1. Before Photography

Part 1: Discovering Light

The most basic aspect of photography is our understanding of how light works, and the first known writings on this come from well over two thousand years ago in China. Mo Ti (later known as Mo Tsu) was a philosopher who lived from 470 to 391 BC. Unlike most philosophers he came from a poor background, perhaps why his teachings were based on the conviction that all men were of equal worth.

His followers or 'Moists' were taught that right living demanded they take responsibility for the well being of others and ensured that their actions did not harm others, but practised a universal love for others. If people follow this path, the world is 'ordered and peaceful,' if not, 'the world becomes disorder, violent, and chaotic.'

Although difficult to argue against, these ideas did not generally win the affection of the rich and powerful, and Moism soon died out. Mo Ti also thought deeply about the natures of shadows, realising that they were formed by light travelling in straight lines, the first recorded law of optics. He also was able to use this to explain why the images formed when light entered a darkened room through a small aperture were inverted, so can be credited both with recognising the role of an aperture in forming an image and also with an understanding of what later became known as the 'camera obscura' which will be looked at in more detail in a later section.

Back in the more primitive west, the Greek philosophers were also noticing similar effects. Aristotle, around 330BC, wondered how the sun, shining through a square hole into a darkened room, could create a circular image, but it was a problem for which he had no solution. He did however note that decreasing the size of the aperture in viewing an image created a sharper image.

Euclid (around 325-265BC) in Alexandria setting out his 'Geometry', clearly understood that light travelled in straight lines, and he also wrote a treatise on 'Optics' which discussed among other aspects ideas about binocular vision. Two copies of this work survived and when it translated and published with notes in 1573, Egnacio Danti added his description of the camera obscura to show how Euclid had arrived at his conclusions.

Heron of Alexandria produced his 'De Speculis' and 'Caoptrica' around 125 AD. His is the oldest surviving Greek work on mirrors - plane, convex and concave and he also stated the law that the angle of incidence is equal to the angle of reflection.

A few years later, around 150 AD, Ptolemy, also from Alexandria, wrote his 'Optics' extending the work of Heron and Euclid. Ptolemy was the first to write about refraction, perhaps because clear glass was now available.

Part 2: Ways of Seeing

Light itself and how we see objects was also a problem that attracted the Greeks. Empedocles (483-424 BC) thought of light as matter, small particles emitted by objects that travelled to reach our eyes. When we think of light as photons we are using a model similar to his.

Others such as Herodotus (484-425 BC) and later Aristotle (384-322 BC) also argued that objects were visible and had the properties we perceived because they emitted light that is detected by our eyes, although they did not see light as matter, but rather as an 'emanation', something given off by substances. We might regard this in more modern terms as light waves, although the wave theory of light dates from the work of the Dutch mathematician and physicist Christiaan Huygens, (1629 - 1692).

Plato (428-347 BC) also speculated about the nature of seeing, thinking of it in terms of a reaching out from the eyes of the viewer to discover the subject. It was a view modelled on the idea of touching, although making use of an invisible agent.

Of course we now think scientifically in terms of rays of light radiating from objects in straight lines in all directions, some of which enter into our eyes to form a retinal image, producing sight. However true this may be in physical terms, Plato's model is firmly embedded in our language and ways of thought. We think of seeing as a kind of touching, essentially a tactile act, concerned with textures. Looking at something is an active process. We seldom think in terms of the rays from objects making themselves seen by us.

This tactile metaphor of seeing applies even more to the act of photography than of sight. Taking a photograph - especially a still photograph - is seen very much as an active proves in which we reach out and grab our copy of the scene we have framed in our viewfinder. We feel it that way, and so do people that we photograph. Whether we are photographing people who fear we are stealing their souls or urban dwellers who think we are invading their privacy, our act of photographing is at times resented as an intrusion.

Video cameras are somehow less intrusive, perhaps seen more as a passive device, one that receives signals, into which the images flow. Filming lacks the kind of deliberate selection and isolation implied when we frame the image and press the button. On numerous occasions I've seen people treat still photographers with suspicion and even rage while ignoring the video cameras recording them.

The first description comparing the working of the eye to a camera came from the great Abou Ali Al Hassan Ibn Al Haitham, born in Basra on the Persian Gulf, in 965 AD. Better known under his Latinised name of Alhazen, he worked in Alexandria from around 1015 to 1021 on his great treatise on optics. It was his work, translated into Latin around 1270, which brought this knowledge to Western Europe.

Part 3: Lenses

Some natural quartzite and other transparent crystals can be shaped to act as convex lenses. One of the first to be found in archaeological excavations was discovered by Sir Austen Henry Layard in his excavations in Babylon in 1850, and was dated from around 900BC. However many consider - particularly because of its facets - that its purpose was decorative rather than useful.

More recently, Robert Temple found many examples of similar early crystal lenses in museum collections around the world, which are usually not acknowledged as such. He thinks the Layard 'lens' is a damaged example of a lens.

His book 'The Crystal Sun', posited that an advanced optical technology was widespread across the ancient world. As well as convex lenses similar to the Layard lens he also found concave lenses and some showing the use of complex 'toroidal' grinding techniques to correct eyesight for astigmatism. His controversial book suggests that as well as spectacles and other similar uses, the ancients also made telescopes and microscopes.

One part of the evidence for his theory is the existence of many designs on early artefacts which are too small and intricate to be seen or made with the naked eye. The cover of his book shows a Greek drawing which could be of a man looking through a telescope. Perhaps if he had written this work before his work speculating on alien visitors from Sirius it would have received more careful academic consideration.

One of his more interesting speculations concerns Archimedes (287-212 BC), who wrote of the use of a large burning glass as a weapon to set fire to ships in an opposing fleet. Temple claims that this may actually have been used - an early example of true 'Star Wars' technology.

Whatever opinion may be formed of some of his more fanciful suggestions in this and other books, it does seem likely that lenses were rather more common than had previously been though in the ancient world, and were probably in use in Egypt from around 2500BC.

Glass was probably first made in the Middle East, between the Rivers Tigris and Euphrates - now Iraq - around 2500 BC. Early glass was not clear and it was only around 100BC that the Romans managed to produce a clear material.

With the fall of the Roman Empire, many of their secrets - including some of their glass making skills - were preserved in Egypt and Syria. However it was not until the discoveries of Venetian glassmakers from around 1200AD that clear glass again became available again in the West. Lenses for eyeglasses (spectacle lenses) began to be mass-produced in Venice in about l275.

Among those in England who studied the work of Alhazen, following its translation into Latin around 1270, were Robert Grosseteste (1168-1253), the Chancellor of Oxford University who made use of plano-convex lenses, and Roger Bacon (1214-1294). Grosseteste carried out optical experiments and Bacon published his famous works on optics and other subjects. Their work marks the beginning of the scientific study of optics in Western Europe.

From somewhere around this date, lenses were commonly used in camera obscura, allowing a brighter image and a sharper picture. The disadvantage is that the aperture to screen distance had to be precisely matched to the power of the lens and also to the distance of the object from the lens. In room size camera obscura this normally meant using a moveable screen.

The original camera obscura - what we might now call a pinhole camera - required no focussing, although the aperture diameter for optimum sharpness is highly dependent on the aperture to screen distance. Making the aperture larger than optimum gives a brighter but less sharp image.

That a smaller aperture could also make the image less sharp could only be explained by the wave theory put forward later by Huygens, but early camera obscuras mainly used apertures well above the optimum size. For visual use the extra brightness was more important than a small loss of detail.

Over the next few centuries, there were various advances in lens design. The scioptric ball was a lens using two biconvex elements mounted in a ball-shaped mount. It was in some ways the first wide-angle lens, introduced in 1636 by Daniel Schwenter, professor of mathematics and oriental languages at Altdorf. Although the actual angle of view of the lens was not great, the mount enabled it to be swivelled to cover an extensive scene piece by piece, enabling drawings to cover an extensive view.

It was another 300 years before the first true wide angle lens was to be made, the Globe Lens, designed and sold by C. Harrison and J. Schnitzer of New York in 1857. This gave a similar angle of view to a 28mm on a 35mm camera and had to be stopped down to f35 or smaller for use. Many stereo cards were taken using this lens.

Johann Zann's 'Oculus Artificialis Teledioptricus' of 1658, not only gave the first description of a reflex camera, using a mirror to invert the image, it also described the construction of a 'Galilean' telephoto lens, using the same principles as modern telephotos.

The advantages of combining lenses of different powers and different types of glass were a subject of study. The first partly colour corrected lens - an achromatic lens - is said to have been made by Christiaan Huygens, in 1677.

More normally its invention is ascribed to English barrister Chester More Hall in the 1730s. Hall noticed that the new flint glass dispersed colours more than the old crown glass and reasoned that you could combine a convex crown glass with a weaker concave flint glass to give an overall magnification but keep the colours together.

To keep his idea secret, Hall ordered the two lenses from different lens makers, but they both subcontracted the actual manufacture to the same lens-grinder, George Bass. Bass realised what Hall was doing, but kept his secret for 20 years when he told John Dolland who promptly made his own achromatic lens in 1759 and took out a patent, charging other opticians a heavy royalty. When they found that the invention had been made earlier by Hall, they went to court to get the patent revoked, but the court ruled that Dolland should keep the patent as he had made the invention public, allowing others to make use of it.

Part 4: The Camera

The first cameras were 'camera obscura', literally 'darkened rooms.' As the first section of this feature described, the effects of light passing through small apertures into these rooms were described and explained by the ancient philosophers. Knowledge about their writing came to the west through the translations of the texts by Euclid, Ptolemy, Heron, Alhazen and others into Latin from around the eleventh century.

The camera obscura shown in these texts were still literally rooms, although a drawing by Johannes de Fontana in 1420 shows what may be a portable camera obscura. One major use of the camera obscura was for the observation of the sun and solar eclipses in particular, and it remains a safe method for viewing these.

I made a reasonably sized instrument for an eclipse here some years ago from a long cardboard tube. This was fitted with a small hole at one end and a screen at the other. A hole in the side of the tube a few inches above the screen allowed convenient viewing. The whole instrument could be fixed to a tripod and pointed to the sun. The image it gave was surprising bright and clear.

The invention of printing by Johannes Gutenberg around 1450 led to an explosion in publishing of scientific works, which were no longer limited to a small handful of hand-copied manuscripts. Works began to be published both describing and illustrating the camera obscura. Most histories of photography carry at least one picture of these, usually one of those in Helmut Gernsheim's 'The Origins of Photography'. This is rather easier to find than his pioneering work on the subject, 'The History of the Camera Obscura From the Earliest Use of the Camera Obscura in the Eleventh Century Up To 1914'.

Leonardo Da Vinci certainly drew a camera obscura in his manuscripts, but these were not published until some centuries later. The first printed description appears to have been made by one of his pupils, Caesare Caesariano (1483-1543). Caesariano published his translation of Vitruvius's 'Treatise On Architecture' which included this in 1521.

Reinerus Gemma-Frisius (1508-1555) used a camera obscura to observe the 1544 eclipse, and published his results in the following year, complete with a drawing of the apparatus which illustrated how it worked. The most widely used early illustration is probably from a book by Giovanni Battista Della Porta (1538-1615), which he published in 1588. (Like most of the diagrams mention here it is reproduced in the 'Camera Obscura' link in the box above.)

Perhaps the most attractive of the early illustrations is fittingly enough, in a book by Athanasius Kircher. Published in 1646, this shows the use of the camera obscura as a tool for artists. It was this use that was to be most important for the next almost three hundred years, with many well-known pictures being created with their help. For most artists, the camera obscura was merely an aid to sketching - for example probably in the work of Canaletto.

Philip Steadman's intriguing study of Vermeer makes clear his considerable reliance on the camera obscura. From the evidence presented in his book, 'Vermeer's Camera', much of which is available on the web site, it seems fairly clear that Vermeer painted directly in the camera obscura. His work has always intrigued because of its natural use of lighting and the superb tonal effects. In many ways it has always seemed more photographic than painterly. Steadman shows how some of the effects Vermeer used where the effects of a lens, as well as showing how one of the rooms used in a number of the paintings can be reconstructed in three dimensions.

More portable versions of camera obscura were developed; tents and boxes that could easily be carried. One of the most portable was the 'camera lucida' a kind of prism on a monopod first developed in 1666 by Robert Hooke (1635-1703). It required great skill to make a good drawing from its use and although the name has become well known it is unlikely it saw much use by professional artists.

The mistaken suggestion by David Hockney that many artists made use of the camera lucida instrument has forced lecturer Robert Woodrow to put some useful information about it on his 'Camera Lucida' Art History web site. You will also find a link to his essay 'Origins in Shadow (a history of pictures)' which I only found when I had finished writing this feature but covers some similar issues and is recommended highly.

Other camera obscura were erected as observation towers, generally rooms topped by a rotating lens. These were relatively common in the last century as tourist attractions and those still open to the public remain popular. I visited the modern example in the Royal Observatory last month and watched fascinated as it projected a detailed view of the Thames and East London. There are at least two great sites on the Internet which deal with these, where you can find the nearest to you to visit. Foredown Tower is a camera obscura erected on the top of an old water tower in Portslade near Brighton. Originally built for the 1990 Garden Festival in Gateshead , Tyne & Wear it was moved here the following year when the festival finished.

Its web site has an extensive list of other camera obscura in the UK, Europe, USA, Canada, Cuba, Australia, New Zealand, Africa and Asia as well as temporary and lost ones. If you know of a camera obscura near you, please check if they list it and if not get in touch. There is also some general information on the subject at this site.

'The Magic Mirror of Life' at Bright Bytes Studio, showcases the collection of Jack and Beverley Wilgus, with some fine vintage pictures related to the subject as well as some useful texts and links. They also have some fine examples of portable and box camera obscuras in their collection. They also have a great deal of material on camera obscura rooms in the USA and elsewhere, including an illustrated account of their visit to some of those in the UK.

The next feature in this series will look at the development of the chemistry of photography and the early attempts at producing a workable process. Later features will cover the daguerreotype and calotype.

2.Finding the chemistry

Part 1: Chemistry of Light

As the previous feature showed, the knowledge to produce a camera was available in the ancient world, both in China and in the Greek world. Not only had they appreciated the principle of the camera obscura - which could have been applied in a pinhole camera - but were aware that a converging lens could be used to produce a brighter image.

The other vital technical element is the light sensitive medium. Of course some materials had long been known to be sensitive to the rays of the sun - skin being an obvious case. In this case, although the reaction is relatively permanent, it is too slow to be of practical use in photography, although many people have shown it possible to create crude negative images.

The ancients also noticed the bleaching of colour in some plant materials when protected from the light. One of its most noticeable results is the pale patches left on a campsite after the tents have been taken up. Various photo artists have made pictures using pigments extracted from plants that fade in the light, and more recently artists Heather Ackroyd and Dan Harvey have been making large photographs using specially selected live grasses. Ackroyd and Harvey's photographs cast in grass are created through a photosynthetic print process. Instead of black and white, the images are shades of green and yellow.

Most practical photographic processes have however been based on the light-sensitive nature of silver salts (though other materials have been used.) These have dominated largely because they are more light sensitive than other materials and in particular because methods were found to amplify the effect.

Sophocles, well over 400 years before the birth of Christ, wrote of the need to keep light-sensitive substances in darkened rooms, although this was a metaphorical rather than a scientific statement. Vitruvius in the first century BC noted that red lead (minium, Pb304) rapidly turned black in sunlight.

The first existing reference to the light sensitivity of silver salts comes almost two thousand years ago, when Pliny (23-79 AD) makes a reference to what is probably silver chloride being darkened by the sun or moon. The darkening by moon is unlikely, but the Greeks in general were not great experimenters, rather recording what others had told them and speculating about things. Like many tales these may have gathered some additions by the time they reached the philosopher. What it does show is that someone had noticed the darkening of silver salts by light.

One of the earliest real chemists was the Arab alchemist Jabir Ibn Haiyan, better known in the West as Geber (ca721-803CE). Abu Musa Jabir Ibn Hayyan was working as a doctor and alchemist in Kufa (now in Iraq) in the second half of the Eighth Century. He recorded his experiments in a number of books, introducing a scientific method and rigour into alchemy. As well as emphasizing the need for correct quantities of materials he also introduced or improved most of the basic techniques of chemistry, and prepared a vast number of acids and other substances. Of most interest to us is his preparation of nitric acid, which he used to dissolve silver, giving silver nitrate. He noted that this compound darkened in the light.

Geber's major works on chemistry were translated into Latin in the Middle Ages by Robert of Chester (1144 AD) and Gerard of Cremona (1187 AD). Many scholars believe that some of the works attributed to him were written by other Arabic alchemists in the following two centuries using his name. There was also a 14th Century Spanish alchemist - sometimes known as the 'False Geber' who also wrote under this name.

Part 2: Alchemy to Chemistry

Despite the translation of much of Geber's work, it was not until 1556 that the light sensitive nature of silver nitrate was rediscovered. Georg Fabricius (1516-1571) from Chemnitz added salt to silver nitrate solution, forming a white solid, silver chloride, which went black in sunlight. However because of his theoretical ideas he found this discovery of little interest. Fabricus's researches were wide ranging: as well as being an alchemist, he was a poet, teacher, historian and archaeologist, and was probably best known for his popular guide-book to the antiquities of Rome.

Fifty years later in 1614, Angelo Sala (1576-1637), an Italian Calvinist who left Italy to avoid religious persecution to settle first in the Low Countries and later Hamburg, published a paper including his work with powdered silver nitrate. He found this turned black on exposure to the sun, although he did not make it clear whether this was due to the light or the heat of the rays. He also found that it stained paper black if in contact with it. Among his other studies, Sala was also the first to point out the use of St John's Wort as a treatment for depression.

Robert Boyle (1627-91) also noted the blackening of silver nitrate on exposure in 1667, but he put it down to the action of air on the material. Although one of the most eminent scientists of the time he apparently jumped to an incorrect conclusion without examining the evidence or carrying out suitable experiments.

Further work on the light-sensitivity of silver salts was carried out in 1693-1694 by German chemist Wilhelm Homberg (1652-1715). One of his experiments involved dipping bone in silver nitrate solution; it then darkened in sunlight. Homberg showed the darkening was due to the rays of the sun, but, like Sala, failed to make clear whether it was a result of their light or heat.

It was not until the work of Johann Heinrich Schulze in 1725 that this was sorted out, (although there were further confusions over the next 75 years.) Schulze noticed the effect (using chalk dipped in silver nitrate and nitric acid) and tried to reproduce it with heat. When these experiment failed he turned to the effect of light, and found that this produced the darkening. Schulze carried out a number of lecture demonstrations using card with cut shapes wrapped around silver nitrate bottles and produced darkening giving a crude impression of these shapes in the solution.

It was one of Schulze's other experiments with silver nitrate that perhaps first had application. He had written with silver nitrate solution onto paper and showed that when exposed to light the invisible letters darkened and became visible.

The French Chemist Jean Hellot (1685-1766) may well have been aware of Schulze's work as both worked trying to prepare phosphorus. In 1737 Hellot proposed the use of weak silver nitrate solution as an 'invisible ink' for use by spies, that could be made visible by prolonged exposure to sunlight. Hellot, who was born and died in Paris, was perhaps better known for his work for the Vincennes porcelain works (later transferred to Sevres where it became more famous), including a turquoise blue colour he invented for it.

Work on the light sensitivity of silver chloride was continued by the great Swedish chemist Carl Wilhelm Scheele (1742-86). In 1777 he correctly identified the reaction as producing metallic silver and also found that the violet end of the spectrum was most effective, with the effect of red light being almost imperceptible. Scheele refused to give up his job as an apothecary to take up a university professorship, but he was the discoverer of seven of the natural elements (nitrogen, oxygen, chlorine, manganese, molybdenum, barium and tungsten), as well as one of the main founders of organic chemistry. Scheele's work was later confirmed in detail by the experiments of Jean Senebier, (1742-1809), who notes in his experiments that the time taken using the red rays was 20 minutes, while the violet rays needed only 15 seconds.

Scheele also made another vital observation that should have helped to produce a working photo chemistry, but appears to have been overlooked. He found that silver chloride would readily dissolve in ammonia, but that the black metallic silver was insoluble. This enabled him to preserve his specimens after exposure. The sheets of paper he coated with silver chloride were washed in ammonia and then dried. He had discovered a method of fixing the images, but this was apparently overlooked by later workers.

A different approach to the idea of producing images came from the work of Elizabeth Fulhame, published in her book 'An Essay on Combustion: With a View to a New Art of Dying and Painting' in London in 1794. The wife of a London doctor, she was obviously in contact with some of the leading scientists of her day. Although long neglected, she is now regarded by many as the first to put forward the idea of catalysis. Her work included observations on the light sensitivity of some gold compounds.

When Polish scientist Johann Wilhelm Ritter (1776-1810) decided there might be invisible rays to the violet side of the spectrum, he detected them, following Scheele's method, by using 'horn silver' or silver chloride, which was darkened. Working at Jena University in 1801 he found to his surprise that these invisible rays were even more effective than the visible blue light. As Kenneth Caneva has pointed out, Ritter did not fully understand the significance of what he had observed and it was only much later that the true nature of these ultraviolet rays was able to be understood.

Many of the other leading scientists of the day also took an interest in chemical reactions caused by light, including the study of systems other than silver chloride. William Hyde Wollaston,(1766-1828), the inventor of the camera lucida, studied the effect of light on guaiacum gum, the sticky material produced by the lignum vitae tree (one of its main uses was medicinal, as it contained the expectorant guaiacol.)

American born Benjamin Thompson Rumford,(1753-1814), a 'physicist and scoundrel' who was noted for his work on heat and the conversion of work to heat, in 1798 claimed that the changes in silver chloride attributed to light were actually due to heat, although he was proved wrong a few years later by Robert Harrup in particular in 1802.

Thomas Johann Seebeck (1770 - 1831) from Estonia showed that using filtered light gave similar effects to light separated by a prism, with the blue light being most effective. Sir Humphry Davy experimented with the light sensitivity of lead oxides - as had Vitruvius so many years earlier. (His work with Wedgwood is dealt with in the next section.)

One other important contribution made to the chemistry needed came from John Frederick William Herschel (1792-1871). In 1799 the French chemist Francois Chaussier announced that he had found three ways to prepare a new salt which he called hydro-sulfure de soude and which he said could be used to treat skin infections. In English it was called hyposulphite of soda, although now known as sodium thiosulphate, or colloquially as 'hypo'. Roughly 20 years later, Herschel found that silver chloride would dissolve as readily in a solution of this substance as 'sugar dissolves in water.'

Part 3: Wedgwood

There are those who believe that the image on the famous 'Turin Shroud' is a medieval photograph, produced in a camera obscura between 1260-1320 AD. There is indeed some scientific evidence to back up this claim, although further tests on the shroud would be needed to come to a firm conclusion. Certainly experiments have been carried out which show that a very similar photographic image can be produced in the camera obscura using only materials readily available at the time - 'quartz (rock-crystal), the silver salts (specifically silver nitrate (eau prime and silver) and/or silver sulphate (oil of vitriol and silver) and ammonia (urine)'. This will not surprise anyone who has read the two previous sections of this feature.

One persistent rumour is that the first photographs were made at the Birmingham, England works of the leading engineers, Boulton and Watt, in the 1770s. Several nineteenth century histories of photography stated that both Boulton and Watt experimented with photography and at least one early American writer claimed Matthew Boulton as the inventor of photography, some twenty years after his grandson had issued a pamphlet denying their was any truth in the story.

One source for such rumours is undoubtedly Samuel Smiles, writing in his 'Industrial Biography' (1863), where he states that photography (he calls it sun painting) was invented by Leonardo da Vinci in the fifteenth century and then lay forgotten until 1760 when Tiphaigne de la Roche in Paris described it in his book 'Giphantie' (the title is an anagram of his first name.) Smiles then continues:
Still later, at the beginning of the present century, we find Thomas Wedgwood, Sir Humphry Davy, and James Watt, making experiments on the action of light upon nitrate of silver; and only within the last few months a silvered copper-plate has been found amongst the old household lumber of Matthew Boulton (Watt's partner), having on it a representation of the old premises at Soho, apparently taken by some such process.
A footnote states that the plate can be seen in the Museum of Patents at South Kensington and that the account of the discovery states that "an old man of ninety (recently dead or still alive) recollected, or recollects, that Watt and others used to take portraits of people in a dark (?) room; and there is a letter extant of Sir William Beechey, begging the Lunar Society to desist from these experiments, as, were the process to succeed, it would ruin portrait-painting." However such Victorian works are seldom reliable sources and there seems to be no evidence for this suggestion.

The first well-documented attempts to produce pictures using light sensitive materials in a camera were those of Wedgwood and Davy in the late 1790s, published in 1802. Thomas Wedgwood,(1771-1805), started his experiments around 1795 and described his work in an 1802 paper 'An Account of a method of copying Paintings upon Glass, and of making Profiles, by the Agency of Light upon Nitrate of Silver' published in the 'Journals of the Royal Institution of Great Britain.' Wedgwood had called upon Sir Humphrey Davy, one of the leading scientists of the era, to assist him with his work.

Apparently following a suggestion made by Lord Brougham to the Royal Society in 1795, Wedgwood and Davy had been successful in creating images which they called 'sun prints' by laying objects on top of paper and leather which had previously been coated with silver nitrate solution. This produced 'profiles' of the objects, the paper remaining white where it was covered and blackening to show the outline of the object. These were what W H Talbot was later to call 'photogenic drawings' and we would now call 'photograms'.

Unfortunately when viewed in sunlight, these images rapidly darken all over, as the silver compounds have not been removed from the lighter areas. They were unable to successfully fix the images. The best results were obtained on a pale coloured leather. In part this may have been because it was more absorbent, but it is likely (as J B Reade pointed out in the 1830s) that this was due to the presence of gallic acid in the leather which acts as a photographic developer.

Their experiments can readily be repeated using a real chamois leather, brushing this with silver nitrate, drying and exposing to sunlight either using a photographic negative or suitable objects to make a photogram. The images produced are rather weak, but I know one produced around twenty years ago which has been stored in darkness and only viewed occasionally using dim light which is still clearly visible.

Wedgwood tried to make images using the camera obscura, but found the image was 'too faint to produce, in any moderate time, an effect upon the nitrate of silver.' He was a little more successful in reproducing drawings by contact printing, although he noted that the darker areas were not copied well. The claim of Wedgwood and Davy to have taken the first real photograph rests however on his use of the solar microscope. This directs sunlight from a large mirror (often outside a darkened window) through the specimen to produce a brightly magnified view on a screen.

Wedgwood and Davy used both silver nitrate and silver chloride in their experiments, although the nitrate was found more convenient. They used a lens to create an image, they showed how to contact print an image. Their work was truly the dawn of photography, but it was not yet in a state that was ready for extensive use. Possibly if Wedgwood had lived longer, or taken less opium (and the two were almost certainly intimately connected) he might have taken his work further.

Part 4: Niépce

Joseph Nicephore Niépce,(1765-1833), and his elder brother Claude were inventors from a wealthy family who lived a few kilometres south of Chalon-sur-Saône, Burgundy, France, where he administered the family estate at Le Gras in the village of St. Loup-de-Varennes. He was interested in developing a lithographic process using tin plates in place of the stone of Senefelder's processs. He got his son Isidore to draw images onto the printing plates since he could not draw himself. Unfortunately his son was drafted into the army for the battle of Waterloo in 1814, so Niépce (pronounce it nee-eps) started research into ways of automatically recording images.

His first experiments were with silver salts, well known to be light sensitive, and he is thought to have taken his work a little further than Wedgwood and actually obtained images using the camera obscura. There is no actual evidence for this belief, and if it is true probably resulted from his trying much longer exposure times - perhaps of several days. However the images he obtained were negative images, and, like Wedgwood, he could not find a way to make them permanent, so he abandoned work with silver compounds.

His next experiments were with a material called 'Bitumen of Judea' which was used as a resist in some engraving processes. This is a naturally occurring mineral that has been known since ancient times, a deep black substance found where it once oozed out of cracks in rocks from natural petroleum deposits. Common in some areas of the Middle East (hence the name), it was also found in a quarry about 60 miles to the south-east of where Niépce lived, at Seysell.

Bitumen of Judea has two properties that made it attractive for Niépce. On exposure to sunlight it both loses its black colour, fading to a light gray, and it also hardens. This hardening during exposure meant that the exposed material would be retained on the plate while the unexposed material was washed off with oil of turpentine or oil of lavender. The lighter parts of the image were thus represented by the hardened bitumen, rendered pale grey by its exposure.

In the darker areas of the subject, the plate had no bitumen coating as the exposure was not sufficient to harden it, and it all washed off. To make these areas appear dark, either a dark material could be used for the plate, or it could be held so that the surface reflected a dark area. In practice it worked better both with the darker grey pewter than with glass of copper. Pewter also had an advantage over glass for making printing plates, although copper was probably even more suitable both for etching and because it has a more durable surface.

Niépce's progress was slow, not least because he had other affairs to attend to, particularly the marine engine he had patented together with his brother, which needed further development and promotion, as well as the family estate. However, by around 1822 he was getting some successful results with the method, using it to produce a print on glass of a black ink drawing of the Pope. He soaked the paper of the etching in oil to make it more transparent, but it still required an exposure of several hours. None of these earliest experiments have survived, but there are a number of later examples of such 'heliographic' prints by Niépce.

One of the problems with using the camera obscura was the lateral reversal of the image. This had equally been a problem when using this type of camera when drawing, and could be solved by the use of a prism in front of the lens. Early in 1826, Niépce bought his first professionally made camera, a 16 x 20 cm format, together with a prism and an achromatic lens from the Paris optician, Charles Chevalier. In May he ordered a batch of pewter plates to use in place of the glass, copper and zinc of his earlier work.

The 'first photograph from nature' was probably taken shortly after this, although it was not until around fifteen years later that the term 'photograph' came into use, Niépce calling his pictures 'Heliographs'. He set up the camera on a firm base looking out of one of the upper windows of the family house. The exposure needed was extremely long - several times the 8 hours often mentioned - and was made over several days, according to both Niépce's notes and the recreation of his experiments carried out by Jean-Louis Marignier, research director at Laboratoire de Physico-Chimie des Rayonnements, Orsay, France. Probably the successful result was the culmination of a series of unsuccessful attempts using shorter times.

As you can see from the web site at the Ransom Center of the University of Texas at Austin where the 'worlds' first photograph' is now exhibited, the image is only visible if held and viewed at the correct angle to the light.

Niépce also took some of the plates he had exposed under drawings, washed off the unhardened bitumen as usual and put them into etching solutions. The remaining bitumen protected the metal from etching, while the unprotected metal was dissolved away to form pits in the surface. For printing, all of the bitumen was removed leaving a plate with etched pits that can be inked up and printed in a normal printing press.

His bother Claude had come to live in England to try and promote their marine engine and in 1827 news reached Joseph that he was dangerously ill. Joseph came to visit his brother who was living in Kew, just to the west of London and he brought his image fixed in the camera obscura and some examples of the etchings with him. In Kew he met the botanist, Francis Bauer, a Fellow of the Royal Society, who immediately recognised the significance of his work and persuaded him to write a paper to present to the Royal Society.

