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Dark Rooms and Magic Mirrors

The camera obscura, or how to capture the sun

In a room dimly lit by candles, a group of nobles, burghers, and common people take their places on some benches. The candles are blown out: all is blackness. Bright illuminated images, coloured and moving, flash onto a white sheet secured to the wall. A scene appears; the people murmur to each other, some recognizing the village, the town, and the horses which they recently left to come into this darkened room. They exclaim at the faithfulness of the image, at the movement of the little shadows, at the amazing perspective so coveted by painters. A dancing devil appears, sending terror through the room. A few wise souls, initiated into the mystery of the camera obscura, are amused by the fear which grips their credulous neighbours, who are already reaching for their purses to buy the indulgence of the magician.

A dark room, with an audience gazing at a white screen and awaiting the arrival of a moving illuminated image. If we imagine ourselves to be at any point between the thirteenth and seventeenth centuries, what a scene of anticipation this is! If we could film the changes in costumes, the increasing size of the room, the appearance of a large projector behind the audience, we would see in a few minutes—like a time-lapse film of a flower blooming—the progress of a long wait which lasted over half a millennium. The only devices our ancestors could use to entertain and frighten themselves with optical visions borrowed from everyday life or from the fantasies of the mind, at least until the arrival of the magic lantern in the seventeenth century, were a dark room ('camera obscura', in Latin) and some complicated tricks with mirrors.

The principle of the camera obscura is simple: if a small aperture is pierced in the wall or window shutter of a fully darkened room, the scene

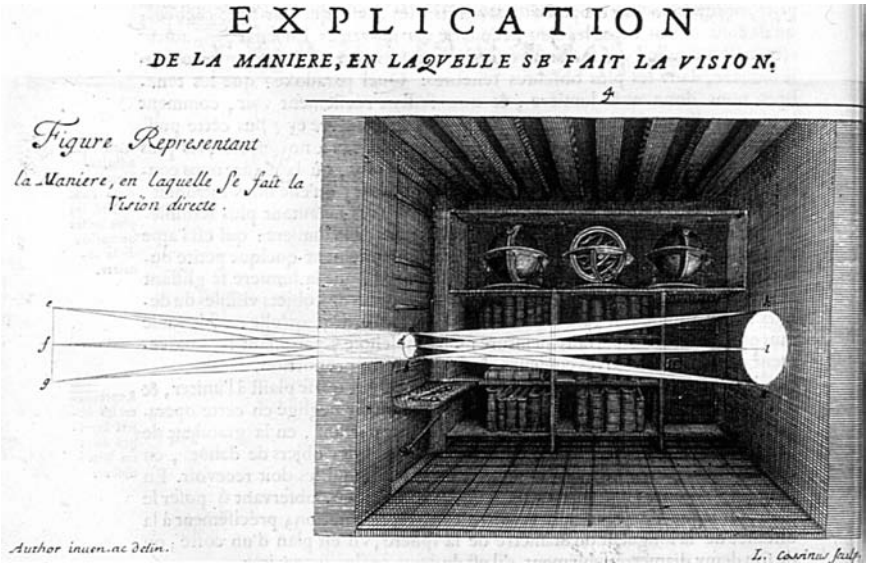

Fig. 1. Chérubin d'Orléans, *La Dioptrique Oculaire* (Paris, 1671). Collection: Bibliothèque Nationale.

outside (or any other exterior object) will be projected into the interior of the room, on the wall opposite to the aperture. A screen formed by a piece of paper or a white sheet improves the image. If this screen is close to the aperture, the image is reduced in size but very sharp; if further away the image is larger, but also more blurred and less colourful. Either way, it is projected upside down, since the light rays from the highest and lowest points of the exterior scene, travelling in straight lines, cross as they pass through the aperture. The result is a double inversion of the image, both top to bottom and left to right. Leonardo da Vinci, in the sixteenth century, and the astronomer Johannes Kepler in 1604, drew a clear analogy between the human eye and the camera obscura. Our crystalline lens takes the place of the aperture, while the retina which lines the back wall of the eyeball is comparable to the screen mounted on the wall opposite the aperture (see Fig. 1).

The phenomenon of projection of light rays has been known since antiquity. The Greek philosopher Aristotle (384–322 BC), among others, observed the passage of a beam of light through some kind of opening. He did not specify if this experiment was conducted in a dark room, and made no mention of the images which may have been visible. Aristotle remarked only that the projection of the sun's rays through a

square, round or triangular aperture always produces a circular image. He could not explain this fact rationally. It was not until the seventeenth century that Francesco Maurolico, of Messina in Sicily, finally shed some light on this optical problem: compared to the size of the sun, the small aperture which Aristotle used was effectively a single point.[1] The light rays passing through that point took the form of a cone of light, with the aperture at its summit and the sun at its base. As they left the other side of the aperture the rays spread to form a second, smaller, cone of light. This problem greatly intrigued the scholars of the early middle ages, as manuscripts from that period demonstrate.

Without awaiting the theoretical explanation of the phenomenon, several thirteenth-century astronomers and opticians created the true camera obscura, which captured images from the exterior inside a darkened room. The English friar Roger Bacon (1214–94) recounted Aristotle's experiment, without crediting him, in his work *De Multiplicatione Specerium*[2] (*On the Multiplication of Species*) written in 1267, but he added one important element: the presence of a screen, a wall (*paries*) onto which the light rays were projected. Like his predecessors, Bacon noted that the opening through which the light rays passed did not need to be circular. This phenomenon was the basis of his theory, astonishing in its intuition, that light propagated by means of spherical waves. If the image projected through a square aperture was circular, it was simply because the light had resumed its natural spherical shape.

Roger Bacon is credited with an anonymous manuscript from the thirteenth century, found among the Latin holdings of the Bibliothèque Nationale in Paris, which contains the first known description of an eclipse viewed in the camera obscura:

> One day when the sun is in eclipse, would you desire to observe the whole eclipse, to know its starting point, its extent and duration, without damaging your eyes? Observe the passage of the sun's rays through any round hole, and watch with care the illuminated circle which the rays form on the surface onto which they fall . . .[3]

Even if this now seems obvious, this text does not state whether this marvellous experiment was conducted in a camera obscura. However, a contemporary and follower of Bacon, the English Franciscan monk John Pecham or Peckham (1228–91) of Canterbury, in a treatise on optics entitled *Perspectiva Communis*, did specify that the solar rays of the eclipse should be captured 'through any kind of aperture in a dark place'.

The camera obscura of the thirteenth century does not only appear to have been used for viewing eclipses. It allowed astronomers to avoid direct observation of the sun, which was dangerous for the eyes. The French scientist Guillaume de Saint-Cloud viewed an eclipse on 5 June 1285 without taking any optical precautions, and suffered a violent dazzling which lasted for several days. Wherever he looked, even with his eyelids closed, he saw a persistent bright disc. To observe the sun in safety, Saint-Cloud thereafter used the camera obscura, this time described quite explicitly:

> Make a hole in the roof or the window of a closed house, directed towards that part of the sky where the eclipse will appear, of about the same size as the tap hole in a wine barrel. As the light of the sun enters by this hole, place at a distance of about twenty or thirty feet from the hole a flat object, for example a board, and you will see that the light rays form a circular image on the board even if the hole is angular.[4]

The spectacle of everyday life

In Andrey Tarkovsky's 1966 film *Andrey Roublev*, set in fifteenth-century Russia, a character watches with surprise as an illuminated image forms on a blank wall in front of him. It represents a group of moving horsemen, but they are seen upside down. Tarkovsky then shows the closed shutters of the room: a small opening has allowed a shaft of light through to project the image onto the wall.

Although we know that scientists from the thirteenth century onwards observed the sun in a darkened room, we do not know if they sought at the same time to capture the outside world, whether that might be the road or countryside surrounding them, or the threatening horsemen bearing down upon them. 'What takes place in the street when the sun shines,[5] as the Italian Gerolamo Cardano would later describe it, did not appear on the screen of the camera obscura until the start of the sixteenth century.

The use of the camera obscura for viewing exterior objects, and not just for astronomical studies, appears to have been mentioned first in the writings of Leonardo da Vinci (1452–1519). Da Vinci did not, however, abandon Bacon's earlier use of it as a method of studying the sun without burning his eyes; he hoped to use the rays entering the aperture of the camera obscura to calculate the precise distance of the sun from the Earth. Without giving further details, he discussed 'illuminated objects'

whose images 'penetrate through some small hole into a very dark habitation'. A sheet of white paper served as the screen:

> These images if they proceed from a place that is lit by the sun will actually seem painted upon this paper, which should be very thin and seen in reverse; and the said hole should be made in a very thin sheet of iron.[6]

To view the image by transparency from the reverse side of the screen was ingenious: in that way the true orientation of the image, laterally inverted at the aperture by the intersection of the light rays, was restored. But the scene or objects were still always projected upside down.

The first published graphical representation of projection of the sun through an aperture into a dark place is found in *De Radio Astronomico et Geometrico* ('On Astronomical and Geometrical Rays'), by the Dutch mathematician Reinerus Gemma-Frisius, published in 1545. On 24 January 1544 he observed a solar eclipse at Louvain from the safety of his camera obscura.

The principle and construction of the camera obscura did not change from the thirteenth century to the start of the sixteenth: the only variation was whether the aperture was formed in a wall or in a shutter. But between 1521 and 1550 an important modification was introduced: a biconvex lens (with both its surfaces rounded outwardly) was placed in the aperture, which greatly improved the quality of the image by concentrating the light rays. It was another Italian, Gerolamo Cardano, who disclosed this improvement in his book *De Subtilitate* ('On Subtleties'), printed at Nuremberg in 1550. From this time on, scenes in the street outside formed part of the repertoire of the camera obscura:

> If it pleases you to view what takes place in the street when the sun shines, place a disc of glass in the window and, the window being closed, you will see images projected through the opening onto the wall opposite; but the colours will be dull. Therefore place a very white sheet of paper at the place onto which the images are projected.[7]

The glass disc (*orbem e vitro*) might be assumed to be a biconvex lens. A French translation of *De Subtilitate* published in Paris in 1556 went so far as to use the description 'a round body made of glass' (*la rotondité faicte du verre*).

In the eighteenth and nineteenth centuries the camera obscura was deprived of a great portion of its history by the erroneous attribution of its invention to the sixteenth-century Italian scientist Giovanni Battista della Porta (1540–1615). In fact, della Porta merely published a description of it, in a four-part book entitled *Magiae Naturalis* ('Natural Magic'), printed in Naples in 1558. This mistaken paternity is found repeated in supposedly authoritative works, such as the *Leçons de Physique* of Abbé Nollet (1743) and the *Encyclopédie* of Diderot and d'Alembert (1753), among other sources.

