil of lavender solution and the unexposed areas, those parts that did not harden through the action of UV light, washed away. The resulting plate was a negative version of the engraving but one that could be etched to produce positive prints on a press. Niépce began exposing scenes directly in the camera and created what is con-
considered to be the first photographic image: View of the Window and Courtyard at le Gras, 1826. In 1827, Niépce took his discovery to England with the ambition of presenting it to the Royal Society. Unwillingness to reveal all of the “secrets” proved to be a stumbling block for acceptance by the organization, and Niépce returned to France convinced that the English were inept.

In 1819, while Niépce was busy working on a way to save his images using Dipple oil (oil from the bones of animals) and oil of lavender (today sold as an oil to instill feelings of love and peace), Sir John Herschel (1792–1871) discovered that a solution of thiosulfates (hyposulfite of soda) substances would dissolve silver chloride. Herschel’s discovery, identical to Chaussier’s in 1799, was the foundation for his announcement in 1839, twenty years later, that he could fix a photograph—a word he made up.

Meanwhile, in 1826, Niépce and Louis Jacques Mande Daguerre (1787–1851), who was independently about to discover photography, were introduced to one another by an optician named Charles Chevalier. In some historical accounts, an engraver named Lemaitre initiated their introduction. Daguerre was widely known as an engaging entrepreneur and the proprietor of the famous Parisian Diaorama, a theater-like experience likely based on Robert Barker's Panorama from 1794.

In 1827, Niépce’s brother Claude became ill while in England and Joseph attempted to go and visit him. Travel plans went astray in Paris, and Joseph took the opportunity to meet with Daguerre, where they drank tea, discussed Niépce’s work, Daguerre’s knowledge of heliography, and his personal collection of superior cameras. In 1829 the two men signed an agreement stating that they would be a partnership for the purpose of improving Niépce’s invention. A few years later Niépce died (1833), and by 1835 Daguerre had worked out a technique for developing the sensitized, silver iodized (copper plates exposed to fumes of iodine) metal plates with the fumes of hot mercury. Do not try this at home. By this time, Daguerre had decided that the invention of photography was solely his and began referring to his images as “Daguerreotypes.” In 1837, Daguerre figured out how to “fix” an image with sodium chloride, something Herschel had discovered eighteen years earlier, with hyposulfite of soda. On the 7th of January, 1839, the well-connected French physicist and director of the Paris Observatory, Dominique François Arago, presented Daguerre’s work to the Academy of Sciences, and in September, 1839, Daguerre demonstrated the process in public for the first time.

How a Daguerreotype Is Made

First, it is very important that you do not perform this procedure without some expert advice and training in the Daguerreotype process. Boiling mercury for Daguerreotype development is very hazardous business, and the resulting fumes can be lethal to your being. Here’s how it is done, with just enough information to explain it but not enough to actually do it.
Prepare a sheet of copper that has been electroplated with a coating of metallic silver (The Sheffield Process) and buff it to fine shine.

Place the metal plate in a light tight box (an iodizing box) that contains iodine. In the box the plate will absorb the fumes of the iodine, which will react with the silver, turn orange, and result in a light-sensitive silver iodide coated plate.

In a low light environment, load the sensitized plate into a camera and expose it to a subject in bright sunlight. This exposure will average about 15 to 25 minutes.

Next, develop the plate with the fumes of mercury that has been heated to 140°F. During this stage, conducted in very low light, the mercury will merge (amalgamate) with the silver in the exposure’s highlights.

Finally, the plate is washed with a diluted solution of sodium thiosulfate (originally sodium chloride; D aguerre, 1837) and washed with water. The shadows of the image are plain polished silver, and the highlights are a pale white amalgam created by the mercury’s effect on the silver during development. Once dried, it is permanent.

Figure 1–11


This half plate Daguerreotype, created by New York artist Jerry Spagnoli, is from “The Last Great Daguerreotype Survey of the 20th Century.” The scene depicts the 4 minutes of exposure needed to make the plate as the century changed. The text in the plate reads backwards because that is how the Daguerreotype records life.