Unfortunately Niépce's presentation to the Royal Society in December was not a success, as he was not prepared to disclose some of the secrets of the process. Unlike the members of the Royal Society, he was an inventor concerned with making a living. They were mainly rich and able to pursue science for its own sake. When he would not make a full disclosure, they returned his paper and examples without recognising his achievements.

Part 5: Lost & Found

Although Niépce's work and in particular his 'first photograph from nature' was mentioned in many of the histories of photography, for over fifty years it was lost to sight. The picture had last been seen in public at the great photographic exhibition held at the Crystal Palace, London in 1898. It took several years of research starting in the late 1940s before historians Helmut and Alison Gernsheim located the image in 1952.

On Bauer's death in 1841, the material had been sold first to Dr. Robert Brown, and then to J J Bennett. After Bennett's death in 1884, they were split at auction between the photographer H P Robinson and the editor of the Photographic News, H. Baden Pritchard. Robinson had bought the three 'heliographic' reproductions and the photo-etching, and these eventually passed to the Royal Photographic Society collection on his death (they were lent to the Science Museum for display.) Pritchard died shortly after buying the photograph and the text and nothing was known either about his family or the fate of his Niépce material.

Knowing that to most people the picture would simply look like a dirty metal plate which could easily be disposed of as rubbish, Helmut Gernsheim wrote a letter to the Times newspaper in 1948 explaining the situation and asking for information about the Pritchard family and the photograph. The Times would not print it then or when he tried again in 1950. A few months after this second attempt, the editor of one of the Sunday newspaper 'The Observer', contacted Gernsheim to interview him on the photography of Lewis Carroll which he had recently discovered, and when asked, agreed to publish his appeal for information.

Immediately Gernsheim was contacted by Pritchard's son, but with the bad news that the family had not seen the picture since the 1898 exhibition. A year and a half later he got a message from Mrs Pritchard. Her husband - Pritchard's son - had died, and the Niépce picture and other items had been found in a trunk that had been stored and forgotten in a depositary since 1917. Unfortunately, there was bad news - their was no sign of a picture on the plate - it had faded.

Gernsheim knew this could not be true - it is an extremely permanent process. On being shown the picture he was able to hold the plate at the correct tilt to the light and get her to view it from the right angle, when the picture magically became visible. They were the first to see it for over 50 years. He told her that what had seemed worthless, on the strength of his identification, was now priceless.

Gernsheim argued that rather than be sold to the highest bidder and possibly disappear into a private collection it should be seen by the world. Mrs Pritchard was persuaded that the best way for this to happen was for the items to become a part of the Gernsheim Collection as a gift from her. Gernsheim was true to his promise, showing it in numerous exhibitions and having the reproductions make that are familiar from the history books. Because it had been a gift, when the University of Texas acquired the collection, the Niépce items were again passed on without valuation.

Niépce had produced the first photograph from nature, but although a great achievement, it was clearly also a dead end. The process was too slow, the pictures were not clear enough and there was little likelihood of improvement. He went back to work to try and improve the results. Shortly he joined forces with another experimenter, Louis Jacques Mande Daguerre. The story of their partnership, and the process which Daguerre announced to the world, is one of the subjects of the next feature in this series.

Daguerre and Niépce - The invention of photography

Part 1: Daguerre & Diorama

Louis Jacques Mandé Daguerre (1787-1851) was a painter who specialised in the production of panoramic dioramas. These were paintings, which could be illuminated either normally from the front or from behind. Suitable painting on the back of the material was made visible by shining a light through. In this way a scene could be made to turn from day into night by changing the illumination.

Similar effects are still to be found in museum displays, but at the time they were the nearest the public could see to a moving image, and Daguerre made his living by charging the public to see them in his galleries. His Diorama opened in the Rue du Faubourg-du-Temple, just outside the edge of the fashionable streets, in Paris in 1822. It was on a grand scale with huge canvases, possibly 20 meters wide and the height of the room, seeming to the audience to come to life with his lighting and sound effects. Like many artists, Daguerre had used a camera obscura to help him with his paintings.

In his pictures, figures would appear mysteriously in empty chairs or rocks would start to tumble from mountains to the amazement of the viewers. Daguerre apparently began his experiments with photography hoping it would provide him with an easier method to produce such pictures, but in this he was not successful. Although the Diorama was a great success, Daguerre apparently quarrelled with his partner who came to London with some of the pictures, and in the early 1830s was bankrupt, although he recovered from this.

Diorama pictures by Daguerre and his staff were shown in a number of cities around England, as well as in Edinburgh. When he went to live in Bry-sur-Marne, just to the east of Paris, he created one for the church there, which is now in need of restoration. Probably by chance, Bry-sur-Marne has become something of a centre for imaging in France, perhaps more to do with the film studios in nearby Joinville-le-Pont than with its association with the founder of photography.

Daguerre apparently started his experiments with photography around 1824 working in a similar way to Wedgwood and Davy with silver nitrate soaked paper, and with silver chloride on paper, but he soon abandoned his work with these materials, probably because he could find no way to make a positive image on paper.

At some point, he moved on to experiment with coatings on glass and metals, but apparently made little progress. Probably his change of direction came through hearing about Niépce's experiments from the optician and lens-maker, Charles Chevalier, who had made a camera for Niépce early in 1826, although they had other acquaintances in common. Through his Diorama, Daguerre had become very well known in Paris.

Part 2: Partners

Joseph Nicephore Niépce himself attended Daguerre's show in 1827 and was greatly impressed, writing that it was the greatest show in Paris, but the two men probably did not meet until several years later, around 1829, when someone, possibly Vincent Chevalier or the celebrated engraver Augustin François Lemaitre, introduced Daguerre to Niépce and the two men discussed their work. After a certain amount of hesitation, Niépce agreed to cooperate with Daguerre and in 1829 they entered into a partnership agreement for a period of ten years. Both men started work using resinous coatings on metal plates - such as the bitumen with which Niépce had made the first successful picture from nature.

Their first experiments were directed at finding some way to darken the metal surface, and one of the materials with which they experimented was the element Iodine, which had been discovered by the French chemist, Bernard Courtois, in 1811. Courtois was a manufacturer of potassium nitrate (saltpetre) and had obtained iodine by burning seaweed and treating the ash with sulphuric acid. Several other French chemists were quick to confirm his results, and in 1813 the great chemist Joseph Louis Gay Lussac showed it to be an element, similar to chlorine and named it iodine. Courtois had first seen it as a purple vapour, but on cooling it gives deep purple-black crystals.

These crystals are readily handled and stored, and on warming gently they change directly from the solid to a purple vapour, which reacts readily with many metals. Small amounts of iodine found in our food are essential for health (in our thyroid hormone), but the element is poisonous and extremely irritating to the eyes and mucous membranes. The change directly from solid to vapour is known as sublimation, and makes it suitable for forming an even layer of a metal iodide on a clean metal surface by placing this in a suitable 'fuming chamber' with iodine present. Being relatively newly discovered by French chemists, iodine was very much in fashion as one of the latest things in chemistry, and it may well have been this that inspired the two men to try out its use.

Both Niépce and Daguerre also would have known that by using a silver plate (or rather the more practical alternative of a silver coated copper plate) they could use iodine to form a light sensitive coating. Unfortunately, although this was easy to make it was not very sensitive to light. By the early 1830s however, Daguerre had apparently found a way to make these iodised silver (silver iodide coated) plates much faster.

The story usually told is how, having prepared an iodised plate to try in a camera and started on a lengthy exposure, clouds came over and Daguerre was forced to abandon his work for the day. He removed the plate from the camera and saw there were no traces of an image on it, so decided he could make use of it when the weather improved, putting it in a dark drawer for safe keeping. On taking it out the following day he was astonished to see an image had appeared.

Part 3: Inventing the process

Whether or not this story of the mercury from a broken thermometer was true (and modern historians love to debunk such myths), it encapsulates two key elements of the successful photographic process that Daguerre was to discover, and which were also vital to later processes. The first was the idea of a latent image - that an exposure too short to produce any visible change in the photographic plate could have succeeded in forming a hidden image. Along with this came the second vital part of the process, the idea that some substance - what we now call a developer - could amplify this hidden image, rendering it visible.

It remains unclear at what date Daguerre noted this effect, or when he was able to show by further experiments that the material that had brought out this latent image was mercury vapour. This was of course a common material in the laboratories of the time, being used in large quantities in instruments such as the barometer and in smaller amounts in thermometers. The dangers of this material - a cumulative poison through inhalation of the vapour - were not fully realised until relatively recently, and even in my schooldays it was liberally distributed around most laboratories. Children loved to play with 'quicksilver', letting it run along the paths on their palms. Whether or not the story of the broken thermometer in the drawer was true, mercury was likely to be present in Daguerre's lab, and its vapour to build up in almost any closed space.

Daguerre apparently recounted how he first tried experiments with each of the other chemicals that were present in the drawer and found they had no effect on an exposed plate. Having eliminated these, he inspected the drawer more thoroughly and found traces of mercury present, and it was then a simple matter to show that this was the developer he was seeking. Daguerre was not himself a scientist, but he knew many of the leading figures in Paris at that time, including Jean-Baptiste Dumas (1800-84), one of several noted French chemists of the times, and was able to pick the brains of him and others to help solve his problems.

Historians argue about the exact date of Daguerre's breakthrough. From the letters between the partners, we know that Niépce had given up with the use of iodine by 1831, but that Daguerre had some more promising results and was to continuing to work with it. The letters are suggest less cooperation that might be expected between partners, but probably they were wary of putting down much on paper in case it should be read by others. Both were inventors who hoped to make a great deal of money from a successful invention.

When Niépce died of a stroke in 1833, the agreement specified that his son, Isidore, should take over his side of the partnership. From the correspondence between Isidore Niépce and Daguerre it is clear that it was Daguerre alone who was responsible for reducing the exposure times needed from hours to minutes. Certainly by 1837, Daguerre was able to use exposures of 4 minutes in bright sunlight.

A second problem was the nature of the images themselves. Like Niépce's heliograph images of the mid 1820's, the images Daguerre was making were a dull pale grey colour on a metallic surface. Like the earlier images they were essentially negative rather than positive, with exposure darkening the light sensitive material. While at first the two men strove to make the images more visible by darkening the unchanged metal surface chemically, at some point one or other of them realised that the reversal could occur physically by holding the image at the correct angle to the light to reveal the dull white highlights while making the highly polished metal background dark. It was a realisation vital to the success of the Daguerrotype.

This need for the correct lighting and viewing angle is of course shared by Niépce's very different looking Heliograph, and was also to be made use of in later processes such as the Ambrotype and tintype. It removes the need to find some way to actually reverse the tones from the negative, replacing it by what we might now call a virtual reversal.

Related to this was the problem of keeping the images in good condition and avoiding the tarnishing of the silver metal. It was necessary to seal the metal plate in a case behind glass to prevent in from oxidation by reaction with oxygen and in particular sulphur containing pollutants in the atmosphere.

Daguerre's letters to Isidore Niépce also make clear that by 1837 he was trying to make portraits and that by 1838 he had been successful in this. Until recently, none of these early portrait experiments were thought to have survived, although some of the still life pictures were dated from several years before.

In 1989, the French photography dealer Marc Pagneux bought a small daguerreotype at the Porte de Vanves flea market on the edge of Paris for 600 Francs (around a hundred dollars). It was a poor example, the head and shoulders of an unknown man, rather small and not very clear, and he apparently thought little about it until he took it to pieces in order to restore it. He then discovered inside a more primitive casing, suggesting it could be a very early example. On the back in writing which an expert identified as Daguerre's own, was the date of 1837. Analysis of the picture suggested it was taken by a 6 inch lens, possibly the one invented by Daguerre in 1832 and used for some of his experiments.

Controversy still rages over whether this image is the first known camera portrait, not least because Daguerre stated the process was too slow to allow portraiture when he announced it to the world in 1839, despite his earlier letters stating his success. For the portraits he is thought to have been able to cut the time required to 2 minutes, still an ordeal and hardly likely to produce absolute sharpness, but certainly making portraiture of a sort possible.

It was also in 1837 that Daguerre solved the remaining problem of fixing his images - using a solution of common salt. It was not a very effective method (and later was soon abandoned in favour of hypo) but from then on it was possible to make pictures that would last. By this time he had reduced exposure times to a matter of 4 minutes in bright summer sun and 15 minutes in the winter.

Part 4: Marketing Photography

Both Daguerre and the Niépces, father and son, had invested a great deal of time, effort and expense in their researches and naturally wished to profit from the discovery. Daguerre agreed with Isidore Niépce that they should try and find either a single buyer for the process or to find a hundred subscribers to put up the 200,000 francs they thought it was worth. Despite the novelty of their invention, they failed to attract any interest, possibly because none of those they approached could see how they could make money from it.

Having failed to make money in this way, in 1838 Daguerre managed to interest the prominent scientist Louis Arago (1786-1853) in his work. Arago had worked with Augustin FRESNEL (1788-1827) on the wave theory of light and had also discovered rotary polarisation. He was the director of the Paris Observatory and very well connected in the scientific and political establishment, being both a Deputy and also the Secretary of the French Academy of Sciences. Arago managed to sell the process to the state, with both Daguerre and Isidore Niépce being given a generous annual payment, six thousand francs a year to Daguerre and four thousand francs to Niepce, for the rest of their lives. In exchange for this, the process was presented 'free to the world,' and the process was names, at Daguerre's request, Daugerréotypie

Daguerre set out to promote the process and make more money from it, giving public demonstrations of how to do it, publishing a 'how to do it' book and getting his brother in law to set up a business selling cameras with a label with Daguerre's signature. Far from presenting the process free to the world, he proceeded to take out an English patent on the process in August 1839, and to start to negotiate with possible agents in countries around the world to spread the invention and profit from it.

Perhaps his lack of openness on the subject of portraiture was because it was indeed impossible with the equipment that he was marketing, which had a longer and possibly slower lens than that used in his experiments.

The Daguerreotype flourished briefly in the other countries of Europe, with improvements in the chemistry and in optics made by many, particularly the use of bromine (quickstuff) introduced in 1840 by John Frederick Goddard, a lecturer at the Polytechnic of Central London (and apparently, perhaps even earlier by Dr. Paul Beck Goddard of Philadelphia), and chlorine by French born Jean Francois Antoine Claudet, one of the first commercial portrait photographers, with a studio in central London. Elsewhere, others also independently came up with the use of these accelerating substances.

Gold toning also greatly improved the results of the process and was in common use from the middle of 1840 on, following its suggestion by the French scientist Armand Hippolyte Fizeau, (1819-96) who had studied with Arago and later became better known as the first person to measure the speed of light in 1849.

In late 1840 or 1841 Voigtländer began to sell a wide aperture lens designed by Josef Max Petzval (1807-1891), Professor of Higher Mathematics at the University of Vienna. His design was a response to a competition for better lenses. He used a team of three corporals and eight gunners from the Austrian army as a human computer, working for six months to carry out repetitive calculations of paths of light rays. His solution used four lens elements in two pairs. One pair was cemented together, the other was air spaced, and the lens stop was between the two pairs. The lens had a narrow field of view at 20-24 degrees -ideal for a portrait lens - and its lack of edge definition was unimportant for the purpose, although probably, along with political considerations, resulted in it only gaining second prize, and the contest was won by an inferior design by the Frenchman, Chevalier.

The revolutionary aspect was its aperture - at f3.6 it was over 4 stops faster than the f17 Wollaston-Chevalier lens marketed by Daguerre. Petzval later had a disagreement over payment with Voigtlander and never made the profit he deserved from his work. Many modified versions of his lens were used over the years, and the basic principles he established are behind the design of many modern lenses.

Daguerre's English patent greatly restricted the use of the daguerreotype in England, mainly restricting it to commercial portraiture, which was the only application that could generate the income needed to afford the licence fees. Antoine Claudet took out a licence in 1840, and was followed by Robert Beard in 1841. Because of the patent, early photography in England other than this largely used the rival Calotype process announced in the same year by W H F Talbot.

Further features in this series will cover practical details of the daguerreotype process, its popularity in the USA in the 1840s and 50s, modern daguerreotypes, the work of WHF Talbot, other inventors of photography, and early Calotype photographers.

3.How to make a Daguerreotype

Part 1: Daguerre's Manual

Warning

Although this feature will give some of the practical details needed, you should be aware that the chemicals used in this process are extremely dangerous and should only be handled by those trained in using them and with the appropriate apparatus and precautions. Much of the older literature on the subject fails to point out the hazards of the process.

Making daguerreotypes involves the use of hazardous chemicals that should only be handled in a proper fume chamber with forced ventilation. In many places there will be official regulations covering the handling and disposal of these materials and also the machinery and dangerous dusts produced in the cleaning and polishing of plates.

There are occasional workshops at some major photography centres, and some modern daguerreotypists may also give private tuition. If you want to make your own daguerreotypes you are strongly advised to take instruction from experts, which should also cover the health and safety issues. The details given in this feature are intended to give those interested in the process - whether collectors or photographers - an insight into how the images were - and are - created, not as a working manual.

Daguerre's Manual and other early publications

Since the publications of the 1840s and 1850s have long been out of copyright and in the public domain, it is possible for them to be put on the web. A number of dedicated individuals have done so, scanning in and converting some of these to text. Most of those available are texts by American authors. At least 2000 copies of Daguerre's original manual are thought to have been printed and sold (or given away), together with more translated into other languages, but relatively few have survived, and they are now extremely rare and expensive museum items. There are modern reprints available, but the copyright problems in using these are more complex. Daguerre's original publication was apparently in the public domain (as its original publisher found to his cost) and it is perhaps surprising that it is not available in full text in English on the web.

If your Hungarian is up to scratch, you can read Daguerre's text as translated by Dr Jakab Zimmerman and published in 1840, the first manual for the process in that language. Possibly of more use, you can also download all of the illustrations from the work, which show the various pieces of equipment needed for the process, as well as the cover page. These are large line drawings which give a good idea of the originals, although the file size is relatively small.

Daguerre's process was first broadly outlined to the world in a speech to the French Academy of Sciences by M Louis Arago on 8th of January 1839. It was reported worldwide, with the first account in an American newspaper probably coming on February 23 in Boston. The news travelled a little slower then, when the fastest transatlantic journeys took over two weeks, while desperate journeys of five of six weeks under harsh conditions more were more common.

However, Arago was describing what was still a secret process, and his purpose was to sell the secret the Academy and the French nation rather than to reveal any details. It was not until August 19, following the grant of the pensions to Daguerre and Niépce by the Chamber of Deputies in July, that the process was revealed. Arago gave a lecture in which he gave details of the process, and the Paris newspapers published these and other information on August 20th. The news reached the London press for August 23 and spread rapidly.

More practical information became available with the publication of Daguerre's pamphlet in early September, and by the middle of the month the process was being demonstrated in London by an unknown French photographer, Ste Croix (possibly someone better-known using a false name.) D W Seager, an Englishman, was apparently given a copy of Daguerre's pamphlet hot from the press as his ship sailed from England to New York. He obviously made good use of the 15 day journey to study its contents in detail, and as soon as he left ship in New York had the necessary apparatus made. Astonishingly, his pictures, the first daguerreotypes to be made in America, were being exhibited before the end of September.

The daguerreotype process depended on the availability of silver coated copper sheets. The major early process for producing these was invented by Thomas Boulsover, (1705-88), a cutler in Sheffield, England, around 1743. He fused a thin sheet of silver to an ingot of copper alloy. The combined metals were then hammered and rolled to give a silver coated copper plate known as 'Sheffield plate' or simply 'rolled plate.' Around 1780 plate coated on both sides was produced by extension of the same method. This remained the main method of producing silver coated copper until a few years after the invention of the daguerreotype when it was largely replaced by electrolytic methods.

Part 2: The Process

OUTLINE OF THE PROCESS

- A silver coated copper plate was cut to size
- The plate edges were bent to fit the holders and corners snipped.
- It was cleaned and highly polished
- In the darkroom, the plate was sensitised by allowing it to react with iodine vapour, forming silver iodide. (For more sensitive plates, treatment with iodine was followed by bromine, then iodine again.)
- The plate was exposed in a camera, for between 15s and 15 minutes depending on the lens aperture and light etc.
- The plate was developed by putting it in a box above warmed mercury, the mercury vapour acting as developer. (A later alternative procedure, Becquerel development, used red light, but gave a lower plate speed.)
- The plate was fixed by pouring sodium thiosulfate solution across it, and washed with distilled water to remove the fixed silver halides.
- Most daguerreotypes (except in the early years) were then gold toned by covering the horizontal plate with gold chloride solution and heating from below. It was then washed briefly and dried using heat.
- The plate was then sealed behind glass and mounted in a case.

A good short description of the process is given in the book 'The Silver Sunbeam'. Although by 1864 when this was published the daguerreotype process had been relegated to Chapter 39 of this fine photographic text, (available in full on the Albumen site - see box at top right,) it still gives full and precise directions.

MORE DETAILED NOTES

1. Cutting the plate

Rolled plate was cut to size to fit the camera using large tin shears or a guillotine. Daguerre's largest normal size was the 'whole plate' of approximately 81/2 x 61/2 inches (ca 215 x 165mm) , but the plate was often cut into smaller parts - giving half, quarter-, sixth-, ninth-, and sixteenth-plate sizes.

2. Shaping the plate

The plate was bent at the edges to fit into the holders, normally using a special tool, and the corners snipped to avoid snagging the polishing materials.

3. Polishing the plate

Various complex procedures were used to get a high polish on the surface. Some of these involved the use of nitric acid and heating of the plate as well as a great deal of rubbing with materials such as fine pumice stone followed by jewellers rouge. Later it was possible to buy prepared plates that needed less polishing. It was important to avoid breathing on the plate, let alone touching it. Large studios used special polishing machines with a conical shaped buffing wheel. Polishing had to continue until the surface was entirely free from lines.

4. Sensitising the plate

The polished plate was then sensitised. This was normally a three stage process, using two coating boxes. These had a sliding lid which extended out to one side. The plate was held facing down in this extended part. The lid was then slid across so that the plate was exposed to the vapour in the box. The boxes often had a glass jar inside to hold the fuming material.

The first box contained some iodine 'scales' on a piece of flannel at the bottom, the second had some lime (calcium hydroxide) which had been soaked with bromine. The boxes were kept in a reasonably warm place in the darkroom so that they iodine and bromine vapours filled them.

The darkroom would have a yellow or orange window so that the plate could be examined. It was first exposed to iodine, and examined at intervals. As the thickness of the coating increases, it changes colour, from yellow, to rose, to blue and then to green, then repeating the sequence. The thickness of the layer has a marked effect on both the speed and the contrast of the image.

Generally it was fumed with iodine until it had gone through the colour sequence once and then attained a rich straw or gold colour. It was then fumed in the bromine box to give a deep orange and returned for a short time to the iodine until the orange had a purple tinge. Depending on the room temperature, the fuming could take anything from a minute to an hour, but at a normal room temperature (20C) times of around a minute for each step might be typical.

5. Exposure

5. The plate was put in a plate holder to fit the camera, with a dark-slide to protect it from the light. The camera was then set up, and focussed on the subject using a ground glass screen. For portraits a head clamp was often used.

The exposure time depended - as with other processes - on the light and the lens aperture, as well as the plate speed. Most studios used large windows to get maximum light, using white painted walls and ceiling and mirrors to reflect more onto the subject. Since the plates were only sensitive to blue light, the process could be made more comfortable for the sitter by using blue glass to cut the light intensity without reducing its photographic effect.

For architectural and general subjects, lenses were needed that were sharp into the corners and distortion free. These were normally of small aperture and so exposure times were often lengthy - of the order of 10-15 minutes. Portraits only needed to be sharp near the centre and a little softness at the edges might even improve the effect. Simple meniscus lenses of relatively wide aperture gave acceptable results and could cut exposures to perhaps a minute, while lenses made to the new f3.6 Petzval portrait lens design allowed exposures to be cut to around 15-20 seconds on bright days.

For exposures of this order, a lens cap was adequate as a shutter. First the ground glass was replaced by the plate holder. The lens was then capped. The dark-slide was pulled out and the lens cap removed to start the exposure. When the time was up, the lens cap and then the dark-slide were replaced and the plate holder removed from the camera and taken back into the darkroom for processing.

6. Development

The plate was removed and placed on the mercury box. This was generally an inverted square pyramid with a small amount of mercury at the bottom. It was heated by a small spirit lamp to maintain the mercury at around 50-60ºC. At intervals the plate would be lifted from the box and examined using a lighted taper to see if the development was completed. An alternative development method, the Becquerel process, was discovered around 1850 - see the next page of this feature.

7. Fixing & Washing

The plate was then fixed by pouring sodium thiosulphate solution over it (at first the less effective sodium chloride was used.) Generally the plate would be held by its edges and the solution 'flowed' over it and into a jar. This could then be used to pour the solution a second time. The plate could then be washed with a few changes of distilled water.

8. Optional Gold Toning

The image was made more obvious and also more stable by gold toning, and most daguerreotypes except for early examples are gold toned. The plate was clamped exactly horizontal, using a special holder with an adjusting screw, and then covered with a small volume of gold toner, usually a dilute gold chloride solution. The plate was heated from below with a spirit lamp to speed the reaction. When it had reached the right colour, the gold chloride was poured off, the plate rinsed with distilled water and then dried over the spirit lamp.

9. Mounting

Daguerreotypes were always sealed and cased, to protect the delicate surface from abrasions and tarnishing in the atmosphere. A brass mask was placed on top of the plate, then a sheet of glass and these were then bound together with adhesive tape to ensure the plate was sealed. This was then placed in a protective case and was then ready to be presented to the client.

Because the metal plate did not absorb chemicals, no lengthy washes were required. In a typical studio, the total processing time after the picture was taken could be around twenty minutes or a little less - time for a cup of tea though perhaps something a little stronger would be needed after the ordeal of having your image fixed.

Part 3: Contemporary Work

Contemporary daguerreotypists use methods little different from those of the 1840s, although power tools such as bench grinders may make the polishing of the plates less arduous. Most avoid the use of mercury, which is a dangerous cumulative poison. As most of us know from Alice in Wonderland, hatters often showed psychotic symptoms, due to the cumulative effect of the mercury compounds used in preparing the felt for hats. Lewis Carroll - or rather - Charles Lutwige Dodgson - was of course a keen photographer, although using the wet plate process.

In the 1850s it was observed that exposing the plates to a red light had a similar effect to using mercury. One of those to observe this was Edmond Becquerel, and the method is known as Becquerel development. It was not widely used in the early days as mercury is more effective, giving about three times the speed. Becquerel development also gives more contrasty results and it is harder to get good pictures. However it removes the need for a mercury development box and removes one of the major health hazards.

Of course both bromine and iodine are also toxic, and to carry out the process safely you need a chemical 'fume cupboard' with an efficient extraction system.

The polishing of the plates is also hazardous, particularly because of the fine metal containing dust produced. Here a good mask respirator with a particle filter is essential, and a grinder equipped with proper dust collection is needed if you are going to make many daguerreotypes.

There are some fine sites on the web giving illustrations and details both of the historical process, and also of the modern daguerreotype. Highlights online include a reproduction of a 'Scientific American' article from 1887 and a great online 'brochure' produced for the exhibition 'Mirror with a Memory' which includes photographs showing all of the equipment needed for each stage.

There has been a considerable increase in interest in the daguerreotype over the past ten or so years. One organisation which has both stimulated and catered for this interest is the Daguerreian Society, and if you have a particular interest in the process you may wish to join this. They have made much interesting material available on their web site.

The Contemporary Daguerreotypes site has a good description of modern methods as well as a number of fine examples by contemporary daguerreotypists. Here you get to feel some of the reasons why some photographers are still entranced by the process. It is unique in the sense that each image is unique - if you want another copy you have to take another plate, but also in the way the image is 'held in a mirror' emerging fresh each time you view it. Many of us became hooked on black and white photography through seeing the image come up in the developing tray. There is something of a similar revelation in the viewing of a daguerreotype image.

Further features in this series on early photography will cover the popularity of the daguerreotype process in the USA in the 1840s and 50s, the work of W H F Talbot, other inventors of photography, and early Calotype photographers.

Photogenic Drawing

Part 1: Key Facts

This feature looks at the early work of WHF Talbot, often wrongly stated to be 'the inventor of photography', and deals with his work up until 1839 when the daguerreotype was announced. Talbot's later Calotype - the first successful negative-positive photographic process - will be the subject of a later feature.

- William Henry Fox Talbot (1800-1877) was a member of the English landed aristocracy, a gifted mathematician, philologist and scientist who had links to the leading scientists and artists of his day.

- He used the name H F Talbot, and it is incorrect to refer to him as Fox Talbot.

- Talbot's work on 'photogenic drawing' (photography) up to 1839 contained little in terms of scientific novelty over the earlier work of Wedgwood and Davy, Niepce or the other contemporary experimenters around the world.
- He used writing paper, soaked it in salt solution, wiped it dry and then brushed it with silver nitrate to produce a surface coating of light sensitive silver nitrate.

- By repeating the sensitising process several times he made the paper sensitive enough to record an image in a camera obscura in roughly half an hour in good light.

- Talbot made the earliest known existing photographic negative - exposed in a camera with the intention of being used for making a positive print - of a lattice window at Lacock Abbey in 1835. It is now in the Science Museum collection at the National Museum of Photography, Film and Television at Bradford, England.

- Some of Talbot's early photogenic drawings (in modern terminology, photograms) are remarkable for their beauty, both for the elegance of design and the colour of the images, which mainly range through purples, reds and browns.

- The colour and delicacy of these images is linked to the incomplete fixation methods Talbot used, which unfortunately also made them sensitive to light of all colours, preventing public exhibition as they only have an estimated display lifetime of three hours.

- In 1840-41, Talbot, following some suggestions from fellow scientist Sir John Frederick William Herschel (1792-1871), developed and patented the first practical positive-negative photographic process, the Calotype process. This process, which will be the subject of a further feature, can be seen as the basis for all later silver based photographic processes.

- Herschel who was knighted in 1831, had discovered the use of sodium thiosulphate (hypo) as a photographic fixer in 1819. He introduced many of the terms we use in photography, including 'photograph', 'fixer', 'positive' and 'negative'.

- Herschel, on hearing of Talbot's 'photogenic drawings' in 1839, worked out their basis independently in a few days, and produced his own examples.

- Herschel also invented a number of other photographic printing processes, including the Anthotype, which used plant pigments - such as that from red poppies, and a number of processes based on the light sensitivity of iron salts including the Cyanotype (blue print), the Kallitype (brown print) and the Chrysotype (gold print).

Part 2: Early Years

William Henry Fox Talbot's mother, Lady Elizabeth Fox Strangways, was the second daughter of Henry Thomas Fox Strangways, the 2nd Earl of Ilchester. She married William Davenport-Talbot who owned Lacock Abbey, some 5 miles south of Chippenham, Wiltshire, in 1796. William Henry Fox Talbot was born in 1800 at Melbury Abbas, but unfortunately, Davenport-Talbot died a few months after his son's birth, leaving the estate with large debts. For some years William and his mother lived in the houses of relatives. His mother remarried in 1804 to Rear Admiral Charles Fielding, and by this he gained not only a father but he soon had two younger half-sisters. They remained close to him throughout his life.