Della Porta's book certainly enjoyed an immediate success. Republished several times, by the end of the seventeenth century it had been translated from its original Latin into Italian, English, German, and French. Hurriedly printed popular editions circulated in France at this period. This probably explains why the earlier works by Gemma-Frisius and Cardano came to be forgotten, particularly since della Porta carefully avoided referring to them.

Della Porta demonstrated quite an inclination for the marvellous. *Magiae Naturalis* is full of horrifying and repugnant recipes for 'creating a Mandragora', making a woman talk in her sleep, or transforming men into animals; we also learn the causes of the repulsion of an elephant when confronted with a sow, or the terror of the lion when it hears the crowing of a cockerel. It is hardly surprising that della Porta was accused of sorcery by Pope Paul V. He also indulged himself by issuing prophecies, some of which, by misfortune, came true.

Della Porta described the camera obscura in detail in the fourth book of the 1558 edition of *Magiae Naturalis*, which dealt with 'catoptric experiments' ('catoptrics' is the science of optical effects by reflection, especially at mirrors, as opposed to 'dioptrics', which deals with refraction effects, particularly through lenses). In the same account, without identifying it as such, della Porta noted the phenomenon of retinal persistence of vision. He advised the adjustment of the eyes to complete darkness—'you must stay a while, for the Images will not be seen presently'—before looking at the projected image:

> For when men walk in the Sun, if they come into the dark, that affection continues, that we can see nothing, or very scantly; because the affection made by the light, is still in our eyes; and when that is gone by degrees, we see clearly in dark places.[8]

A new edition of della Porta's text was published in Naples in 1589, this time in twenty sections rather than four. This edition presented a

genuine innovation, in the idea of organizing a true optical show by means of the camera obscura.

> How in a Chamber you may see Hunting, Battles of Enemies, and other delusions.
>
> Now for a conclusion I will add that, than which nothing can be more pleasant for great men, and Scholars, and ingenious persons to behold; That in a dark Chamber by white sheets objected, one may see as clearly and perspicuously, as if they were before his eyes, Huntings, Banquets, Armies of Enemies, Plays, and all things else that one desireth. Let there be over against that Chamber, where you desire to represent these things, some spacious Plain, where the Sun can freely shine: Upon that you shall set Trees in Order, also Woods, Mountains, Rivers, and Animals, that are really so, or made by Art, of Wood, or some other matter. You must frame little children in them, as we use to bring them in when Comedies are Acted: and you must counterfeit Stags, Bores, Rhinocerets, Elephants, Lions, and what other creatures you please: Then by degrees they must appear, as coming out of their dens, upon the Plain: The Hunter he must come with his hunting Pole, Nets, Arrows, and other necessaries, that may represent hunting: Let there be Horns, Cornets, Trumpets sounded: those that are in the Chamber shall see Trees, Animals, Hunters Faces, and all the rest so plainly, that they cannot tell whether they be true or delusions. Swords drawn will glitter in at the hole, that they will make people almost afraid. I have often shewed this kind of Spectacle to my friends, who much admired it, and took pleasure to see such a deceit; and I could hardly by natural reasons, and reasons from the Opticks remove them from their opinion, when I had discovered the secret.[9]

Della Porta's show foreshadowed the magic lantern projections of the following century. But comparing them from a present-day viewpoint, the Italian's camera obscura appears almost superior to the lantern, whose hand-painted glass slides could not offer the complete illusion of this scenic device. Della Porta's images, projected into the room by the crystal lenses and the mirror used since 1558, showed real actors, who moved in front of scenery to the sound of accompanying music.

However, the camera obscura could offer nothing more than an ephemeral spectacle: at nightfall, its images vanished. Della Porta's productions must also have been very costly and difficult to assemble. The sun had to be out to illuminate the scene, and the scene had to remain within the field of view of the lens. The process was not perfect,

but it did speed up research into more effective ways of obtaining illuminated moving images. Thanks to della Porta the camera obscura, suddenly diverted from its scientific vocation, became a 'théâtre optique', a method of illumination capable of projecting stories, enacted scenes and fantastic visions. It left the domain of science and astronomy to enter those of artifice, play-acting, the marvellous, and illusion.

After the appearance of *Magiae Naturalis*, the science of optics became one of the favourite recreations of the nobility and of scholars, and one of the most desirable accessories for acrobats and conjurers. For the 'commoners' of the sixteenth century who had not read della Porta, the sudden projection of a devil or wild animals onto the screen of the camera obscura would remain, for some time, a phenomenon which was inexplicable and therefore supernatural. A new resource was opened up for quacks and tricksters. Not long after the book's publication it was possible for an individual initiated into its mystery to profit from the more or less general ignorance of the world at large in optical matters, presenting shows of magic and sorcery whose sole 'device' was the camera obscura, and whose sole aim was to extort money from the gullible spectators.

The Belgian Jesuit François d'Aguillon (1566–1617) was one of the first to denounce this new form of quackery. In 1613, at Anvers, he published a magnificent folio volume dealing entirely with optics, perspective, and geometrical and stereographic projection: *Opticorum Libri VI* ('The Sixth Book of Optics'). D'Aguillon had attended one of these quack shows. The process of projection he described was the same as della Porta's, except that the image was presented upside down, without the use of a mirror. There was no music: the quack preferred complete silence, which was even more distressing, to accompany his trickery.

> The method by which certain tricksters attempt to take advantage of unknowing people: they pretend that they know Sorcery, while they know little of what that means; they boast of making the ghosts of the devil appear from Hell itself and show them to the spectators. They bring curious and interested persons, who wish to know everything on dark and secret subjects, into a dark room [*obscurum conclave*] where there is no light, excepting a narrow shaft which passes through a small piece of glass [the lens]. They then tell them in a severe tone to make no sound and remain calm. When all is complete silence and no person moves or utters a word, as if they were attending a religious service or a vision, they announce that the devil will shortly arrive. At the same moment, an assistant puts on a

> devil mask, such that he resembles the images of demons which one is used to see, with a hideous and monstrous face and horns on the forehead, a tail, and a wolf's skin with claws at hands and feet. The assistant struts to and fro outside, as if he were sunk deep in thought, in a place in which his colours and shape may be reflected through the glass into the chamber. In order that these cunning inventions produce a greater effect, all must remain in silence as if a god were about to emerge from this device. Some persons begin to turn pale, while others, terrified of what is to come, begin to perspire. After this, they take a sheet of paper and hold it in front of the ray of light which has been allowed to enter the chamber. One may see on it the image of the imitation of the devil coming and going; the people watch this, trembling. The poor people and the inexperienced do not know that they are only watching the shadow of a trickster; they waste their money quite uselessly.[10]

The quack projectionist played upon the realism of the show, and his phantasmagorical apparitions produced their effect perfectly. Only the learned such as d'Aguillon or Nicéron remained calm. The Parisian Jean-François Nicéron (1613–46), a member of the monastic Order of Minimes, looked coldly on this witches' sabbath. Nicéron was an expert in optics and anamorphoses (distorted images which would reveal their 'secret' from particular viewpoints or by particular methods). He was famous in his lifetime for his transformation paintings which appeared in the galleries below the cloisters of the Paris monastery of the Minimes, in Place Royale. As one approached his 'optical wonders, the main subject disappeared, and one could only perceive a landscape'.[11] He was therefore well placed to denounce the spectacles of sorcery in the camera obscura:

> This type of delightful Perspective has sometimes so deceived the eye that those who are in the chamber and who, after having parted with their purse, watch it completely in the hands of those who are counting and dividing their money in a wood or on a floor, believe that this representation takes place by magic . . . If there should be someone concealed behind the screen who plays the spirit, as they say, to speak like those who make the marionettes dance, the simpletons believe that it is the persons in the picture who are speaking, since they see them open their mouths and move their lips: and as soon as the window is opened, the whole scene disappears, just as one invokes the sabbath where one wishes the sorcerers to attend . . . Those who possess a place in the fields may have this sort of Perspective at little expense; and if one wishes to

> view the images, which appear reversed, the right way up, there are several methods for righting them, such as by means of convex lenses or by a mirror, and even to enlarge them to make them appear as in life, as I have seen done by Monsieur Le Brun, General of La Monnoye.[12]

The 'Perspectives' which Nicéron described presented a complete spectacle: a human image, in colour and moving, synchronized with the offstage voice of an actor. In spite of this technical achievement, the quacks and tumblers rapidly abandoned the camera obscura, because of the complexity of its productions and the intense light which was needed to illuminate the external subject. They soon found another agent for the spreading of superstition, the magic lantern. Meanwhile the principle of the camera obscura was taken up by some of the greatest scientists of the seventeenth century, such as René Descartes (1596–1650), whose *Dioptrique* ('Dioptrics'), published in 1637, contains a precise description of the camera obscura. After that the secret, of which della Porta had offered a glimpse, was completely unveiled. Rationalism imposed itself and the showmen's source of revenue dried up.

If scholars condemned the diabolical visions produced by the camera obscura when it was manipulated by unscrupulous 'directors', they approved and recommended without reservation the beauty and charm of its illuminated views when they represented, for example, exterior landscapes. The miraculous aspect was that the pictures moved. It was therefore necessary to capture 'some square, or busy street, or some beautiful building, or blossoming flower-bed, to have greater pleasure', according to the French Jesuit Jean Leurechon (1591–1670), for whom the camera obscura was 'one of the most beautiful experiments in Optics':

> Above all, there is pleasure in seeing the *movement* of birds, men and other animals, and the shaking of the plants in the wind . . . This beautiful painting, in addition to its being disposed in perspective, innocently represents that which the painter has never been able to place in his picture, namely *continuous movement* from place to place.[13]

Nicéron was equally struck by this 'continuous movement' (a phrase which might apply just as neatly to the whole progress of pre-cinematographic research): 'the outdoor objects convey not only their sizes, shapes and colours, but also their movements, which are always missing

from the artists' paintings.'[14] The ideas of Leurechon and Nicéron curiously foreshadowed the nineteenth-century aesthetic controversy which set painting and photography against each other, photography being 'plagiarism of nature by optics' according to the French poet Alphonse de Lamartine (1790–1869), whose attacks on 'daguerreotypomania' also, indirectly, attacked the camera obscura. In Nicéron's time, some painters began to use the camera obscura to create their paintings with absolute precision: this amused Nicéron, who observed quite correctly that the artists were tracing 'a static picture taken from a moving one'.

The camera obscura, which gave a spectacle which was 'so delightful, and which suggested enchantment', which made 'little ghosts'[15] appear, remained a widely practised entertainment throughout the seventeenth century. Around 1630 a camera obscura opened to the public in Paris. It was situated at the Samaritaine, a fountain of huge dimensions constructed in 1603 on piles close to the second arch of the Pont-Neuf, on the Louvre bank of the Seine. Unfortunately it was demolished during the nineteenth century. From this position, the camera obscura captured a view of the Louvre, the sky and the birds, the Seine, and all the activity on the bridge: a glorious spectacle open to everyone.