(Courtesy of the artist)
It is interesting to note that commerce and marketing began to influence truth at this point. Arago was doing such a spectacular job promoting Daguerre that he blatantly ignored the fact that there was physical proof that Daguerre was not the first person to produce a photographic image. Francis Bauer had informed the press that Daguerre's invention was identical to Niépce's in February 1839 and that he personally had actual images that had been given to him by Niépce. A clerk in the French Ministry of Finance, Hippolyte Bayard (1801–1887), had shown his own photographic images to Arago on the 20th of May, 1839, three months before the announcement of the Daguerreotype. After Arago announced Daguerre's genius, Bayard reacted to the news by making a self-portrait (1840) showing himself as a drowned man and expressing in sarcastic sentiments his feelings that the government had given Daguerre everything—that being the case, the wretch had drowned himself and here was the proof. Bayard's technique was a positive paper process similar to William Henry Fox Talbot's (1800–1877), even though there has never been speculation that either man knew of the other's experiments. Bayard coated his paper with silver chloride and inserted the moist paper in his camera for a lengthy exposure. Following that, he immersed the darkened print in a bath of potassium iodide to yield a positive image that he fixed with potassium bromide.

By the late 1800s the medium had literally exploded into public consciousness. Following a rapid, often overwhelming, series of photographically related processes and discoveries, the pinhole camera had come into its own. As photographic emulsions became more sensitive, photographers around the world were making pictures using pinhole cameras to make images of everything, from Egyptian archeology to romantic Pictorialist expressions.

As the nineteenth century came to an end, commercial enterprise entered the fray, and pinhole cameras such as the "Ready Photographer" and the "Glen Pinhole Camera" were manufactured and sold worldwide. These inexpensive cameras came with such extras as glass plates, foil lenses, chemistry, and printing frames. All at once there was a great flurry of activity as artists and scientists attempted to capture the "fairy pictures" that Talbot had described, the ones that had scooted by their eyes in the camera obscura. Finally, after 2,300 years, everyone was interested. Still, for my historical betting dollar, it was the nomad in the tent who did it first.
A Little Science

A pinhole camera will create an image that will vary in size and viewpoint according to the distance between the aperture hole and the surface the resulting image falls on, be it a sensitized film, paper, or wall. If the pinhole is close to the end surface it will yield a wide-angle image. If the distance is further away, it will provide an image that is normal to telephoto. The distance is called focal length. The greater the focal length, the larger the image.

The focal length of a pinhole camera is calibrated in the exact same manner as a traditional “grown up” camera: 25 mm = 1”. A 3” focal length will cover a 4” × 5” inch piece of film, and a camera with a 6” focal length will cover an 8” × 10” piece of film. If your focal length is too short then you will make circular pictures just like George Eastman did in his first flexible film, roll camera in 1888. This information changes when you do away with the flat film plane and start bending the film or paper in the camera. If your pinhole aperture is small enough, almost every non-moving subject that you point your camera at will be pretty sharp; remember the trick with your thumb and the hole in the paper. In the end, there is no limit to what form your images can take and how you can alter the concept of the pinhole camera.

Generally, the quality of an image will continue to be more defined as the pinhole becomes smaller. This gradual increase in definition will eventually deteriorate if the hole is too small due to diffraction (the spreading of light at the edges of an opaque object). There are specific proportions that are considered ideal for particular aperture to plate distances. These mathematical proportions have been worked out by people who take pleasure in exact numerical definitions, and the results of their work can be found in many pinhole texts. Basically, a pinhole of 1/64” diameter is quite adequate for focal lengths up to 6”. A smaller diameter, that is, 1/100”, will provide a nice life size ratio for making detailed pinhole images of close-up objects using the same focal length.