Some sources - particularly older histories of photography - refer to Talbot as 'Fox Talbot' or even 'Fox-Talbot'. He always preferred to be known simply by the name Talbot, and was normally referred to as this by his contemporaries. He signed his name as either Henry F. Talbot or H.F. Talbot, preferring Henry to his father's name of William. Modern historians usually call him WHF Talbot, although the incorrect 'Fox Talbot' is certainly more memorable.

The young Talbot - as was normal at the time for those of his class - was taught at home by his mother, who had a gift for foreign languages, as well as strong interests in botany and gardening. Talbot began a life-long interest in these areas as well as excelling in other subjects. Talbot was sent to school at Harrow when he was 11, presumably as his mother felt he needed more than she could offer.

Harrow, along with Eton, were (and are) England's two leading public schools, and Harrow was often thought to place an undue emphasis on academic matters, which were not generally highly regarded by the aristocracy.

Talbot stood out so much from his fellows that they elected him to be Head Boy in his first year. He excelled in all his classes. although he was banned from further chemistry experiments after causing a dangerous explosion. At the end of the year, Harrow decided he was too bright for them, and for the next few years he was educated privately by tutors at home.

In 1817 he went to study at Trinity College, Cambridge University where one of his tutors was the famous polymath, William Whewell. Although noted as a brilliant student, he did less well than expected in his final exams. He excelled in a number of fields, translating a book from German, following his interests in the ancient world and also becoming a first class mathematician.

One of his interests was spectroscopy, and in 1824 he went to Germany to visit the great Joseph von Fraunhofer in Munich. Fraunhofer had a few years earlier accurately measured the wavelengths of over 324 dark lines in the solar spectrum; more recently he had made the first diffraction grating. Earlier he had developed an achromatic objective lens for telescopes which is still basically in use today.

While visiting Fraunhofer he met an older English scientist who was later to contribute greatly to his work on photography, John Frederick William Herschel (1792-1871, knighted in 1831). The two became friends and were later to work together on some of their projects. Herschel was the son of a famous astronomer and was himself best known for his work in that area, but was also interested in the physics of light.

It was Herschel who later introduced Talbot to the Scots scientist Dr (later Sir) David Brewster in 1826. Talbot and Brewster were both interested in experiments on light (Brewster had already produced his work on polarisation of light, and invented the Kaleidoscope, later he was to produce the stereoscope which became a popular fad in Vitorian parlours after it was taken up by Queen Victoria at the Great Exhibition of 1851; Brewster's viewer used lenses and was more convenient than the earlier mirror device invented by Sir Charles Wheatstone.) Talbot and Brewster also became close friends.

Part 3: Life at Lacock

Lacock Abbey was founded in 1232 by Ela, Countess of Salisbury, as an Augustinian Nunnery in memory of her husband, William Longespee, the illegitimate son of Henry II, who was one of the barons who witnessed the Magna Carta. There was a Prioress and 15 nuns, and Ela herself became the first Abbess (she was also the county of Wiltshire's only female Sheriff.) Like other English religious establishments, the Abbey was dissolved when Henry VIII wanted more wives than the Catholic church was prepared to allow. It was then sold to William Sharington for £783 in 1539; he rebuilt it as a stately tudor mansion, incorporating the thirteenth century chapter house, sacristy and cloisters.

Sir William Sharington (or Sherrington) had travelled in Europe and took an interest in architecture. He was one of those to introduce some of the ideas he had seen in Italy to England. He died in 1553, and as he had no children, the property passed to his brother Henry.

Henry's young daughter, Olive, fell in love with a Mr John Talbot from Salwarp; he came from a branch of the noble Talbot family but was virtually penniless, so her father forbade the couple to meet. Talbot was banned from the house after the couple were found whispering sweet nothings in a cellar. Olive sent a letter to John, saying she since she was not allowed out to meet him, she would talk to him from the roof of the Abbey. When he turned up that evening, she called from the roof that she would leap down if he would catch her. He, taking this as an expression of her feelings rather than a promise of action, replied warmly and positively, inviting her to join him. She did.

Olive jumped accurately, knocking John to the floor, where he lay unconscious. Thinking he was dead, she screamed loudly and in despair, bringing out her father and his staff. The old man was so moved by her courage in this desperate leap (or perhaps so worried about what she might attempt next) that he immediately changed his mind. They were married in 1574, and John Talbot died in 1581. The house passed to Sherrington Talbot (d 1642), their eldest son who took his mother's surname as a given name. His eldest son and heir was also named Sherrington Talbot (d 1677).

After the English Civil War, John Talbot, the younger Sherrington's son, was knighted by King Charles II. From him, the house passed to his grandson, John Ivory Talbot (he was the son of his elder daughter, Anne Talbot, who married a Sir John Ivory), who employed architect architect Sanderson Miller to make extensive alterations in the then fashionable Gothic revival style. John Ivory Talbot left it to his son, who died childless and his daughter thus inherited the property. Her son, William Davenport Talbot, was the father of William Henry Fox Talbot.

Davenport Talbot was a soldier and had allowed the estate to run down, while running up heavy debts. Following his death in 1800, the property had to be let until 1827, by which time Talbot's mother had worked hard to get the as Lord of the Manor. The Abbey and the adjoining village of Lacock were given by Talbot's descendants to the National Trust in 1944. The Abbey, a fine building with medieval, renaissance and gothic features as well as a fine garden is open to visitors and there is a museum of photography in the gatehouse.

The village which contains many traditional lime-washed half-timbered and stone cottages and a magnificent thirteenth century tithe barn shows little sign of the modern world except for the people and cars, also being protected by the English National Trust. It is in great demand as a film set, and was used in a recent adaption of Jane Austen's 'Pride and Prejudice'. If you are visiting England, Lacock is worth a detour; it is in the south west of the country, around 5 miles south of Chippenham and only 12 miles from Bath.

As well as pursuing his various scientific interests, Talbot was also elected as the Member of Parliament for Chippenham in 1832, standing as a Whig (liberal or reformist) member. Almost at the same time he also got married. The following year, 1833, during the parliamentary recess, he went with his new wife and his two sisters to Italy. He was frustrated at being the only one of the party unable to make proficient sketches of Lake Como - if he had been as proficient with the camera lucida as Herschel he might never had turned his thoughts towards photography.

As he compared his pitiful spidery pencil wanderings with the beautiful image on the camera obscura, he mused to himself 'how charming it would be if it were possible to cause these natural images to imprint themselves durably, and remain fixed upon the paper'. Back home in England, his parliamentary duties meant that it was not until the spring of 1834 that he was able to begin his experiments.

Part 4: First Experiments

Talbot was aware from his reading while at university that silver salts were known to be blackened by light. He started by simply spreading silver nitrate solution on paper and then he 'set the paper in the sunshine, having first placed before it some object casting a well defined shadow.' He called the results he obtained 'sciagraphs ', meaning drawings of shadows.

It was some time after, when he was 'in possession of several novel and curious results' that he bothered to consult the literature and came across the work of Thomas Wedgwood and Sir Humphrey Davy at the turn of the nineteenth century (discussed in 'Finding the Chemistry' - see box at right.) He notes that they had abandoned their work because they could find no way to preserve the images they obtained, which darkened uniformly when viewed in the light. Talbot had by then already found methods which - if not completely, at least partly solved the problem.

As well as using objects placed on the prepared paper, Talbot also worked with an image scratched by a more artistic friend into a coating of opaque varnish on a glass plate. The images formed were the first examples of the technique now known as 'cliché verre'.

The methods of protecting his images against the further action of light (Herschel was later to suggest the term 'fixing') that Talbot had found were not perfect, but they did have a bonus over later methods. He found that soaking the print in a solution of potassium iodide or saturated common salt made it much less sensitive to light.
Although these methods are not effective, they have little affect on the colour of the print. By variations in the sensitising method
'merely varying the proportions and some trifling details of manipulation, any of the following colours are readily obtainable:

Sky-blue
Yellow
Rose-color
Brown, of various shades
Black
Green alone is absent from the list, with the exception of a dark shade of it, approaching to black.'

Talbot's existing prints have a wide range of colours, some quite beautiful, but unfortunately most of us are unlikely ever to see them. The real things are simply still too sensitive to light to allow them to be exhibited. Research by Dr Mike Ware suggests that noticeable fading would be produced by exposure to even limited light levels in only three hours. At least one such print exhibited in the USA in the late 1980s was discovered to have faded badly, despite the light used in the show being filtered to remove all UV and blue light. Ware's researches showed that the processes used by Talbot to 'fix' the prints are only partly successful. They do slow - but not eliminate - the sensitivity of the material to the UV and blue light, but they also make the images sensitive to all colours of light.

Of course you can see such colours yourself without the danger or damaging the unique and priceless originals, simply by using the methods described by Talbot. For exhibitions, in place of the originals, it is possible either to produce replicas using the same methods, or to make careful photographic reproductions of the existing prints. Even the act of photographing the originals has obviously to be carried out with great care to avoid any damage.

A modern print made using a salted paper prepared in a similar way to WHF Talbot, but printing from a modern film negative. Note the brush strokes at the edges of the image. This print has been fixed in hypo and gold toned, giving a slightly purple brown colour. © Peter Marshall, 1992

Quotations above are from Talbot's pamphlet 'Some Account of the Art of Photogenic Drawing or, The Process by Which Natural Objects May Be Made to Delineate Themselves without the Aid of the Artist's Pencil'(sic), as reproduced in Beaumont Newhall's fine book 'Photography: Essays & Images (1980).

Part 5: Camera Obscura

Like other experimenters, Talbot wanted to make images direct from the camera obscura. He worked hard to make the coated paper more sensitive, but without great success. He had realised that if he could make such tonally reversed images, these could then be printed onto paper to give a second reversal that reconstituted the original appearance. Earlier workers, including Niépce, seem to have given up because they could not find a method that gave a direct positive image.

Talbot had the local carpenter construct a number of small boxes to which he fitted short focal length lenses with the highest possible relative aperture. These would be loaded with paper and then left in a suitable position for the half hour or so needed for exposure. His wife, Constance, gave them the nickname 'mousetraps.' It was in 1835 with one of these 'mousetraps' that he recorded the earliest camera made photographic negative in existence, a view of an oriel window at Lacock in which all of the small glass panes are clearly visible. It is now in the collection of the 'National Museum of Photography, Film and Television' in Bradford, Yorkshire, where you can view a replica.

Photography - or rather 'photogenic drawing' as he called it, was only one of the many subjects that claimed Talbot's attention. Although he left Parliament in 1834, he was still active in politics, helping to save Kew Gardens and its unique botanical collection for the nation. He published two books on his Classical and Antiquarian Researches in 1838, and was also awarded the Royal Society's Royal Medal for his research of integral calculus.

It was late in 1838 before he had time to take up his photographic experiments again, working to prepare a paper for the journal of the Royal Society. The publication of the preliminary news about Daguerre's work in January 1839 came as a shock. He knew he could not demonstrate his process in the poor light of winter, but arranged for Michael Faraday to show some of his 1835 images - still well-preserved - at the Royal Institution on 25 January, and for the reading of his paper "Some Account of the Art of Photogenic Drawing" at the Royal Society on the 31st Jan. Three weeks later he gave the society details of his methods.

The Royal Society failed to support Talbot, perhaps because the results achieved by Daguerre seemed to be so much better, but also possibly as they felt he had added little to the work of Wedgwood and Davy which they had published over thirty years earlier. He had to publish his paper privately as a pamphlet when they refused to print it in the 'Transactions', and he also contributed a short article to 'The Literary Gazette' of 23 Feb, 1839. The pamphlet is most remarkable for his comments on the various applications to which the new process could be put, including the recording of accurate portrait silhouettes, the making of 'cliché verres' and it's use in recording microscope images, architectural landscapes, copies of sculpture and engravings.

Next week's feature will look at the practical details of Talbot's photogenic drawing and also give instructions for making your own prints following his method of salted paper printing. Later features will look at his Calotype process, early printed books using photography and some of the great photographers who used the Calotype process.

Salted Paper Prints

Part 1: Key Facts

'Photogenic drawing' used ordinary paper which had been given a coating of silver chloride or similar light-sensitive silver salt.

Prints were made by placing objects on this paper and exposing to light. In the 20th century this way of working was named as a 'photogram'.

Photogenic drawing was a printing out process - the image actually appeared during the exposure to light.

Photogenic drawing can also be used as a method for contact printing from negatives - prints made in this way are known as salted paper prints or salt prints.

Contact printing requires the negative to be held in close contact with the printing paper, usually in a special printing frame, while being exposed to light through the negative.

Exposure times in salt printing vary from around 10 minutes to 8 hours depending on the strength of the light source and how transparent (or translucent) the negative material is.

As with all contact processes, the print is obviously the same size as the negative.

Talbot fixed his images by using strong salt (sodium chloride) solution, or a weak potassium iodide solution. Neither was totally effective.

Later, Herschel's suggestion of hypo (sodium thiosulphate) as fixer was adopted. This was fast and totally effective.

By repeating the sensitising process several times, Talbot found he could increase the speed of the salted paper sufficiently to use in a camera obscura.

Typical exposure times in the camera obscura were around 30 minutes, with apertures probably around f8 in modern terms.

The paper negatives were fixed and then often made translucent by treatment with wax or oil before being placed on top of a fresh sheet of sensitised paper and contact printed using sunlight as the light source. Typical printing times would be around 30 minutes to an hour.

Although rapidly for use in the camera by the Calotype process, the basic salted paper print was the normal process for photographic prints on paper until replaced by the albumen print around 1850.

After 1855, salted paper remained in use mainly as a proofing medium and by a few who preferred its matte image. It saw a revival in the 1980s and 1990s as a part of a growing interest in historical and alternative processes.

Part 2: Talbot's method

1.Talbot started with a sheet of best quality writing paper 'with a good firm quality and smooth surface'.

2.This was dipped it into a weak solution of common salt and then wiped dry

3.The sheet was then coated on one side with a weak solution of silver nitrate (a saturated solution diluted with six to eight times the amount of water) and dried in front of a fire.

The paper was then ready for use for making photogenic drawings or as Talbot more poetically wrote *'nothing can be more perfect than the images it gives of leaves and flowers, especially with a summer sun : the light passing through the leaves delineates every ramification of their nerves.'*

A more modern version of this procedure is still used by those photographers today who wish to make salted paper prints - also known as salt prints - see parts 3 and 4 of this feature for full directions.

For use in the camera, the speed of the material needed to be increased. Talbot found he could do this basically by repeating the treatment. He first washed the prepared paper with a saturated solution of salt, and dried it. Tested at this stage it was more or less insensitive to light, but if re-brushed with *'a liberal quantity of the solution of silver'*, it became more sensitive than before.

By repeating the coating several times, it would become fast enough for use in the camera (though his exposures might be 30 minutes.) Talbot obviously found the process rather unpredictable, noting that sometimes the paper would begin to darken without any exposure to light, showing the process had been taken too far.

After each coating with silver, he clipped a small part from each of the sheets he was working with, numbering them carefully to correspond to the sheet, and *'placed (them) side by side in a very weak diffused light for about a quarter of an hour.'* If one of them darkened considerably, the corresponding sheet was ready to be exposed in the camera obscura. It was a crude but effective system of control for a process where there were too many variables to guarantee success by simply following a given procedure.

Part 3: Talbot's results

Looking at Talbot's early results from the camera - or rather at reproductions of them - it is not surprising that they were generally not regarded highly compared to the splendidly sharp and detailed daguerreotypes. In some cases it is hard to see any image at all, others are more weak splodges than detailed pictures. His first existing negative shows a window made of small panes, and on the back he notes that it was possible to count them all when it was first made. Presumably it was no longer possible when he made the note. The image is certainly not now highly detailed and the shadows in particular are completely empty.

Although the photogenic drawings - made as what we now call 'photograms', by placing objects such as leaves and lace on the paper - have considerable elegance and are finely delineated, his early camera attempts can only be seen as suggestions that it might be possible to get the process to work rather than as a successful solution. It was a problem that Talbot was to solve himself in the following years with the Calotype process.

The major problem was of inadequate sensitivity to light. These first photographic materials relied entirely on the printing out of the image, which is slow. In the Calotype, Talbot made use of what became called a developer to amplify the effect of the light, bringing out the 'latent image' from the apparently unchanged paper. It was this discovery that was really to lead to the domination of the next 160 years of photography by silver based materials. A further feature will deal with the calotype in detail.

Another aspect of the problem that Talbot faced was inadequate fixation. After exposure he either washed the paper with a dilute solution of potassium iodide or a strong solution of common salt before 'wiping off the superfluous moisture, and drying it.' The potassium iodide solution formed silver iodide that was largely insensitive to light, but too strong a solution would dissolve parts of the image. As he had found in his repeated coating, using a large excess of salt solution produces a very low light sensitivity. However images fixed in these ways still faded in light - and certainly the bright sun needed to expose through the paper negative will have also caused fading of the negative.

When Talbot visited Herschel at Slough on 1 February 1839, he received a solution to the problem. Herschel's wife, Margaret, noted in a letter to a friend that 'when something was said about the difficulty of fixing the pictures, Herschel said "Let me have this one for a few minutes" and after a short time he returned and gave the picture to Mr Fox Talbot saying "I think you'll find that fixed" - this was the beginning of the hyposulphite plan of fixing.'

It was also Herschel who provided a clue - in the shape of gallic acid - that was to be the key to Talbot's discovery of the latent image and development in the Calotype. There are many of us who have made prints using salted paper and even a handful of photographers currently using the Calotype process - some have used actors to recreate Talbot's later pictures at Lacock Abbey. The recreation of images in camera obscura using his methods, and making prints from these again following his directions would perhaps be an interesting project. It is the only way any of us can possibly see these kind of images in the same condition as when Talbot made them.

Part 4: Make your own Salt Prints

Ordinary writing paper is now factory produced and no longer of suitable quality for any of the alternative processes. Machine made papers generally have shorter fibres and fall to pieces readily when wet, and you need to use a suitable hand or mould-made paper, usually sold for use in watercolour painting.

Silver nitrate needs to be handled with care - you should use gloves and wear safety glasses. When handling any finely ground chemical powder a mask should be worn. Silver nitrate is a poison that can build up in the body and it can both burn and stain skin. It produces stains and marks that are often very difficult to remove from some surfaces.

Like all chemicals, both solid and solutions should be kept in a secure place, locked away from possible reach of children. Silver nitrate solutions are sensitive to light and are normally stored in brown bottles, but it also helps to keep them in a cupboard.

Procedures normally give precise quantities required for solutions measured in grams. However, there is seldom any real need for great accuracy, and many people have made salt prints without using any weighing equipment. Chemicals such as silver nitrate will generally be bought in fairly small quantities and you can make up the full amount into an appropriate solution.
You can use ordinary table salt or sea salt, making up a solution of roughly 1-2 ounces (25-50g) per litre of water.

Other salts, which some people prefer, include ammonium chloride, potassium citrate, potassium tartrate and potassium bromide. You will often get small differences in image colour and paper speed using the different salts or mixtures of them.
The silver nitrate solution is generally around 10-12% by weight - so you can dissolve 7g (1/4 oz) in around 60ml of water.

I've used a range of watercolor papers, including Waterford Hot Pressed which was possibly my favourite, along with Rowney's Georgian. Some other papers give better results if coated with a dilute gelatin solution and left to dry before use - this is called 'sizing' - but Waterford works well without. Most watercolor papers are already sized when you buy them, and extra sizing is often not needed. You will get good results with most papers.

You also need a brush to coat the paper with - a wide, thin brush is best. Japanese hake brushes which do not have metal ferrules are probably the best, as the silver solution corrodes metal.

A further feature will deal with making large format negatives for printing onto salt paper, but unless you have a large format camera you may like to follow Talbot's examples and start work with photograms, using materials such as leaves or lace etc. If you do have a large format camera, take a picture specially and try doubling your normal development time as you need a much higher maximum density than normal for salt prints.

Talbot used the sun for his exposures, which meant the times he could work in England were limited. Unless you are blessed with a sunnier climate you may want to find another light source. You need something which is strong in ultraviolet, such as a tanning bed - or you can buy or make special light sources using mercury lamps or UV fluorescent tubes similar to those in sunbeds.

A printing frame is needed to hold the negative in contact with the paper. You can buy or make these, but a sheet of plate glass and a card or ply backing board with some rubber bands round will do (for large prints the weight of the glass is enough to ensure contact.) These were once cheap photo accessories, and small sizes (such as 5"x4") can still be found cheap in junk shops. I had a good look at an expensive hand-made version, particularly the price-tag, took out a pencil and designed my own, which took about an hour to make. Precision freaks will want a vacuum frame!

Part 5: Step by Step

Making a salt print

1.Tear or cut the sheets of paper to the size required - you need at least a one-inch margin around your negative. Mark the top side of the paper on each piece.

2.Make up the salt solution, soak the paper in it for 2-3 minutes at room temperature or slightly above, gently brushing each side while under the solution to remove any air bubbles. Lift out, drain and hang to dry, putting down newspaper if necessary to catch the drips. Paper treated in this way can be used as soon as it has stopped dripping or dried and used weeks or months later.

3.Tape the salted paper top side up to a board. Put the negative on top and mark the position of its corners lightly with pencil.

4.In dim room lighting (away from sun and fluorescent lights), pour a few ml of silver nitrate into a small beaker or dish. Dip the tip of the brush in, and spread left to right across the paper making sure to cover the marked area. Keep the brush wet. Repeat using a series of top to bottom strokes. Try to get the surface of the paper evenly wet all over, but without any pools of solution. Don't return any excess the solution to the bottle; add a little more to it to coat the next sheet. Leave horizontal until any liquid on the surface has been absorbed, then hang to dry in a dark place. Use gentle heat from a hair-dryer if you are in a hurry to get on.

5.Put your negative on top of the dry prepared paper, matching its corners to your pencil marks. Unless you have a proper hinged-back printing frame, secure it to the paper down one edge using crystal clear transparent tape, making sure this does not go over any of the image area. Check you have the negative the correct way up. Put under the glass or in your printing frame.

6.Typical exposure time needed is 10 minutes in bright sun, but you can remove it from the light and peel back the negative slightly to inspect the image. Take care not to move the negative - this is where a proper hinged-back printing frame is a great advantage. Expose until the highlight detail is slightly darker than you want it - the shadow areas will normally seem too dark, but will lose some density on processing.

7.In dim light, remove the paper from the printing frame and put into a tray of water - preferably use distilled or purified water for the first rinse. Use gloves and be careful how you dispose of this first rinse in particular as it will contain most of the silver nitrate. If possible it should be added to your normal waste fixer for recycling. Later rinses will have much lower silver content. Agitate for about a minute before pouring off, and repeat several times (using tap water for these later rinses.)

8.If your image is successful, you may wish to gold tone at this stage. Prints with developed edges are often trimmed to avoid waste of gold toner. You will find instructions for gold toning in books dealing with alternative photographic processes. As you may expect, it adds considerable expense. Gold toning was a later development not use by Talbot. I'd suggest you leave it until you have gained some experience in the process. Gold toning changes the image colour (not always for the better) and improves image stability.

9.For prints that can be displayed and last, you should fix using hypo.

If you are interested in following Talbot's methods, you will find his instructions in various sources, including Beaumont Newhall's 'Photography: Essays and Images'. Talbot does not appear to have washed his early prints either before or after 'fixing'.

For prints that will last longer, fix using a solution of 25 gm (1 ounce) of hypo crystals in 500ml of water with a pinch of soda (sodium carbonate) added. You can also use normal print fixer, diluted perhaps twice as much as usual, but this will alter image colour more and also remove more of the highlights. Fix for up to 5 minutes, keeping a careful watch on the highlights and remove theprint and wash immediately if these start to disappear.

10.Wash for around an hour in occasional changes of water and then hang to dry.

Part 6: Suppliers & Resources

Various books have been written with methods for making salted paper prints in the more than one hundred and sixty years since they were introduced.

Henry H. Snelling's 1849 volume 'The History And Practice Of The Art Of Photography' is subtitled 'The Production Of Pictures Through The Agency Of Light' and claims to contain 'all the instructions necessary for the complete practice of the Daguerrean and Photogenic Art, both on metalic, plates and on paper' (sic), and is well worth downloading from the web if you want to experiment further. Snelling more or less copies the details given by Talbot for making salted paper, but does add a number of further details.

The year after this was published saw the publication by Louis Desire Blanquart-Evrard of his work using albumen. This was an idea first proposed by an anonymous contributor to 'The Athenaeum' in May 1839 but Blanquart-Evrard was the first to put forward a practical method that contained the chlorides in the albumen. Albumen rapidly replaced salt printing as the normal photographic print because of its greater brilliance and depth of tone, and remained the dominant print medium until 1895 (finally going out of production in 1929.)

All paper prints in the first ten years of photography were salted paper prints, but after around 1855 it was probably mainly used for proofing. However, modern salted paper prints that I have made are a good match in terms of colour and tonal range to many matte prints from the 1850s (and later) identified in collections as 'albumen prints' and although it is possible to make matte albumen prints I suspect these are relatively scarce. If a print is matte, made before 1885, and does not have yellowed highlights it is highly probably that it is a salted paper print, whatever the curator's label.

Many later photographic books also had instructions for salt printing and other early printing methods, but they were dropped out of most photographic textbooks by the 1930s. One of the best known from this period, 'Photography, Theory and Practice' the English edition of 'La Technique Photographique' by L P Clerc, contains details of this and other by then obsolete processes such as albumen printing. Not available on the web, it is relatively common and cheap secondhand.

If you are interested in older processes and practices, you will find books such as the 1911 'Cassell's Cyclopaedia of Photography' enthralling. I find it a useful source of information particularly for its many line drawings and learn something new every time I pick it up. However the older chemical nomenclature and weights and measures do make life a little trying at times, and there are some procedures suggested which bear no relation to common sense let alone health and safety procedures. Almost every page deserves a health warning. It lists salted paper under one of its alternative names, Plain Paper.

The best modern source of information on the whole area is 'The Albumen & Salted Paper Book' by James M Reilly. First published in 1979 and long out of print it is now available in full on line - a generous gesture from the author. It really tells you everything you could wish to know.

The same year saw the publication of William Morgan's 'The Keepers of Light', which remains a key text for those interested in older processes. Since then a number of other books have also appeared which cover alternative processes in detail. Although some of these have excellent articles and illustrations on salt printing, there is nothing essential in them that is not available in the earlier works.

There are also a number of online resources, including the alternative processes mailing list and a number of fine web sites. Materials for the processes can also be found online at specialist dealers, including Bostick & Sullivan and ? in the USA and Silverprint in the UK. Many articles on alternative processes have appeared over the years in various photographic magazines, and there have been independently produced magazines dedicated to alternative processes in both the UK (now defunct) and the USA.

Among the resources on the web are sites with some directions for the process, others with good examples of prints made using it, and also places where you can ask questions of others using the process, including a web board and a mail list. For the mail list it is a good idea to search the online archive to see if your query has already been answered, as well as to read messages for a few days to see how the list operates before asking your questions. You also need to remember that some of those who answer questions on such mail lists are less reliable than others.

The Calotype

Part 1: Key Facts

There are probably more errors and misconceptions published about the calotype process than any other aspect of photographic history. This feature will correct some of them and give some details about the process and its invention. For details of William Henry Fox Talbot's earlier 'Photogenic Drawing' process and his early biography, see the features 'Photogenic Drawing' and 'Salt Printing' - link in box to right.

- WHF Talbot worked on the calotype process from 1839 to 1840, patenting it and announcing it to the public in 1841; many others at the same time were also attempting to improve on his photogenic drawing, but with less success

- the calotype differed radically from the photogenic drawing which Talbot had announced in 1839, though many have confused the two

- the calotype is a process for making negatives not prints; if you see a print labelled in a museum collection or book as a 'calotype', this is incorrect - it is probably a 'salted paper print from calotype negative'

- prints from calotype negatives were made using the same salted paper process announced by Talbot in his photogenic drawing pamphlet of 1839 (see feature - link in box at right)

- the major advance of the calotype process was its use of a 'latent image'. The image formed on exposure in the camera was invisible or very faint and was then made visible by the use of a 'developer' in a similar manner to the use of mercury to develop a daguerreotype

- the calotype used a develoer both in the sensitising of the paper and after exposure

- gallic acid, used as the developer was first introduced into photography by Sir John Herschel in 1839, and Talbot followed his suggestion in looking at its possibilities, finding a novel way in which to use it

- It was also Herschel who showed Talbot the use of hypo as a fixer, which became a part of the calotype process. The Rev Joseph Bancroft Reade, whose name is given in some accounts as having introduced both hypo and gallic acid, also learnt of them from Herschel.

- gallic acid is obtained from tannin, a common material in many plants and extracts from them such as tea, coffee and whisky, as well as the oak galls from which it got its name

- the calotype negative provided the first practical method of producing prints on paper from a camera exposure

- unlike photogenic drawing, the calotype gave reliable results, and the exposure times were considerably shorter - typically several minutes in bright sun

Part 2: History

Full details of William Henry Fox Talbot's photogenic drawing process were announced to the public in his privately printed pamphlet 'Some Account of the Art of Photogenic Drawing or, The Process by Which Natural Objects May Be Made to Delineate Themselves without the Aid of the Artist's Pencil.' This was read by him to the Royal Society in London on Jan 31, 1839 and published for Talbot by R and JE Taylor shortly afterwards, when the Royal Society declined to publish it. Accounts had already appeared in magazines such as the 'Literary Gazette'.

Surprisingly, the British Library has only recently acquired a copy of this rare twelve-page pamphlet (the British Museum probably had a copy at the time of publication, but if so it has been lost.) Their press release which states 'The text is a straightforward, non-technical description of Fox Talbot's 'calotype' process, written with infectious enthusiasm' is just one of the more recent examples that confuses photogenic drawing with the later calotype process, although it is particularly disappointing that this major British institution should parade its ignorance on this matter.

It is a confusion that was at one time probably a more or less deliberate part of a British cultural imperialism. We liked to be able to claim that we had invented almost everything before the foreigner, and particularly before the French. In the case of photography this was hard to sustain in face of the work of Niepce and Daguerre, and even harder when the only British candidate for 1839 was 'photogenic drawing'. As all who tried it at the time realised, it was a very poor and unreliable substitute for the delicate and finely detailed daguerreotype.

The calotype (named by Talbot from the Greek for 'beautiful drawing') was the first real competition for the daguerreotype, but unfortunately it was only announced two years later, in 1841. For British claims to have any real validity it was necessary to somehow confuse the two processes and the two dates, a confusion that succeeded extraordinarily well over the following 150 years of photographic history.

When Talbot visited his friend Sir John Herschel at Slough on the day following his talk at the Royal Society, their photographic work was doubtless the main subject of their meeting. Talbot was able to show Herschel some of his results, and - as previously mentioned (see feature 'Salted Paper Prints') - Herschel was able to show Talbot how hypo could be used as a fixer.

Herschel around this time started his mass of experiments on photosensitive materials, and by the middle of the following month had tested over 400 different materials. Unlike Talbot, who generally kept the details of his work to himself until he was ready to publish, Herschel was keen to share his discoveries immediately with others. On 28th Feb he wrote a long letter about his recent results to Talbot, including the comment that the most promising experiments he had made had been using silver nitrate and gallic acid.