Meanwhile, scientists had managed to multiply the spectacular powers of the camera obscura. In 1642 Mario Bettini, an Italian Jesuit, published the following instructions: if one pierced twelve holes through the wall or shutter and placed an armed warrior outside the chamber, a small army of twelve men, all following exactly the same movements, would appear projected onto the white sheet of the screen. To make the image appear the right way up, Bettini used a large powerful plano-convex (hemispherical) lens on a stand, placed in front of the aperture inside the chamber. The lens concentrated the incoming light rays towards another similar lens; between the two, the light rays crossed over again, and the image projected from the second lens appeared on the sheet (see Fig. 2).[16]

Technical improvements to the camera obscura

More refined applications of the camera obscura developed very quickly. Around 1611 the German astronomer Johannes Kepler (1571–1630) made a 'small portable tent' which could be put up anywhere, in the open countryside or in the street. Its lens turned 'like a windmill, which could view all the points of the horizon in turn'.[17] The images were captured on a sheet of paper laid flat inside the tent, and could be traced onto the

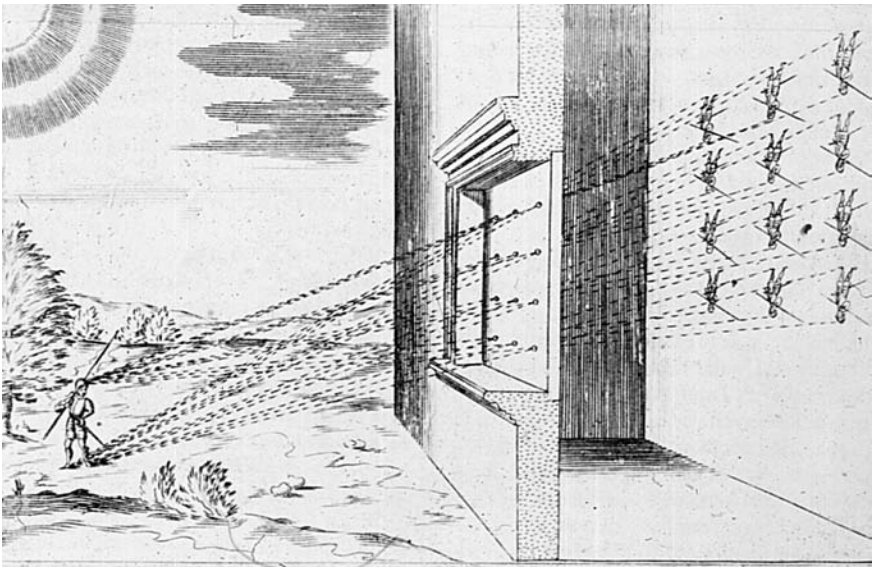

Fig. 2. Mario Bettini, *Apiaria Universae Philosophiae Mathematicae* (1642). Collection: Bibliothèque Nationale.

sheet to form a drawn image of the scene. When the drawing was finished, 'one turns the tent slightly, one takes a new view of the landscape and one can again draw the whole horizon'. This highly practical system was repeated by the French optician Vincent Chevalier in 1823.[18] The great German writer Johann Wolfgang von Goethe (1749–1832) owned a camera obscura of this type, preserved today at the National Goethe Museum in Weimar, in which the canvas tent was replaced by four wooden panels mounted on four feet. One side of the chamber could be opened, to allow the user into the chamber to draw the landscapes captured by a lens located at the top of the device.

Nicéron, meanwhile, transformed the camera obscura into 'a form of portfolio'.[19] At the start of the eighteenth century, some craftsmen and opticians made camera obscuras in the shape of books, much sought by optical enthusiasts. One example preserved today in a private collection has the appearance of an enormous folio, bound completely in calfskin. On the gold-blocked spine, the title consists of the single word *Optique*. The 'book' is completely hollow, containing a mirror and three small sheets of wood decorated with hand-painted flowers and arabesques, which may be assembled together with the book cover to form a box. On the top is placed the mirror, which reflects all external landscapes and

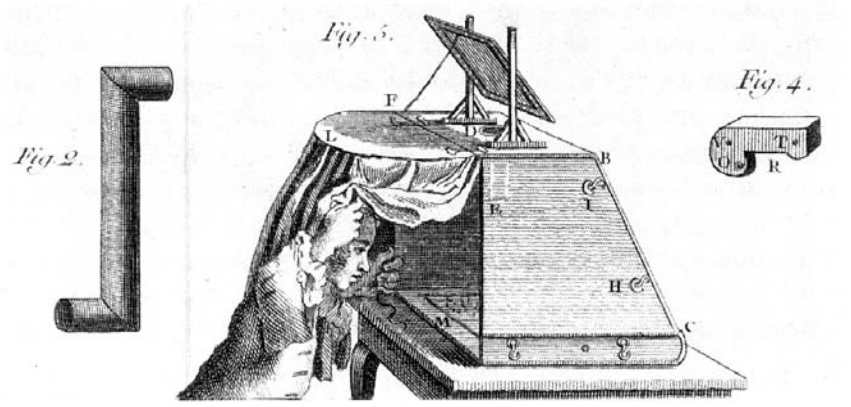

Fig. 3. Camera obscura, after van s'Gravesande.
Collection: Bibliothèque Nationale.

views through a small aperture into the interior of the box.[20] The greatest refinement of this example is that it also functions as a *boîte d'optique* or peepshow box (see Chapter 4): with a biconvex lens placed on the flat portion of the binding it can be used to view engraved perspective views or *vues d'optique*.

The German Daniel Schwendter, in his book *Deliciae Physico-Mathematicae* ('Scientific and Mathematical Delights') printed at Nuremberg in 1636, gave a drawing of another type of camera obscura, known as the 'oeil artificiel' (artificial eye) in France and the 'scioptric ball' in Britain. A wooden ball was placed in the aperture of the camera obscura, so as to be pivotable within a fixed frame. The ball was pierced on opposite sides by a pair of holes, into which lenses were fitted. This ingenious system allowed exploration of the complete exterior landscape, since the 'eye' could be moved from left to right and top to bottom. In France, the Capuchin monk Chérubin d'Orléans (1613–97) described this method in 1671, adding a long tube of strong wood about a metre in length to the 'eye'. This tube would project onto a screen the 'eclipses and spots of the sun'.[21] Chérubin named his equipment the *Oculaire Dioptrique* ('Dioptric eyepiece').

In his book *Ars Magna Lucis et Umbrae* ('The Great Art of Light and Shadow') of 1646, the German Jesuit Athanasius Kircher also presented several quite complex new designs of camera obscura. Some of these methods using engraved mirrors will be described later. While this individual makes his appearance here quite discreetly—we will meet him again soon—in fact he played a major role, simultaneously genius,

charlatan, and clown, in all the optical developments of the seventeenth century, even after the importance with which he credited himself has been reduced to its real dimensions. Kircher described one large camera obscura intended for landscape painters, which was located in the open air. Inside, he stretched a wall of papyrus. The painter had only to enter the chamber to be able to copy the whole exterior landscape onto the paper.[22] Kircher's camera obscura was, he claimed, portable, even though its dimensions would not have made mobility an easy proposition.

In the end, around 1670, it was the Bavarian mathematician Johann Christoph Sturm (1635–1703) who invented the simplest and most manageable camera obscura, which was very quickly adopted across the whole of Europe. He explained the construction of his 'portable camera obscura' (*camera obscura portatilis*) in *Collegium Experimentale Sive Curiosum* ('Gathering of the Experimental and Curious'), published at Nuremberg in 1676 (see Fig. 4). Sturm also used a 'wooden eye, which can turn and direct itself in all directions', and placed it at the front of a

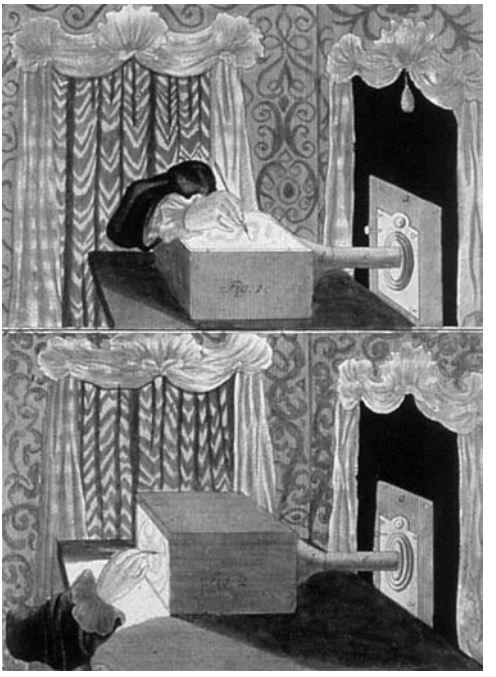

Fig. 4. Two camera obscuras, after Johann Sturm. Illustrated in Martin Frobene Ledermuller, *Amusements Microscopiques* (1768). Collection: Bibliothèque Nationale.

box of strong paper, formed of two pieces arranged one inside the other 'in order to extend or shorten the length of the chamber according to need'. Daguerre's daguerreotype camera of 1839 would be constructed on nearly the same principle, as we shall see later. Sturm then placed an inclined mirror in the movable portion of the chamber:

> Above this mirror I place a thin transparent paper soaked in oil, and I also place above it another box so that the oiled paper is enclosed in darkness, when the observer places his head in the opening to view the objects which present themselves on the paper. This dioptric and catoptric machine is then placed in front of an open window, such that the face of the objective lens is directed towards the street. All objects in the street will be presented first to the objective lens, which throws them upwardly onto the oiled paper; which represents the best-known and most realistic paintings, in that one can recognize and perfectly distinguish the faces and clothes of the people passing more than a hundred feet away.[23]

These improvements brought a very distant possibility onto the horizon: if the objective lens could be improved, and the oiled paper could be replaced with a plate sensitized with a chemical agent, we might obtain a photograph. The dream of fixing the fleeting images of the camera obscura, other than by painting, would not become a reality until the start of the nineteenth century.

For the moment, the camera obscura of the seventeenth century could be found in all the great 'cabinets of curiosities' of the period. A fashion which lasted for many centuries, the cabinet of curiosities presented rarities of nature (precious stones, foetuses, stuffed animals), scientific and optical instruments, ancient coins, engravings of the great masters, in short anything and everything which could arouse 'curiosity', inside a room or a large piece of furniture. They were also, after a fashion, pre-cinematographic museums: as well as the camera obscura, they might contain lenses, prisms, anamorphoses, picture discs, and all types of 'mirrors of pleasure' or magic mirrors, whose projections rivalled those of the camera obscura.

Magic mirrors

From its birth, the camera obscura had a poor cousin of more complex character, which followed its own independent development, enlivened by occasional encounters with its parent, the mirror. By its nature, the

magic mirror could never equal the realism and precision of the camera obscura. However it did have a certain mystery, and the human being has always been fascinated by the reflection of its own image, especially when that *alter ego* is deformed by subtle variations.