Exposure time is dependent on the size of your pinhole and the focal length of your camera. This is referred to as the f-value. An f-value is figured with the following equation: Let’s say that you have a focal length of 6” and a pinhole diameter of 1/64” and you want to know the f-value. Simply divide the focal length (6”) by the pinhole diameter (64), and you will come up with an f-value of f 384.
Of course, available light will also play a large role in determining exposure and extensive testing of your camera, and the film and/or paper used within it will provide a matrix for subsequent use. There are formulas for determining the exact exposure times for pinhole exposures, but I have found that the variables of the handmade pinhole camera are significant enough to call for individual testing of one’s camera rather than a carved-in-stone standard.

Eric Renner and Nancy Spencer, the gurus of pinhole photography, estimate that there have been more than fifty separate charted formulas defining workable pinhole diameter/focal length perfection. These formulas come with complex mathematical equations that define what happens to your image when numbers are assigned to the diameter of the aperture, the wavelength of the light, and the focal length of the camera. The gist of this is that you can spend all your time doing scientific testing for optimal sharpness or you can build or purchase different pinhole cameras and go and make pictures. If your camera isn’t providing you with the sharpness, or romanticism, that you want, then keep modifying it until it does.

**HOW TO MAKE A PINHOLE CAMERA**

**The Basic Materials**

- A container that you can make light tight. This can be anything from a plastic film container to a cathedral.
- A can of black matte spray paint. You will want to be sure that your container does not have a lot of light bouncing around inside of it during lengthy exposures, so it is necessary to spray it with at least two coats. You can also use black paper or, for that extra plush interior that reflects no light at all, black velvet.
- Tin foil, metal flashing material, brass shims, a cut-up soda can—anything thin and sturdy that you can punch a needle hole through for your aperture. K & S Engineering Co., Chicago, IL, makes a wide assortment of brass, aluminum, and copper shims that are excellent for pinhole aperture plates.
- A pair scissors or shears that are able to cut a thin metal shim and a selection of needles.
Needle-nose pliers for pushing the pin through the metal and a utility knife.
A ruler or hard edge metal measure and a pencil.
A roll of 1- to 2-inch black tape.
A piece of fine emery cloth or carborundum paper for fine sanding metal.
A timing device, like a watch, to keep track of exposure times.
A darkroom, if you are using a material that needs chemical development. If you are using Polaroid Type 55 P/N Film you do not need a darkroom (see Chapter 2).
You may want some paint or decoration for your camera to make friends envious and to inspire children.
Some multigrade resin coated (RC) satin finish photographic paper for prints or paper negatives. Options include Lith film, Ilfochrome paper, Type 55 P/N Polaroid, and a 4”×5” Polaroid, etc. You can use Ilfochrome paper in your pinhole camera and make one-of-a-kind, direct positive, color prints as long as you have a way to safely store and transfer the Ilfochrome exposures to a commercial lab for processing. An example is in the late 70s work of Willie Anne Wright who did her well-known “Beach Series” using 8”×10” and 11”×14” wooden boxes fitted with slots for film holders at different focal lengths. Color balance was corrected with an 85 B glass filter behind the pinhole aperture, and her exposures were between 3 and 5 minutes. In case you are curious, alternative process exposures in pinholes can be done but you need the patience of a hero because the sensitizers are so slow.
A sense of humor.
Pinhole Construction

Select a container and think about what kind of image you want to create. Wide angle, tele-photo, macro, multiple lens, long and narrow, short and wide, mural size, button size—you decide. It might be a fine idea to make several cameras so that you can shoot the same thing with all of them and see the difference. Begin by measuring your focal length (the distance between the film plane and the aperture) and determine what your coverage is going to be. The shorter the focal length, the wider the angle of view. A good way to see how much coverage you're going to get is to place a mark at the rear of the top middle edge of your camera, on the film plane of the camera, and draw straight lines to the front left and right corners. If you follow those lines, out to the horizon, you will see what your coverage area will be.