By the end of the following month, Talbot was writing (in a letter quoted in R. Derek Wood's article 'Latent Developments from Gallic Acid, 1839', an invaluable source for information in this area) to recommend the use of silver nitrate followed by gallic acid to a fellow scientist. Earlier in the middle of March, Herschel had talked on his work to the Royal Society, announcing publicly the efficacy of hypo as a fixer and also mentioning in an aside the use of gallic acid.

Among those present at this meeting was the Rev Joseph Bancroft Reade of Peckham, South London, who was quick to take up Herschel's suggestions and within a week or two had good results with the method. He mentioned this to the optical instrument maker Andrew Ross who met Talbot and told him, possibly later the same day, by certainly by a day or two later. Talbot may also have heard of others making good use of the material. Photography was very clearly a hot topic of the time.

Prompted by news of this success, Talbot went to a chemist in Oxford Street and bought a dram of gallic acid. Exactly how much this was is unclear, as there were then several sets of weights and measures in use in England; however chemicals were generally sold in 'avoirdupois' and a dram was 1/16 ounce (just under 2 g) while in making up formulae, 'apothecaries' measures were used, in which a dram (or drachm) was 3 scruples or 60 grains - just under 4 grams.) It was certainly a small bottle, but the amounts needed are fairly small. Talbot began his experiments with it at Lacock a few days later in early April.

These early experiments were based on the idea of using an organic material to increase the light sensitivity of silver salts, which had been a well accepted concept for many years. The paper was first washed with silver nitrate and then with the gallic acid, to form what was generally referred to as 'gallo-nitrate of silver' or 'gallate of silver'. Although Reade, Talbot and Herschel among others found the material gave a useful speed increase, it was still not really a usable process.

It was not until September the following year (1840) that Talbot returned to experimenting with gallic acid, probably making the first real calotype on 20-23 September 1840. He carefully kept the details of his discovery secret (apparently to the extent of cutting out the words 'gallic acid' from his laboratory notebook with a sharp blade.)

In part his secretiveness will have been because of his intention to patent the process, apparently at the urging of his mother, Lady Elizabeth Fielding and colleagues including Sir David Brewster. The patent title for the calotype (British Patent 8842) which contained a brief overview was awarded on 8 February 1841, and fuller practical details were deposited in August of the same year.

Part 3: A Little Chemistry

In a further fascinating short article, R. Derek Wood points out that one of the articles written a day or so after Daguerre's presentation of his process in August 1839 had described the use of mercury as bringing out the 'yet invisible and only latent' image. Later, in the same description of his interview with Daguerre the unknown author had likened this to the use of invisible inks, which on warming become 'visible as if ink was formed there from nutgalls'.

It is indeed curious, and surely not coincidental that the major materials involved in the manufacture of medieval indelible ink were to play an important role in photography.

Oak gall based inks had largely replaced the older carbon based inks by the late Middle Ages. They were made using tannin, which was normally either boiled or fermented to hydrolyse the gallotannic acid it contained to produce gallic acid (and some digallic acid). This was then mixed with iron(II) sulphate (known in antiquity as vitriol, later often as green vitriol, to distinguish it from copper(II) sulphate which was called blue vitriol, although vitriol could be a mixture of metal sulphates.) The gallic acid reacted with the iron(II) irons to produce an iron(II) gallate complex which slowly oxidises in air to give a dense black insoluble iron(III) gallate. Recent research suggests that it may in fact decarboxylate to form a pyrogallate complex.

As Wood suggests, writing made using only one component of the ink could be used as an invisible ink, being revealed in a way analogous to the development of a daguerreotype or calotype by painting the paper over with the second component.

The use of gallic acid was thus associated with the production of permanent marks on paper, as was also iron(II) sulphate. Both had an important role in early chemistry, with a silver complex of gallic acid acting as the developer in the calotype process. Iron(II) sulphate was also widely used as a developing agent in later years, after its introduction by Robert Hunt in 1844, and it later became the developer of choice for most users of the collodion process.

Chemically, gallic acid is 3,4,5-trihydroxy-benzoic acid, and is closely related to a number of other materials which have been used as photographic developers. On gentle heating it loses the carboxylic acid group and produced pyrogallol (1,2,3-trihydroxy-benzene) which was introduced as a photographic developer by F Scott Archer in 1851. It was the negative developer of choice for many large format photographers, including Edward Weston, and has recently seen a revival in use through formulae such as the PMK developer developed by Gordon Hutchings. Pyrogallol forms both a silver image and a coloured stain which intensifies the image.

The remaining components of inks were water - obviously a vital component in photographic processes - and Gum Arabic, a pale yellow to golden orange gum exuded in lumps often the size of a walnut by the Acacia tree found in Egypt and the Middle East and also used in cookery. Gum Arabic was used to slow down the absorption of the ink into the paper, so that the ink dried more on the surface, giving a more intense colour, and also it could impart a glossiness to the dried ink. Gum Arabic was used for a similar purpose in some photographic formulae and was also the basis of the gum bichromate process popular among pictorialist photographers around 1900 and also enjoying a revival in recent years among those interested in handmade photographic papers.

Development in the calotype process was physical development, where the silver producing the image came largely from the developing solution rather than from the paper coating. The silver in solution is in the form of silver ions, Ag^+ and this requires to be chemically reduced to give silver metal:

$Ag^+(aq) + e^- \rightarrow Ag(s)$
(reduction)

The electrons for this process have to be supplied by a corresponding oxidation reaction of the developing agent, in which it releases elections. In the case of polyphenols such as gallic acid, this is likely to involve the loss of hydrogen from the phenolic groups to form quinones and hydrogen ions. Schematically this may be represented as:

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  \\                  \
   C - OH                C = 0
   |           ->       |      +  2H+   +   2e-
   C - OH                C = 0
  //                  /
(oxidation)
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although the actual reactions will involve silver complexes of the gallic acid.

This development process occurs preferentially (and almost entirely) at those sites in the image where there is existing silver due to the exposure in camera.

Talbot's instructions (see next part of this feature) called for the initial production of a light sensitive material containing a silver-gallic acid complex - the same material as was later used to develop the paper. Some development could thus take place as the paper was exposed (generally while still damp) but would be limited in particular by the lack of water present preventing much diffusion of the complex to the site of development.

Part 4: Talbot's Instructions

Talbot presented his calotype process in a lecture to the Royal Society in London which he shortly after published as a reprint 'The Process of Calotype Photogenic Drawing, Communicated to the Royal Society, June 10th 1841.' This is reprinted in Beaumont Newhall's 'Photography: Essays & Images'.

Talbot's instructions for the process in this lecture were clear and concise and gave all necessary detail. Shortly after the announcement it was possible to buy iodised paper ready for the final sensitising and use.

- Making Iodised paper

The quantities mentioned by Talbot have been converted into modern measurements. Some amounts have been changed proportionally to make more sensible quantities.

Smooth surfaced writing paper was trimmed to remove any areas with watermarks before use. The preparation of the paper was best done using candlelight.

1. A soft brush was used to brush silver nitrate solution over one side and the paper was then dried; gentle heat could be used.

2. When dry or almost dry, it was put into a tray of potassium iodide solution for 2-3 minutes, drained, rinsed with water and blotted before being dried. Again heat could be used.

The 'iodised paper' at this stage had a pale yellow coating of silver iodide and could be kept for any length of time if protected from light.

- Solutions

Silver nitrate:

Silver nitrate	6.5 g
distilled water	170 ml

Potassium iodide:

Potassium iodide	57 g
water	1000 ml

- Calotype paper

The final sensitisation of the iodised paper to produce calotype paper was usually performed a few hours before use, although it could be kept longer - up to several months - but sometimes deteriorated. Again the preparation was carried out in candlelight

1. Mix together equal amounts of solutions A and B immediately before use in the quantity needed as the mixture does not keep. This mixture Talbot called 'gallo-nitrate of silver'.

2. Brush the coated side of iodised paper with this solution, and leave for half a minute

3. Rinse the paper in water, blot it and dry it using gentle heat only.

When dry the paper was ready for use (it could even be used while still damp.) Talbot stated it was more than a hundred times more sensitive than any previous photographic paper.

Solution A:
Silver nitrate 6.5 g
Distilled water 57 ml
Strong acetic acid (33%) 10 ml

Solution B:
A saturated solution of pure gallic acid in cold distilled water (about 1 g per 100 ml.)

- Exposure

In his original lecture, Talbot suggested an exposure time of one minute using a lens of aperture f15, but in a later note this was amended to 10 seconds in bright sunlight. Using an aperture around f3 and a bright subject, a good impression could be obtained in as short as one second. However some other sources give rather longer exposure times around 5 minutes as more typical.

As Talbot noted, the paper after exposure generally appeared quite blank, though there might be faint traces of an image.

- Development and Fixing

Talbot carried out development by brushing the paper over with the gallo-nitrate of silver solution and then warming it: "it is a highly curious and beautiful phenomenon to see the spontaneous commencement of the picture, first tracing out the stronger outlines, and then gradually filling up all the numerous and complicated details." Development was by inspection and when the picture was complete, it was rinsed with water, blotted and dipped into potassium bromide solution. After a minute or two it was then rinsed briefly with water and dried.
Potassium Bromide solution:
6.5g in 250 ml

- Making Prints

Although the negatives obtained could be printed on calotype paper, much better results were obtained by using the salted paper process, which gave "tints more harmonious and pleasing to the eye." Full details of this were given in the feature 'Salted Paper Prints' (see box, top right.)

Any prints from this era in collections labelled 'Calotype print' are almost certainly incorrectly labelled. Almost all prints on paper before the 1850s (and matt surface prints for some time later) are salted paper prints. Although Talbot and probably others made prints on calotype paper they were generally rather unsuccessful experiments.

The calotype negatives often faded during the exposure to the bright sun needed in making salt prints. They could be revived by redevelopment.

Part 5: Later Improvements

Various minor modifications in the sensitising bath were made with the aim of increasing the speed of the process, but none were very effective. Iron(II) sulphate (then called iron protosulphate and later often know as ferrous sulphate) was found to be an improved developer.

It is unclear why Talbot recommended the use of potassium bromide as fixer rather than the more effective sodium hyposulphite whose use had been well known for a couple of years. Possibly 'hypo' dissolved some of the lightest detail of the negatives, especially if used for too long or in too strong a solution. It may be that it led to some staining on the negatives because of the totally inadequate wash times then in use. In the early days, prints were simply 'dipped' into water rather than washed. Not surprisingly few if any survive completely unfaded.

Many calotype negatives were made more translucent either by dipping them into almond oil (now widely used in the cosmetic industry) or by rubbing them with wax and then ironing with a hot iron between sheets of blotting paper.

In 1851, the French painter-photographer, Gustave Le Gray (1820-84) invented a variation of the calotype known as the waxed-paper process. For this the paper was waxed before coating, and then soaked for an hour in rice water containing lactose, potassium iodide, potassium cyanide and potassium fluoride. After this it was then dried and sensitised before use with silver nitrate solution acidified with acetic acid. Development was with gallic acid.

Exposures were generally from 20 seconds to 15 minutes depending on the lens aperture and the light conditions. As well as recording very fine detail there is a complete absence of traces of the paper grain in images printed from these negatives. Although slower than the calotype (and much slower than the wet collodion process) it was favoured by many travellers as it avoided the carrying of heavy glass plates and the need to sensitise and process the negative immediately. Le Gray was also an early experimenter with collodion and later produced many fine pictures with the wet collodion process.

The calotype process was an instant success, and its main drawback was the patent that Talbot took out, and the large licence fees that he demanded for those who wanted to make use of it prevented its widespread adoption. William Langenheim acquired the patent rights for the United States, but the process was a commercial failure there. Talbot failed in his efforts to obtain a French patent, and the process was also free to use in Scotland. Outside of its use by Talbot and a circle of his friends it was in these other countries that the process say most use.

Talbot's patent was to continue to be an issue even after his calotype process was made obsolete by the invention of wet collodion in 1851, as he insisted that this new method was also covered by his patent. In 1852 he was persuaded to allow amateur photographers to take pictures without a licence, but he continued to charge professional portrait photographers and took several who would not pay to court. The matter came to a head in December 1854, when the case of Talbot against portrait photographer Martin Laroche came to court.

After a three day trial, the jury decided that although Talbot's claim to have invented the process was true, his patent did not cover the use of wet collodion. Following this decision, Talbot gave up his attempt to petition for a prolongation of the patent at the end of its normal 14 year life, and it expired in February 1855. By then, few people wanted to make use of it, although it remained a more convenient method for some travellers.

A further feature will look at some of the great photography produced using this process, notably the work of David Octavius Hill and Robert Adamson working in partnership in Scotland.

Photography in the 1840s

Part 1: Odious Comparisons

Following the announcements of the daguerreotype process in 1839 and the calotype process in 1841, there were two photographic processes in general use (see links in box at right for further details.) In 1851, the wet collodion process was introduced, which is often stated to have made both the earlier processes obsolete. Both continued in use for the particular applications to which they were best matched, and the replacement was much more gradual than is usually suggested.

A while ago I read the published autobiography of an English photographer that recounted the incident from his youth that turned him to photography. In the 1890s while he was a young boy in Kent, an elderly wandering photographer had come to his village making daguerreotype portraits and he had been allowed to help with the process. The itinerant claimed to have learnt the process from Daguerre himself - and quite possibly he had done so - some fifty years earlier. The process was still meeting his and his clients' requirements over 40 years after it was 'obsolete.'

Many books have listed and compared the relative merits of the calotype and the daguerreotype as if they were a matter of choice for the photographer of the time similar to that between Kodak or Fuji or Ilford film. Often the comparison takes on a chauvinistic bias - unsurprising given the long history of conflict between France and England. Both were viable photographic processes, but they served different social and economic functions, as a result of their different properties.

Daguerreotype	Calotype
Announced in 1839	Announced in 1841
Direct positive process	Gives a negative that has to be printed
Uses light sensitive silver halide	Uses light sensitive silver halide
Detailed manual published shortly after announcement.	Outline published with announcement.
Exposures typically 10s-10 minutes	Exposures typically 30s-20 minutes
Gives unique original	Gives negative which can be used to produce as many prints as required
Image on metal plate	Negative and prints on paper
Image needs protection of sealed case	Image needs no special protection
Detail in image limited only by lens/focus	Detail in image lessened by texture from paper
Image difficult to view and needs correct orientation to see	Image clearly visible from any position
Rapid process - 15-20 minutes from exposure to delivery of final image	Slow process - typically several days to deliver final image (can be printed many years later)
Images generally required individual presentation in case	Images can be incorporated into albums, pasted into books etc
Process benefits from mass-production techniques	Process suitable for hand production as required
Plates relatively heavy	Sensitized paper is light
Processed immediately	Negatives best processed shortly after exposure; printing can be left for later
Usually small (plates are expensive)	Often large (paper is cheap)

The daguerreotype spread rapidly around the world as scientists and others with an interest in science read the news in the papers and magazines in the industrialised countries. Photographers soon set out from Europe and the USA to create daguerreotypes in other parts of the world. Often their work in these countries created much local interest, and many of them inducted some of those interested into the new art.

There were some limitations on the spread. Although Daguerre's process had been released 'free to the world', it was covered by Daguerre's prior patent in the UK, which limited it to those professionals who could afford a licence. Similarly Talbot patented his calotype process in the UK and USA, again limiting its growth in these countries, but his efforts to get a French patent were unsuccessful.

In general, most professional photographers used the daguerreotype process in the 1840's, while the calotype was generally favoured by those who were not attempting to earn an income - at this time mostly gentlemen scientists rather than what we would now regard as amateur photographers. In the next decade however there was an increasing professional interest in the calotype, as the possibilities of travel photography were explored.

Part 2: The Daguerreotype

The daguerreotype had almost two years start on the calotype, but there was another clear advantage. You could buy Daguerre's manual, follow its directions and the process worked. The calotype was a little trickier, as Talbot had issued an outline rather than detailed instructions, and many of those who tried it were disappointed with the results they obtained.

The Reverend Calvert Richard Jones (1802 - 1877) was a keen (and very proficient) amateur watercolour artist who took a great interest in the discovery of photography. He was also a friend of Talbot's younger cousin, 'Kit' (Christopher Rice Mansel Talbot), having been at Oxford University at the same time. Talbot apparently did not much approve of Jones who he felt was taking advantage of Kit's wealth in staying and holidaying with him.

In March 1841, Jones made a daguerreotype of Kit Talbot's house, Margam Castle, producing the earliest known photograph in Wales. He went on to try the calotype process, but at first met with little success. Requests to Talbot for further information and advice seem not to have been answered and Jones went to France to get ideas from Hipploыte Bayard, who having first invented his own direct positive process on paper in 1839, had switched to using the calotype.

Later Jones and Talbot became good friends, and even went together on a number of photographic expeditions. In 1845, Jones went to stay with Kit Talbot in Malta, later travelling to Italy. He sent his calotype negative back from there to be printed at Talbot's printing works in Reading. The pictures from his travels in Europe and in the countries of the United Kingdom show that he used his artistic training to good effect in the selection of subjects and viewpoints.

The daguerreotype was ideally suited to use by professional portraitists in their photo studios, where they had well equipped and organised workshops for preparing and processing the plates. Their great success in America and in particular the high technical quality of the best work there - the term 'American Daguerreotype' was used as a byword for quality - was largely due to the use of mechanical methods of plate polishing and preparation in a highly controlled manner, an early application of mass production techniques. A separate feature will deal with the great masters of the American daguerreotype.

Short processing times were vital for the smooth running of an early portrait studio. After the ordeal of sitting (or standing) absolutely still for perhaps several minutes in dazzling light, the client had only a short period to recover before the photographer's assistant had finished the processing and the picture could then be taken away.

Usually people wanted a picture of themselves or their loved ones. They did not want multiple copies, but a single copy. The daguerreotype in its impressive case was a precious object, with a magic that the paper print lacks. Like an icon, there are rituals associated with viewing it, holding it in one's hand and angling it to the correct position to see the image clearly.

Daguerreotypes are normally small because of the high cost of the metal plates - they were normally cut into small pieces - often as many as 12 or 16. The highly detailed images demanded close attention with the image in your hand. They were treasured objects, prized possessions of those who could afford to own them. They were small enough to carry around with you to show off to your friends and relations.

Of course there are daguerreotype images of other subject matter. There are landscapes, city views, historical sites and others. Particular clients may have commissioned some, but others will have been made by photographers to demonstrate their mastery of the process.

In the first flush of the discovery, every scientist and experimenter had a go at the daguerreotype, with varied success. After this, it became very much a professional process, and well over nine tenths of the business was in individual portraiture. Unless the sitter was very unhappy with the result, the daguerreotypes went with them as they walked out of the photographer's door. Some pictures had to be made for the 'shop window' with a more universal appeal than a portrait of Joe Public, and local scenes were one way to meet this need.

The earliest photographic travellers had no choice but the daguerreotype, but the advantages of the calotype soon became clear. It avoided having to carry cases of heavy metal plates and the paper could be prepared in advance with less need for lab facilities on the spot, although it was still generally advisable to process the negative as soon as possible as the results were still unreliable. However making the prints could safely be left for when the photographer (or his negatives) reached home.

The major disadvantage of the daguerreotype for their purposes was that it remained a single unique image. Marketing the work was difficult with only a single image; the best multiple results were obtained from engravings based on it (some were even engraved direct onto the plate, destroying the original image in the act.) However, these results no longer had the cachet of having been reproduced directly from nature without the apparent use of a human hand; they made the photograph simply another aid to drawing - comparable to the camera obscura.

Part 3: The Calotype

The main problem - discussed above - in the early years of the calotype process was in getting acceptable and repeatable results. Some of the early examples - such as the work of Charles Piazzi Smyth (1819-1900), who made the first photographs in South Africa in 1842 - are clearly not great examples of either technical or artistic expertise.

The calotype is often stated to produce broad effects rather than fine detail, and there is some truth in this, although it is perhaps overstated. Some calotypes show a great deal of relatively fine detail, with, for example, every brick of buildings being visible. However there is a slight loss, because the image in the negative is not entirely on the surface of the paper, but is on the surface of the fibres (and to some extent absorbed into them) below the surface. This gives rise to a small amount of diffusion of the image in contact printing.

The broad effects are probably mainly due not to a lack of detail but to the combination of underexposure leading to empty shadows and the effect of self-masking in the printing process leading to a compression of the darker tones. Both can give rise to large dark areas with little detail in the prints.

Calotypes can also suffer from empty white areas, mainly caused by insufficient exposure when making the prints. Exposure of salt prints needs to be continued until the highlights are rather more distinct than is needed in the final print, as some loss occurs during processing, particularly during the fixing stage. Probably as photographers got more concerned about the problems of fading and took greater pains to fix the image they lost more of the highlights in processing.

Similar effects can be seen in printing on modern silver gelatin papers, where they result from a mismatch in contrast between negative and paper. Photographers such as Bill Brandt in the 1960s and later made deliberate use of this to create strong graphic effects, reprinting much of his early work on considerably more contrasty paper. With the early materials, contrast in both negative and printing material varied considerably and photographers neither appreciated the possibilities or the need for control.

The calotype process produced some of the finest portraits in the history of the medium in the work of David Octavius Hill and Robert Adamson, working as a team in Scotland from 1843-7. Their important work will be the main subject of a feature dealing with early photography in Scotland.

However, for the professional portrait studio, the calotype had a great disadvantage that was not related to image quality. It simply took too long to produce a print. While the customer could be handed a daguerreotype image after a short rest at the end of the tiring ordeal, the salted paper print from the calotype took much longer to produce, and would normally require another visit to collect the work.

There were calotype portrait studios - the first probably being opened in London by Henry Collen, (1800-1879), in August 1841. Collen did not come to an agreement with Talbot for the licence required until the following year, when it was backdated to cover his work from August. Licences were expensive; Talbot took 30% of Collen's takings for his use of the process.

Also in 1842, Talbot persuaded the leading portrait photographer in London, Antoine Claudet, (1797-1867) to give his process a try. While Claudet saw the advantages of the process, he also saw its limitations - in particular that it was slower and the detail less fine, and continued to use the daguerreotype for most of his work. The more limited detail of the calotype could of course be an advantage in some portraits, where later portrait photographers were to make great use of soft focus and diffusion. In later years - after Talbot relinquished his patent - Claudet did make use of both the calotype and the wet collodion process rather than the daguerreotype.

For the travelling photographer, or anyone who wished to sell multiple copies of pictures, the calotype had obvious advantages. Paper was light to carry and could be prepared in advance. More or less immediate processing of the exposed sheets was however still advisable as the process lacked reliability, but once dry the paper negatives could be easily transported or sent back home for later printing.

The Irish photographer, John Shaw Smith, (1811-1873), an Irish landowner of independent means living in County Cork, made a number of trips to Southern Europe and the Near and Middle East between 1850 and 1852, when he reached as far as Petra. He took about 300 calotypes of architectural sites, generally using exposures of around 7 minutes in bright sunshine. His calotype negatives were largely forgotten until his work was exhibited at the Victoria & Albert Museum in 1951. The collection of negatives is now viewable online at George Eastman House.

Apart from this ease of carriage, there were important cost advantages in using paper rather than expensive metal plates. However the main point was that it was possible to produce a large number of prints for sale, rather than having a single image. Editions of prints could be sold and albums could be produced for sale.

Part 4: Wax and Eggs

It was in France (like Scotland, free from the restrictions and expense of Talbot's patent) that the calotype was developed further, reaching its peak in the 1850s, when some writers on photography have pronounced it dead. The feature 'The Calotype' mentions the work French painter-photographer, Gustave Le Gray (1820-84) who in 1851 announced the details of his improved calotype known as the waxed-paper process. Waxing the paper before sensitisation prevented the solution from sinking into the paper fibres, producing an image on the surface of the paper; this gave an increase in sharpness and finer detail.

A second important introduction was a new printing process using egg white or albumen. Again this held the image on the paper surface as well as enabling a larger amount of silver halide to be used. Both Nièpce de Saint Victor and Louis Désiré Blanquart-Evrard (1802-1872), had suggested the use of albumen in making negatives on a glass support in 1848, and neither process was very satisfactory, but it was Blanquart-Evrard who went on in 1850 to introduce its use in prints.

The first use of albumen in making prints had in fact been suggested within a few weeks of Talbot's 1839 announcement of his process, but as the results were no better (if not worse) than those from plain salted paper, it was soon abandoned. Blanquart-Evrard published a simple recipe in 1850 that could give dramatically improved prints with a greater depth and brilliance. The albumen print was to be the dominant print medium for the next 40 or 50 years, and albumen paper remained in commercial production until 1929.

Almost all early negatives were printed out - that is they were exposed onto the printing paper until the image was fully visible. In fact it was necessary to print until the image was darker than required, as some bleaching normally occurs in processing. There were some experiments with the use of printing materials that were given a short exposure to produce a latent image and then developed, but these were not generally adopted.

Perhaps the most important reason that developing out materials were less useful then was the difficulty in giving consistent exposures before the invention of the electric light bulb. Making materials of consistent speed was also beyond the grasp of current technology (it is a problem that has only really been solved in very recent years - and even now some batches of film are outside the standard when testing - and may be sold under a different label.) A further reason was that development generally gave a less attractive print colour than printing out.

For printing modern negatives, the self-masking of printing out materials (see above) is a nuisance, but for the wide variations in exposure and development of the calotype it was essential. Even in the days of gelatin glass plates, photographers still tended to give very generous exposures and to greatly overdevelop by modern standards. Many prints on modern materials from these negatives are unsatisfactory.

Recently I saw a good example of this in a show of the work of E J Bellocq, a commercial photographer based in New Orleans. In 1912 he made an amazing series of portraits - many nude - of the women of the red light area there. Kept by a local historian, the plates were printed by several photographers before photographer Lee Friedlander bought them in the 1970s. The earlier prints appear to have been made on normal development papers, and generally have poor highlights, with unconvincing skin tones. Friedlander made a set of prints using a printing out paper that revealed for the first time the true quality of the work, and were also the basis for a finely printed book on the work.

As mentioned above, further features will deal in detail with the great American daguerreotypists, with Hill & Adamson and photography in Scotland, and with the fine work of early French photographers using the calotype process in the 1850s.

The Great French Calotypes

Part 1: The Golden Age

The calotype has often suffered from a bad press so far as the history of photography is concerned. Contrary to the ideas of many, it was a process capable of resolving a high level of detail and giving surprisingly good tonal reproduction, though like all photography in the first roughly fifty years, it was sensitive to ultraviolet and blue light only.

Perhaps one reason for the misconceptions is that the process was only fully exploited around and after the date when some historians have pronounced it dead, made obsolete by the announcement of new and superior wet collodion process (aka wet-plate) in 1851 (to be the subject of a later feature.)

Such simple views of photographic history have suggested that all photographers immediately switched over to this significantly improved method. Clearly wet collodion - or wet plate - was an important advance, and a definite improvement on the existing daguerreotype and calotype processes (see box at right for more details on these.) However not only did many photographers continue to use the calotype - sometimes in tandem with the new process - but the decade of the 1850s was its golden age.

Wet plate seems to combine the advantages of both existing processes. It could give very fine detail like the daguerreotype, with none of the diffusion caused by the paper base of the calotype negative. Like the calotype it produced a negative, from which any number of prints could be made - and printing was easier and faster because the image was on a glass plate rather than on paper. The prints it produced, whether salt prints (see box at right) or albumen prints, could be viewed and handled with the same ease as those from the calotype - they were produced on the same material.

Yet the same years as the wet plate process was coming into use were also a golden age for the calotype, with a great output of fine images, particularly from French photographers. The calotype reached its peak in the improvements to the wet exposed process made by Louis-Désiré Blanquart-Evrard, (1819 - 1875), from 1844-7 and in the dry waxed paper process, perfected by Gustave Le Gray in France between 1849 and 1851, and it remained popular for some years. Many of the greatest pictures of the 1850s were salt prints made from calotype paper negatives. Many of them are of such quality that they are often assumed to have been produced from wet plate negatives, and certainly in reproduction it is seldom possible to distinguish the two.

The daguerreotype also was slow to die out. It remained for some years the medium of choice for cheap portraiture, with the assembly line approach of professionals such as Edward Anthony's photographic firm in New York City. You paid your 25 cents, queued to have your portrait taken, and almost before you had recovered from the ordeal the image was there in its case waiting for you. Compared with the calotype or wet plate, this was instant photography.

From the late 1850s, the daguerreotype began to be replaced for rapid portraiture by two collodion bases processes, first the ambrotype (aka positive collodion), using a glass based negative mounted in front of a dark backing, and then later the tintype (aka ferrotype and melainotype), which used the collodion directly on a black enamelled metal base. These processes will be covered in more detail in a later feature on collodion based photography. Both apparently first discovered in France, the ambrotype in 1851 by J-R La Moyne, and the tintype by Adolphe Alexandre Martin in 1852, both were later granted US patents.

The great advantage of the calotype, particularly of Le Gray's waxed paper version, was that the paper could be prepared beforehand and was used dry. A traveller could prepare a number of sheets for use on a journey. Unlike the original calotype material, the paper was normally exposed dry, and did not need to be developed immediately. Wet plates - as their name suggested, had to be used while wet. They needed to be prepared , exposed and processed to a negative in the space of a few minutes.

Wet plate photography made the taking of photographs outside of the studio into an expedition involving carrying darkroom and chemicals, the locating of a water supply and also the glass plates themselves were heavy and fragile. Many photographers in the 1850s made use of both processes, only taking pictures away from home using wet plates if the job or the client demanded more than the calotype could provide.

Although the calotype had been invented in England, and some of the finest early examples were from here and from Scotland, by the end of the first decade of photography its development had clearly shifted to France. It was here also that the first government sponsored photographic project took place, and also where the first real mass production of photographs took place.

Part 2: The First Print Factory

The first photographic society was established in Scotland in the early 1840s and a year or so later there was a 'Calotype Club' in England. However these were more like groups of friends who met to discuss their work, and the first real photographic organisation was the French 'Société Héliographique' of 1851. Chaired by the diplomat and amateur photographer Baron Gros, this included major figures in the arts and sciences - the painter Eugene Delacroix and Victor Regnault, art critics and photographers including Hippolyte Bayard. Bayard was another of the inventors of photography, with his direct positive paper process, with which he had produced the first photographic exhibition in 1839 (and there are stories of him having made a photograph in the 1820s.) The Societe Heliographique also produced the first photographic magazine, 'La Lumiere' in early 1851.

WHF Talbot's Reading printing works (see 'The Pencil of Nature' - box at right) had been very much a cottage industry, and was ill equipped to meet a need for volume production of photographs. His two main productions - 'The Pencil of Nature' and 'Sun Pictures in Scotland' both ran into difficulties, in producing the images for them at a reasonable speed, but also with consistency and quality. Added to this was the problem of fading because insufficient was known about how prints should be treated, particularly their fixing and washing.

The need to produce prints rapidly and cheaply was clearly essential for the commercial exploitation of photography. The Societe Heliographique immediately set up a working party under Blanquart-Evrard to tackle the problem of large-scale photographic printing.

