Powell's Patent Pinopticon

(Or: the art of making art to make art)

Pinhole photography involves the use of a small hole as an aperture replacing the lens. It is often used as an alternative to lens-based photography as the resultant images are softer with almost infinite depth-of-field, this gives them a more artistic quality. The ability to produce images with almost any form of commercial or handmade camera is also a big attraction for many.

A Brief History of the Pinhole

The first recorded mention of the pinhole (in an admittedly ambiguous fashion) comes from China; writing in the 5th century BC the philosopher Mo-Tsi spoke of forming reversed images of a person on a screen when passed through a small aperture:

"CANON: The turning over of the shadow is because the crisscross has a point from which it is prolonged with the shadow.

EXPLANATION: The light's entry into the curve is like the shooting of an arrow from a bow. The entry of that which comes from below is upward, the entry of that which comes from high up is downward. The legs cover the light from below, and therefore form a shadow above; the head covers the light from above, and therefore forms a shadow below. This is because at a certain distance there is a point which coincides with the light; therefore the revolution of the shadow is on the inside."

The pinhole was widely used by scientists as a means of studying light. Aristotle, Alhazen and Leonardo are all known to have experimented with the Pinhole. It was also used extensively throughout the renaissance as an aid to painting, with Brunelleschi's Small Aperture Perspective Device being used extensively by painters to achieve accurate one-point perspective. Da' Vinci is known to have used it in many of his works and even wrote about the subject:

"If you transmit the rays of the sun through a hole in the shape of a star you will see a beautiful effect of perspective in the spot where the sun's rays pass."

Another form of the perspective device was the camera obscura, which initially used a pinhole to produce an image. This whole room camera was initially seen as the work of the devil and a form of witchcraft by many.

Figure 1: A Camera Obscura

Soon after the 'invention' of Photography in 1834 by William Henry Fox Talbot photographers began experimenting with the pinhole as a means of forming an image. Sir David Brewster was one of the first to use the pinhole and was the man responsible for coining the term itself. The earliest surviving pinhole photographs were made by the archaeologist Flinders Petrie while he was excavating in Egypt. These images are slightly controversial as there was a lens placed in front of the pinhole, but it has been theorised that using one of his pinholes the lens would have no effect.

Figure 2: A Group of Cedars by Lord Rayleigh (early pinhole image)

Pinhole fell out of favour during the early 20th century when photography pushed towards maximum sharpness and realism, and had no room for the soft, arty images that pinhole produced. Famous photographers like the legendary Ansel Adams may well have had an (involuntary) part in pinholes demise, as their influence and emphasis of maximum sharpness was the complete antithesis of the pinhole.

The mass production of inexpensive lens cameras and the huge increases in film speed left no room for an impressionistic technique. By the 1930's the pinhole was only used as a teaching tool, and was seen as having the one advantage of being able to be made easily from a kit.

The technique was revived during the 1980's by photographers who wanted to break away from the norm and try something different. The ability to take images with almost any camera appealed to many and photographers such as Dominque Stroobant, Justin Quinnell and Eric Renner started experimenting with anything from a camera concealed in the mouth to a whole room. The art is now gaining popularity globally and there is even an international pinhole day held every March where people are invited to take a picture and send it in.