Spray several coats of matte black spray paint into the inside of your constructed “camera.” Note: if you are using a bread truck or your apartment, this may not be a good idea, and you will have to figure out another solution, that is, black paper or fabric. Then draw an “X” from corner to corner to show you where the exact middle of your camera is. This will be, if you are feeling conservative, where your pinhole aperture will go. Take your matt knife and cut a small hole in the camera where your piece of tin foil or brass shim metal will be placed. Scribe an “X” to show you the center, and, very gently, push your nee-
dle through the material. With tin foil, you are pretty much done, but you have a very fragile aperture that can easily be damaged. If you are using a brass shim then you will want to complete the following steps.

As soon as the needle begins to protrude through the other side of the shim, stop pushing and turn the metal piece over. Gently push the needle back through the same hole and twirl it as you go in much the same manner as an acupuncturist does when inserting needles into a body. Go back to the front side and repeat the penetrating twirl until you have a nice hole. Take a piece of fine emery cloth, silicon, or carborundum paper and gently massage both sides to remove any irregularities or burrs. When the hole is smooth, gently push your needle back through it to clear out any metal dust. Check your perfection with a magnifying loop. Remember that a small hole with rough edges will result in a defraction of light and a blurry imagery. **The Golden Rule of Pinhole: fuzzy holes make fuzzy pictures.**

**Putting the Camera Together**

Now it is time to put the newly made pinhole aperture into the camera and to create a shutter, also known as a piece of black tape over the hole. First, take your foil or shim with the pinhole and tape it inside your camera, being sure the pinhole is centered over the small hole you cut out. Make sure that the seal around the aperture plane is perfect and light tight.

To make a shutter, take an inch or two of the black tape and stick two pieces of the tape together (sticky side to sticky side), leaving one of the ends longer than the other. You are going to want to put your shutter somewhere during the exposure, and the best way to manage this is by leaving a sticky end tab on the shutter so that it can adhere to your camera when shooting. When it is time to expose, simply grab the pull-tab, uncover the pinhole, stick the shutter somewhere on the camera, say the magic words, “al-H azan,” and wait. At the conclusion of the shot, cover the hole up again, being positive that the tape is making a tight seal with the pinhole to avoid stray light.

You may wish to construct a system for easily inserting your film or paper into the camera. The easiest solution is to tape the film or RC paper to the side of the camera opposite the aperture hole. A better solution, requiring a little more time but worth the effort, is to make a channel set-up so that you can slide your film or RC paper along permanent tracks. This is similar to a paper easel or 4” × 5” film holder channel system. In fact, you might want to consider taking a 4” × 5” film holder and making it a permanent part of your camera. If you intend to use different size films and papers in your camera then you must either build different format channel systems or make cameras specifically for the size film or paper you intend to use. Don’t forget the information regarding focal length and image size. Now figure out a way to be sure that your camera is light tight and that it is easily disassembled for the next loading of light-sensitive material. It is now time to test your creation.

**Testing the Camera**

Load up the camera in the darkroom with either film or satin finish RC paper. It is faster to test paper, so that should be your medium for the light tight test. Remem-

![Image](image_url)
ber that if you are using paper, the shiny or emulsion side faces the lens just like in printing. If you are using film, hold the film so that your right index finger is on the upper right-hand corner notch code of the film. The emulsion side is now facing you. This side faces the aperture and the scene in front of the camera. Load the film sheet in total darkness. Back to the test:

- Place a piece of paper, or film, on all inside surfaces of the camera.
- Close up the camera in the darkroom and don’t forget to put your shutter (tape) over the lens.
- Go outdoors and place the camera in direct sunlight for 15 to 20 minutes but do not remove the shutter. Every so often, move the camera so that a different side faces the sun.
- Go back into the darkroom and process the pieces of paper.

If all of the pieces of paper or film are unexposed, then you have made a fine camera and you are ready for some serious pinhole photography. If some or all of your paper has gray or dark exposed light leaks showing, you will have to figure out where they are and fix the camera with more paint or tape. It is important to understand how the image is coming into the camera. Continue the testing process until there are no more light leaks, and keep your sense of humor.