Magic mirrors, enchanted mirrors, mirrors of pleasure, deceptive mirrors, coloured mirrors, mirrors of sorcery, concave, convex, multi-faceted mirrors, catoptric theatres, and catoptric boxes: there was a huge range of strange methods of transforming real vision into 'aberration'. From the point of view of pre-cinematographic history, the methods mentioned here were the most important systems of projection, apparition, and animation using mirrors. For a discussion of other related media of the time, see Jurgis Baltrušaitis' remarkable book *Le Miroir* on the 'revelations and fallacies' of catoptrics.[24]

The thirteenth-century evangelist of the camera obscura, Roger Bacon, took up the subject of mirrors in his work *De Mirabili Potestate Artis et Naturae* ('On the Marvellous Power of Art and Nature'), written to clear himself of the accusation of sorcery which his superiors brought against him in front of Pope Nicholas III. Bacon, as a good Christian, did not deny the existence of magic, since the Church implicitly recognized and admitted the presence of demons. But he maintained that Art and Science combined gave results just as marvellous, when practised by learned minds, as the satanic forces manipulated by those who practised 'goety' (from the Greek *goeteia*, sorcery). His testimony proves that by the thirteenth century, the science of mirrors was quite well advanced. With 'special devices', wrote Bacon, one could take advantage of 'the common herd with wonders which in reality did not exist'. He suggested the possibilities of catoptrics, while remaining rather coy about the 'devices' to which he referred:

> One may construct devices and mirrors such that they produce a multiple appearance, and a man may resemble an army, such that one may make appear several suns or several moons . . . One can cause great terror in an enemy town by making multitudes of stars or men appear above it, such that its inhabitants scatter in terror. One may also construct devices in which bodies appear so that the largest appear small and vice versa, or those which are high appear low, or invisible objects are made manifest.[25]

In the footsteps of philosopher-scientists such as Euclid, Ptolemy, and Witelo (or Witek, of the thirteenth century) it was once again the Italian scientist della Porta who proved to be the most communicative and

imaginative on the creation of apparitions using mirrors. His aim was to inspire fear in his visitors using deforming or coloured mirrors, or to catch them unawares with unexpected projections. Della Porta was also the author of *De Humana Physiognomonia* in 1586, a work which foreshadowed the eighteenth-century work of the 'physiognomist' Johann Casper Lavater (1741–1801). This described mirrors which stretched or shortened faces, made men older or younger, twisted them and made them ugly, or gave them the heads of donkeys, the beaks of cranes, the snouts of pigs (the formulae for these effects appeared in *Magiae Naturalis* in 1558 and 1588), all of which were an inspiration to this seeker of morphological similarities between humans and animals.

Della Porta claimed that he succeeded in creating an 'image hanging in the air' with the aid of a mirror. In the centre of a darkened room, he set up an inclined mirror on the floor. An aperture was formed in the opposite wall, in the shape of a truncated pyramid with the narrower end pointing towards the mirror. In this pyramidal aperture an image painted on a slightly transparent paper sheet could be placed. The mirror caught the image (lit from behind by the sun or an artificial light source) and reflected it onto the ceiling or a wall. In this way

> the Picture placed without, which your eye cannot see through the hole, may seem to hang pendulous in the Air; which will cause admiration to behold.[26]

This system was repeated by Jean Leurechon in 1621, who also discussed distorting mirrors, 'which show on one side a death's head and on the other a beautiful face'. Nicéron, too, made transforming mirrors, with prismatic sections cut out, which presented secret images such as political or religious anagrams.

Unusual projections were (and still are) also created by Japanese and Chinese 'magic mirrors', which are apparently very ancient in their origins. These are mirrors of cast copper or bronze; on one of their two surfaces relief designs are engraved representing flowers, animals, monsters, or lettering. The other surface, which is highly polished and slightly convex, is formed of an alloy of tin. When this polished surface is presented to the sun, it reflects a large amount of light, and the designs which appear on the reverse, non-illuminated, surface can be seen projected onto a white sheet or screen. This phenomenon may be due to very slight convex, concave, and flattened areas in the polished surface caused by the engraving of the decorated reverse surface, although there is little convincing work in the west on these curious devices.

Enter Kircher

In the middle of the seventeenth century, just as the science of catoptric and dioptric magic appeared to be making no progress, it was set back on the road by Athanasius Kircher, a man of irrepressible imagination. He succeeded in combining the two techniques of projection: the camera obscura and mirrors. He created some quite elaborate optical systems and displays of illuminated images, which however always remained completely dependent on the presence of sunlight.

Kircher was born on 2 May 1602 in the village of Geisa, near Fulda in Germany. In 1620 he entered the Society of Jesus. At this time, Germany was torn by religious and political conflict: the Thirty Years War had begun in 1618. The young Jesuit had to flee to Münster, then to Heiligenstadt in Saxony, where he studied grammar, mathematics, Hebrew, and Syriac. One day he was asked to prepare a small entertainment in honour of the Archbishop Elector of Mainz; it was presumably on this occasion that Kircher's passion for optical illusion and scenic artifice revealed itself for the first time.

In 1631 the Swedish King Gustavus Adolphus invaded Franconia. Kircher took refuge in Avignon, at the Jesuit college, and installed a laboratory in the Tower of La Motte (which was demolished in the nineteenth century). Using assemblies of mirrors, he amused himself by capturing the rays of the sun and the moon. His second book, *Primitiae Gnomonicae Catoptricae* ('First Principles of Gnomonics and Catoptrics') dealing with experiments with mirrors, was published in Avignon in 1635. Three years later, Kircher gained the chair of mathematics at the College of Rome, then the centre of the Jesuit organization. In 1637 he travelled to Syracuse and attempted to repeat the experiment in which Archimedes claimed to have succeeded in using one or more mirrors to set fire to the Roman ships which were besieging the town. Kircher painstakingly recorded all his experiments, keeping in mind a future book dedicated to light and shadow.

'It is needless to state his name: his renown is known as far as the Antipodes.' This phrase, which accompanies the portrait of Kircher in a work by Giorgio di Sepi,[27] one of his pupils, was not an exaggeration. In this engraving Father Kircher, with white beard, bright eyes, and skullcap on his head, looks out at the reader with a malicious air. Kircher was a great collector of 'curiosities'. His museum is now dispersed throughout the whole of Europe, but in his own day it was housed in the gallery of the College of Rome. The French noblewoman Sophie of Hanover met Kircher in Rome in November 1664 and noted: 'He is a strong good

man. I have still not had the liberty to view his rarities, because it is necessary to ask the permission of the Pope.'[28] Kircher was also a prolific author: when he died in Rome, on 27 November 1680, he left forty-four books of his own composition, of which about twenty were folios, and some two thousand letters which are still unpublished today.

In 1644 he completed his book *Ars Magna Lucis et Umbrae*, a true monument in pre-cinema history. Kircher dedicated it to Archduke Ferdinand, the son of his protector Emperor Ferdinand III of Austria, who had granted him the privilege of publication at Vienna on 1 June 1644. Kircher's dedication is dated 1 November 1645. *Ars Magna* appeared in Rome in 1646, just after Innocent X had been named as the 234th Pope, although a few copies exist carrying the date 1645. With its 935 folio pages, thirty-six engraved plates, and over 500 drawings, Kircher's work is certainly one of the best optical compendia of the seventeenth century. All aspects of catoptrics and dioptrics are dealt with: light, shadow, illusions, colours, refraction, reflection, projection, distortion, mirrors, lenses, and so on. It also discusses astronomy: the sun, the stars, the moon, comets, and eclipses. Everything is explained in a learned tone, with greater or lesser degrees of success.

Like della Porta in 1558, Kircher dealt with 'natural magic': that is, the study of the numerous incomprehensible phenomena of nature. True 'black' and 'white' magic, like that of the 'Master Devil' and of Albertus Magnus, was vigorously condemned. Particularly in its second part, *Ars Magna* was also a scholarly compilation of the writings of Bacon, Cardano, della Porta, d'Aguillon, Bettini, and Schwendter. Kircher, whose imagination never seems to have stopped, accompanied this catalogue with some of his own inventions, for which he had to coin new names. A maelstrom of strange words sweeps the reader along: 'Sciagnomics' (the science of measuring shadow), 'Actinobilism' (the propagation of radiation), 'Echocamptics' (the propagation of echoes). 'Parastatic magic', presented in the tenth book, 'is nothing less than a closed science to those who know nothing of light and shadow.'[29] This secret science allowed illuminated images to be shown before a large number of spectators, using apparatus whose operation was often quite complex.

Among other achievements, Kircher claimed to have succeeded in making precious stones ('emeralds, pyrope, sapphires, amethysts') appear in the interior of a darkened room. After closing all the shutters, he opened a small rectangular hole through which the sun's rays entered. The rays passed through five crystal prisms arranged horizontally in a decorated wooden frame. The rays of the solar spectrum then passed

through six lenses with surface facets, placed in a circle around a seventh lens of the same diameter. The facets dispersed the coloured rays from the prisms into a thousand splinters, forming bright multicoloured patches on the wall and floor of the room.[30]

Kircher also invented a *lucerna artificiosa* ('artificial light') which created one illusion which he could not have foreseen: some of the most serious historians have been deceived into believing (some still to this day) that this was the invention of the magic lantern. In fact, it was a sort of 'wine barrel'[31] topped by a chimney, with a handle on the side. Inside was a burning candle, whose light was reflected from a parabolic mirror and concentrated by a biconvex lens. In this way, Kircher says, one would obtain

> a light so bright that in the night the letters of a book, even the smallest, can be seen as distinctly as if one used a telescope. Those

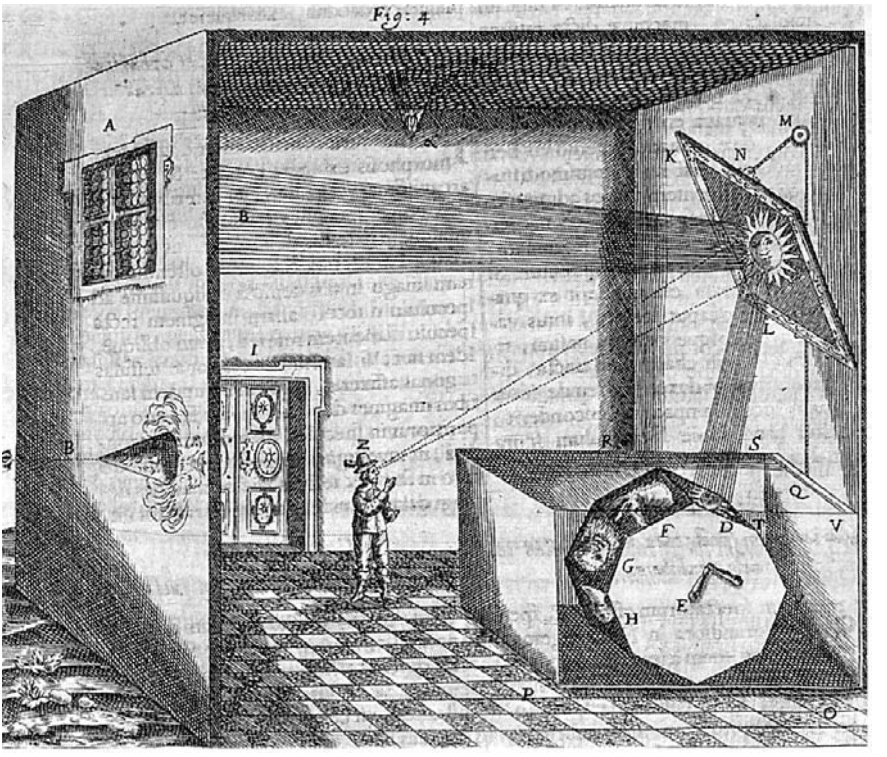

Fig. 5. Metamorphosis machine, illustrated in Athanasius Kircher, *Ars Magna Lucis et Umbrae* (1646). Collection: Bibliothèque Nationale.