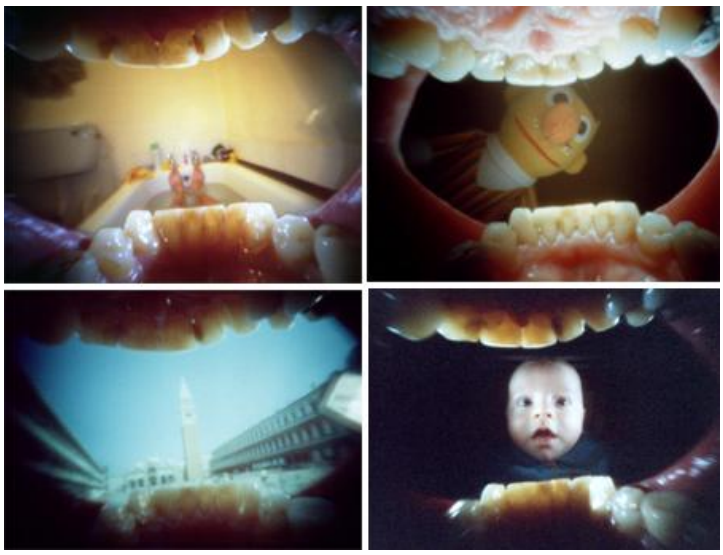

Figure 3: Some of Justin Quinnell's work

The Pinhole and Science

A pinhole works like a simple lens; by selecting a narrow angle of light a recognizable image can be formed. This works because light rays from an object ordinarily spread out over a large area causing them to become blurred and indistinct. A pinhole only allows a small number of light rays to pass through, thus reducing the angle of projection. By narrowing the angle of light rays allowed to enter like this, the rays are focused into a smaller area and thus look sharper; the smaller the pinhole the less light is admitted and the sharper the final image. Whereas a lens actually focuses light onto a smaller area; a pinhole merely filters out most of the light reaching it and selects a much narrower spectrum. As a result of this filtering a pinhole admits little light and thus needs much longer exposures than a conventional camera.

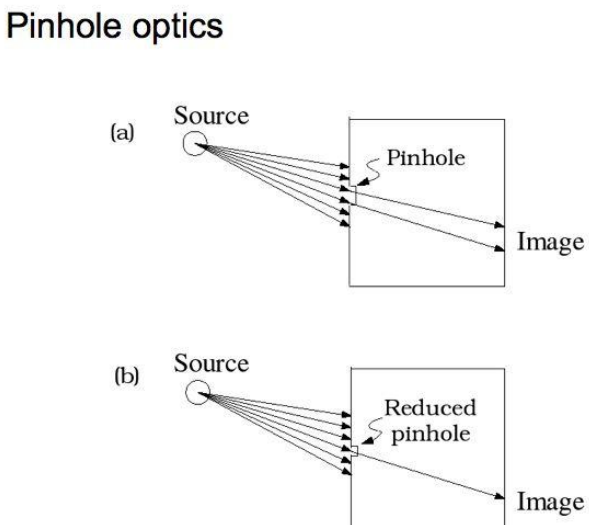

Figure 4: How a pinhole filters light

One fascinating version of the pinhole camera is the eye of the Nautilus. This cephalopod of the family Nautilidae has an eye which lacks a lens; the pupil acts as a crude pinhole and thus forms an image just like a camera obscura. This bizarre evolutionary trait may well be due to the fact the Nautilus first evolved millions of years ago and has remained largely unchanged (so much so that it is regarded as a 'living fossil'). The Nautilus is also of interest as its shell is an almost perfect Fibonacci spiral.