His report examined the problems Talbot had faced. Even on a good sunny summer day, a single waxed calotype paper negative could only produce three or four salt prints, as exposures running into several hours were required. The shorter day length and poor weather frequently experienced in winter made the yield even lower - if work were possible at all. It is hardly surprising that most early salt prints are rather 'weak' by modern standards - even compared to modern salt prints. They were simply not exposed for long enough.

(Waxed calotype negatives and the waxed paper process are often confused. From the invention of the calotype process, printing times had been shortened by treating the developed paper negative with wax or oil - often by rubbing with wax and then heating to melt the wax into the paper fibres. The dry waxed paper process, perfected by Le Gray, applied the wax before making the paper light sensitive and taking the exposure.)

Blanquart-Evrard's solution was to make use of a short exposure - less than a minute - to produce a latent image that was then brought out by development in a suitable developer. This made it possible to produce several hundred prints per day from a single negative, a vast increase in productivity.

In the Summer of 1851, Blanquart-Evrard set up a factory, the 'Imprimerie Photographique', near Lille, the centre of the French cotton industry in the north of France (often called the 'Manchester of France'.) For the next four years he employed around 30 women on a seasonal basis. He organised the work on rational lines as an assembly line for the production of prints, dividing the process into its individual steps each carried out by a different worker.

Where salt prints had previously cost around 5 francs each, the factory could make them - depending on size - for around 5-15 centimes (100 centimes = 1 franc) By the time the factory closed in 1855, it had produced around 100,000 prints. Blanquart-Evrard went on to set up his own printing company in Jersey with Thomas Sutton,(1819 - 1875), where he also collaborated with Sutton on the early issues of the photographic magazine 'Photographic Notes' (1856-1867). Sutton was also the inventor of the first mirror reflex camera in 1861, the forerunner of today's SLR, and took the pioneering photographs of a tartan ribbon for James Clark Maxwell's experiments with colour photography in the same year. His 1858 panoramic camera produced 120 degree views using a water-filled spherical lens.

Most of the pictures printed by the factory were landscapes and pictures of architecture, including many archaeological studies. Another large proportion were reproductions of paintings, etchings and sculpture. Although the painter Paul Delaroche is famously quoted as having announced 'From today, painting is dead' when Daguerre's invention was announced, in fact photography from its earliest days was put to the service of art.

Not only were photographs soon being used as source material by painters (and in some cases actually paintings were actually made on top of photographs), for the first time works of art were made available to a wider public in the form of exact (if black and white) reproductions. No longer was the only way to experience a great work to go and stand in front of it; no longer did artists need to stand in front of the pictures of the masters and copy them - although many for very good reason continued to do so.

Part 3: Great Expeditions

The French and British Empires were at the height of their power and influence in the mid-nineteenth century, with much of the world being under their colonial rule. There was a great deal of travel and trade emerging, particularly with improvements in travel through the century. There was a great deal of interest - and ignorance - about the distant lands and photography was quickly seen as a way to bring back images to satisfy this interest. Today much of photography is driven by the fashion industry and the cult of the celebrity, but in the nineteenth century it was the lure of distant lands that dominated.

Early photographic travellers used the daguerreotype process, with photographers Joseph-Philibert Girault de Prangey, (1804-92) travelling in Egypt and the Near East in 1841-4. Girault de Prangey was an artist who had earlier travelled sketching the area. Jules Itier (1802-77) travelled in Africa and the West Indies taking daguerreotypes, and in 1843 his work as a customs inspector took him to Vietnam and China. In his spare time he travelled extensively, photographing in the East Indies and Pacific Islands, and his journey back to France in 1846 too him to Borneo, Manila, and Egypt. After this he remained in France, still photographing until his death in 1877.

The publisher and optician Nöel-Marie Paymal Lerebours,(1808-1873), realised the commercial potential of such images and published the first part of his 'Excursions daguerriennes' in 1842, sending out artists with daguerreotype cameras to take pictures as well as buying images from the USA, Russia and elsewhere, to meet its promise of providing readers with the most remarkable views and monuments from around the world. By the time it was complete in 1846 it contained 112 views, mainly aquatints engraved following the daguerreotypes, with the engravers embellishing the images with details unrecorded by the camera such as clouds and figures in the scenes. Among those etchers who worked with Lerebours was Charles François-Daubigny (1817-1878), one of the true masters of that medium.

Armand Hippolyte Louis Fizeau,(1819-96), a French physicist noted for being the first to measure the speed of light, had made his first major contribution to photography with the invention of gold toning for daguerreotypes in 1840. From 1841-4 he was working on methods of producing printing plates directly from daguerreotypes, achieving more success than others engaged on the problem. Fizeau started by using an acid to etch the plates, when the image areas acted as a resist to prevent attack. A finely powdered resin was then drifted onto the plate and heated so it adhered, much in the same way that a photogravure plate is treated to give a ground, breaking large areas up into a number of small areas. The next step was to use electroplating to give a harder surface that could stand the pressure of the press.

Many others were involved in similar experiments around the same time, including Sir W R Grove in England and A J F Claudet, who was awarded a French Patent in 1843. Fizeau appears to have been the most successful, and he produced copies of at least three prints, but it was not until much later than successful methods of photomechanical printing were developed.

The successful methods of reproducing photographs in the 1850s were either the relatively expensive use of actual calotype prints, or printing from engravings made in wood or metal based on photographs. Wet-collodion could be coated onto an engraving plate, sensitised and then used to copy (or take) a photograph, providing a photographic guide for the engraver where a high degree of accuracy was required.

Part 4: Calotype Travels

It was however, only with the introduction of the improved calotype processes around 1849 that travel photography really came into its own, although there had been some pioneers from the British Isles using Talbot's original method as well as the early daguerreotypists.

Maxime Du Camp set out for Egypt in the company of writer Gustave Flaubert, armed with photographic equipment that he hoped would save the great deal of time he had spent sketching on previous trips. Unfortunately, despite his lessons from Gustave Le Gray, he was unable to get the dry waxed paper to work, and was only able to photograph after a photographer calling at Cairo on his way to India was able to show him how to use the Blanquart-Evrard method using wet calotype paper.

Du Camp returned to France in 1851 and his pictures were printed at the Blanquart-Evrard factory. His book, 'Egypte, Nubie, Palestine et Syrie' was a success when published in 1852, selling around 200 copies at the high price of 500 francs. Each copy contained 125 original photographs - around 25,000 prints in total. This was the first French publication illustrated by real photographs.

Other photographers followed Du Camp's lead, including Felix Teynard who came back from Egypt with 160 calotypes in 1852 which were published in instalments, John B Greene's 1854 'Le Nil, monuments, paysage photographiques', Auguste Salzmann's 'Jerusalem' (1856) and the final great volume of Calotypes, Louis De Clercq's 'Voyages en Orient, 1859-60.'

John B Greene,(1832-1856), was the son of an American banker and grew up in France. He died tragically young at 24 from tuberculosis in Cairo. His work impresses by his use of space and the realisation of photographic qualities. Where Du Camp creates splendid records of the monuments and inscriptions that give us a real impression of being there and seeing these things, in Greene's work we have something far more personal and subjective. Du Camp's work is perhaps literary, and certainly has something of the romance of the East, while Greene's is more about a state of mind and a visual experience.

Possibly the most technically perfect calotypes are those of Felix Teynard, a civil engineer who, inspired by the work of Du Camp and others, decided to go and photograph Egypt. Unlike most of the other photographers he had no commission and no particular knowledge of the archaeology (and no archaeological adviser.) What he obviously did have was a great love of the shapes and lines of the buildings, ruins and trees, and a strong feeling for the way that light gave them form. Images such as his 'Karnak (Thèbes)- Premier pylône - Ruines de la porte et des colosses vues du point E (Égypte et Nubie, pl. 66)' still attract us through their composition - in particular the choice of viewpoint with the palms visible through the great gateway, the play of light on the stones and the feeling of space from the foreground to the ruins.

Teynard took at least 160 pictures in 1851-2, and they were brought out in batches, exhibited at the Paris Exhibition in 1855 and finally published in his 'Égypte et Nubie' in both Paris and London in 1858. However sales of the work were low and there are few copies known. Teynard, so far as we know, never took photographs again after this expedition. His work has become much more available through publication in recent years in books and magazines.

Louis De Clercq's work includes some great panoramic images, generally taken from a high view point and exposed on several sheets of negative paper, such as his 'Panorama de Jérusalem', 1860. and 'Beyrouth - Panorama de la ville, côté de la mer (1859)'. These are works on a grand scale - the Beirut image is roughly 142cm long - about 46 inches. There are also closer and more intimate images of details of the cities, and in particular a set of images of the 'Stations of the Cross' following the route according to tradition of Christ. The whole work - six volumes of prints covering Syria, Jerusalem and Palestine, Egypt and Spain - remains one of the great achievements of photography.

Part 5: Documenting France

The 1851 'Mission héliographique' was the first government sponsored documentary photography project. The French 'Commission des Monuments Historique' employed five photographers: Hippolyte Bayard, Edouard Baldus, Henri Le Secq, Gustave Le Gray and O Mestral, to photograph a list of ancient monuments which were on their restoration program. It was intended to use the pictures to plan some of the details of the restoration work, and the photographers hoped that their work would be published, although this was not to happen at the time.

The results needed to be highly detailed, but none of the photographers used the 'state of the art' wet plate process. Bayard used glass plates, but with an albumen coating, giving some of the advantages of collodion, but lacking its speed. The other photographers worked with paper negatives. Baldus used a process involving iodised gelatine, but Le Secq, Mestral (of whom little is known) and Le Gray all chose to use Le Gray's waxed paper process.

Altogether almost 300 paper negatives made for the project have survived, and although the work was not published, several of the photographers went on to gain further government work.

Charles Marville made many fine architectural studies using dry waxed paper, and in 1862 became the official photographer of Paris. Marville trained as a painter and illustrator before becoming a photographer. He travelled around Italy, Germany and Algeria photographing using the calotype process, before becoming official photographer for Paris in the early 1850s.

Marville worked for many years documenting the changing of Paris as new wide boulevards were built to allow greater military control of the city, going through many crowded areas of the city. His work on Paris is often seen as one of the first great documents of photograph, and as a precursor of the work of Eugene Atget (see box, top right.)

Images from some of these photographers now sell for very high prices. At a recent auctions, 'Beech Tree, Fontainebleau', an albumen print made by Le Gray around 1855 set what was then a world record price for a single photograph, £419,500. It is a pleasant image with the noon light making the leaves glow, a photograph as much about how the light interacts with objects as with the objects themselves. The links with the sensibilities of the French painters of the era and the impressionist movement are clear. In some of their paintings you can see such photographic effects as this diffusion and also of the way strong light appears to eat into the subject. We think of the painters as concerned with the visual, but often their access to the visual was the photograph.

The record was not to last long; a few lots later and it was topped to the tune of £507,500 by a later picture by Le Gray, printed from two wet plate images. Le Gray became famous for his maritime views, and one of these was the record-setting 'Big Wave at Sete'. By taking two exposures, one for the sea and another for the sky, he was able to reproduce tones in both areas. It was a technique pioneered by Hippolyte Bayard.

Albumen Prints

Part 1: History of the Albumen Print

Writing in 1910, John A Tennant, the Editor of 'The Photo-Miniature', noted; "*Twenty years ago, when photography was not a popular pastime but a mysterious hobby, a photograph could be only one definite thing, namely - a so-called silver or albumen print.*" Although that was the case in 1890, by 1910, as he went on to state, "*The albumen print is as good as forgotten.*"

The albumen print had dominated photographic printing from a few years after its invention in 1850 until around 1890, when it was fairly rapidly superseded by gelatin based papers, although other materials, including collodio-chloride, carbon and platinum papers were also in use.

In more recent years there has been a small-scale revival of interest in albumen printing, as a part of a general increase in interest in historical and pictorial processes that started in the late 1970s. James M Reilly published his 'The Albumen and Salted Paper Book' in 1979 and it remains the definitive text on the subject, now available in full online (see box at right.) The same year also saw publication of 'The Keepers of Light' by William Crawford, which although not containing a detailed practical account of this particular process, created a great deal of interest in the area.
Availability

You cannot buy albumen paper. The Chicago Albumen Works (CAW) was founded in 1976 and supplies (when available) a fine gelatine-chloride printing out paper (POP) made specially for them by Kentmere Photographic Ltd in Kendal, on the edge of the UK's scenic Lake District (fine walking country.) Poor weather (for which the Lake District is famous) often means the paper cannot be made in the relatively short season that production is possible.

Although the CAW makes prints for institutions etc using albumen and other processes, albumen paper does not keep once sensitised, but has to be used within a few hours. The CAW decided that people who were going to sensitise paper would mainly also want to coat paper with albumen themselves. The Centennial Printing Out Paper, mentioned above, although a gelatine paper, gives similar results for those who want an easier to use medium. They even supply it on a resin-coated base for those who want this convenience rather that using the superior fibre base material.
Resources

If you want to try albumen, you will need to make your own. Fortunately there are many good descriptions available online (and brief details later in this feature), with a particularly fine Albumen web site developed by photography conservators Paul Messier and Tim Vitale, which includes a number of reprints of classic works on the process and some fine examples. Of course as with all prints, there is no substitute for seeing the real thing. Many will have examples of albumen prints in family albums, and most photographs from the period 1860-1890 on show in museums and galleries will also be albumen prints.
Properties

Albumen took over from salt printing (see box, top right) because it enabled prints to have a greater tonal depth and scale, as well as (after some initial problems) increased permanence. The first albumen prints differed little if at all from salt prints (many from the 1850s in museum collections are probably wrongly labelled, with good salt prints tending to be identified as albumen prints.) Some later examples of glossy albumen prints have a pearly depth and quality to them that has only been bettered by the best carbon prints.

Part 2: Invention of the Albumen Print

- Albumen in Early Photography

Albumen is simply white of egg, and thus a very common and well-known substance. It is perhaps not surprising that within three months of WHF Talbot's 'Photogenic Drawing' process, the first photography on paper, a person identified only by the initials 'H.L.') wrote to the London magazine 'The Athenaeum' in May 1839 suggesting that the paper used for the process should be coated with a mixture of white of egg and water.

Probably most at the time found this an unnecessary complication in what was already a rather tricky process, although when Robert Hunt published the first general photography textbook in Glasgow in 1841 he included this as a suggestion. There appears to be no record that it was ever widely used. H.L. had put forward albumen as an alternative to the use of a salt (sodium chloride) solution, which most found to give rather better results.

- Albumen Negatives

Experimenters turned again to albumen in the search for better negatives. The major problem with the calotype process was the paper support, and it was obvious to all that glass would be a preferable support. The problem was in getting the light sensitive salts to stick to glass. Those of us who have washed dishes know that egg is particularly difficult to remove from plates and cutlery, and an obvious choice for sticking anything to glass.

Niepce de St Victor, nephew of Nicephore Niepce who had produced the earliest known photographs, made successful experiments using albumen-coated plates in 1847, publishing his results the following year. Another French photographer, Louis-Désiré Blanquart-Evrard, announced his similar work at the same time. However this process never became popular, although Hippolyte Bayard used it in his work for the government sponsored 1851 'Mission héliographique' (see more on this in the feature 'Great French Calotypes', box at top right.)

Part of the reason negative albumen never caught on was the slow speed of the plates, but also WHF Talbot held patents that covered it and restricted its use. Probably more importantly, preparing the plates was a slow and messy business. With the invention of the much more rapid wet plate process in 1851 (see 'Wet Plate / Collodion', box at top right) it became largely a historical curiosity.

-Albumen Paper

Blanquart-Evrard's more important contribution to photographer was the application of albumen to the problem of making prints on paper. He found that by using albumen he could make prints that had greater depth and contrast than the old salted paper. He disclosed his results to the French Academy of Sciences in May 1850, and other photographers soon rushed to try out the invention. Other photographers had also been working with albumen, including another fine French photographer, Gustave Le Gray.

-Albumen coating

The procedure used by these early albumen printers was a simple one. They took egg white, added around one fifth of its volume of a saturated solution of sodium chloride (salt) or ammonium chloride, and whisked it to a froth, as if preparing meringue mix. Unless they wanted gloss prints, some water was added to the egg before whisking. After leaving overnight, the froth settled out to a clear liquid, which was carefully decanted off into a dish. Paper was then carefully laid on top of the liquid in the dish, left for a minute or two and then hung up to dry. Once dry it could be ironed to make it flat. The paper could then be kept until required for use.

-Sensitising

The paper was then again floated on a bath, this time containing a 25% solution (by weight) of silver nitrate. After 5 minutes or so it was hung to dry, and used more or less immediately. It was exposed and processed in exactly the same way as plain salted paper (see Salted Paper Prints - box, top right.)

The albumen acts to seal the paper fibres and sets as a coating on the top of the paper. The salts in it are held in this layer, and so the image is held on top of the paper rather than sinking into the fibres as it tends to with salted paper. This gives a greater intensity to the image, and also greater sharpness. In a good albumen print the shadows show a greater transparency.

Part 3: Improvements in Albumen Prints

-Paper Choice

Although there was some initial resistance by photographers to the new medium, by the end of the 1850s most had gone over completely to albumen paper.

The best papers for the process were found to be thin, smooth, high quality papers and these could only be produced at mills with good water supplies. The paper also affected the colour of the final prints, with those made on the English Whatman paper being a red-purple colour, while paper from Blanchet Frères et Kléber at Rives in France being more neutral. Rives paper soon became one of the most used, along with paper from the Belgian mill of Steinbach, whose paper was generally known as Saxe.

-A New Industry

The first factory made albumen paper appeared in 1854 in Germany, and Dresden later became the world centre for its production. Although there were factories in other countries including the USA, most photographers preferred the German product.
Albumen was found to give greater glossiness and depth if left for some days before use. As it goes off, it becomes more acidic, more homogeneous and also less viscous, as well as extremely malodorous. The Dresden factories accelerated the fermentation by increasing the temperature and adding a bacterial culture. In his book, Reilly calculates that one of the two large factories was using six million eggs a year to coat its paper. The atmosphere around as these rotted must have been extremely unpleasant. Yolks for sale

Only the white of egg is used as albumen, leaving the problem of what to do with the millions of yolks. One of the more useful recipes Reilly quotes in his 'Albumen & Salted Paper Book' is from the British Journal of Photography of 1861, which gives a really excellent lemon cheesecake. It is delicious and probably the best reason of all to try albumen printing.

The large manufacturers needed to find customers who baked on an industrial scale or had other uses for egg yolks. The success of the Dresden manufacturers probably depended as much on this as on the cheap labour and eggs in their area. Labour was important, as although the albumen was beaten in steam driven churns, all of the remaining steps of the process were carried out by hand, although the sheets were fed into a calendaring machine rather than a hand iron to smooth them. The women (and it was mainly women, their labour being cheaper) who worked in these factories must have had strong stomachs.

-Double Coating

The second significant development that improved albumen paper was the introduction of double coating. This was used both to even out the coating, which always flowed a little during drying, and also to build up a thicker albumen layer, giving extra brilliance and depth. Double-coated paper also produced a higher gloss finish.

Simply coating the paper a second time in the albumen doesn't work, as the first coat dissolves. The first coating needs to be hardened. This was usually done commercially simply by keeping it in a warm store for six months, but for the more impatient, this natural hardening could be accelerated using a jet of steam. A more practical method is to use an alcohol bath. This is usually 70% isopropyl alcohol (propan-2-ol) and 30% water, and should contain the same proportion of dissolved chlorides as used in the albumen. The paper is soaked for about 15 seconds in this bath, then hung to dry. The sheets tend to curl when dry and should be flattened under a weight.

The second albumen coating was made by floating the paper on the same bath as the first for a couple of minutes. When hung to dry it was hung the opposite way up to help even out the coating.

-Fuming with ammonia

Most American albumen printers seemed to have fumed the paper using ammonia after sensitising, while this seems seldom if ever to have been done in Europe. There seems to be no difference in the quality of the prints. Reilly suggests in his 'Albumen & Salted Paper Book' that fuming may have been necessary where weaker silver baths were used.

Part 4: Practical Tips on Making Albumen Prints

Trays

It is hard to make albumen paper in very small batches, but you can keep the unsensitised paper for some time (longer if you add citric acid as a preservative.) You will need at least one (preferably two) tray for floating the paper. Flat bottomed square or rectangular pyrex baking trays or similar should be used rather than photographic trays which have ribs or grooves making them unsuitable. The Pyrex 3-qt dish is roughly 13 x 9", the 2 qt around 11x7" and they also make an 8" square dish, fine if you intend to print from 4x5" negs. You need a tray with a flat bottom at least half an inch in each dimension wider than your paper. Get trays specially for photographic use rather than borrow them from the kitchen. Pyrex dishes are cheaper than porcelain and better because they allow you to examine the underside of the paper while it is floating, so you can see air bubbles.

Papers

Choose a light weight, smooth surfaced high quality rag paper, such as a one ply Strathmore 500 drawing paper, Cranes (Kid Finish 32#, Platinotype or Parchment Wove 44#) or Arches (Platinotype). Cut the paper into suitable sized sheets to fit your negatives (and the trays.) Albumen printers often used to coat very large sheets and cut them up for use, but you will find it easier to start with pieces roughly an inch or so larger each way than your negatives.

Eggs

A suitable starting amount is a dozen large eggs, though you may need a few more to get 500ml unless they are large. Free range eggs make me feel better, and the fresher the better. Others report finding no differences in the results.

Lighting

You can work in normal electric light, for preparing and working with the paper. You need to avoid sunlight and fluorescent lighting when sensitising and processing, but you do not need to use a safelight to use albumen paper normally.

Outline:

1. Separate the eggs and prepare the albumen: Break the eggs singly into an egg separator and retain the yolk and any stringy bits while tipping the whites into a measuring jug until you have 500ml (you can scale down the amounts if you have less.) Don't let any yolk get mixed in - keep any eggs where you break the yolk separately to use in cooking. Make the lemon curd pie with the yolks. Superb.
2. Add (per 500mls egg white - scale to the amount you have)2ml 28% acetic acid
    15ml distilled water
    15g ammonium chloride
    2 drops PhotoFlo or other wetting agent.
    2ml 28% acetic acid
    15ml distilled water
    15g ammonium chloride
    2 drops PhotoFlo or other wetting agent.
3. Stir in a bowl with an electric mixer for a couple of minutes until you just have froth, cover with a plate or cling film, leave in fridge overnight, then remove the froth and pour the clear liquid into a jar using several layers of muslin as a filter.)
4. Leave in the fridge for at least a week to age. I've not experimented with letting it ferment at this stage; if you live on your own well away from other homes you might risk it. Make sure it is carefully labelled and their is no chance of anyone mistaking it for anything edible. You

should use a separate fridge that isn't used for food.

5. Pour the albumen into a flat bottomed dish - it should be at least ½ inch deep. Scrape the surface with paper to remove any air bubbles .
6. Mark one long edge of your paper and hold by opposite corners. Carefully lower it and let it go flat on the albumen. Check there are no air bubbles under it (with thin paper you can see them through the back as white patches. Don't let it curl up from the albumen. Leave it there for around 2 minutes, then lift carefully by one corner and allow to drain. Avoid getting any albumen on the back of the paper.
7. Hang to dry on a line using pegs at the corners of the marked edge, qnd continue floating the other sheets you have ready. You will need to remove excess albumen from the bottom edge as the paper dries. If you want the paper to have a sheen use warm air and avoid high humidity when drying.
8. *For double coating only*, prepare a hardening bath containing 210ml isopropyl alcohol, 90ml distilled water and 15g ammonium chloride. When the paper is dry, immerse it in this bath for around 30 seconds, then drain off and hang to dry.
9. *For double coating only*, as soon as the alcohol has evaporated you can float the paper on the albumen bath exactly as in step 6. When you hang it to dry, make sure to hang by the unmarked long side.
10. Float the paper on a silver bath containing 30g silver nitrate in 250ml water, with a little citric acid (10-15g.) Citric acid improves contrast and gives cleaner highlights. The silver concentration can be from around 10-15%. Wear thin rubber gloves and safety glasses, as silver nitrate is toxic and stains any organic material it contacts. Four hands are needed to hold down the corners with large sheets. Check there are no air bubbles and float for 3 minutes before you drain and hang. Put newspaper under the line to catch any drips. Alternatively you can measure out solution to cover the paper into a small container with a dropper - use one drop for every two square inches plus five drops - and spread it with a metal-free brush or a small piece of foam rubber or similar. Some people recommend a glass rod or spreader. If you use a bath you will need to filter or decant off the solid that forms occasionally, and also add silver nitrate to retain the concentration.
11. Print the paper by contact using sunlight or a UV light source as soon as the paper is dry. If you don't have a printing frame, tape the negative to the paper along one edge using crystal clear tape to provide a hinge and cover with plate glass. Your negative must be very contrasty - try increasing your normal developing times by 50-100%. You will need to reduce exposure slightly to retain clear highlights - perhaps rating film ½ to 1 stop faster.
12. Expose until you have good highlight detail - you normally lose a little in processing. If your negative isn't contrasty enough the shadows will have filled up, but this is better than empty highlights.
13. Rinse your print in two or three small portions of distilled water. There will be a lot of silver in this rinse so dispose it carefully or recycle. Then wash for ten minutes in tap water until there is no cloudiness in the wash.
14. If you can afford it, tone in a borax, sodium acetate or thiocyanate gold toner by inspection, then rinse in water. There are suitable toners in the Reilly book on page 80-81. Only the sodium acetate bath keeps.
15. Fix in 20% plain hypo fixer (200g per litre) for 5 minutes, then optionally 3 minutes in Kodak Hypo Clearing Agent (KHCA.)
16. Wash for at least an hour. You can cut down wash time to 30 minutes and probably increase permanence if you used KHCA. Squeegee gently with a damp chamois and hang to dry.
17. Uncurl the print, place it under a large pile of books for a couple of days. Traditionally, prints were mounted while still damp; if you want to do this, use a starch paste and a good quality unbuffered mounting board. Modern practice keeps prints unmounted - store them in polyester sleeves with a sheet of unbuffered mount board or similar for protection, and mount in a normal hinged overmat for exhibition or framing.

Resources

There are several good descriptions of the process on the web, some with helpful illustrations if you need them. Don't worry about minor differences in procedures, they are likely to make little difference to the results. You can watch online or download a series of video clips of Doug Munson at the Chicago Albumen Works showing the steps in producing and sensitising the paper.

Part 5: Fading and Yellowing in Albumen Prints

Causes of Fading

The fading of prints was one of the key problems of early photography, with the Photographic Society of London setting up a committee on the subject in 1855. Surprisingly it came up with some highly pertinent recommendations, recommending the thorough washing of prints and gold toning. Two French investigators, Alphonse Davanne and Jules Girard, carried out detailed and exhaustive scientific investigation of the process, and their study, published the same year, emphasized the importance of using fresh hype (sodium thiosulphate) fixer.

Albumen prints brought fresh problems. Their thicker coatings were relatively impermeable and washing out of the chemicals - particularly the sulphur containing hypo - required longer times. One of the favourite methods used in the early years for gold toning - the sel d'or (gold salt) method - which mixed an acidic gold solution with the fixer, often resulted in decomposition of some of the fixer to produce sulphur which could not be washed out and was a major cause of print fading.

Separate Gold Toning

A move to separate toning in alkaline gold solutions (first introduced by James Waterhouse around 1855) before fixing in fresh hypo produced significantly more stable prints. The kind of rapid fading that had often been a problem with the earlier salt prints and albumen prints largely became a thing of the past. Alkali gold toners deposited more gold, helping to protect the image.

Yellowing of Highlights

Over the longer term another problem emerged with albumen papers. Their highlights began to turn yellow or light brown. Davanne and Girard again investigated, and reported in 1859 that the non-image areas of albumen prints still contained silver compounds. Later experiments showed that roughly 5% of the silver was retained in combination with the albumen as the so-called 'silver albumenate'. This could not be removed by hypo, although it was taken out by potassium cyanide. Cyanide unfortunately also removed too much of the image silver for its use to be practical in this process (although despite being a deadly poison it was often used for collodion positives.)

The yellowing of highlight areas occurs as the silver albumenate slowly breaks down to give silver, which then reacts with sulphur compounds in albumen to give brown silver sulphide. There is no known solution to reverse the effects of this fading. The presence of the silver albumenate in the print also prevents the successful use of 'bleach and redevelopment' techniques which can occasionally be of use in restoring other faded silver prints.

All nineteenth century albumen prints show some evidence of yellowing, although in a few cases it is relatively slight and only noticeable if the print is compared to a white paper surface. The rate of yellowing is less if the prints are stored under low humidity (30-40%) and in pH neutral or even slightly acid conditions - buffered storage materials should be avoided as these are mildly alkaline.

Cracking

All albumen prints show a cracking or crazing, although you may need to use a magnifying glass to see it on some prints. Albumen swells greatly when wet, and shrinks when dry, and this happens in normal processing. As it swells, it also cracks, lacking the elasticity to prevent this occurring. These cracks often become more apparent with age, presumably because the albumen will swell when humidity is high and shrink when it lowers.

Part 6: Recognising Albumen Prints

Staining

The first stage in recognition of an old photographic print is to determine whether it is a silver print at all. Any print that has no staining, fading, spotting or yellowing of highlights is unlikely to be a silver process from the nineteenth century. It may well be a Woodburytype or carbon print, although there are other possibilities.

Print colour

Albumen prints and salted paper prints are generally a warm brown colour, though they may also be a purplish black or brown. Very rarely they may be close to neutral black. The colour depended on the paper, the salts used in the albumen coating and the toning method used.

Highlight areas and print borders (if any) will show some yellow or brown stains in all albumen prints. Such stains are not however uncommon in other types of prints.

Texture

Early albumen prints have a matt finish, similar to that of salted paper prints. From the 1860s on, albumen prints are likely to be glossy, with those from around 1870-1890 mainly printed on double coated albumen paper giving a very glossy finish. Gelatin and collodio-chloride prints may also have a high gloss.

In the 1890s, there was a trend by artistic photographers away from glossy papers to matt surfaces. Largely this was to emphasize their difference from the commercial studio photographers. As well as resulting in a revival of the use of plain salted papers, photographers, particularly those inspired by Baron Arthur von Hübl's 1896 book 'Der Silberdruck auf Salzpapier' began to use matte-albumen papers. These were available commercially in Germany and Europe from around 1898 until the late 1920s.

Cracking

All albumen prints show evidence of cracking, although you may need a magnifier to see it in some cases. The cracks are caused by the material swelling when it absorbs moisture and are inherent in the process. There are some nice electron microscope (SEM) images of the effect in a 1993 paper by Paul Messier and Timothy Vitale (see box, top right), which showed that conservation treatments using water increased the cracking. However, similar effects can sometimes be observed in other types of image.

Date

The date of a photograph is often important in establishing what process was used to make it. Dates may be recorded on photographs (although they are not always correct.) Where the identities of any people are known, their apparent ages in the picture may provide a rough date. There may be other evidence available - such as marriage certificates - that allow some pictures to be precisely dated.

Experts can also often date photographs by clothing, although such evidence is not always reliable. People may dress up for pictures in clothing that is long out of fashion, either deliberately or because it is all they have.