> who see this flame from a great distance can take it to be a large fire.[32]

Kircher's *lucerna artificiosa* was nothing more than a simple projecting lamp. *Ars Magna* also contained a description of the 'catoptric theatre' which Kircher had designed: this consisted of a large box whose interior was covered with mirrors, in the centre of which a scene or figure could be placed to be multiplied many times by the mirrors.[33] Nicéron mentioned the existence of such a theatre in Rome in 1638; perhaps he was referring to Kircher's device. Nicéron also said that Hesselin, a counsellor and chamberlain of Louis XIII of France, possessed an example of the catoptric theatre:

> Is it not to become rich at no cost, at least in appearance, to see by the combination of many mirrors placed in a box to that effect, to see, I say, medals, pistols, pearls and precious stones multiplied to infinity?[34]

Kircher also described himself as the inventor of a metamorphosis machine, inspired by della Porta's distorting mirrors, although his installation was much more elaborate (see Fig. 5). Kircher's 'catoptric transformations' took place in a quite vast room. The guest who was taken into it would only see a mirror inclined towards him, high on the wall, lit from the front by the sun's light entering through a window. As he approached, the visitor would see himself in the mirror, but on his shoulders would be the head of an animal. Eight different animal heads could be made to appear in succession. To do this, Kircher had constructed a large octagonal wheel, on the sides of which he painted eight different images representing the heads of animals resting on a human neck. The wheel was hidden in a casing, open only at its upper side, with a handle on the side to rotate the eight-faced wheel. Each image was reflected by the mirror, illuminated through the window of the room. The inclination of the mirror could be controlled by a cord. 'It is certain that the head will appear sometimes as a cow, as a goat, as a bear, etc. All these will appear as though natural, but on a human neck.'[35]

What Kircher aspired to more than anything, it appears, was to astonish his followers by the almost universal nature of his knowledge. However, he did not want to pass himself off as a sorcerer, and denounced the quacks who used optics to take advantage of the credulous. Kircher's aim in revealing all these illuminated and shadowy optical tricks was partly to enlighten the general public. For him, the

methods of catoptrics were the domain of experimental science, and a practical way of teaching the laws of optics and light. The spectacular effects of mirrors made his object lessons on 'natural magic' all the more effective.

Kircher's 'new cryptology'

As well as his artificial light, multiplication of precious stones, catoptric theatre, and the octagonal wheel with its animal heads, Kircher gave performances based on projection, using concave mirrors onto which letters were engraved or biconvex lenses onto which he had painted images (see Fig. 6). He called his technique, which envisaged a secret language (or at least a language reserved for the use of the initiated), the 'new cryptology' or 'catoptric alphabet'. This consisted quite simply of an alphabet of inverted letters, which were reproduced at the end of his book. Outside a camera obscura, a mirror and a powerful biconvex lens were set up on a long shaft, with an image or inscription in inverted Roman, Greek or Hebrew characters painted or engraved on the mirror —*Pax vobis* ('Peace be with you'), in the illustrated example. The sun reflected off the mirror, whose painted or engraved image was transmitted, focussed by the lens, and projected onto a white sheet inside the camera obscura.[36]

This method was inspired by earlier work. In 1588 della Porta had given instructions for projecting letters with a mirror, and in 1621 the treatise *Steganographia* by Johannes Trithemius had appeared in Germany. This was a very comprehensive work, written in a deliberately obscure style, on secret, cryptographic, and magic writing. The German Daniel Schwendter, in 1638, also described a system of projecting shadows without a lens, which certainly provided Father Kircher with some inspiration:

> To project an inscription onto a wall by shadow, thanks to a mirror, with the sun: if I face the sun and wish to project a writing in front of me onto a place in shadow, for example the name of Paul V, I attach seven plane mirrors [corresponding to the seven letters of the name 'Paulus V'] next to each other on a plank, I cut out the letters from a thick paper like board, and I glue them one after the other onto the mirrors. And since I wish now that these letters will be represented on a wall in shadow, I place the plank with the mirrors facing the sun, such that the light will be reflected onto the chosen wall, and because the letters cover a part of the mirrors, that part is

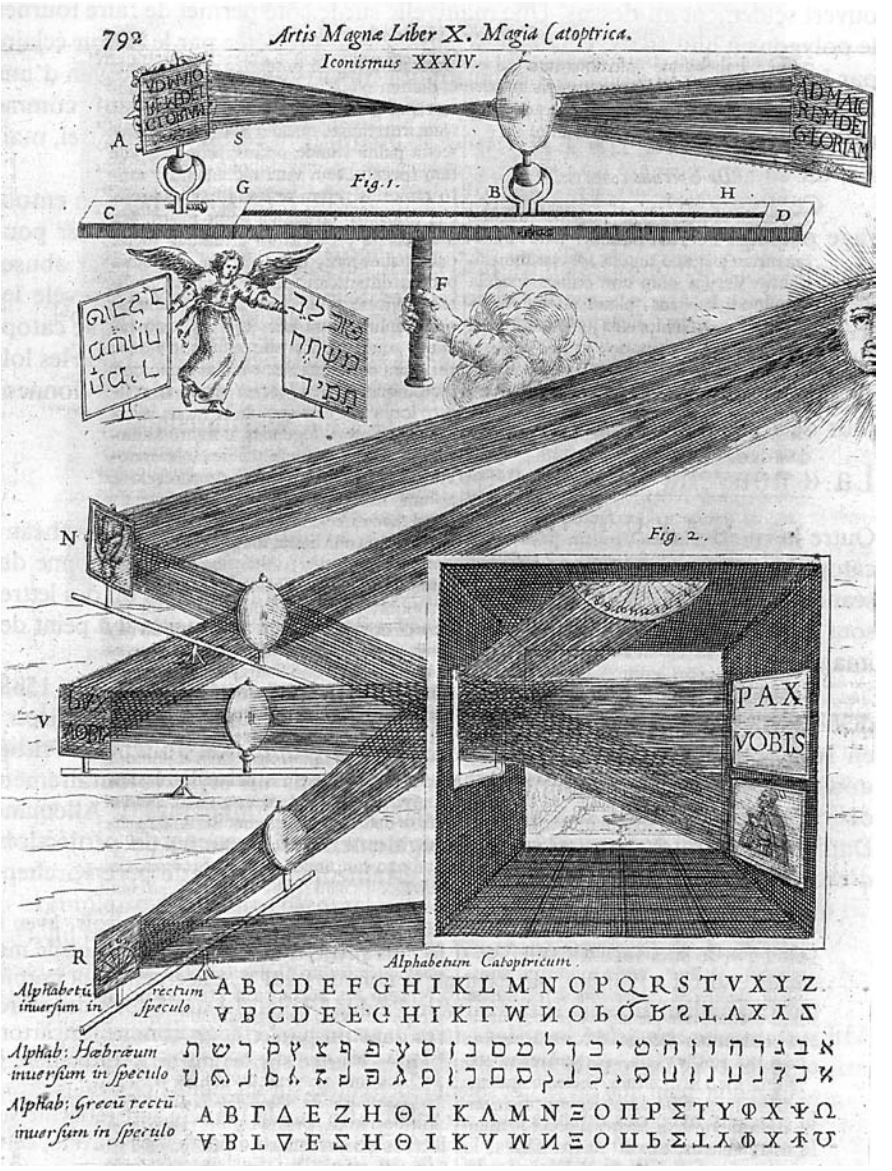

Fig. 6. Optical building for solar projection using engraved mirrors, illustrated in Athanasius Kircher, *Ars Magna Lucis et Umbrae* (1646). Collection: Bibliothèque Nationale.

> not illuminated on the wall; but the letters appear in shadows and are recognizable in the middle of the light.[37]

Kircher therefore simply recycled the system which Schwendter had described, adding a set of lenses to the mirrors. This was a great improvement, as one of Kircher's pupils, the German Gaspar Schott, explained:

> Nowhere in literature have I seen the writings of the *Artificium Steganographicum* presented more subtly than in the *Ars Magna Lucis et Umbrae*, where Kircher sets out the new catoptric cryptology, by means of which, thanks to the catoptric art, that is to say with the aid of mirrors, two friends separated by a great distance may write to each other secretly and speak to each other, express the hidden thoughts of their souls as if they were present . . . This invention, certainly, was known at a certain time previously, in the time of Pope Paul V . . . However Father Kircher has developed and perfected this invention . . . And now, they are many who make use of the precepts of Kircher to show marvellous things to great applause and admiration from the spectators.[38]

Schott also disclosed, unfortunately without going into any amount of detail, that another Jesuit, Andreas Tacquet (1612–60), a Belgian mathematician born at Anvers, had achieved distant projection with Kircher's catoptric process, probably at Louvain about 1653–4. It is possible that Tacquet used another method described by Mario Bettini[39] in 1642 and repeated by Kircher in 1646. In this process an image was painted directly onto a large powerful biconvex lens, illuminated by the sun; perhaps Tacquet even painted his images onto plates of glass, to place them at the focus of this lens. Whatever the case, this provides a good example of public performance with illuminated images, before the appearance of the true magic lantern:

> The most excellent mathematician of Louvain, Andreas Tacquet, of our Society, presented the whole journey from China to Belgium of Father Martin Martini. And I myself saw in Rome these things realised by the same device. This invention is completely admirable and very worthy of the curiosity of kings and the greatest princes . . . We call this art Catoptric or Catoptrographic Magic.[40]

The science of illuminated projections as it stood at the middle of the seventeenth century was simultaneously highly ingenious, very

complex, and extremely primitive. The human mind, following its natural inclination, sought to do better than these vague and fleeting images. It was in the course of the seventeenth century that the fundamentally important devices on which the development of the cinema would eventually rest were invented, replacing the older natural processes, which were limited by their very nature, with the mechanisms of science.