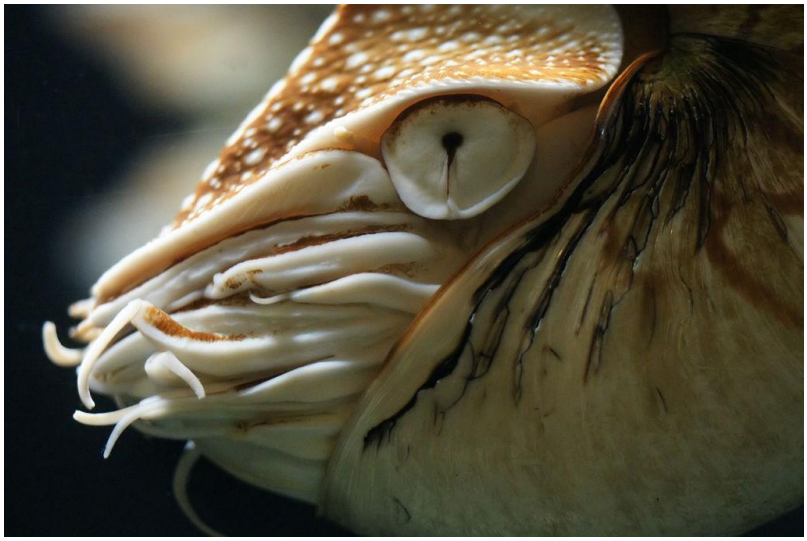

Figure 5: A Nautilus' eye

The pinhole is also widely used in studying high-energy particles; this is due to the fact that a lens has been found to absorb x-ray and gamma ray emissions. The first soft x-ray image of the sun was taken in 1960 and the pinhole has since been used extensively in studying everything from supernovae to the reactions of a particle accelerator. One of the most common methods involves the use of a HURA (Hexagonal Uniformly Redundant Array) which is a multiple pinhole aperture; images are exposed, then developed and unscrambled by computer.

The Process of Creation

My pinhole camera was constructed from ply-wood and decorated in a Victorian style. The first step was to create a digital mock-up using Blender software; this allowed me to see whether the components would all fit together and whether the camera would match my design specifications (in this case the ability to quickly change pinhole size, room for a 4x5" darkslide, and a 165mm focal length). After checking the measurements the individual pieces were exported to a vector format (.svg) and cleaned up. The pieces were then cut into 6mm ply on the college laser-cutter; while a rather unusual choice for such a basic camera, using the laser cutter allowed me to ensure the pieces would fit together, and meant I was not relying on my rather dodgy carpentry skills. This also allowed me to actually complete the camera in the limited time period allowed!

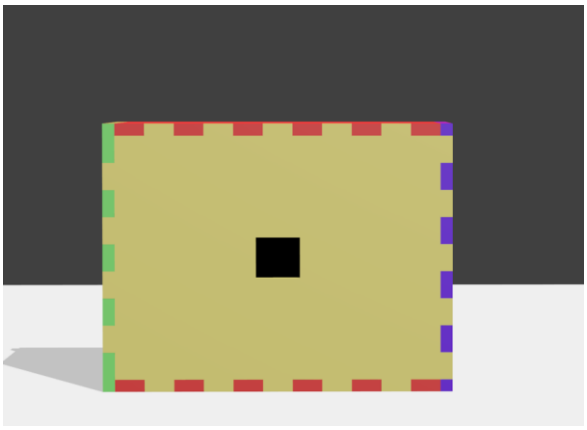

Figure 6: 3D mock-up of the camera

After all of the pieces were cut they were assembled into the final camera design. Any seams were light-proofed with felt and a steel holder for the aluminium pinhole plates was assembled (I am rather more confident with working metal than I am with wood). The assembled camera was then primed and painted using acrylic paints. The entire process of assembly and painting took approximately 4 weeks.

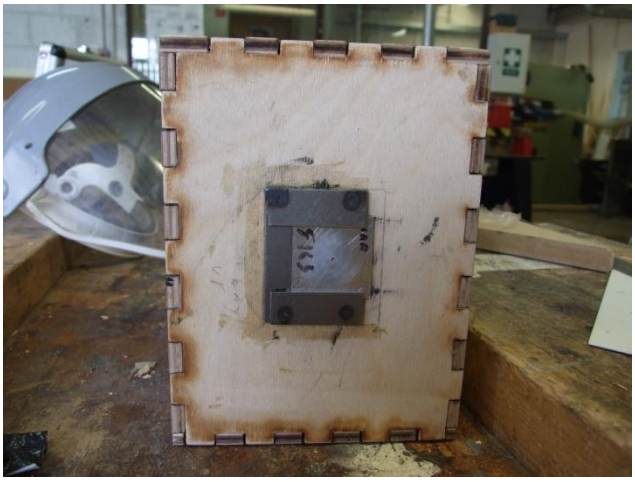

Figure 7: Assembled Camera

Figure 8: Painted Camera

Fortunately the box of delights was light-tight and no major modifications were required. It was primed black and gradually colour was built up over a number of layers. Astronomical designs were chosen as it is reminiscent of the symbols found in Victorian romantic paintings. Finally it was sprayed with matt varnish as a seal against the elements.