Evidence in the photograph - such as advertisements, newspaper posters or buildings of known age can also be useful in dating photographs. Captions should always be read carefully and it is wise not to jump to conclusions. At least one modern exhibition and book refers to an image by an unknown Victorian photographer called 'Virginia Waters', active in the 1860s, photographing in Windsor Forest. She is still there, water flowing out from her lake and cascading down her artificial waterfall on which I spent happy hours climbing as a child (see box, top right.)

Commercial portraits and other photographs - most likely processes for paper prints:

- 1840 -1855: salted paper
- 1860-1895: albumen
- 1900-1920: gelatine or collodio-chloride papers
- 1920-2000: gelatine papers

In the period 1855-1860, both salted paper and albumen were widely used. In the 1890s there were a wide range of materials in use. By 1900, albumen had more or less disappeared (although glossy albumen papers could be bought until 1926)

Books

For prints produced by the more artistic studios, and also artists and serious amateur photographers, a wide range of processes were used from the 1890s to 1920s, including platinum and carbon prints as well as less common processes such as gum bichromate. There were also a number of silver-based processes which attempted to produce results indistinguishable from platinum, such as the kallitype, some of which were often platinum toned. You can find more information about identifying old prints on the web (see box, top right.)

The Silver Sunbeam: A Practical and Theoretical Text-Book on Sun Drawing and Photographic Printing, Comprehending all the Wet and Dry Processes aat Present Known,With Collodion, Albumen, Gelatine, Wax, Resin, and Silver
Towler, John. New York, NY, 1864. Reprint edition by Morgan and Morgan, Hastings-on-Hudson, NY, 1969.
Now out of print, but available online at the Albumen site - see link in box at top right.

Coming into Focus: a Step-by-Step Guide to Alternative Photographic Printing Processes
Barnier, John, editor.
Chronicle Books, San Francisco, CA, 2000.
A well illustrated book with information about a range of processes. Includes a familiar name to 'About Photography' readers in the section on salt printing.

Historic Photographic Processes
Farber, Richard.
Allworth Press, New York, NY, 1998.
A book that is often recommended.

The Keepers of Light
William Crawford
Morgan & Morgan, 1979
Gives a good introduction to most of the alternative processes, although it does not give practical details for albumen. May only be available secondhand.

Alternative Photographic Processes, A Working Guide for Image Makers
Webb, Randall and Martin Reed
Silver Pixel Press, Rochester, NY, 2000.
First published in the UK as 'Spirits of Salts', Aurum Press, London, UK, 1999. Randall Webb, Terry King and myself first became interested in alternative processes sitting together in a lecture by an elderly UK photographer who had made gum prints since the 1930s. All three of us have since written about and taught workshops on several of the alternative processes.

True Blue (cyanotype)

Part 1: Blue Prints

Blue is an odd sort of colour, although it always came out top in the kind of surveys I used to get students to make when we were studying colour theory and asked random people to name their favourite colour. We also used word association and other simple questions based around patches of the colour to find how our 'victims' regarded blue, and came up unsurprisingly with associations with coldness, with sky and sea, water and certain football teams.

Blue - as we found in designing our test materials - is also a colour we have many arguments about, and deciding what was a typical blue caused long arguments. It also creates a problem for those teaching about the colours of the rainbow, for while Richard of York may have been clear about green, blue, indigo and violet, most people these days think indigo is blue and have no word for the hue between indigo and green. Those who have studied computer imaging may now recognise it as cyan.

For many years, the cyanotype (also known as ferroprussiate print) remained a favourite medium for producing proof prints from negatives. Among its advantages were its simplicity, the fact that no darkroom was needed and the extremely low cost involved. The most expensive part is almost always the paper, and virtually any paper that does not disintegrate on soaking can be used. Amateurs without a darkroom could print their negatives simply, and there are many examples still in existence in family albums and historical collections, including many made and sent as postcards.

The cyanotype was also a good process for use with young beginners in that the materials involved (in the traditional method) are non-toxic. Many at least in past days were introduced to the magic of photographic printing through blue printing in school science classes and clubs.

This feature will introduce you to more of the history of the process, give a simple explanation of the chemistry behind it and give you clear, straightforward instructions to show how you can make your own blueprints. It will also look at the work of Mike Ware, whose researches have resulted in new methods of working in this and other processes.

Part 2: Blue history

Prussian Blue, the pigment that gives the blue print its colour, had first been produced in 1704 and was soon in wide use as an artist's pigment, and the light sensitive nature of some iron salts was also known in the eighteenth century, but it was Herschel who first combined these ideas into a workable process. It was also Herschel who suggested the name 'cyanotype' for the process, from the Greek words thought to mean 'blue' and 'imprint'.

Herschel also tried a number of other processes, including the gold print or 'chrysotype'. I've never seen Herschel's own results, but the prints I got from similar methods are a little disappointing as you can see. Mike Ware (see Part 4) has produced an improved version of this process using modern chemistry that gives much more controllable results. If you are feeling rich enough you can read the articles he and others have published on the process (some are rather technical) and try it yourself.

More recently, my old friend Terry King of 'Hands On Pictures', with whom I worked on such things in the late 1980s, has revisited and improved on what we started then. I showed that the same ferric oxalate sensitiser, followed by the use of appropriate baths after exposure could be used to produce platinum, platinum/silver (satista) or kallitype prints. Terry has extended this to after-treatment with gold and ferricyanide solutions to produce what he calls the Chrysotype Rex and Cyanotype Rex. Both these improved processes have their advantages, and one is their relative simplicity. However more interesting is perhaps the liberation of the cyanotype from the standard blue, with King producing some finely toned examples. A further advantage is the great increase in speed, with exposures down to less than a minute for some negatives.

Many of us who have used the cyanotype process in recent years have done so using a method that differs little from that suggested by Herschel, although generally using a more light-sensitive variety of the ferric ammonium citrate that was first commercially available around the turn of the century, having been produced by Valenta in 1897. The major photographic texts from the 1920s and 1930s such as 'Photography: Theory and Practice' by L P Clerc contained adequate directions, suggesting that the process was still in common use; (copies can be found cheaply in secondhand book shops.) Like the salted paper print introduced by WHF Talbot some eight years earlier, the process still works in more or less its original form and is relatively convenient. In recent years, a new 'improved' version of the process has been introduced, thanks to the pioneering work of Dr Mike Ware. Both processes still have their uses.

One of the first photographically illustrated books - before Talbot's 'The Pencil of Nature' - was illustrated by cyanotypes. The first part of Anna Atkin's fine 'Photographs of British Algae: Cyanotype Impressions' was produced in 1843, containing what we now call photograms (for the first hundred or so years of photography this word was used more or less interchangeably with photograph) made by placing pressed, dried specimens of seaweeds etc on cyanotype paper.

Further interest in the blueprint - other than as a proofing material - was largely because of its resistance to fading. Most early silver prints were found to be at least partly faded after a few years, and various investigations were made both to reduce the fading of silver prints (particularly with longer wash times) and to look for alternative processes. This was a major impetus behind research into colloid based printing methods such as gum bichromate and carbon printing in the nineteenth century.

One of the great early French photographers, Henri Le Secq, apparently became so concerned about the possible loss of his work through fading that from around 1870 he began reprinting much of his best work as cyanotypes, producing some fine prints that are still in good condition. These works are sometimes given an earlier date, perhaps reflecting the date of making the original negative rather than the print. Although cyanotypes show some short-term fading on exposure to light, with the Prussian blue being converted into a colourless compound, this process is largely reversible (there may be small amount of permanent loss.) Under normal conditions of display and storage, cyanotypes are generally regarded as permanent, but must be protected from alkalis.

The blueprint also allowed photographs to be easily made under difficult conditions, such as the work of Charles Loomis, a photojournalist recording the exploration of the American West, and Henry Bosse's views of the Mississippi in the 1890s. During the Boer War siege of Mafeking, South Africa, in 1900, a local photographer was commissioned by military commander Robert Baden-Powell to produce both bank notes and postage stamps. Although Her Majesty Queen Victoria was doubtless impressed by his resourcefulness, it is less clear whether she was amused by the idea of his head standing in the place of hers on these special issues. Baden-Powell is of course better known for his 'Scouting for Boys' and the worldwide movement this brought into being.

A few of the 'secessionist' photographers around the 1900s made use of the cyanotype, but generally it was seen as a proofing medium, or one for amateurs in photography. (See the 'Stieglitz' link for more on the photo-secession.) Twentieth Century textbooks of photography - if they made mention of it at all - treated it mainly as a process for reproducing drawings or textile printing. It was not until the revival of interest in printing media and non-silver printmaking of the 1960s that the process was revived for creating fine-art prints by photo-artists such as Robert Fichter (famous for his tee shirt that proclaimed 'Edward Weston is dead') that blueprints began to be exhibited in any numbers. Further interest was spurred on by the publication of a number of books dealing with 'alternative' printing processes, of which the most influential was William Crawford's 'The Keepers of Light' (1979), still in bookshops recently, although apparently now only available secondhand.

Crawford's work differed from most in dealing with more than the technical aspects of the work at some depth, as well as in covering a wider range of processes than most with generally workable practical details - unlike some publications. Although looking at the use of cyanotype by Le Secq and others, Crawford also quotes Peter H Emerson's words from his 'Naturalistic Photography for Students of the Art' (1889):
'... no one but a vandal would print a landscape in red, or in cyanotype.'

Part 3: My way

I first made blueprints as a part of science lessons and they were not impressive in terms of quality. It was with Crawford's instructions in hand that I turned to making pictorial cyanotypes in the 1980s, and they worked well. I later found the original source of his formulae and found that he (or more likely an intermediate author) had miscalculated, resulting in the formula being half strength, but the differences this made were small. In such respects cyanotype is a forgiving process.

For around ten years I worked with a variety of historic processes - including salt prints, platinum and platinum palladium, kallitype, gum bichromate, carbon printing, various oil processes and even photogravure. Those working with them tend to prefer the term 'alternative' processes (the bromide print after all dates from around 1873). Of course in their hey-day, processes such as platinum were very much mainstream, relying entirely on factory-produced papers. Most of the great platinum prints were produced on these.

The reasons why cyanotype has never really been taken seriously as a printing process are perhaps complex, but the insistent blue colour (differences in paper and techniques produce different blues, but still blue) is important. Without agreeing entirely with Emerson, a belligerent polemicist who overstated every case, he did have a point. Blue would not be the colour of choice for many subjects. The blue print has also suffered from its association with the low quality commercial copy material and also the ease and simplicity that made it a suitable nursery activity.

Many examples of cyanotype show a limited tonal range, often with distinctly blue highlights. Others lack mid-tones, being a blue equivalent of 'soot and white-wash'. Neither effect represents the character of the medium, although both could at times be used for effect. As in other printing processes, the negative contrast needs to be matched to the process to give correct results, and a cyanotype can then give a tonal range an quality similar to that of a matt silver print, although never quite achieving the same possible maximum density - blue never quite becomes black.

Cyanotype together with most other historic processes also fell out of favour with a trend towards larger prints and smaller negatives in the twentieth century. The older processes were all contact processes, producing an image the same size as the negative, far too slow to make use of an enlarger to produce magnified prints. Typical exposure times in bright sun for a cyanotype range from 10 to 25 minutes.

Commercially the blueprint process became vital for the copying of plans and ready prepared paper could be bought cheaply by the roll. Most of the research into the process was directed towards this use, but the materials produced were not suitable for pictorial use, normally giving poor contrast with blue-stained highlight areas. Today few 'blueprints' - even those with material form - are blue, but up to around 50 years ago it was the only cheap large-scale copy process. In the 19th Century it was also developed for industrial uses such as the printing of cloth.

For copy use, the blueprint was first replaced by methods using diazo chemistry, which was faster and gave clearer images, and later by electrostatic copiers.

Part 4: Cyanotype theory

For a more detailed and authoritative discussion of the chemistry of the process the technically knowledgeable reader is referred to the work of Mike Ware (see box), in particular his book 'Cyanotype'.

Iron forms two series of compounds, ferrous and ferric (more recently known as iron(II) and iron (III) compounds.) The most familiar of ferric materials is rust, a hydrated ferric oxide. Iron tonics and tablets may contain either ferrous compounds such as ferrous sulphate or ferric compounds, including ammonium ferric citrate.

It is possible to convert ferric compounds to ferrous compounds; this requires the addition of electrons to the metal, a process known chemically as 'reduction'. The chemical which loses the electrons to the iron is know as a reducing agent and is 'oxidised' in the process.

It is also possible to oxidise ferrous compounds to ferric, which is generally the more stable of the two states under most normal conditions on earth which has an atmosphere containing oxygen. The relative stability of the two forms also depends on the acidity (pH) of the solution and also the other materials that are attached to the iron atom.

Potassium ferricyanide has the iron with six cyanide radicals around it (which is clearer in a more recent name, potassium hexacyanoferrate(III)). Since these cyanide radicals are firmly held to the metal atom, this compound lacks the poisonous character of soluble cyanides, and the traditional cyanotype is the safest of all photographic processes.

Compounds which contain the same metal in two different states - such as ferrous and ferric ion - can be intensely coloured because of this, and Prussian Blue - which chemically used to be called ferric ferrocyanide - is an example of this, whereas the related ferrous ferrocyanide is white (Prussian White), although it readily oxidises to give Prussian Blue.

Reading earlier accounts of the process is often confusing, not least because some authors mix up their ferro's and their ferri's. You can make Prussian Blue by putting some potassium ferrocyanide solution in a test tube and adding any ferric solution.. You will get a similar blue colour by adding any ferrous compound to a solution of potassium ferricyanide, and though some textbooks may call this 'Turnball's Blue' and say it is ferrous ferricyanide, this is actually ferric ferrocyanide (Prussian Blue) as well. The greater stability of the ferrocyanide compared to the ferricyanide leads to the rapid formation of this, rather than the expected compound.

Prussian Blue is generally not a nice simple compound like sodium chloride, but has a degree of irregular structure and composition, with several major forms. Its structure may include other metal ions such as potassium and may also undergo partial hydrolysis. Preparing it in different ways gives a material with different properties, including different shades of blue and also a different ability to form a dispersion in water.

The essential steps in the cyanotype process are:

- the production of ferrous iron by a photochemically induced reduction of ferric iron;
- the production of Prussian Blue by the reaction of this ferrous iron with the ferricyanide.

Although cyanotypes can be produced using a coating of potassium ferricyanide alone (presumably relying on oxidisable material in the paper or paper coating), this material is very slow and low in contrast, as well as generally producing a greener blue, probably due to the replacement of some cyanide radicals in the blue complex by hydroxyl due to hydrolysis. Herschel's more practical formula added ferric ammonium citrate, which was much more light sensitive, to the ferricyanide.

Names of chemicals often cause a problem not least because of various changes over the years. Ferrous ammonium citrate can also be called ammonium ferrous citrate, ammonium iron(II) citrate and other variations.

For the ferric iron to be reduced to ferrous ion, something else has to get oxidised, and the ferric ammonium citrate contains a suitable material actually complexed to the iron atom in the form of the citrate ion. For this reaction to occur, an energy barrier has to be overcome - or else the citrate would not be a stable compound. The absorption of photons can provide energy, but it needs the higher energy blue or UV radiation to get the reaction to occur.

One complicating feature is that the potassium ferricyanide acts as a rather effective filter for blue and UV light, increasing the exposures needed. Once the complex has enough energy to react, it will rapidly produce a ferrous complex. The ferrous ions which can be released from this will then react with the ferricyanide to give ferric ferrocyanide - Prussian Blue.

In areas that are greatly exposed, a bronzing effect is often seen, with the image becoming lighter. This is probably due to the formation of some Prussian White in these areas, which will be oxidised to Prussian Blue during the processing. Another of Herschel's neologisms was in the use of the word 'solarisation' to describe this effect of lightening with increase in exposure.

Since Prussian Blue is unstable in alkali, it is essential to keep the water used to 'develop' the cyanotype at least slightly acid. As most tap water is slightly alkaline, and you should add a few millilitres of dilute hydrochloric acid (still sold in some hardware stores as 'muriatic acid') to a bucketful to use. Other acids such as nitric acid can also be used, but it is best to avoid oxidisable organic acids such as citric or tartaric acid, which can later break down the image.

Most of my cyanotypes were given an initial wash with distilled water, which also tends to become slightly acidic on storage due to the absorption of atmospheric carbon dioxide. As well as the possibility of hydrolysis of the Prussian Blue, the use of a slightly acidic wash appears to cut down the dispersion of the image.

Prussian White in the image will slowly oxidise in the air to give Prussian Blue, so cyanotypes normally show a distinct intensification over a day or so (mostly by the time they are dry.). You can get the final result more or less immediately by using a hydrogen peroxide bath.

Part 5: Making cyanotypes

NEGATIVE

First you need a large negative - the size you want to make your print. If you have a 4x5" or larger camera you can just go out and take one, but contact prints from smaller formats are rather small. You can produce enlarged negatives by printing direct onto a positive working film, or by making an interpositive and then printing that to give a negative. You can also use an ink jet printer to produce negatives on transparent film, but it is difficult to get sufficient density.

Increasingly, those using alternative printing methods make use of digitally printed negatives. These can be produced commercially using an image-setter for highest quality, but excellent results can be acheived by making prints onto clear plastic sheets - such as the Pictorico film - with normal inkjet printers. However it can be difficult to find film which will give sufficient density.

Traditionally, the cyanotype process - even the faster improved Ware method, are really too slow to use paper negatives. One of the advantages of Terry King's new Cyanotype Rex method is that it's speed should allow the use of paper negatives - either on normal photo paper or inkjet prints. By exposing with the image on the paper in contact with the sensitive surface you can get impressively sharp results, but if you prefer a more diffuse result, simply expose with the back of the negative on the light-sensitive material. However, I cannot give practical details of this method at the moment.

PAPER

Cyanotypes are best made on watercolour papers, which should be high quality, 100% cotton. Use a mould made paper with a 'not' surface rather than the smoother 'hot pressed', and a weight of 150gsm or more. Avoid any papers described as 'buffered'. The best I've used is Fabriano Artistico, but others have their own preferences. Experiment to find what you like best. Good art shops will have a range of papers for sale, often by the sheet (usually quite large - perhaps 30x20") and relatively expensive - perhaps around 2 US dollars a sheet, but you can buy much more cheaply in bulk from specialist paper suppliers - so get together with some friends if you can.

EQUIPMENT

You will also need a brush for coating and a couple of preferably brown glass bottles - try a pharmacy for these - to hold around 100ml (4 oz). The best sort of brush is a 'Hake' brush - a Japanese style brush with no metal ferrule, but you can use a watercolour lacquer brush. Choose a brush perhaps an inch wide (or more for large prints) and fairly thin. For very large-scale work try a paint roller or sweeping brush. The only other necessary equipment is a contact printing frame or sheet of glass. If you don't have a proper frame you may need a flat base (wood or another sheet of glass) and a couple of strong rubber bands to hold the glass firmly to the base.

You can use the sun to expose your prints, though if you have a sun lamp of any type this should also work. Serious workers with these processes usually buy or build light sources using special fluorescent tubes or graphics arts lamps - see the web for more details if you decide to do this.

CHEMICALS

The chemicals you need for the traditional method are safe and can be obtained from specialist photographic suppliers as well as standard chemical houses. In the past I've found them even more cheaply at some graphics arts suppliers.

You need:
- Ammonium ferric citrate (green)
- potassium ferricyanide

You can use the brown form of the ammonium ferric citrate if the green is not available. You also should buy some 10% hydrochloric acid or alternative unless your water supply is acidic and some hydrogen peroxide if you want to see your results immediately. Mike Ware recommends adding a wetting agent such as 'Tween 20' but I've got good results without it. It is perhaps less relevant if you coat paper with a brush.

From my local supplier, 100g of the citrate costs the equivalent of around 13 US dollars and 100g of the ferricyanide around 5 US dollars. Buying larger quantities brings the price down, but this will make quite a few prints. The optional chemicals would perhaps add another 10 US dollars to your shopping bill. You can get distilled or purified water from pharmacists, auto supplies stores etc.

PREPARING THE SOLUTIONS

This is very simple and you will save a lot compared to the ready prepared solutions that can be bought. If you want to try out Mike Ware's 'New Cyanotype' it may be easier to buy the solution ready to use, though it is not difficult to make your own.

Make up the following stock solutions using distilled/purified water:

Solution A
- potassium ferricyanide 10g

Dissolve in 100ml water.

Solution B
- ammonium ferric citrate 5g

Dissolve in 20ml water

If you are going to make a lot of prints, make up a larger quantity (25g/100ml) but this solution often goes mouldy. Solution A keeps well. The amounts of chemical are not critical - a rough guess is good enough, but use a balance if you have one.

COATING THE PAPER

Mix together equal amounts of A and B before use in a small dish or beaker - work out roughly how much you will need to coat a day's supply of paper. Allow around 2 ml for an 8x10 print. Cut or tear the sheet of paper into smaller pieces allowing an inch or two margin around your negative size. Mark the position of the corners of the negative on each sheet to define the area that needs to be coated.

Coat the paper away from sunlight in a fairly dimly lit room. Normal domestic tungsten lighting can be used. Use newspaper or a cloth to cover any surfaces than might be stained by stray drops. Dip the brush into the solution and brush it across the image area, working from side to side. Dip the brush in again as necessary - don't let it get dry, but never leave pools of solution on the paper. Once the area has been covered, brush it from top to bottom to ensure even coverage and no gaps. Brushing helps ensure the solution is absorbed into the paper fibres. Leave flat to dry for a few minutes while you complete coating the other sheets. Throw any unused mixed solution away at the end of the day's work.

Peg the sheets on a line in a fairly dark area to dry. If you are in a hurry you can use a warm air flow, don't let it get too hot and keep it as even as possible. Keep the dried sheets in the dark and use within a day or two of coating. Make sure it is thoroughly dry before you use it, or you may damage your negatives.

EXPOSING THE PAPER

Put the emulsion side of the negative next to the coated surface of the paper, then cover the negative with the glass. If you don't have a proper printing frame use clear adhesive tape along one edge of the negative as a hinge to fix it to the paper. Close the frame or use rubber bands to get good contact, and take outdoors (or to your UV light source if you have one.) In sunlight, exposures will normally be between 10-20 minutes, while on dull days or in shade it will take much longer (perhaps around an hour in shade on a sunny day. After 10 minutes, or when the area of coated paper outside the negative is clearly solarised and turning a paler colour, bring the frame out of the strong light, carefully open the frame and peel up a part of the negative to inspect the print area. You need to expose until the darkest shadow areas are just solarised and the highlights are significantly darker that you want. If it isn't ready, put it back and expose more.

DEVELOPING AND FINISHING

Prepare a tray or bowl of water, either using distilled water, or using tap water with 1-2ml of dilute hydrochloric acid (for childrens' workshops etc work without acid for safety). Place the fully exposed print in this face down and agitate gently for a minute or two. You can then transfer the print to another tray and wash in gently flowing water (or occasional changes) for a further 10-20 minutes. Check that there are no traces of yellow in the highlights.

An optional bath for a few seconds in a dilute hydrogen peroxide solution (if you buy a 3% solution, dilute this around 1+10) will show the final print densities, but these will largely develop while it is drying in any case. Follow this peroxide rinse by a short final wash in water. Hang the print on a line to dry.

One advantage of processes on watercolour paper is that it dries flat. You can retouch if needed using blue watercolour pigment and a fine sable brush.

Part 6: Mike Ware

Mike Ware worked for many years in one of the finest university chemistry departments in the world (I left with my first degree to work in the dyestuffs industry around the time he arrived as a lecturer) and is now an Honorary Fellow in Chemistry. He has also spent many years working on updating historical photographic processes in the light of modern advances in chemistry, with perhaps his most spectacular success being his work on the Chrysotype or gold print. He has also developed new methods for platinum printing, an improved iron/silver process he christened the Argyrotype and, of most interest here, an improved cyanotype.

Ware is also the author of the authoritative book on the cyanotype process, 'Cyanotype' which fully lives up to its subtitle 'The history, science and art of photographic printing in Prussian blue.' If there is anything in this feature you want to know more about, this book is probably the place to find it. It is a work that reflects his chemical knowledge, and his lengthy and painstaking research both into the process and into historical sources. When this book first came out a couple of years ago, I was asked if I would review it, but the editor concerned left it on a bus on his way to see me! I received a replacement copy shortly after I'd made the first draft of this feature. Perhaps its only weakness is the complete lack of illustrative material. There are a few places where my approach differs to his, for example in preferring rougher surface papers and brush coating, and most of my own work was done before his methods were fully published. If I were starting again on cyanotype I would read this volume very thoroughly and it should be in every serious photography library. There are other, more practical manuals that perhaps guide the beginner more clearly in the practical aspects.

Opinion among makers of cyanotypes is still divided on the merits of the improved process. Without doubt it gives considerably shorter exposure times. I tried out the new method soon after the first details were made public (I think there are now some minor changes to it). At that time I had worked for some time with the traditional method and had sorted out all of its problems to get the results I wanted. If I had needed a new process, perhaps I would have persisted longer. As with all of the alternative processes, although science has its place, it also has its limitations. There are just so many 'individual' variations in how we prepare and use the process that a scientific approach, although it can give significant insights - cannot really cope.

Were I starting again, I would probably start with the Ware process, and find out how to get it to make the prints I want on the papers that I want to use, rather than the smooth and ultra-pure materials that have a greater appeal for Ware (and are more suitable for scientific experiment.) It has a few minor disadvantages - the materials are toxic, harder to prepare and appear to be more sensitive to paper coatings, but as well as being faster is apparently capable of greater maximum densities.

Practical Collodion

Part 1: Materials for wet plate

> Warning: *This feature is not meant as a practical manual, but to explain the methods used and problems faced by wet plate photographers in the 1850s-1880s. Knowing how the pictures were produced helps to fully appreciate their work.*
>
> *The process involves the use of a number of hazardous chemicals and harmful materials that should only be used with proper ventilation and other precautions. The nature of the process makes it difficult to avoid skin contact or inhalation. Quite a few early photographers are known to have died from affects of photographic materials, and they probably shortened the life of many others.*
>
> *Anyone wanting to carry out this process practically is strongly advised to attend a workshop and to learn safe working practices to reduce the risks. Several of those who run workshops also sell manuals that cover the modern use of the process. So far as I am aware there are no detailed modern instructions on the web.*
>
> *The instructions and formulae in this feature are given for information only and come from contemporary texts published while the process was still in common use, several of which are available as full texts on the internet, as well as other sources from the early twentieth century, when the process was still in use in commercial photography and graphics arts studios.*

Materials for wet plate

Collodion

In the early days of photography, many photographers prepared their own pyroxylin, and even made their own diethyl ether. You can read the stories of the explosions that wrecked darkrooms, laboratories and houses and injured or killed photographers and chemists in the magazines and newspapers of the time. You are strongly advised to buy collodion rather than attempt to make your own should you attempt the process.

Dissolving pyroxylin in a mixture of alcohol and ether produces collodion. The alcohol needed to be water-free absolute ethanol or industrial methylated spirits. In some countries you may need a special licence to buy this, or have to pay excessive duty on it. Ether is very volatile, and the heavy vapour from it can easily build up on the floor or worktop and then be ignited by any hot surface. The vapour is also an anaesthetic and can also knock you out.

At the height of the wet plate era there were a number of suppliers of photographic quality collodion, but it is harder to find now. It is still listed in at least one major chemical catalogue, but there are several products listed as collodion in alcohol/ether and it is unclear which if any might be suitable for photographic use. Specialist photographic suppliers such as Artcraft and Bostick & Sullivan (see box at top right) supply ready-made photographic collodion.

Virtually every user of the process who made collodion seems to have had a marginally different formula for it. A typical preparation contained:

Pyroxylin	5 g
Ether (ethoxyethane, diethyl ether)	70ml
Alcohol (absolute ethanol)	120 ml

Often the pyroxylin was mixed with around half of the alcohol to dissolve, and then the rest of the alcohol and ether was added

In hot weather more alcohol was used to slow down the evaporation. Generally this mixture was placed in a full bottle and left in a cool dark place for at least one to two weeks before use. It would keep for some time, perhaps a year or more.

Iodiser

Most of the classic iodiser formulae use cadmium compounds, now known to be highly hazardous. Many photographic papers have had to be reformulated to meet regulations that prohibit any cadmium in effluents in some countries. These materials are still listed in chemicals catalogues. Other materials used in some formulae - such as lithium iodide - may also be hard for individuals to obtain, although large chemical suppliers list them.

Again, there were many recommended mixtures of bromides and iodides. One of the simplest used only cadmium iodide and ammonium bromide:

Alcohol (absolute ethanol)	100 g
Cadmium iodide	10 g
Ammonium bromide	5 g

The chemicals were mixed and shaken at intervals until the salts dissolved. It was kept in the dark in well stoppered glass bottles.

The iodised collodion for coating the plates was mixed from one part of the iodiser to ten parts of the plain collodion. It needed to be left for two or three days after mixing before use, and remained usable for several months if kept sealed in a cool dark place. During the wet plate era many photographers bought commercially prepared iodised collodion, which gave more consistent results than making their own.

Simple wide mouth bottles could be used for collodion, although there used to be special "cometless" collodion bottles available to avoid the problem of the collodion drying out on the mouth of the bottle. With other bottles, any dried up material must be carefully removed before coating a plate to prevent them being carried onto the new plate, producing defects in it.

Outline of Wet Collodion Process

An outline of the process was included in the first part of this feature (see box at top right, and is repeated here for convenience:

1. Collodion is mixed with an iodiser, which contains bromides and iodides dissolved in alcohol.
2. A glass plate is carefully cleaned and either edged with rubber solution or coated with an albumen substratum layer
3. A pool of the mixed collodion is poured onto the plate, which is tilted to spread it evenly, and excess is poured off.
4. When some ether and alcohol has evaporated and the surface is tacky, the plate is put into a solution of silver nitrate in water for 2-3 minutes. This stage produces light-sensitive silver halides.
5. The plate is drained and quickly put into the plate holder
6. The exposure must be made before the plate dries out (about 10 minutes.) Exposure times in good light were typically around 1 -10 seconds at f11
7. Developer solution (usually acidified ferrous sulphate or pyrogallol) was poured onto the plate and tilted to cover it evenly and kept moving until development was complete - usually several minutes
8. The plate was briefly rinsed with water
9. It was fixed using a bath of potassium cyanide (poisonous) or sodium hyposulphite
10. It was washed for a couple of minutes (longer if hypo was used)
11. Often plates were intensified, most commonly using a mixture of developer and silver nitrate, although lead or mercury intensifiers were also used.
12. Plates were then dried
13. The plate was heated gently over a spirit burner and a varnish was then poured onto the collodion and flowed across to give an even coat. When this had set the plate was ready for printing.

Part 2: Coating the wet plate

Cleaning the glass

The glass used for plates is ordinary window glass, carefully cut to the correct size. Very thin glass was harder to handle. Photographers - particularly those who cut their own glass from larger sheets - were advised to check that the glass fitted the plate holder for their camera as an essential first step.

The glass needs to be clean and absolutely dust free. Glass was cleaned by immersion for an hour or more in a strong nitric acid solution or by an alkaline solution such as potassium carbonate or other glass cleaning solution. It was then be fully rinsed and dried in a rack.