2

Light in the Darkness

The *lanterne vive*

The earlier stages of the ancestry of the cinematograph include the camera obscura, magic mirrors, and Kircher's 'cryptologic' projections. Mention of the name of Kircher, more wrongly than rightly, still tends to evoke the words 'magic lantern'. But before we come to that particular ancestor of our film projectors, we should pause in front of a simple light box, the modest pioneer of the great adventure which was to follow. This was the *lanterne vive* (literally 'bright lantern' or 'living lantern') of the Middle Ages.

The *lanterne vive* could only emit a coloured glow and did not allow true projection. A strip of translucent paper, on which were painted grotesque or devilish figures, was inserted into a cylinder of paper or decoratively pierced sheet metal. On top of the cylinder was placed a sort of propeller made of tin, which was free to rotate about an axis formed by an iron rod, and which secured the translucent drawing in place. A candle burned at the centre of the device. The heat given off by the candle caused the propeller to turn, rotating the painted strip so that the brightly coloured images travelled around the light at their centre. A viewer would see the pictures travelling round the cylinder, and projecting indistinct coloured images into the surroundings. If the cylinder was made of pierced metal, multi-coloured images could be made to dance on the surrounding walls. It was a rather limited effect, but did have a certain charm.

This small illuminated show remained very popular for a long time. In the sixteenth century, passers-by and children might stop, as night fell, in front of *lanternes vives* hanging like signs outside the shops of barbers, confectioners, and *oyers* (sellers of roast meats). The French poet

Mathurin Régnier (1573–1613), in one of his *Satires* written around 1608, wrote of an ancient Egyptian who

> . . . resembled the transparent *lanterne vive*
> Used by a baker to amuse the children,
> Where tied birds, she-monkeys, elephants,
> Dogs, cats, hares, foxes, and every strange beast,
> Run by, one after another . . .[1]

The moving bestiary of this *lanterne vive* seems to have quite captured Régnier's imagination. All the same, the images moved without true animation. The device's attraction arose from its light, the shimmering colours, and a mechanism which could appear supernatural to those who did not know its secret.

An older, and less common, design was described by Jean Prevost of Toulouse in 1584. His *lanterne*, without an adjective, showed 'by the light of a candle, horsemen and soldiers, coming and going'.[2] It was described in a small octavo book, *La Première Partie des Subtiles et Plaisantes Inventions* ('The First Book of Fine and Pleasing Inventions'), along with strange formulae for scaring the 'stupid commoners', such as placing a candle on the back of a tortoise and releasing it into a cemetery at night. The paper which surrounded Prevost's lantern was treated with nut oil to make it translucent. Using thick paper or card, he fashioned a type of wheel like 'that which turns the grinding stone of a mill'. The smoke and heat of the candle operated the wheel, which rotated a wooden platform on which a series of cut-out figures were placed. The figures cast simple shadows, rather than the traditional coloured images, onto the oiled paper as the wheel turned. Prevost tried, a little primitively, to recreate as much movement as possible by mixing warriors and animals:

> Arrange four men on horseback, each holding a lance at rest, except for the first who holds a type of trumpet to his mouth; and make sure that their front legs are raised, to represent a horse which is jumping . . . In the middle, place four helmeted harquebusiers with their swords at the ready. Lower down, arrange four pikemen, between whom, if you wish, a hound may be running after a hare, or some such fantasy. You should have this cut by a barber, since they are skilled in this lively art, and it is they who commonly keep these night lanterns against their window to amuse the passers-by, by contemplating the order of these men-at-arms . . . Then there will be the pleasure of viewing through the paper by the light of the

> candle, the turns and rapid passages of these brave warriors, without their ever breaking ranks. But above all take care, as a very necessary precaution, that by some hindrance the movement does not stop: for fear that the fire will catch the fabric, at the risk of a military combustion: because it would be a great shame to lose such brave men so cheaply.[3]

In the eighteenth century, the *lanterne vive* was renamed to become, less poetically, the *lanterne tournante* ('rotary lantern'). It could be found in some cabinets of curiosities, such as that of Joseph Bonnier de la Mosson which was sold off in 1744.[4] In the nineteenth century it could be bought in markets, made by simple craftsmen; by 1884 it cost no more than 50 centimes. Even today, in some toyshops, modern versions of the old *lanterne vive* can still be found: its marvellous power is still effective, at least among children.

The family history of the magic lantern includes a few other 'lost children', which are difficult to name or illustrate with any certainty. These devices remain mysterious. Part of the problem lies in the poor interpretation of some old references, giving rise to many legends and confusions. For example, Henri Langlois, founder of the Cinémathèque Française, regretted never having tracked down for his Musée du Cinéma one of 'the multi-coloured magic lanterns described by Omar Khayyám, which brought joy to the markets of Persia in the eleventh century'.[5] He had no chance of finding such a thing: the Persian poet and mathematician Omar Khayyám, who lived in the eleventh and twelfth centuries, did not describe a magic lantern, but a shadow show enclosed in a box illuminated by the sun (a nineteenth-century English translation refers to a 'Magic Shadow-show/Play'd in a Box whose Candle is the Sun').[6] Langlois was probably confused by a poor French translation. Interesting as it is, the Khayyám reference is unclear: perhaps it refers to the traditional shadow show known as *ombres chinoises* ('Chinese shadows'), or perhaps to projection using the camera obscura. Shadow shows have not been covered in this account, since they appear to form part of a separate study.

A much more interesting lantern reference is found in an Italian manuscript preserved in the Bayerische Staatsbibliothek in Munich, dated to around 1420 and attributed to Giovanni da Fontana (1395–*c.*1455), a Venetian scholar of art and medicine. The work is entitled *Bellicorum Instrumentorum Liber cum Figuris Delineatis et Ficticiis Literis Conscriptus* ('Book of Instruments of Warfare with Drawings and Enciphered Descriptions') (see Fig. 7). Fontana describes all types of

Fig. 7. Giovanni da Fontana, *Bellicorum instrumentorum liber cum figuris delineatis et ficticiis literis conscriptus* (*c.* 1420).
Collection: Bayerische Staatsbibliothek.

equipment for warfare, including mechanical and hydraulic systems. One page includes a drawing of a man in a cloak, holding in both hands a large cylindrical lantern topped by a conical chimney pierced by small holes. Inside the lantern is a rod-shaped object which may be a lamp, and also the figure of a monstrous devil brandishing a spear, with two wings on its back, horns on its beastly head, and claws on its feet. This image appears again, by some miracle, on a much larger scale, in front of

the man holding the lantern. A caption explains the image: 'Nocturnal apparition for terrifying viewers.' However, the lantern shown does not have a lens tube, and the devil drawn inside the lantern is the right way up, as is its enlarged projected representation. It cannot therefore have functioned like a true magic lantern.

A second image shows a lantern with a long tube in the shape of a truncated pyramid, pointing upwards. The tube is attached to the front surface of the lantern, the rest of whose body is cylindrical. A wick is placed inside the lantern, and the body is open at the top. A note in the margin reads: 'The light of the night, which nobody in England is allowed to use, as a result of the bad use to which bandits have put it.'[7]

Fontana's text therefore describes two different lanterns. One, of conventional construction, resembles the *lanterne vive*. The other design could be a sort of hybrid lantern, simultaneously '*vive*' and 'magic'. It could perhaps have been used to project a bright image onto the type of mirror described by della Porta in 1558, to make an 'image hanging in the air' appear. We might imagine that because of the 'bad use' to which bandits applied the 'light of the night', Fontana was careful to word his description rather enigmatically, after the manner of Roger Bacon.

An anonymous text of the sixteenth century entitled *Le Journal d'un Bourgeois de Paris sous le Règne de François Ier* ('Diary of a Citizen of Paris in the Reign of François I') only makes the mystery deeper. This manuscript, preserved in the Bibliothèque Nationale, was not published until 1854.[8] It mentions a 'lantern by which one sees all things' which belonged to a priest named Cruche, a writer of farces who also performed in his dramas on a platform in Place Maubert. His lantern showed a pecking chicken underneath a salamander, 'which carried on it a thing which was enough to kill ten men'. This was a caricature of François I's love for the daughter of a courtier named Lecoq (hence the reference to the chicken, *coq* in French). The story ended badly for Father Cruche: a group of about ten gentlemen went to see 'the said comedy', violently beat up the showman, and were about to throw him into the Seine. Cruche managed to calm their anger by showing his priest's tonsure, which saved his life. Shortly afterwards, on 19 November 1515, François I forbade 'the performance of any comedy against the honour of the King and those who surround his person'.

Was Cruche's lantern 'magic' (a belief expressed by the photographer Frederic Dillaye in 1884) or '*vive*'? Or was it perhaps a type of *boîte d'optique* or peepshow, in which the pictures were lit from behind and viewed through an eyehole? Given an already imprecise description, it is safest to avoid drawing any definite conclusions.

The arrival of the magic lantern

A gap of some two centuries separates the invention of the 'light of the night' and that of the 'lantern of fear' or magic lantern. It is almost impossible to believe that it took two hundred years to add a group of lenses and a slide carrier to the lantern described by Fontana. However, there is no trace of the true magic lantern until 1659, perhaps 239 years after Fontana, seventy-one years after the second edition of della Porta's *Magiae Naturalis*, and thirteen years after the publication of Kircher's *Ars Magna Lucis et Umbrae*.

The 'magic' lantern (it was not christened as such until 1668) represents the longest-lasting, most inventive, and most artistic of the 'ancestors' which were eventually snuffed out by the birth of the cinema. For the whole length of its reign, which extended over three centuries, it presented artificial fixed and moving images to a public ever more filled with wonder, ever more demanding. It went round the world with prodigious speed. Scholars and craftsmen invented a thousand crude or ingenious ways to make its images move, to improve the 'illusion of movement', the driving force of pre-cinematographic research.

The principle of the magic lantern remained the same, with a few small variations, from the seventeenth century until the end of the nineteenth. It was an optical box made of wood, sheet metal, copper, or cardboard; it was cubic, spherical, or cylindrical in shape; and in a darkened room it projected images painted on a glass slide onto a white screen (fabric, a whitewashed wall, even white leather, in the eighteenth century). Its images covered every subject: diabolic, grotesque, erotic, scatological, religious, historical, scientific, political, and satirical. The image was generally 'fixed', but could also be 'animated' if the slide included a mechanism which allowed the subject to be moved. All that was necessary was to place the slide upside-down in the 'slide carrier', in front of light focussed from a candle or oil lamp, and immediately, as Goethe wrote in 1774,

> as soon as the little lamp appears, the figures shine on the whitened wall; and if love only shews us shadows which pass away, yet still we are happy, when, like children, we are transported with the splendid phantoms.[9]

Sometimes a silvered reflector was placed behind the flame or lamp, to concentrate the light towards the lens tube at the front of the lantern. A chimney on the roof of the box would clear the smoke from inside. The

arrangement of the lenses in the tube varied from design to design, especially in the nineteenth century, but in general consisted of a powerful plano-convex lens, with its flat side facing the light source, which converged the light rays onto the painted slide, followed at the end of the lens tube by one (in the simpler designs) or two plano-convex lenses which enlarged the image and projected it the right way up.