**Finding the Correct Exposure**

It would be numbing to try and provide you with a mathematical set of calibrations to guarantee a perfect exposure with your pinhole. There are simply too many variables to make pedantic recommendations. The time of year and day, the “real” size of your pinhole, the temperature, the atmosphere—nearly anything could make a difference. The wisest procedure, with a new pinhole, or a change in
season, is to work intuitively or take the time to make a series of exposure tests using film (Polaroid or conventional sheet film) or RC photographic paper. Begin making exposures in bright sun, with a good guess. Process the material and go from there. With a preconstructed Leonardo or Lensless Camera Co. pinhole and Polaroid Type 55 P/N (positive/negative) film with a 4” × 5” Polaroid back, you can begin with a 10-second exposure. Pay attention to the cleared negative rather than the positive. (See Chapter 2.)

All but the most expensive light meters will not work well with pinhole cameras. There is, however, a relatively simple calculation that will permit you to meter for an ƒ-stop and convert the time given to one suitable for your pinhole camera. If you are technically minded you may want to try the following formula and see if it works for you.

- Set your light meter to an ƒ-stop and call it “A.”
- The meter will give you an exposure time that you call “S.”
- Figure your pinhole camera aperture and call it “B.”
- Now find the correct exposure time with the formula and call it “X.”

\[ S \cdot B^2 / A^2 = X \]

Your times will obviously be quite lengthy, but because you’re using a pinhole camera, you already know that. The basic pinhole rules of thumb when doing this sort of calculation with black and white film are:

- For exposures between 1 and 10 seconds, double the exposure time indicated on a meter.
- For exposures between 10 and 100 seconds, multiply the given time by 5.
- For exposures over 100 seconds, multiply the exposure time by 12.

Making Pictures

Select a subject. Most of the time it is a good idea to photograph something that doesn’t move, but many pinhole photographers love the ghostly quality of movement in their images. Leaves blowing in the wind, moving water, parts of bodies, blinking eyes in a portrait—are all wonderful in the light movement tracks they deposit on the film plane. Position the camera so it will not move and untape the shutter. Check your watch and count each second during the exposure—“one Ansel Adams, two Ansel Adam, three Ansel Adams”—keep notes on each shot and begin to calibrate how your camera works.

When your exposure is complete, go back into the darkroom, remove the paper or film, and process it. If you want to process everything at once later in the day you must keep the material in a light tight box. In the field, you can use a changing bag to remove, load, and store your exposed and unexposed light-sensitive materials. After processing, you will probably want to make a print. If you are using film, then the contact process is as simple as making a contact sheet. If you are using RC paper and printing through it as a paper negative, there are a few ways to make the print.

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### Pinhole Camera Aperture Exposure Table

Calculating specific exposures for your handmade pinhole camera is complicated due to the variables of homemade construction. The Lensless Camera Mfg. Co., however, has created the following table of apertures and ƒ-stops for their products. The film format of the camera is irrelevant because only the working aperture and focal length determine the ƒ-stop.

<table>
<thead>
<tr>
<th>Focal Length</th>
<th>Pinhole diameter (1000ths)</th>
<th>Pinhole diameter (fractions)</th>
<th>ƒ-Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>675 mm/27”</td>
<td>0.0156”</td>
<td>1/64</td>
<td>f/2000</td>
</tr>
<tr>
<td>450 mm/18”</td>
<td>0.0156”</td>
<td>1/64</td>
<td>f/1200</td>
</tr>
<tr>
<td>300 mm/12”</td>
<td>0.0156”</td>
<td>1/64</td>
<td>f/840</td>
</tr>
<tr>
<td>225 mm/9”</td>
<td>0.0156”</td>
<td>1/64</td>
<td>f/630</td>
</tr>
<tr>
<td>200 mm/8”</td>
<td>0.0156”</td>
<td>1/64</td>
<td>f/560</td>
</tr>
<tr>
<td>150 mm/6”</td>
<td>0.0156”</td>
<td>1/64</td>
<td>f/420</td>
</tr>
<tr>
<td>100 mm/4”</td>
<td>0.0156”</td>
<td>1/64</td>
<td>f/280</td>
</tr>
<tr>
<td>75 mm/3”</td>
<td>0.013”</td>
<td>1/77</td>
<td>f/230</td>
</tr>
<tr>
<td>50 mm/2”</td>
<td>0.013”</td>
<td>1/77</td>
<td>f/154</td>
</tr>
</tbody>
</table>