The edges of the glass were rubbed with a file or a carborundum stick, which removed any sharp edges that could cut the hands of the photographer. It was also found that this improved the adhesion of the collodion to the glass, which otherwise tended to peel from the edges. An alternative method to prevent this was to wipe the edges of the glass with some rubber solution - this was done just before coating.

Polishing the glass

The glass plate was then polished, usually using either 'rottenstone' or 'powdered tripoli' with alcohol. The plates were held in a special clamp to make this easier and avoid any finger marks. Rottenstone is like pumice, but finer. Tripoli is a mineral found in Seneca, Mo., and used in most metal polishes.

When the alcohol had all evaporated, the remaining dust was removed with a soft cloth and the polishing completed with a clean chamois leather. It was vital that the surface be dust-free before coating. The edges could be coated with rubber solution at this point by dragging a piece of cotton wool with a few drops of the solution on it around all four edges. Sometimes the plate was coated with a thin albumen layer before the collodion coating. Albumen (made from egg white) adheres better to glass and similar materials, as anyone with experience of washing up dishes will know.

Coating with collodion

The plate was held firmly by one corner between finger and thumb. Collodion was poured on at a neighbouring corner in sufficient quantity, and the plate tilted so that it is entirely covered before pouring the excess back into the bottle from the opposite corner. It was important to keep rocking the plate during this process and after so as to get an even layer. This was a skill that took considerable practice to master - and some photographers never quite managed to get perfect results.

The plate was kept moving while the ridges that were originally formed evened out, and the layer was then tested in a corner using a finger until it no longer yielded under a slight touch. This was the sign that it was ready to go in the sensitising bath. It took perhaps 20 seconds for the plate to reach this stage in summer, but several times as long in a cold darkroom in winter. Adding alcohol increased the time before it became tacky.

Sensitising the plate

The following steps need to be done in the darkroom with a suitable safelight. A darkroom could be created by pasting brown paper over the window of a room, producing a suitable dim light. The plates were only sensitive to blue light, and any yellow safelight was suitable. If you should try the process, suitable protective clothing including gloves and glasses are recommended, and clothing should be protected by a suitable overall for this and other processing stages of the process, as silver nitrate produces staine on fabrics that can seldom be removed.

The plate was lowered into a bath of silver nitrate, using a suitable holder, making sure that the whole surface was completely covered in a single movement. It needed to be kept in the silver bath for 2-4 minutes, until it had an even creamy appearance.

The silver bath used contained roughly 9 grams of silver nitrate for each 100 ml of solution, and was made using distilled water with roughly 1 drops of pure nitric acid added per 200 ml. The bath was filtered occasionally and replenished by adding silver nitrate to keep it to this strength as it was used up.

The plate was then lifted out and excess solution allowed to drain back into the silver bath. The glass on the back of the print was wiped before the plate was put into the plate-holder to prevent transferring more silver nitrate solution. The vintage camera I borrowed to try this process some years ago was designed to catch drips when the plate was in the camera. Wet plate tends to be a messy process.

Equipment and Transport

You can make most of the equipment needed for the wet plate process or adapt modern equipment. There is at least one specialist, the Star Camera Company, that makes fine replicas of old wet plate cameras, as well as simpler but practical designs. They can also supply all the other equipment needed by the well turned out wet plate photographer. If you want to attempt location photography you will have a lot to carry with you. Early photographers used heavy backpacks, barrows, carts and even caravans to take their chemicals and darkrooms around with them, and you will need to follow their example.

Part 3: Exposure and Development

Exposing the plate

The plate had to be exposed before it dried out, giving typically a maximum of 5-10 minutes to make the exposure. The subject had to be set up and ready before coating the plate - it was useful in studios in particular to have an assistant to carry this out while the photographer attended to the client.

If you want to use this process with a camera designed for sheet film, you will need to make a special back to hold the glass plate, which is thicker than a sheet of film, and also check that the focussing will be correct when using the plate back. You can buy specially made plate cameras, including some fine replicas of old cameras, and also wet-plate backs to fit modern large-format camera designs.

Exposure times

Exposure is a matter of experience, and depends on the composition of the collodion and iodiser, as well as its state and age. W H F Talbot wrote in a letter than his camera operator had achieved good results with 5 seconds and some even at 1 second, but failed to state the aperture was in use. We can assume he was referring to exposures on bright sunny days.

Although large format cameras then in use would often have been fitted with lenses of relatively wide aperture (perhaps f4 to f8) they would normally have been used with a metal plate with a circular aperture (a stop) to reduce the apertures (in modern terms) to perhaps f11 or f16 to give reasonable depth of field - except for some portraits where speed was more essential.

Wet plates enabled photographers to show such effects as waves on the sea, suggesting exposures of fractions of a second were possible. However more commonly times of around 5 to 20 seconds appear to have been used. Although slow by modern standards, these exposures were considerably faster - at least 60 times faster - than calotype or daguerreotype where similar conditions would have required exposures of a minute or more.

Other sources suggest that using a portrait lens with a 'moderate aperture' will give good results in the shade on a sunny day with an exposure of six or seven seconds. Landscape lenses had smaller apertures and exposures for them (again with a moderate stop) usually were of a minute or two.

Since the photographer was able to see the results almost immediately, any wrongly exposed results could immediately be discarded (the glass would be cleaned off later so it could be reused) and a fresh plate prepared and exposed.

Development

The dark slide would be put back into the plate holder, which was then removed from the camera and taken back to the darkroom. The plate would then be held over a tray and a suitable volume of developer poured onto it. The plate would be tilted and kept moving until to ensure even coverage.

Usually the developer was poured off into a glass, then poured back onto the plate a number of times. Development was controlled by inspection, as a fairly bright safelight could be used. A useful modern accessory is a special plate holder that holds the plate and has a lip round it to retain the developer.

Generally the image would appear rapidly, perhaps in around 10 seconds, and development would be continued until there was no further increase in density - perhaps two minutes. Development in a tray was less effective as the process depended on the excess silver nitrate that was still present on the plate. Fresh developer was used for each plate.

Developer Formulae

Developers used for collodion were acidic solutions rather than the alkaline developers we use for films and papers. The most common were ferrous sulphate solution, acidified with either dilute sulphuric acid or dilute acetic acid, and the organic developer pyrogallol (also called pyrogallic acid, chemically known as 1,2,3-trihydroxybenzene), also used in acidic solution. Ferrous sulphate had been first been suggested as a developer for calotypes by Robert Hunt in 1844.

A typical formula for a pyrogallol developer would use a stock solution as follows:

Pyrogallic acid	2.5 g
Glacial acetic acid	100 ml

This would be diluted 1+ 6 with water for use and gave good results for negatives.

An iron sulphate developer was often preferred for positives, a typical formula being:

Iron (II) sulphate (ferrous sulphate)	30 g
Glacial acetic acid	30 ml
Water	500 ml

In fact many photographers made use of both developers, as iron-developed negatives were often intensified after fixing (see details in the next section of the feature) using a pyrogallol and silver nitrate solution. Iron developer was rapid to use, but tended to give overall fogging or veiling of the negative. Various restrainers, including gelatine and sugar were found to improve this.

Part 4: Further Processing

Fixing

When development had reached the required density, (it could be seen clearly under the yellow safelight) it was stopped by washing the plate for a few seconds under the tap. Fixer was then poured on in the same manner as developer. The best fixer was potassium cyanide, introduced by Martin and Marc Antoine Augustin Gaudin in 1853. This was generally kept as a saturated solution and diluted with two parts of water for use. Cyanide was faster in use and produced cleaner results than sodium thiosulphate (hypo.)

Unfortunately potassium cyanide is extremely poisonous, and resulted in a number of unfortunate deaths in the darkroom, although these were often (if not always) caused by photographers drinking it in mistake for a glass of some other liquid. Sobriety in the darkroom has much to recommend it.

Cyanides in contact with strong acid release deadly hydrogen cyanide gas, and great care needs to be taken over their use and disposal. Despite the dangers, most commercial photographers and plate-makers used cyanide, and treated with proper respect there were few casualties.

Sodium thiosulphate takes longer to fix the image, and also requires roughly twice the washing time after fixing - about five minutes rather than the one or two for cyanide. It was generally used as a plain 20% solution in water.

Intensification

If the negative was not dense enough, it was possible to intensify it using lead or mercury intensifier, both of which added their own hazards to the darkroom. Development often had to be stopped early as the plates tend to fog if it is continued too long. As mentioned before, it was also common to intensify by redevelopment using a mixture of developer and silver nitrate, when further physical development occurred, adding silver to the image.

Some photography textbooks from the period urged that it was better to take the picture again rather than try to rescue it by intensification, strongly suggesting that intensification was very common. If the highlights were veiled by fog, it was also possible to reduce them using a suitable reducer, such as an iodine/cyanide formula.

Drying and Retouching

If required quickly, the glass plates were dried by gentle warming over a spirit lamp, keeping them in motion so as to avoid the glass cracking. Otherwise they could be left to dry in a rack, preferably angled with the image on the lower side so that dust did not collect on them. A final heat drying might still be required to remove all cloudiness from the collodion.

If there were defects on the negative, they could be retouched when dry. This was obviously more important where the collodion negative was to be used as a direct positive 'ambrotype'. These could also be hand coloured at this stage. When the negative was to be printed, it was often easier to retouch the print.

Varnishing

The collodion image was relative delicate and could be damaged by contact with paper while printing. The negatives were varnished to give a tougher finish, and this also increased their clarity. Various varnishes were used, containing materials such as yellow amber, lac, and gum sandarac. These were either dissolved in volatile solvents such as chloroform and ether and applied to the cold plate, or used in alcohol, when the plate and varnish would be warmed to around 40 ºC both to speed the hardening and also to increase the transparency of the coating.

Positive calotypes (ambrotypes etc) were sometimes made on a tinted purple glass. More often they were made on clear glass and a black varnish applied to the back. After this had dried they would then be mounted and put in a suitable case. Some of the early cases are similar to those used for daguerreotypes, and sometimes these images are mistaken for them, although the difference is almost always clear to those familiar with the images. Positive wet plates, whether 'ambrotypes', tintypes or ferrotypes, do not have the mirror effect of a daguerreotype, and can be viewed from any angle.

Printing

Immediately following its introduction, prints from albumen negatives were mainly made using the salted paper process. The albumen process came into general use at the end of the 1850s, and most wet plate prints were printed using this. A further feature will deal with the albumen process.

Dry Plate Revolution

Part 1: Genesis

The Biggest Change in Photography

Forget film to digital. The change that really stood photography on its head, changing the whole course of photography, the most important development in the history of the medium came on September 8, 1871, when Dr Richard Leach Maddox wrote an account of his experiments with gelatine in the 'British Journal of Photography.'

Earlier Experiments

Maddox was not the first to work on similar lines, and others at the time were perhaps on similar lines, including J Burgess, Richard Kennett and Frederick Charles Luther Wratten (1840-1926). Gelatine was the key to the development of a workable dry plate process, something that had been the grail of photographers since the 1840s. Many had experimented with a wide range of materials, mainly apparently drawn from the kitchen, including honey, beer, liquorice, ginger wine and raspberry jam (jelly to some.) Reading these conjures up pictures of landscape photographers fleeing across the fields with swarms of wasps and bees in painful close support, but the reasons for their failure was more prosaic - they were generally unreliable and needed very long exposures.

Collodion Dry Plates

There had been usable dry plate processes, but they were generally painfully slow compared to wet collodion. Some even involved gelatin, which had been suggested by Robert Bingham (1824-70), a chemical assistant at the London Institution in Finsbury Circus in 1850. In 1856, Dr Richard Hill Norris in Birmingham, England, patented a process for coating collodion plates with gelatine to keep them usable for up to six months and set up the 'Patent Dry Collodion Plate Company' (apparently also known as the 'Birmingham Dry Collodion Plate Company') to market them.

Aerial Photography

Hill supplied plates to James Glaisher, later president of the Photographic Society of Great Britain, in 1862 for his attempt to photograph from a balloon. Glaisher was quoted by the Photographic News as saying "I here tried to take a view with the camera, but we were rising too quickly and revolving too rapidly for me to do so; the flood of light, however, was so great that all I should have needed would have been a momentary exposure as Dr. Hill Norris had kindly furnished me with extremely sensitive dry collodion plates for the purpose." By this time, Norris had produced his 'Extra Quick Dry Plates', which he claimed to be as fast as wet collodion.

A second attempt, also described in the 'Aerial Photography' issue of the 'Photo-Miniature' of July 1903 (now available on line), to use similar plates from a balloon the following year also failed, but this does appear to suggest that dry collodion processes were more advanced than most sources suggest. Previously in 1861, Professor Samuel A King and JW Black, had succeeded in making a picture of Boston from the air using wet collodion; this is also reproduced in the Photo-Miniature for July 1903 as 'THE FIRST PHOTOGRAPH TAKEN FROM A BALLOON.'

Dry Collodio-Albumen Process

The dry collodio-albumen process was more widely practised, and a full description of it by Joseph Sidebotham, a Manchester, England hat manufacturer and keen photographer, was published in 1861 and is available on the superb 'Albumen' web site. Plates made using this method would keep for several weeks, but the disadvantage was in the lengthy exposures needed. Sidebotham suggests that for "a well-lighted landscape, Rosse's orthographic lens with medium stop being used, about five minutes are sufficient; some views would require even two or three times as much."

When the Marseilles Photographic Society in 1862 offered a prize of 500 Francs for "a dry-plate process that can produce a photograph of a street scene in full sunlight, including action and movement", there was little chance of their money being taken; it was not until the late 1870s with improvements in the gelatine dry plate that this became possible.

Part 2: Gelatine For Sale

Coat It Yourself

Although Maddox had made the important suggestion of using a silver halide suspended in gelatin, plates made by this method were generally too slow to be of great use. Despite this, within a couple of years, other experimenters were making gelatine-based materials commercially available. By July 1873, J Burgess was offering a ready-made gelatine emulsion from his Peckham, London works. Photographers could buy this emulsion, warm it until it melted and then use it to coat their own plates.

Any photographer brought up on the wet plate process would of course be used to coating plates, and the new material gave the luxury of making plates in advance rather than on the spot. Since photographic materials were still only blue-sensitive, this coating could be carried out using relatively bright yellow safelighting.

Patent Pellicule

Later in the same year, Richard Kennett (?-1896) was awarded a patent for a process using gelatine and silver halides. Halides were dissolved in a gelatine solution and then silver nitrate added to form silver halides, and the mixture then cooled until it set. It was then cut into strips and washed to remove soluble halides before being dried again. It is perhaps unclear what exactly was novel in this method compared to that used by Burgess, but this patented 'gelatino-pellicule' was on sale by November 1873 in two, four and six ounce packets. The smallest two-ounce pack cost a shilling, perhaps equivalent to around 20-50 US dollars given the changes in exchange rates and prices.

Speed Improvements

By 1876, Kennett had managed to increase the speed of his emulsion considerably, selling an improved rapid pellicle material that matched or bettered the speed of wet collodion. However it was two years later that Charles Harper Bennett cracked the problem and produced the first really fast dry plates. Like Maddox, Bennett announced his work in the 'British Journal of Photography' in 1878. The method he used of 'ripening' the emulsion by keeping it at around 90ºF (32 degrees Celsius) for several days led to a remarkable increase in sensitivity, making it perhaps 50-100 times as sensitive as wet collodion. It was possible to take exposures with a fast lens in good daylight at perhaps 1/30 second.

The First Commercial Dry Plates

In April 1878, dry plates came on to the British market from two companies, 'Wratten and Wainwright' in Croydon, near London, and also the 'Bennett' plates from Peter Mawdsley's 'Liverpool Dry-Plate Company'. These cost three shillings for a dozen 'quarter plate' (41/4 x 31/4 inch) plates. By 1879 there were at least fourteen companies supplying dry plates in the UK. One of these was founded that year by Alfred Hugh Harman in the basement of a house in Ilford. Marketed as the 'Britannia Dry Plate', this was the start of what later became Ilford, now celebrating 125 years of photographic manufacturing with their downloadable 2004 calendar.

Part 3: Around the World

Chicago

One of the first dry plate suppliers in the USA was John Carbutt (1832-1905). Born in England, he went to the America in 1853 and photographed the building of the Grand Trunk Railway in Canada until 1859. Afterwards he set up a studio in Chicago, where he is said to have experimented with dry plates (probably collodio-albumen) in 1864.

In the 1860s he took a series of architectural views of Chicago, some of which are on line. He moved to Philadelphia in 1870, immediately after the great fire destroyed some of its finest buildings. Carbutt started manufacturing gelatine-bromide dry plates in 1879, and later went on to produce some of the earliest orthochromatic dry plates in 1886.

Miles Ainscoe Seed was born in England around 1843 and emigrated to the USA. The 'M A Seed Dry Plate Company', based at Woodland, St Louis County, Missouri, also began manufacture of dry plates in the United States in in 1879. Its plates, such as the 'Extra Rapid Dry Plates', "For In or Out Door Photography", "Warranted Perfect and Extremely Sensitive" remained on the market until the company was bought by Eastman Kodak in 1902.

South Australia

Philip Marchant was born in Devon, England in 1846, and travelled to Australia with his family in 1861, when his father had a contract to manage Walter Duffield's Victoria flour mill at Gawler. After two years the family moved to Adelaide, where Philip learnt wet plate photography, In 1864 he went with two friends (one possibly his younger brother) for a two month photographic trip into the hills to the south. Philip was the first photographer in the family, but there were another five over three generations running studios continuously until the 1970s.

Dry plates were often ruined on the slow journey out from England, particularly in the heat and high humidity of the tropics, so Marchant decided to start making them. By August 1880 he was offering the 'guaranteed Adelaide Instantaneous Gelatine Dry Plates' for sale, together with an instruction leaflet giving full processing details which you can also see on line in a fascinating site on the history of photography in South Australia. The plates were said to be seven times as fast as wet plates.

Kodak Australia

Some years later in 1884, Thomas Baker began selling his 'Special Rapid' plates made in Abbotsford, Victoria, later improved as 'Austral' dry plates. He went into partnership with John Rouse to expand the company, which also began to import and sell Eastman products from London, becoming the Australian agents for Eastman Kodak in 1905, and merging with them to form 'Australia Kodak Limited' in 1908 to make materials in Australia when tariffs made imported material expensive.

Part 4: George Eastman

Eastman takes up photography

In Rochester, NY, USA in 1877, a young bank clerk called George Eastman planned to take a summer vacation in Santo Domingo, and a colleague suggested he should make a photographic record. Eastman bought all the necessary equipment for the wet plate process and took lessons from a professional photographer, G H Munroe, the son of a long-established Rochester photographer Myron H. Monroe. Eastman never made the trip, but it was the start of his long and eventually profitable involvement with the medium. He found the collodion process complex and started experiments to try and simplify it.

News from England

Contrary to many accounts, Eastman (and the companies he later founded) took only a minor role in the initial development of dry plates, although he became a major supplier of them only a couple of years after their introduction. Eastman's genius was in organising production and marketing, becoming one of the major founders of the photographic industry.

Early in 1878 Eastman subscribed to the British Journal of Photography and the first issue he received carried the announcement of Bennett's ripening process that greatly increased the sensibility of dry plates. He immediately began experimenting using this, contacting the professional photographer, photographic author and foremost American photographic chemist, Matthew Carey Lea of Philadelphia, to pick his brains on the subject. Carey Lea, simultaneously with William Willis, had in 1877 introduced the use of ferrous oxalate in neutral potassium oxalate, which became a standard photographic developer for dry plates.

Eastman's Coating Machine

With what he learnt from Carey Lea, Eastman, working in his mother's kitchen and using her kettle to prepare his emulsion, was soon producing images using the dry plate process. He found that there were problems in coating plates with gelatin, and invented a machine to do the job better.

Unsuccessful trip to London

Eastman needed money to set up a business, but wasn't able to find anyone willing to lend it, so decided to take his coating machine across the Atlantic to London and sell it there. He walked into the offices of the British Journal of Photography and showed it to the editor, W. B. Bolton. Bolton was impressed and introduced him to Charles Fry the partner of Charles Bennett. However, the British had their own ways of coating plates, and so lacked the interest that Eastman expected in his invention, although they were doubtless ready to learn from his ideas, which Eastman had not at that point patented.

A US Patent

Eastman returned to America and applied for a patent in 1879. You can see the sketch and text of his patent online at the US Patent Office site by typing the number, US Patent 226503 into the search box.

Eastman received his patent the following April and immediately started to set up in manufacture in a loft in State Street, Rochester, as nothing had come of his negotiations in London. By July 1880 he had an improved coating machine, and by August his plates were available through Edward Anthony's New York photographic store. Eastman's success story had begun, despite being well behind others in coming to the market.

Eastman went into partnership with local whip manufacturer Henry Alvah Strong, a family friend, founding the Eastman Dry Plate Company on January 1, 1881. After near bankruptcy when they received an unsuitable batch of gelatin, the company prospered, and in 1884 became a corporation, the Eastman Dry Plate and Film Company, with Strong as president and Eastman treasurer.

Part 5: The Revolution

From Craft to Process

Dry plates eventually revolutionised photography, changing it from a handmade craft to an industrially based process, through the application of industrial techniques such as Eastman's coating machine. The gelatine based process made possible the development of flexible film and cameras such as the Kodak, bringing photography to the masses of the middle-classes rather than it remaining the province of rich amateurs and a few professionals. It was really the start of photography as we know it.

Mass Production and the Modern Age

It was a change that was mirrored in other fields, as craft skills were replaced elsewhere by mass production, with many of the key inventions of the modern world occurring in the next twenty-five years. Electric Light, the fountain pen, motor bike, car, celluloid, the time clock, the movies, dishwashers, radio, the escalator, the paper clip, safety razor and the aeroplane were among the inventions that followed it to usher in the modern age.

New Possibilities

The increased speed of the dry plate created new possibilities for photography. Hand-held photography became possible as well as special applications such as astro-photography. Isaac Roberts (1829-1904), a man born poor who applied himself to part-time study to become a wealthy engineer was a keen amateur astronomer and photographer and one of the first to make dramatic images of the stars and galaxies using the new plates.

Photography as a hobby

By around 1881, most photographers had changed from wet plate to dry plate, and a whole generation of photographers was coming into being who had never coated a plate. Photography, like bicycling, was becoming popular as a middle-class hobby. Relatively little equipment was needed, other than a camera, to use the new plates and make prints. The British magazine 'Amateur Photographer' was first published in 1884 and is still in existence.

Processing could be carried out in a cupboard or pantry or basement storeroom, with any windows covered by a ruby sheet or two, and a candle or spirit powered safelight if necessary. You needed the chemistry - and photographers still made up their own developer and so on from the 'raw' chemicals - and a few trays, bottles and jugs and a rack to leave the plates to dry. Precise measurement of weights, volumes, temperatures and times were not needed when you could develop by inspection.

After drying, the plate negatives would be printed by contact often on the slow bromide papers known as 'gaslight' papers. A simple printing frame was needed to hold negative to paper firmly and allow a corner to be lifted to judge exposure if the image was being printed out rather than developed, using printing out paper (POP.) More sophisticated photographers might prefer the greater density and faster working of developing out paper. Bromide papers were first marketed in 1874, and came onto the market as dry plates became popular in 1880. They soon largely replaced the albumen papers that had previously dominated photography, largely because of their ease of use.

Camera Clubs

Many camera clubs date their beginnings from the early years of the dry plate process, including the New York Camera Club, founded in 1884. The Croydon Camera Club, based a few miles south of central London is another, with the difference that among its early members were members of the Wratten family and others connected with the Croydon firm of 'Wratten and Wainwright', including the distinguished photo chemist Dr Charles Edward Kenneth Mees (1882-1960), one of the inventors of panchromatic plates. Kodak took over Wratten and Wainwright in 1912 because they wanted Mees; he set up the Kodak Research Laboratories for them. One of the conditions of the takeover was that Kodak continue to use the name Wratten to describe their photographic filters. You can see an early picture by a member of the Wratten family and also a view of members on an early club outing on the web page.

Part 6: Gelatine & Collodion

Differences

Silver gelatin emulsions such as those in the new dry plates were radically different from their wet-plate forbears. Collodion is a clearer material, and the salts were dissolved rather than suspended in it, giving a homogeneous solution. Sensitising in silver nitrate solution produced a very finely divided silver halide through the material, resulting both in very fine grain and a low sensitivity to light.

Gelatin emulsions contain a suspension of much larger silver halide crystals, and the ripening process increased crystal size still further. This results in increased light sensitivity, as a larger crystal is more likely to be hit by photons than a smaller one, but at the expense of more visible grain. Since most printing was by contact, this was seldom a problem.

Problems with Dry Plates

The change to dry plates was not without problems for some photographers. Many found the dry plates were simply too fast, as cameras were often not equipped with shutters. A lens cap was good enough for wet plate. Cameras and bellows often had small light leaks that had no effect on the slower materials but could fog the fast dry plates. Rooms dark enough for wet plates often had far too much light and fogged the new materials. And of course, as now, there were photographers who were opposed to change for no better reason than it was change.

Collodion Continued

For applications where rapid exposure was unimportant, but the finer grain of collodion, as well as its clearer highlights were desirable, collodion continued in use. Although dry plates were rare in general photography after 1881, they continued in use in specialized areas such as process work (making plates for photomechanical reproduction) until the 1950s and beyond.

For itinerant photographers, and those in remote rural areas, collodion remained attractive also. The collodion and silver nitrate bath are low in cost per exposure, and the glass plates could be scraped clean and reused, often as soon as your client had his or her damp printed image in their hand. Many eventually went over to working with negatives on photographic paper, but some may to this day still be using collodion where digital photography has yet to reach.

Photography in the dark

Part 1: Early Days

An earlier feature 'Night Photography' dealt mainly with the practical aspects of photography at night. In this feature I look in more detail at the history of photography at night and by flash. This week deals with the early history and the use of magnesium wire and flash powder as well as long exposures at night.The second feature in this two part series will deal with flash bulbs and electronic flash.

From the earliest days, the challenge of taking photographs in darkness has intrigued photographers. William Henry Fox Talbot, one of the inventors of photography, even suggested the idea of being able to photograph using invisible rays in a dark room - although it was only much later that infrared photography actually made this a reality. Talbot made a further contribution in a lecture to the Royal Institution in 1851, when he photographed a rapidly rotating copy the 'The Times' newspaper using the light from an electric spark, giving an exposure time estimated at around 10 millionths of a second.

Almost immediately photography was invented, other inventors had applied the use of 'limelight' to shorten exposure times. Limelight used a gas flame of hydrogen and oxygen to heat up a block of lime, which glows with a bright white light (an oxy/hydrogen flame on its own gives very little light.) The first recorded use of this was again in one of London's Scientific institutions, the 'Royal Polytechnic Institution by L L B Ibbertson (or Ibbetson) early in 1840. The following year it was put to use in the portrait studios by Antoine Claudet and others, with Claudet taking out patents on methods of taking portraits at night.

'Limelight' provided a light source, which had a strong blue component and thus was effective at exposing early photographic materials. Until around the 1880s all photographic materials were only sensitive to blue light. Most other artificial light sources of the time - such as oil lamps - produced a warmer colour light that contained little blue and were thus not much use. Limelight was not a great success, largely because the sources used in photo studios came from a small area and produced harsh results.

A chemical light source, the 'Bengal light'. had a brief vogue in 1860-61, with over 30,000 having the pictures taken by it. This 'Bengal' or 'blue light' is a mixture of potassium nitrate (nitre or saltpetre), sulphur, and antimony, which burns to give a brilliant and long lasting blue light together with copious poisonous fumes. In the photography studios, the light lasted around a quarter of a minute and John Moule who patented it as 'Photogen', used reflectors to soften the light and burnt the mixture in a special lamp with a flue to take the fumes out through the studio window. It must have been pretty unhealthy to live near, and it is perhaps fortunate the public soon lost interest.

Slow combustion flash cartridges fitted with a parachute were at one time marketed in the US. These could be fired by a special pistol to around 200ft, where they ignited, giving around million candlepower for 1-2 minutes, giving light over a radius of around seven hundred feet. Even more powerful devices have been made for military use.

Part 2: Highly Charged

Portrait photographer Gaspard Félix Tournachon (better known as Nadar), was the first to install electric lighting in his Paris studio in 1859, using a large battery of 50 Bunsen cells. These used a zinc container containing dilute sulphuric acid inside which was an unglazed pot containing concentrated nitric acid with a carbon anode, giving an EMF around 1.9v. This chemically dangerous a battery was capable of supplying a voltage of around 95V.

Nadar used an improved version of the carbon arc, originally invented by Sir Humphrey Davy fifty years earlier, Although first light bulb to use a glowing filament was produced by Warren De la Rue in 1820, it had a platinum filament and was too expensive for general use, and its light output was relatively low, especially in the photographically usable blue area of the spectrum.

Not content with taking portraits by electricity in his studio, he transported the whole kit down into the Paris catacombs to photograph the relics there. Exposures of over a quarter an hour were needed, so he used dummies, posed with their backs to the camera, in place of people. Nadar was also the world's first aerial photographer. He took out a patent in 1855 on the use of aerial photography in mapping but it was not until 1858 that he was successful in taking photographs from a balloon. The difficulties involved in this were greatly heightened because of the problems of the wet plate process, which meant the plate had to be coated, the picture taken and development started before the plate dried out.

It was not until twenty years after Nadar set up his studio that Joseph Wilson Swan and Thomas A. Edison both created successful carbon filament lamps in 1879, and the modern tungsten filament incandescent light bulb only came much later, being invented by the General Electric Company and William Coolidge in 1906-10.

Street lighting by electricity started with a few experiments in the 1870s, but the arc lights used were too brilliant and too expensive for widespread application, although they were installed in 1878 along a mile and a quarter of the Thames Embankment in Westminster, London. It was the work of Swan and Edison on vacuum filament lamps that led to cheaper lighting, with Edison constructing the world's first power station in 1883, and although this was not very successful, there were soon many other companies producing electricity and installing lighting in city streets. Gas street lights had first put in an appearance - on Westminster Bridge in London - around 1812, after a public display in Pall Mall in 1807,although William Murdoch had lit his own house with gas in 1792, and they remained a major source of light in many cities for another seventy years or more.

The fact that city streets were becoming brighter, together with improvements in film emulsions and lenses, made it possible for photographers to take to the streets at night, even if lengthy exposures were still normally needed. Some of the finest night pictures from the 1890s are those of Alfred Stieglitz taken in New York.

Part 3: Flaming ribbons

Sir Humphrey Davy had isolated the metal magnesium in 1808 (he named it 'Magnium', as confusingly Manganese was then called Magnesium, but this was sorted out a few years later.) Michael Faraday who succeeded Davy as Professor of Chemistry at the Royal Institution in 1833 pioneered the method of electrolysis of molten magnesium chloride which is still the basis of the major method of production.

It was not until 1859 that Professor Robert Wilhelm Bunsen (famous for his burner!) of Heidelberg and Sir Henry Enfield Roscoe (1833-1915), Professor of Chemistry at Owens College (later the University of Manchester) suggested magnesium wire could be used as a light source for photography (the idea was also suggested at much the same time by William Crookes, editor of the Photographic News.) Magnesium wire could be lit from a candle and burnt with an impressive bright light.