Christiaan Huygens and Athanasius Kircher

Two great names are associated with the appearance of the magic lantern: the German Jesuit Athanasius Kircher, its pseudo-inventor, and the Dutch Protestant Christiaan Huygens, its true 'father'. Huygens, however, was loath to take personal responsibility for the dissemination of the lantern, and his exact role in this adventure has never been made sufficiently clear.

Christiaan Huygens was the first scholar in Europe known to have studied, designed, constructed, sold and distributed the magic lantern. He was also the first, it would appear, to use a moving slide. To understand why Huygens—a rationalist at heart, stern and rigid in character, sharp and demanding in intelligence—concerned himself with an instrument which might be imagined to be the preserve of whimsical souls in the spheres of entertainment or magic (Kircher was certainly one of these), we must go back to the time of Christiaan's father, Constantin Huygens.

Constantin Huygens, lord of Zuylichem, Zeelhem and Monnikenland, was born on 4 September 1596 at The Hague. On 6 April 1627, in Amsterdam, he married Susanna van Baerle, who gave him five children: Constantyn, Christiaan, Lodewijk, Philips, and Susanna. In his own time, Huygens the father was regarded as one of the best poets in the Netherlands, although his style was at times more than slightly tortuous. He was vastly learned, and corresponded with the greatest minds of Europe, such as René Descartes or the French philosopher and scholar Marin Mersenne (1588–1648).

In 1622 Constantin was in London. There he struck up a friendship with a compatriot, Cornelis Jacobsz Drebbel, who held a great fascination for him: Drebbel was an expert in black and white magic, dioptrics, and catoptrics. Born at Alkmaar in 1572, and first employed as an engraver and instrument maker at Haarlem, Drebbel then dedicated himself to the study of science and mathematics. He travelled, and was imprisoned in Prague for presenting magic shows. It was perhaps he who made appear before the Emperor Rodolphe II 'those who had held the

Roman Empire from Julius Caesar to Maurice; and that was done in a manner so alive and natural, that all those who were present at this spectacle believed that it could not have been created save with the aid of magic and necromancy'.[10] By the time Constantin Huygens met Drebbel, he had settled in London permanently.

Drebbel professed to be an alchemist, and claimed to have invented the barometer, discovered perpetual motion and perfected a design for an underwater boat. He had a laboratory, a *Wunderkammer* ('chamber of wonders') worthy of Doctor Faustus. In 1663 several parts of this great cabinet of curiosities survived at the house of Drebbel's son-in-law, one Doctor Keister.[11] Among the strange objects he collected was a mysterious optical device which captivated the young Constantin Huygens. To his father, Christiaan the Elder, who had reproached him for associating with a magician-alchemist, Constantin replied self-mockingly, on 17 March 1622:

> It made me smile that in your last, it pleased you to warn me against the magic of Drebbel, and to accuse him of being a sorcerer. But be assured that, finding nothing of the other nature in his work, there is no need of a bridle to hold me in check. Old De Gheyn will be pleased to hear that I shall bring the instrument of which he showed me the beautiful brown painting, which is certainly a masterwork of his sorcery.[12]

On 30 March 1622 Constantin described this strange device to his father a little more precisely:

> I have with me Drebbel's other instrument, which certainly makes admirable effects in painting by reflection in a dark room; it is not possible for me to describe the beauty in words; all painting is dead at this price, because here is life itself, or something more elevated, if the word is not misplaced. For the image, the outline and the movements come together naturally and in a most pleasing manner.[13]

This description is puzzling: it certainly has a suggestion of the magic lantern, although the word 'reflection' suggests the presence of a mirror. It was probably a catoptric camera obscura, a device which Drebbel had exhibited from 1608 onwards. Young Constantin returned home to his father at The Hague with his mind full of luminous visions. Drebbel died not long after, in 1634, but Constantin Huygens never forgot the lessons and projections of this great magician.

Christiaan Huygens, Constantin's second son, was born at The Hague on 14 April 1629. His father educated him in music, mathematics, and mechanics, and then sent him to the University of Leyden and Breda from 1646 to 1649. Constantin sung the praises of his genius of a son everywhere. Mersenne and Descartes paid attention to the first mathematical works by the young prodigy. After his stay in Breda, Christiaan returned to The Hague and lived with his father, brothers and sister. He published his first works on geometry in 1651 and 1654. Around this time, he also began to study dioptrics. He threw himself into reading the revered Descartes' *Discours de la Méthode*. Constantin too, no longer content with empirical lessons like those of Drebbel, began to study the elliptical and hyperbolic lenses suggested by Descartes. Christiaan, who was truly gripped by a passion for optics, worked in the attic of the house in The Hague, cutting lenses.

At the start of 1655 Christiaan employed a German workman named Caspar Kalthof (or Kaethoff, of Dordrecht), who had spent a long period in England. With Kalthof's help, in March 1655 Huygens constructed his first telescope, which was sent to the German pastor Colvius, with whom Huygens had already discussed work on dioptrics which he hoped to publish 'soon'. In September 1655, Christiaan and his brother Lodewijk travelled to Paris. Kircher had known the France of Louis XIII; Huygens, though, only dealt with the scientific circles and ministers of the reign (1643–1715) of the young Louis XIV. Some years later, on 4 June 1666, he even met the 'Sun King' in person, through the intermediaries of the King's Secretary of State Jean-Baptiste Colbert (1619–83); according to Huygens' own account Louis XIV told him 'strongly pleasing things'. It was while he was in Paris that Huygens came to know Kircher's *Ars Magna Lucis et Umbrae*.[14]

At the end of 1655, returning to The Hague, Christiaan and Lodewijk intensified their work on cutting and polishing lenses. With a telescope he had constructed, Christiaan observed the existence of a satellite (today known as Titan) around the planet Saturn. In following years, European scientists saluted successive discoveries by the Dutchman. In 1657, for example, taking up Galileo's work on the regularity of an oscillating pendulum, Huygens perfected the pendulum clock, which he gave the French name *horologe*. Huygens gave the world a machine which would measure the smallest intervals of time, thanks to the application of a regular escapement mechanism,[15] a mechanical process which would be employed once again in 1896 to drive the film through some types of cinematographic camera.

On 25 March 1658 Huygens released another thunderbolt onto the

world of astronomy when he revealed that the 'arms' of Saturn, already observed by Galileo, were in fact a ring which surrounded the planet. As a result his fame spread considerably. Through discoveries such as these he came to rank alongside the great scholars of the seventeenth century: Galileo, Kepler, Descartes, and Newton, who in 1669 was still an adolescent. Next to Huygens, the work of Kircher appears quite insignificant, in the eyes of the seventeenth-century scholars just as much as for scientists of today. The unfortunate Kircher tried to cultivate the friendship of Descartes, who shied away from him, and the Protestant Huygens derided, or at least ignored, the Jesuit priest.

Christiaan Huygens' father Constantin was among the first to make fun of Kircher's works. In a letter to Descartes on 7 January 1643 Constantin warned him that Kircher's book *Magnes Sive de Arte Magnetica* ('The Magnet, or the Magnetic Art'), published in Rome in 1641, consisted 'more of posturing than of good material'. Descartes replied on 14 January, with cruel precision: 'The Jesuit [Kircher] has a great deal of boastfulness, he is more of a charlatan than a scholar.'[16] But it was only when *Ars Magna Lucis et Umbrae* was published in 1646 that Kircher's critics really went into action. The scientist Cavendish wrote:

> I have recently seen a book by the Jesuit Kircher on light and shadow. There are plenty of magnificent illustrations, which I suspect have not much substance behind them. Monsieur Gassendi [a French astronomer] does not recommend it. I therefore have no wish to purchase it, nor even to read it.[17]

Constantin Huygens took up the attack in a letter addressed to Mersenne, taking great delight in poking fun at the *Ars Magna*, the 'large volume by Kircherus', in which the 'miserable gnomonics so often repeated by those people [the Jesuits] occupies fully two-thirds of his book.' Constantin ended his letter with an incredible story, in itself worthy of a place in the pages of *Ars Magna*:

> You will know for something as strange as it is true, that serious people of age and position declare that they have seen taken prisoner at Anvers, during our recent wars, a man who has the ability to see through clothes; to show that it is not a piece of cunning, when the wife of his Gaoler went to see him with some other women, to console him in his distress, they were truly astonished to see him smile, and pressing him to say what had been the cause he replied coldly, *because there is one among you who is not wearing a shift*, which she had to admit. Consider the above and conclude that Kircherus

> will not forget it in his second edition, because that could truly be titled *Ars Magna*.[18]

As for the young Christiaan Huygens—he was 17 years old in 1646—his opinion coincided with those of Descartes and his father, but with a little more restraint. From the catalogue of Christiaan's library, published after his death in 1695, we know that he kept several of Kircher's books close at hand; but neither of the two editions of *Ars Magna* was included in that magnificent collection.[19]

Huygens' moving slide

In 1659, already at the height of fame after his discovery of the rings of Saturn, Huygens drew ten macabre little pictures in one of his manuscripts, described as 'For representations by means of convex glasses in a lantern'.[20] The images represent a skeleton, sometimes enclosed in a circle, removing its skull from its shoulders and replacing it, and also moving its right arm. In the penultimate illustration the skeleton, with its own head on its shoulders, is shown juggling a second head in the air. The sequence of images is quite remarkable because of its clearly indicated desire for artificial recreation of motion: dotted lines show the required movement of the skeleton's arm. This is the earliest known representation of a moving slide for the magic lantern (see Fig. 8).

To make this moving slide, Huygens probably superimposed two sheets of glass: one fixed, representing the skeleton without the skull and perhaps without the right arm; and one movable, on which he painted the right arm and skull only. This type of slide remained in widespread use until the end of the nineteenth century. For example, around 1850 the London firm Newton & Co. was offering a moving slide featuring a remarkably detailed image of a skeleton; by pulling the movable glass the skeleton could be made to come apart completely, with bones going in all directions.

Huygens borrowed the idea for his slide from the painting *The Dance of Death* by the German Hans Holbein (1497–1543). In 1538 Holbein provided a magnificent set of illustrations for the book *Les Simulachres et Historiees Faces de la Mort* ('The Simulacra and Fabled Faces of Death'), printed at Lyon. These morbid engravings, sometimes terrifying and full of devilish movement, fascinated Huygens. In 1646 he made a large copy of Holbein's skeletons on the garden wall of his house in The Hague:

Fig. 8. Christiaan Huygens, animated magic lantern slide, drawn in 1659. Collection: Bibliothèque Nationale.