Using the Pinopticon

The camera was designed around the use of a 4x5" darkslide, which allows additional exposures without returning to the Darkroom. Into this I loaded photographic paper in place of film, as while much less sensitive to light, it can be loaded under a safelight instead of in total darkness (it is also significantly cheaper). Part of the original design was to have a tripod bushing on the underside of the camera, this allowed it to be kept steady for the length of some of the exposures required (upwards of 30 minutes in some cases!)

Figure 9: The artist at work

Exposures were guesstimated using a light-meter and some photographic know-how; about half of them actually worked, which was far more than I was expecting. After exposure the photographs were carefully developed in the darkroom with extra care taken to ensure that they were in the chemicals for the correct length of time.

Overall, the project seems to have been something of a success. The famous Powell bad luck didn't rear its ugly head too frequently and the final results are interesting from a technical viewpoint, if not perhaps to everyone's taste. I look forward to using the camera in the future and the project has given me a new perspective on the use of modern equipment (do you see what I did there?)

Figure 10: One of the original negatives

The Results

The final images have a somewhat ethereal quality to them due to the soft effect of the pinhole; details are far from sharp, but there is more then immediately meets the eye.

This pinhole self-portrait was a 5 minute exposure and was particularly taxing to complete. As with most of the images it is overexposed, but instead of resulting in a total white-out it has more of a professional, high-key feel to it. Traditionally this is used in fashion or product photography and is almost exclusively carried out in the studio with a dedicated light set-up.

Another image, taken in a forest. This one reminds me of work by Rayleigh and other early pinhole pioneers. "It's like 1840 all over again!" Due to the length of exposure the trunks are distinct while the leaves are blurred. Details in the image can only be seen clearly by close examination.

Glossary of terms used

- Blender – an Open Source graphics package
- Camera obscura – a room with a small aperture in one wall (either pinhole or lens) that projects an image onto the opposite wall.
- Darkslide – a small plastic box with a sliding shutter on either side designed to keep film unexposed until in-camera.
- f/stop – standard measurement of aperture
- Pinopticon – an imaginary word created by the author. Derived from Pinhole and Panopticon - an all-seeing prison designed by Jeremy Bentham in the late 18th century.
- Photography – 'Painting with Light' in Greek, the act of preserving an image formed with an aperture.

Post script

One of the issues that arose during the project was calculating the correct exposure for non-standard f/stops. As a result of the way the camera was constructed, the f/stops of the various pinholes did not fit comfortably into the standard one stop scale (90, 128, 180 etc.), but where such awkward numbers as f/165. Consequently, exposures had to be somewhat 'fudged' and judged to the nearest half-stop.

To counteract this, the Powell-Newby formula for calculating precise exposure time with non-standard f/numbers was developed:

$$et = ms \times 2\text{^}(\left(2 \times log2(aa)\right) - \left(2 \times log2(ma)\right))$$

Where:

- et = exposure time (in seconds)
- ms = metered shutter speed (in seconds)
- aa = pinhole f/stop (actual aperture)
- ma = metered f/stop (metered aperture)

This formula, while not rigorously field-tested, should allow the photographer to calculate the precise exposure time needed when using a pinhole camera. To use it you simply take a meter reading, input the shutter speed and f/stop displayed and enter the f/stop of the pinhole you are using. In order to achieve maximum accuracy possible, it is advisable to only use metered f/stops that are integers; this is because the light meter rounds fractions to the nearest decimal point and would introduce slight errors (e.g. f/5.6 is actually f/ 5.6568542494923802)

This formula, while intended for pinhole, would also work with older cameras that do not have apertures in the standard scale.

In my opinion, the beauty of photography is all the greater for the fact that it relies on scientific and mathematical principles. Just as the great Da' Vinci combined art and science, so too can the modern photographer who wants to return to the basics of their craft. Without maths there would be no photography: something we are losing awareness of in this age of point-and-shoot cameras.