Calculation by The Lensless Camera Mfg. Co., Santa Barbara, CA.
The simplest is making a contact print: 1 or 2 stops down for as many seconds as it will take to make a good image. Another way to make a paper positive is to soak an unexposed piece of paper in water, and, when saturated, place it emulsion to emulsion with your wet RC negative paper. This method will give you a little more detail. The primary difference between the RC paper negative and the film negative is obvious. You will have more detail and probably more control over the final image if you are using film. If you elect to use a paper negative, be aware that some manufacturers have logos on the reverse of the paper; they will show up on your print.

**Pinhole Recommendations**

If your ambitions for pinhole photography exceed this set of instructions then you are in good company. Many artists have taken the pinhole concept and built their entire creative life around it. Pinky Bass, and Eric Renner and Nancy Spencer of Pinhole Resource come immediately to mind.

There are many artists whose imaginative pinhole camera variations are often as vital as the work that comes from them. Chris Pinchbeck uses a trailer as his camera and drives around the country shooting giant Ilfochrome landscapes. One of my former workshop students, Pinky Bass, used an old bread truck for her camera and has a trailer shaped like an old Polaroid camera that functions as a rolling darkroom. Emily Hartzell, a former student of mine at Harvard, turned her New York apartment into a pinhole. Another workshop participant, Frank Varney, built a panorama pinhole to record the geysers of Yellowstone National Park, and Philippe Moroux makes beautiful Kallitypes with negatives from his pinhole cameras.

![Figure 1-19](image)

**Sarah Van Keuren, Audrey, 1999**

Sarah’s pinhole-cyanotype-gum bichromate is a terrific example of employing an assortment of alternative process options within a single image. (Courtesy of the artist)
Eric Renner is the pinhole guru, and his lifelong commitment to the art of the pinhole is pretty extraordinary. This image is from the collaborative series, Through the Other's Eyes, created with his wife Nancy Spencer. To make the image, both Eric and Nancy wore plaster cast life masks over their faces with pinhole cameras set into the eyes.

(Courtesy of the artists)

Chris Pinchbeck uses a trailer as his pinhole camera and exposes direct positive Type R Cibachrome prints. This image is 30” × 75”.

(Courtesy of the artist)
Essentially, any container that can be made light tight, including a thimble, can be turned into a camera.

If you are “handmade” impaired, I suggest that you consider purchasing a hand-built camera from one of several pinhole camera makers in the country. I have terrific pinhole cameras from both the Lensless Camera Company and the Pinhole Resource and have used them for many years now without a hitch; what could go wrong? I shoot Polaroid Type 55 Positive-Negative film with a 4” × 5” Polaroid back, and they are among my favorite cameras. Also, Zernicke Au, at Zero Image in Hong Kong, makes a marvelous 120 mm and 6” × 9” pinhole cameras with Australian Redwood and brass fittings. Please see the resource section in the Appendices for the best sources for pinhole cameras, film, books, magazines, and pinhole paraphernalia. In any case, pinhole photography is supposed to be fun—go have some.
Figure 1–23

Pinky Bass, Body Nostalgia 1

Pinky Bass made this compelling image with a homemade pinhole that she named Bible with Two Points of View Pinhole Camera. The image is a 40" × 32" toned silver gelatin print.

(Courtesy of the artist)