Shortly after this, the Magnesium Metal Company in nearby Salford was marketing magnesium wire and ribbon for photographers. When first introduced this cost the high price of half a crown per foot, but soon improvements in manufacture brought this down to one tenth of the price - around '3d a foot' so that around 80 foot (25m) would cost a UK pound and probably serve for around 50-100 pictures. Still not cheap given the cost of living at the time, but it made the occasional use of this material possible in photography.

To avoid hard shadows from the small light source, it could be kept moving while it burnt. Various special holders were produced for burning magnesium ribbon, most of which seem to be unnecessary gadgetry - photographers were perhaps little different then from now in this respect, although they made it easier to handle the long lengths of ribbon needed for exposures at any distance - ten feet of ribbon for a subject at twelve feet for example.

Manchester photographer, Alfred Brothers, took underground pictures using magnesium in 1864 at the Blue John mine in Derbyshire (presumably the famous fluorspar workings in a large limestone cavern), and also the first known portrait by this method, appropriately of Roscoe. Nadar also apparently used magnesium lighting for his pictures in the Paris Sewers; although these are often dated 1861, it seems more likely they were taken a few years later, around the same time as the underground pictures by Brothers in 1864/5. In the USA, John C Browne was using magnesium for portraits in 1865 and Charles Waldack took an impressive series of views in 'Mammoth Cave', Kentucky.

However the finest underground work taken with magnesium is probably that of Timothy O'Sullivan, earlier one of the celebrated photographers of the US Civil War. In 1867 he was working a photographer for a US Government Survey between Nevada and Denver City in Utah, part of a proposed route for the Central Pacific Railway. As a part of this, O'Sullivan visited the Comstock Lode silver mine, using magnesium flares to photograph its interior. His work stands out for its clear composition and sense of scale.

Another early mine photographer was Mr. Bretz, of the Kohinoor Colliery, Shenandoah, Pennsylvania. He used a number of parabolic metal reflectors to concentrate the light from the 6-10 inches of magnesium ribbon burning at the centre. Later he photographed using five 2000 candle-power electric arc lights, but for his largest work underground, a 22x18 inch negative, possibly the largest every taken underground, he used 'eight or nine ounces' of flash powder

Part 4: Flash, Bang!!!

Although magnesium ribbon was a powerful light source, it was slow-burning, a decent length of magnesium ribbon taking perhaps 10-20 seconds to complete combustion, which limited its use to static subjects. (It continued in use for many years in the darkroom as a convenient light source to expose contact prints.) The obvious development was to increase the surface area by using powdered metal. Various devices were devised using rubber bulbs to blow magnesium powder into the alcohol flame of a spirit lamp, giving relatively short duration intense flashes - lasting perhaps an eighth of a second. There were also experiments with plunging burning magnesium ribbon into jars of oxygen, an exciting spectacle in school chemistry lessons, but hardly convenient for photography. It could be considered a primitive forerunner of the flash bulb.

The next step was to incorporate the oxygen needed to burn the magnesium (later aluminium powder was also used) chemically, using a finely ground mixture of the metal powder and a compound such as potassium chlorate or barium peroxide. When such mixtures were ignited they gave an intense flash of white light, followed by copious clouds of white smoke. Traill Taylor made the first experiments with such mixtures around 1865, but it was only around twenty years in 1887 later that 'flashlight powder' or 'Blitzlichtpulver', developed by Adolf Miethe and Johannes Gaedicke in Germany in 1887 was first marketed, starting the widespread use of similar materials.

Most flash powders were based on magnesium and potassium perchlorate, which gave a light rich in blue and UV, suitable for early emulsions that were only sensitive in these regions, but when orthochromatic and panchromatic plates became popular, strontium and barium salts were often added to increase the amount of green and red light. Other metals such as aluminium, zinc, cerium, zirconium and thorium were also used at times in place of magnesium; aluminium gave slower combustion and the cerium mixtures less smoke.

Careful adjustment of the proportions of magnesium and potassium chlorate in the simple mixture could be used to alter the flash duration, which was also dependent on the amount used. Exposures could be as short as 1/150 second, but were more often around 1/5 - 1/25.

Various holders with incorporated ignition devices - often flints used to make sparks were designed to protect the user from both the light and the blast as well as direct the light toward the scene. When using multiple flashes - necessary to balance lighting or light large areas, it was necessary to synchronise the firing of the two flashes, either using a pneumatic release actuating a 'flint' or small 'cap' or by electrical ignition using the heating of a fine metal wire.

Injuries and fires were caused by flash powder were still a relatively common occurrence, but coupled with a great reduction in the price of magnesium, the introduction of flash powder led to a great increase in flash photography from around the mid 1880s on.

All exposures using flash powder were made by a technique known as 'open flash'. This meant leaving the shutter open, firing the flash and then closing the shutter. When a group of press photographers attended an event that required flash photography, they would arrange their tripods in front of the subjects, open the camera shutters and hold their hats over the lens (part then of every man's dress - even press photographers). One of their number would have prepared the flash powder and would then announce 'Hats off, gentlemen' before firing the flash. If working indoors, because of the large cloud of white smoke that would then fill the room only one exposure was possible - and the wise photographer would often have packed up his tripod and left before the subjects had recovered from the flash sufficiently to complain.

Fortunately the white smoke - mainly magnesium oxide - was relatively harmless, although exposure to any dust is best avoided. The body actually needs about 300 mg/day of magnesium and it is present for example in all green plants in the chlorophyll. Magnesium oxide which is produced when magnesium burns is often taken to relieve minor indigestion. Although magnesium ribbon or wire also produces smoke, there is much less than with flash powder, most being formed as solid ash.

In studios, the release of smoke would have prevented further work and the flash powder was generally used inside large glazed cabinets which had external flues. Away from the studio, large fire-proof bags of cloth made non-flammable by treatment with ammonium phosphate and boric acid could be suspended from stands with the flash equipment inside. These bags could then be taken outside and emptied of ash and smoke after each use.

Photographers I know were still using flash powder into the 1950s and 1960s and possibly later, although most sources state it became obsolete with the invention of flash bulbs around 1930. It still remained the most economical and simplest method of photographing very large interiors.

You should on no account attempt to make your own flash powder - it is a very risky process that will more likely than not lead to serious injury unless you have considerable skill and experience and the equipment needed to handle hazardous explosives. The publishing of recipes on the Internet (and there are many, mostly in articles on bomb-making) is highly irresponsible, and I have attempted to remove any references to them in writing this feature.

In the Canadian Pacific Railway archive is a picture of the Freight Office at Lacombe, with a caption that records it was in part built from the remains of the first station, heavily damaged in October 1911 'by the explosion of magnesium flash powder, held in the trunk of a visiting photographer. CPR baggage-man Evert McLeod died from the injuries he sustained in the accident.'

Another railway connection is the picture 'Broadway Limited at night, Latrobe, Pennsylvania, 1930' taken by Perrie Mahaffey(1887-1961), art director and staff photographer for the Pennsylvania News. His picture of the express taking on water was lit by spreading flash powder for 500 feet along the line, claimed to be 'he most elaborate and pretentious set-up ever attempted in the realms of advanced professional photography'.

Perhaps it was reports of incidents such as the Lacombe explosion that led Thomas G. (Ray) Hitt in Washington State to experiment with photographic flash powder in 1916 as a replacement for gunpowder in firecrackers. This soon became the standard ingredient particularly in the large Chinese fireworks industry, giving a much sharper bang a pyrotechnic innovator. It also changed fireworks, particularly homemade ones, from relatively harmless fun into lethal bombs, and it was the accidents caused by these 'flashlight crackers' that led to the introduction of anti-fireworks laws in many US states.

Should you need to use flash powder it is still available, mainly from theatrical and special effects suppliers, but needs very careful handling.In some countries or states you may need to obtain a licence to use flash powder from your local Fire Marshal or other relevant authority.

One modern reference gives the following exposure advice: 'Flash powder produces light with a color temp. of about 4300K, small quantities give a warm color, larger heaps produce a color that is approx. daylight. Use ISO 100 print film and an aperture of f/11

6 ft	1 gram
12 ft	2.5 gram
24 ft	7 gram
36 ft	12 gram

Spread larger charges in a line and ignite in the middle.'

Among photographers who made use of the new possibilities offered by flash powder were social documentary photographers such as Jacob Riis and Lewis Hine. Riis is said to have caused a couple of fires taking his pictures, and occasionally uses flash in a very obvious fashion, for example in his 'Police Station Lodger, A Plank for a Bed c. 1890', but his work threw light literally and metaphorically into many dark corners of society. He started using amateur photographers to come with him and take pictures in 1887, but learnt to use camera and flash himself the following year, though never considering himself as a photographer. Hine's use of flash is generally more sophisticated - it is at times only possible to decide that flash has been used by considering the probable light conditions. There are a number of fine collections of Hine's work available on the web.

Dictionary of Photographic processes

Albumen prints outnumber any other type of photographic positive made during the nineteenth century. They have a sepia color and slightly glossy surface. Thin sheets of paper were first coated with egg white and salt, then floated on silver nitrate to make them sensitive to light. The image is created by printing under a negative in sunlight. The finished picture is fixed, washed, and often gold toned before mounting. Invented by Louis Desire Blanquart-Evrard of France in 1850.

The **ambrotype** process was patented in 1854 and enjoyed great popularity for a few short years, and again during the Civil War. It produced pictures on glass instead of metal plates. Like the earlier daguerreotype, each image is unique, made one-at-a-time in the camera. The glass is flowed with a sticky material known as iodized collodion. It is then sensitized by being dipped into a bath of silver nitrate, and exposed in the camera while still wet. A chemical developer is used to bring out the image. The glass plate is then backed with black material--paint, cloth or paper--and furnished in a case similar to those used for daguerreotypes. The ambrotype process was marketed as an improvement, because the finished image lacked the glittery, elusive reflective quality of daguerreotypes and was therefore easier to view. Although often confused with a daguerreotype, an ambrotype will always appear as a positive no matter the angle of view. The detail and tonal range, however, tend to be less impressive than in the earlier process.

Autochrome plates were the invention of Auguste and Louis Lumiere, who patented the process in 1904 and began to market it commercially in 1907. Microscopic grains of potato starch were dyed red, green, and blue-violet, then mixed evenly and coated onto a sheet of glass. A black-and-white emulsion was then flowed over this layer. During exposure, the grains of potato starch on each plate acted as millions of tiny filters. The light-sensitive emulsion was then reversal processed into a positive transparency. When viewed, light passes through the emulsion and is filtered to the proper color by the starch grains. The resulting mosaic of glowing dots on glass gives autochromes the look of pointillist paintings.

Calotype was the name given to the first practical negative-positive process of photography. Capable of producing multiple copies of any given image, the calotype (also called Talbotype) was invented by William Henry Fox Talbot in September of 1840. An earlier Talbot invention, photogenic drawing, was also capable of creating photographic images in the camera, but was quite slow and could not be used for photographing people or anything that moved. To make a calotype, plain sheets of writing paper are coated with a solution of silver nitrate, dried, then dipped in potassium iodide to form silver iodide. After being dried again, the paper is floated on a mixture containing silver nitrate and gallic acid. The same mixture is used to develop the negative image after exposure. Following fixing in hypo, this paper negative was generally waxed for transparency and used to make salt prints. The calotype process was used until around 1850 when it became gradually superseded by the collodian process on albumen paper.

Carbon prints, patented in 1864 by Joseph Wilson Swan, offered a permanent image without grain. The process was capable of making exquisite prints with a wide tonal range. Negatives were printed onto a "tissue" containing carbon and other pigments in a gelatin base. The gelatin had previously been made light-sensitive by a bath of potassium bichromate. After washing, the image on the tissue was transferred to a paper base and the backing of the tissue was stripped off.

Chromogenic Print - Color print made from a color transparency or negative. The print material has at least three emulsion layers of silver salts. Each layer is sensitized to one of the three primary colors in the spectrum. During the first stage of development a silver image is formed on each layer. Dye couplers are then added which bond with the silver and form dyes of the appropriate colors in the emulsion layers.

Cibachrome Print - An extremely high-gloss paper manufactured by Ilfochrome and first introduced in 1963. A silver dye-bleach process that forms an image by selectively bleaching dyes already existing within the paper. Renowned as one of the most stable, longest-lasting of all color prints.

Collodion negatives--see Wet Plate

Collodion prints used the same sticky nitrocelluluse emulsion, collodion, as ambrotypes. This was mixed with silver chloride and coated onto paper. The surface could be matte, glossy, or semi-gloss like an albumen print. The whites of the image generally lack the yellowish cast of albumen prints. Collodion prints are difficult to distinguish from other silver prints made circa 1890-1910, and usually require testing by a trained conservator to identify with certainty.

Collotype - A photomechanically printed image made from a photographic image. This process produced an extremely fine and delicate grain, and was favored by publishers who wanted a means of reproduction that emulated the appearance of an actual photograph.

Contact Print - A print that is the same size as the negative used to produce it. A contact print is made by placing a sheet of sensitized material in direct contact with the negative. Nearly all photographic images produced prior to the 1890s were contact prints. The process was also widely used by Edward Weston and others of the modern era.

The **cyanotype** process was invented in 1840-1842 by Sir John Herschel but was most popular around the turn of the century. Herschel was an astronomer and inventor who first used the terms "negative" and "positive" to describe the making of a photographic print. Among the earliest permanent processes, the name cyanotype refers not to the blue tonality of the prints, but rather to the use of ferrous cyanide in the emulsion. In the 1870s it became known as a "blueprint" and is still widely used to reproduce architectural plans. The brilliant blue images have a matte surface. Because iron salts are used (rather than silver compounds) for the light-sensitive material, cyanotypes are highly stable.

The **daguerreotype** process, the first practical form of photography, was made public in August of 1839, but seldom able in its earliest form to produce portraits. This was due to the lengthy exposure time required. The plate was exposed in the camera for as long as 20 minutes in daylight, which required the sitter to remain very still for long periods of time. A daguerreotype is made on a sheet of silver-plated copper. The silver surface is polished to a mirror-like brilliance. The plate is then sensitized over iodine vapor, exposed in the camera, and developed with mercury vapor. By 1840, experimenters had succeeded at increasing the sensitivity of the process by using chlorine or bromine fumes in addition to the iodine vapor. The earliest daguerreotypes tend to have bluish or slate grey tones; a brown-toning process called "gilding" came into widespread (but not universal) use late in 1840. Daguerreotypes have exceptionally fragile surfaces and for this reason, they were always furnished behind glass in frames or small folding cases. Sizes vary but are measured from double whole plate (8 x 13 inches) to sixteenth plate (1 5/8 to 2 1/8 inches) with the sixth plate the most common (2 x 3 inches). The daguerreotype process was eventually replaced by the wet collodian process in the 1850s.

Dilute albumen print--an early variation (first proposed by the inventor of albumen paper in 1850) in which the albumen is diluted with salt water in order to reduce the gloss. The resulting image can have a matte finish like a calotype, with the finer detail and tonality of an albumen print.

Dye Transfer - One of the most permanent and beautifully rendered of all color printing processes, this method required three separate sheets of negative film to be produced through red, green and blue filters. These separation negatives were then projected or contact-printed to make three matrices dyed in cyan, magenta and yellow dyes. Each matrice was then brought into registered contact with a sheet of transfer paper that absorbed the dye, producing a finished print made up of a combination of dye images. The film used to produce this very caustic process was discontinued in 1996.

Ektacolor RC Print - Photographs produced from color negatives printed on paper coated with a resined plastic. The most commonly produced color print of the modern era.

Gelatin-silver see silver print

Halftone - A photomechanical reproduction process of a photograph made on a printing press. An original photographic image is re-photographed through a screen that transforms the continuous tones of the image into a series of dots, relative to the amount of darkness in the original. The new image is then transferred onto a printing plate. The amount of ink deposited onto the plate is determined by the density of the dot pattern. This process was sometimes used in Alfred Stieglitz's Camera Work.

Lightly-albumenized print--see Dilute albumen print

Melainotype--original name for the tintype process.

Photogenic drawing was the name William Henry Fox Talbot gave to his initial photographic invention. As early as 1834, Talbot was making salt prints by placing lace, leaves and other objects on light-sensitive paper and exposing it to the sun. Although Talbot used photogenic drawing paper in the camera--creating negatives by 1835--exposures in the camera often took hours, so most photogenic drawings were made by the superposition of objects.

Photogravure is a photomechanical process; that is, one in which the finished prints are made in ink on a printing press. The method, one of the finest ever developed, transferred the photographic image to a copper printing plate, which was then acid-etched to retain ink in areas corresponding to the blacks of the picture. Due to the very laborious nature of photogravure printing it was later replaced in commercial use by the halftone plate. Photogravure was invented by Karl Klic in Austria in 1879.

Platinum prints - This method of contact printing was used primarily from 1873 to around 1915, when as a result of World War I, platinum paper was replaced for the most part by palladium. A black and white printing process in which the image is formed of metallic platinum or palladium in the fibers of the paper (instead of an emulsion coating on the surface). The hand-coated images are known for their luminosity, extraordinary detail, beautifully rich tonal range, permanence and stability. Platinum and Palladium printing has enjoyed a revival in recent years as well.

Printing-Out Paper - A commercially manufactured paper that was quite popular in the 1880s and 1890s and continued to be produced until the 1920s. Coated with silver-chloride emulsions and designed to develop a print from a negative by using light alone, rather than chemistry. This process was favored by photographers in the early American West, as field prints could be produced to review their work without the need of a darkroom.

Salt print refers to the positive printing procedure invented by Talbot. The negative is placed in contact with a sheet of writing paper which has been floated on salt water and then coated with silver nitrate and sodium chloride. After exposure to sunlight, the finished print is fixed in "hypo', washed and dried. Unless they have been glazed or varnished, salt prints have a matte surface, with the image actually embedded in the fibers of the paper. Their tones can range from reddish brown to chestnut brown with a matte surface quality. This was the earliest form of a photographic positive paper and the most common print produced up until the invention of albumen in the 1850s.

Silver print is a term used here and elsewhere for a variety of processes, many of which cannot be precisely identified without laboratory testing. Introduced in the 1870s, it is the standard contemporary black and white print method used today and is also referred to as a silver gelatin print, or simply as a silver print. The light-sensitive compounds can be silver chloride or silver bromide or a mixture of these. They can be coated onto the paper in a layer of gelatin or collodion; their surfaces can be matte, glossy, or somewhere in between; and their tones can mimic the silvery greys of platinum prints, the warm browns of albumen prints, or a range of other colors.

Talbotype see Calotype

Tintype/Ferrotype - Introduced in the mid 1850s by Prof. Hamilton Smith of Ohio, a printing process in which a thin sheet of iron was coated with black lacquer. The light-sensitive emulsion was then coated on the iron plate just before placing it into the camera for exposure. This serves as the base for the same iodized collodion coating and silver nitrate bath used in the ambrotype process. The plate was then developed, producing a very durable, efficient and inexpensive photograph that was small is size (approximately 2 x 3 inches). When tintypes were finished in the same sorts of mats and cases used for ambrotypes, it can be almost impossible to distinguish which process was used without removing the image to examine the substrate. Used most often for portraiture and made popular in the 1850s by street photographers. Also commonly used during the Civil War and remained popular to around the turn of the century.

Type C Print - A color printing process made from a color negative or transparency which was replaced in 1958 by Ektacolor. Type C is an archaic term which is commonly used generically to identify an Ektacolor RC print, the most common color print made today.

Wet Plate--the name given to a process invented by Frederick Scott Archer of England in 1848-1851. Widely used to produce negatives but also employed in a modified form to produce positives (see ambrotypes and tintypes). As a negative process, a piece of clear glass is coated with a very thin layer of iodized collodion (made from gun-cotton [nitrocellulose] dissolved in ether and alcohol, mixed with potassium iodide). The coated plate is dipped in a silver solution in the darkroom which makes it light-sensitive. After this, the plate must be immediately exposed in a camera. The exposure needs to be completed before the chemicals on the plate have time to dry out--hence the name of the process. After development and fixing, the negative can be printed on any material. Most wet plate negatives, however, were used to make prints on albumen paper. This was the most commonly used process from the mid-1850s until the 1880s, when it was replaced by the gelatin dry plate process.

Woodburytype--a photomechanical process in which the completed prints are not made with light-sensitive materials. One of the most beautiful and permanent of all methods of producing prints in quantity, the Woodburytype process was also among the most difficult. A light-sensitive gelatin material is exposed to a negative, resulting in a three-dimensional relief-map of the image. Then the difficult part: applying huge pressure (with a hydraulic press) on the gelatin relief to make an impression in a block of lead. The lead mold is used to make the prints, which have exquisite tonality and a slightly raised surface. Introduced 1865.

Timeline of photography technology

ancient times: camera obscuras used to form images on walls in darkened rooms; image formation via a pinhole

16th century: brightness and clarity of camera obscuras improved by enlarging the hole inserting a telescope lens

17th century: camera obscuras in frequent use by artists and made portable in the form of sedan chairs

1727: Professor J. Schulze mixes chalk, nitric acid, and silver in a flask; notices darkening on side of flask exposed to sunlight. Accidental creation of the first photo-sensitive compound.

1800: Thomas Wedgwood makes "sun pictures" by placing opaque objects on leather treated with silver nitrate; resulting images deteriorated rapidly, however, if displayed under light stronger than from candles.

1806: Camera Lucida - A lightweight drawing aid that was patented by British Scientist William Hyde Wollaston (1766-1828). It was a "light room" consisting of a rod to which a glass prism was affixed. The glass prism had two sides that reflected the scene at which it was aimed.

1816: Nicéphore Niépce combines the camera obscura with photosensitive paper

1825-**27**(?): Using 'heliography' Niépce produced the first photograph from nature. He photographed his courtyard at his estate in Le Gras. It was taken with a Camera Obscura ad the exposure time was eight hours. The sun had time to move across the courtyard in that time, which is why the shadows are visible on both sides.

1829:Louis Jacques Mandé Daguerre, also French, was the inventor of the Diorama - a panoramic light show used for entertainment. He wanted to find a way for images to "record themselves". He sought out Niepcé and together they abandoned Heliography and began research silver iodide, which is light sensitive.

1834: An Englishman, William Henry Fox Talbot, works in a similar way to Wedgewood and produces paper coated with silver nitrate or silver chloride exposing it with a Camera Obscura. Like Niépce, he is able to produce a negative image, but he also realizes that he can contact print it and make a positive image.

1835:Talbots oldest surviving negative Lattice Window is produced at his home at Lacock Abbey in Wiltshire. He calls it a 'calotype'. Talbot is often called 'The Father of Photography' on account of the discovery that a negative can form a positive and then be reproduced, which is the basis of photography today… well, not counting digital photography.

1837: Louis Daguerre creates images on silver-plated copper, coated with silver iodide and "developed" with warmed mercury; Daguerre is awarded a state pension by the French government in exchange for publication of methods and the rights by other French citizens to use the Daguerreotype process. The quality is fine and exposure times 'only' a few minutes.

1838: Sir Charles Wheatstone publicly presents his reflecting stereoscope to the Royal Society in London. Later Sir David Brewster introduced a compact lenticular version of the stereoscope at the Crystal Palace Exhibition of 1851. This allowed the viewing of 3D stereoscopic slides to become the most popular and pervasive manner of experiencing photographic images in the Victorian era.

1839: In France the invention of Daguerrotypes is publicly announced, sold to the French government and released to the public.

1839: In England John Herschel (1792-1871) managed to fix pictures using hyposulphite of soda.

1841: Talbot patents his process under the name "calotype".

1842: John Herschel (1792 - 1871) introduces the cyanotype process, also known as the blueprint process.

1843: Anna Atkins (1799-1871) became the first person to print and publish a photographically illustrated book, using 424 cyanotypes (or as they were known then: "shadowgraphs"). The book was called "British Algae: Cyanotype impressions". It was printed privately and issued in several parts over ten years. Her book therefore precedes Fox Talbot's own Pencil of Nature in 1844.

1844: Henry Fox Talbot publishes Pencil of Nature.

1851: Frederick Scott Archer, a sculptor in London, improves photographic resolution by spreading a mixture of collodion (nitrated cotton dissolved in ether and alcoohol) and chemicals on sheets of glass. Wet plate collodion photography was much cheaper than daguerreotypes, the negative/positive process permitted unlimited reproductions on salt or albumen paper. The process was published but not patented.

1853: Nadar (Felix Toumachon) opens his portrait studio in Paris

1854: Adolphe Disderi develops carte-de-visite photography in Paris, leading to worldwide boom in portrait studios for the next decade

1855: beginning of stereoscopic era

1855-57: Direct positive images on glass (ambrotypes) and metal (tintypes or ferrotypes) popular in the US.

1861: Scottish physicist James Clerk-Maxwell demonstrates a color photography system involving three black and white photographs, each taken through a red, green, or blue filter. The photos were turned into lantern slides and projected in registration with the same color filters. This is the "color separation" method.

1861-65: Mathew Brady and staff (mostly staff) covers the American Civil War, exposing 7000 negatives

1868: Ducas de Hauron publishes a book proposing a variety of methods for color photography.

1870: center of period in which the US Congress sent photographers out to the West. The most famous images were taken by William Jackson and Tim O'Sullivan.

1871: Richard Leach Maddox, an English doctor, proposes the use of an emulsion of gelatin and silver bromide on a glass plate, the "dry plate" process.

1872: Louis Ducos du Hauron creates the first color photograph.

1876: F. Hurter & V.C. Driffield begin systematic evaluation of sensitivity characteristics of film

1877: Edweard Muybridge, born in England as Edward Muggridge, settles "do a horse's four hooves ever leave the ground at once" bet among rich San Franciscans by time-sequenced photography of Leland Stanford's horse.

1878: Dry plates being manufactured commercially.

1880: George Eastman, age 24, sets up Eastman Dry Plate Company in Rochester, New York.

First half-tone photograph appears in a daily newspaper, the New York Graphic.

1887: Pinhole camera from french designers Messrs. Dehors and Deslanders.

1887: Celluloid film base introduced.

1888: first Kodak camera, containing a 20-foot roll of paper, enough for 100 2.5-inch diameter circular pictures.

1889: W. W. J. Nicol patented the first iron-silver process and he is widely considered to be the inventor of the kallitype. In Nicol's original patent, the print was developed in a silver nitrate bath. He patented several revisions in the early 1890s and in one of these formulas he recommends using silver nitrate in the sensitizer rather than in the developer. This last revision is the method used by most contemporary kallitype printers.

1889: Improved Kodak camera with roll of film instead of paper

1890: Jacob Riis publishes How the Other Half Lives, images of tenament life in New york City

1891: Thomas Edison patents the "kinetoscopic camera" (motion pictures).

1898: Kodak introduced their Folding Pocket Kodak

1900: Kodak Brownie box roll-film camera introduced.

1900: PIXIE multipinhole camera is used in space by NASA taking pinhole images of our universe. Stationed on the Polar Spacecraft.

1901: Kodak introduced the 120 film.

1902: Arthur Korn devises practical phototelegraphy technology (reduction of photographic images to data bits which can be transmitted by wire to other locations); Wire-Photos in wide use in Europe by 1910, and transmitted intercontinentally by 1922.

1902: Alfred Stieglitz organizes "Photo Secessionist" show in New York City

1906: Availability of panchromatic black and white film and therefore high quality color separation color photography.

1907: first commercial color film, the Autochrome plates, manufactured by Lumiere brothers in France

1909: Lewis Hine hired by US National Child Labor Committee to photograph children working mjills.

1913: Kinemacolor, the first commercial "natural color" system for movies is invented.

1914: Oscar Barnack, employed by German microscope manufacturer Leitz, develops camera using the modern 24x36mm frame and sprocketed 35mm movie film.

1917: Nippon Kogaku K.K., which will eventually become Nikon, established in Tokyo.

1921: Man Ray begins making photograms ("rayographs") by placing objects on photographic paper and exposing the shadow cast by a distant light bulb; Eugegrave;ne Atget, aged 64, assigned to photograph the brothels of Paris

1923: Doc Harold Edgerton invents the xenon flash lamp and strobe photography

1924: Leitz markets a derivative of Barnack's camera commercially as the "Leica", the first high quality 35mm camera.

1925: André Kertész moves from his native Hungary to Paris, where he begins an 11-year project photographing street life

1928: Albert Renger-Patzsch publishes The World is Beautiful, close-ups emphasizing the form of natural and man-made objects; Rollei introduces the Rolleiflex twin-lens reflex producing a 6x6 cm image on rollfilm.

1931: development of strobe photography by Harold ("Doc") Edgerton at MIT

1932: inception of Technicolor for movies, where three black and white negatives were made in the same camera under different filters; Ansel Adams, Imogen Cunningham, Willard Van Dyke, Edward Weston, et al, form Group f/64 dedicated to "straight photographic thought and production".; Henri Cartier-Bresson buys a Leica and begins a 60-year career photographing people; On March 14, George Eastman, aged 77, writes suicide note--"My work is done. Why wait?"--and shoots himself.

1933: Brassaï publishes Paris de nuit

1934: The 135 film cartridge was introduced, making 35mm easy to use.

1934: Fuji Photo Film founded. By 1938, Fuji is making cameras and lenses in addition to film.

1935: Farm Security Administration hires Roy Stryker to run a historical section. Stryker would hire Walker Evans, Dorothea Lange, Arthur Rothstein, et al. to photograph rural hardships over the next six years.

1936: development of Kodachrome, the first color multi-layered color film; development of Exakta, pioneering 35mm single-lens reflex (SLR) camera World War II: development of multi-layer color negative films Margaret Bourke-White, Robert Capa, Carl Mydans, and W. Eugene Smith cover the war for LIFE magazine

1947: Henri Cartier-Bresson, Robert Capa, and David Seymour start the photographer-owned Magnum picture agency

1948: Hasselblad in Sweden offers its first medium-format SLR for commercial sale; Pentax in Japan introduces the automatic diaphragm

1948: Edwin H. Land introduces the first Polaroid instant image camera.

1949: East German Zeiss develops the Contax S, first SLR with an unreversed image in a pentaprism viewfinder

1955: Edward Steichen curates Family of Man exhibit at New York's Museum of Modern Art

1957: First Asahi Pentax SLR introduced.

1959: Nikon F introduced.

1959: AGFA introduces the first fully automatic camera, the Optima.

1960: Garry Winogrand begins photographing women on the streets of New York City.

1963: first color instant film developed by Polaroid; Instamatic released by Kodak; first purpose-built underwater introduced, the Nikonos

1972: 110-format cameras introduced by Kodak with a 13x17mm frame

1973: C-41 color negative process introduced, replacing C-22

1973: Fairchild Semiconductor releases the first large image forming CCD chip: 100x100pixels

1975: Nicholas Nixon takes his first annual photograph of his wife and her sisters: "The Brown Sisters"

1977: Cindy Sherman begins work on Untitled Film Stills, completed in 1980

1980: Elsa Dorfman begins making portraits with the 20x24" Polaroid

1982: Sony demonstrates Mavica "still video" camera

1983: Kodak introduces disk camera, using an 8x11mm frame (the same as in the Minox spy camera)

1985: Minolta markets the world's first autofocus SLR system (called "Maxxum" in the US)

1986: Kodak scientists invent the world's first megapixel sensor

1992: JPEG filetype released.