> I have painted in our garden some figures as large as life, in charcoal mixed with oil and in white crayon, against the fencing which separates our garden from that of Count Maurits, they are the figures of Holbeen's *Dodendans* [*Todtentanz*, 'Dance of Death'] which, having been as small as a finger, I have enlarged to the height just mentioned.[21]

In 1659, therefore, Huygens knew the secret of the lantern. He probably used it to amuse his friends and family. But when had he become a 'projectionist' or 'lanternist'? It is easy to put forward hypotheses: very much ahead of his time in science and optics, he had perhaps discovered the principle of the lantern by himself or with his assistant Kalthof. Or perhaps he had set out to simplify Kircher's

'cryptological' processes. Or perhaps, inspired by his father Constantin's stories about Drebbel's catoptric camera obscura, he had the idea of constructing a device capable of creating even greater wonders, to re-create his father's wonderful memories.

Huygens knew how to bring movement to an image projected onto a screen: paradoxically, this first illuminated artificial recreation of life was a represention of death. This achievement of animated projection was certainly a considerable event. Shortly after 1659 the rumour was circulating in Rome that a 'Lantern' (not yet christened 'magic', and referred to respectfully with a capital 'L') existed at Huygens' house. One Father Guisony wrote a long missive to Huygens on 25 March 1660, including this important sentence:

> The good man Kirkher is doing a thousand tricks with the magnet in the gallery of the College of Rome here; if he had the invention of the Lantern, he would truly be terrifying the cardinals with ghosts.[22]

This seems to confirm that Kircher, in 1660 just as in 1646, was completely unaware of the invention of the magic lantern, whose invention has therefore been attributed to him inaccurately.

On 12 October 1660 Christiaan Huygens left The Hague for Paris, arriving there on 28 October. He was welcomed eagerly by the scientific community, and met Pierre Petit on 16 December. Petit (1598–1677) was a middle-ranking mathematician and scientist, who since 1642 had been adviser, engineer and surveyor to Louis XIV, shortly afterwards becoming the Intendant-General of Fortifications. Petit corresponded with Mersenne, Descartes, and the mathematician Blaise Pascal (1623–62). He welcomed Huygens with obsequious respect at his house located behind the Hospice des Quinze-Vingt in Paris, close to the site of the modern Gare de Vincennes. Petit proudly showed Huygens his cabinet of curiosities: 'very well-made' parabolic mirrors, Christiaan noted, as well as spectacle lenses ('too thin'), magnets, 'mirror lamps', clocks, and compasses. Among other encounters in Paris, on 20 February 1661 Huygens went to see a show of 'Italian marionettes' organized by M. de Guederville. In his diary he noted how they were animated, 'by stiff metal wires which are concealed by the feathers which they have on their heads'. On 17 March 1661 Balthazar de Monconys paid Huygens a visit. The names of Petit and de Monconys have a place in the history of projection and will reappear in our story.

Huygens had brought with him to Paris a long-distance telescope and

two microscopes which he had made: perhaps he was also carrying a magic lantern, though there is no mention of it in his diary.[23] On 30 March 1661 he travelled to England, where on 3 May he went to see the London optician John Reeves, one of the great names of projection in Britain. It is perhaps not entirely surprising that shortly after Huygens' journey the magic lantern appeared in the hands of Petit, de Monconys, and Reeves, all of whom were his correspondents and friends, as if he had been sowing the seeds as he travelled around.

Huygens returned to The Hague on 27 May 1661 and set to work again: the editing of his book on dioptrics and light was proving especially difficult. Learned and revolutionary theories were taking shape, and as far as can be judged Huygens did not consider the magic lantern to be among his important works. The excitement which projection generated among his friends was of only passing interest to him. Probably it was the lantern's dual nature which bothered him: it was an interesting optical instrument, but the grotesque and devilish scenes which it projected made it less serious, less scientific; Huygens did not imagine that it could be used to represent scientific images, for example. For him, the device was suitable for putting in a cabinet of curiosities, alongside the marionettes, camera obscura, and anamorphoses. It was an instrument of entertainment for the 'pleasure of the evening', as it would be termed in the eighteenth century. Immersed in his research on the theory of the pulsations of light, Huygens had mentally classified the lantern as a pastime of secondary importance.

This was very different from the view of his father Constantin, for whom this optical box revealed marvels even more stunning than those Drebbel had shown him. He was enthusiastic about the lantern, and asked his son for an example of it in 1662. A ridiculous family quarrel began, resulting in an estrangement of several years—not between father and son, but between Christiaan and the lantern. Constantin asked his son to make a lantern for him in February or March 1662. Christiaan had to agree; he could not refuse his father. But, as he complained to his brother Lodewijk:

> The Hague, 5 April 1662.
> Here is another commission which my Father has given me, to arrange for him a lantern with two or three different pictures to be shown with it. I can make no reply to him except that I shall do what he wishes, and as quickly as is possible for me: but to you I confess that these commissions inconvenience me greatly, and that many others as well as my Father will ask me for similar things. You

> would not believe the difficulty with which I occupy myself with such trifles, which already seem quite old to me, and in addition I am ashamed that people will know that they came from me. People are obliging enough to make it appear that they admire them, but afterwards they make fun of them and not without reason. For the future, if there is no other way, I beg of you to divert any similar chores away from me.[24]

Huygens' displeasure is quite clear. He was afraid that his lantern, or even worse he himself, would become a subject of ridicule, 'and not without reason'. Although he wrote that this 'trifle' was 'already quite old', he unfortunately neglected to specify that oldness. He seems to imply, with shame, that it was he who had invented the magic lantern: 'it comes from me.' But whether this refers to the concept of the device, or to actual examples constructed in the attic in The Hague, is unclear.

Although Huygens was reluctant to produce a lantern for his father, he seems to have responded differently to orders for purchase coming from abroad. The scholars of the seventeenth century often put their equipment on the market: a very lucrative activity, inaugurated by Galileo and adopted particularly by the scientists Chérubin d'Orléans, Robert Hooke, and Pierre Borel. In that same year, 1662, the Duke and Marshal of France Antoine de Grammont (1604–78), whom Huygens had probably met during his journey to Paris, asked him for a magic lantern, which appears to prove that the Dutchman was one of the few—possibly the only one—who possessed the secret of this device. On 12 April 1662 Christiaan wrote to Lodewijk that 'the glasses for the lantern and for the telescope for Monsieur le Mareschal de Grammont are already made and will soon be put into place.'[25] It therefore seems quite clear that one of the first magic lanterns constructed at The Hague arrived in France around 1662.

However, tension between Constantin and his son was increasing. Christiaan never delivered the promised lantern, since he had learned with horror of the true motive behind this request: Constantin wanted to show the magic lantern in Paris, before the Court at the Louvre. For Christiaan, a scientist of international reputation, who supplied Louis XIV with pendulum clocks, and who enjoyed the best of relations with the most serious minds of his time, this would have been a complete disgrace. The Huygens were scholars, not magicians like Drebbel and Kircher.

In order to obey his father while at the same time safeguarding his dignity, Christiaan planned to provide him with a lantern, but with one

lens fewer than usual: that is to say a lantern which was completely unusable. He revealed this scheme to his brother Lodewijk on 19 April 1662:

> Since I have promised to send the lantern it must go, for I do not know how to invent a worthwhile excuse to avoid it. But when it arrives, if you consider it appropriate, you will easily make it incapable of use by removing one of the two glasses which are close to each other, so that there are still two remaining, since there are three in total. I will appear to be unaware of what is lacking, and by means of these explanations as much time will pass as is necessary. And all this is for the best: because it seems to me that ου πρεπει [it is not proper] for my Father to play with those marionettes at the Louvre, and that I am well aware that you would not be pleased to assist him there like cousin Micheli with the Seigneur d'Aumale.[26]

The first magic lanterns of the seventeenth century had a quite simple optical combination, but already it was essential to be familiar with it, and especially to have good lenses, without veins or air bubbles, pale in colour, and transparent. Huygens himself was a master of the art of casting lenses. The Netherlands was one of the leaders, along with Italy and Venice, in the manufacture of optical lenses, thanks to Huygens himself and the workshop of the Musschenbroeks of Leyden. For his lanterns, Huygens used one convex lens (forming a 'condenser' to concentrate the light onto the slide) and two biconvex objective lenses to transmit the projected image. Later in his career, around 1685, he worked on the phenomenon of chromatic aberration, which deformed projected images and surrounded them with a coloured fringe, but never succeeded in solving this problem.

Optical glass of this period was usually made of a mixture of sand, soda, borax, lime, and magnesia (magnesium oxide). The process of melting the mixture was delicate: the heat could form drops and streaks in the material, and cooling sometimes caused flecks and channels, making the lens practically useless. Polishing was done with sand, but Huygens, who readily revealed his methods to other scholars, such as the French Jesuit Claude-François Milliet Dechales, sometimes preferred 'other better materials, such as the spoltiglia which the mirror makers of Venice use, which they say is calcinated emery'. According to Huygens, several tens of hours of work were needed to obtain a good lens:

> After having rounded the glass in a highly concave bowl, and having made it of equal thickness throughout, I give it its first shape with

> coarse sand without water, and then with sand which has been passed through a very fine sieve . . . I add some water, and with this sand I complete the smoothing of the glass, I use some eight or nine hours for each face of these large glasses.[27]

In the middle of the seventeenth century the complexity of lens manufacture remained the main obstacle to the spread of the lantern. Huygens could therefore deceive his father with complete peace of mind: Constantin was incapable of casting, cutting and polishing a new lens with the precise characteristics of the two others in the lantern's lens tube. However, Constantin could acquire the missing lens from elsewhere, for example from the Musschenbroeks. So Christiaan suffered a strange loss of memory: all of a sudden, he could no longer recall the optical combination of the lantern. In spite of all his knowledge, he wrote without humour to Lodewijk (who perhaps had taken his father's side, since Christiaan seems to have mistrusted him), he could not manage it. In short, the lantern he had promised his father could not be delivered. Huygens stalled, punning on the French verb *lanterner* (to keep someone waiting around) in his description to his brother:

> 17 August 1662.
> I still do not know when Monsieur Chieze will depart, sometimes Busero, sometimes Ketting *lanternes* him. It appears at least that he is doing what he can to hurry himself up. I had planned to *lanterne* him again on his departure, that is to say to put him in charge of the lantern which I have made for My Father; but he will be relieved of this, because in spite of all my work and knowledge I have not been able to manage it. I speak the truth, and the brother of Zeelhem can testify how my effort has been in vain, without being able to fit up the same as my first one which I made before, having removed the lenses a long time ago, I do not know how to find where they are at this time. Perhaps Signor Padre will no longer remember, but in case he does, let him know the above reasons, and what is more that I am close to making him a Telescope, microscope and all that he wants, except for the Lantern, whose invention must be counted *inter artes deperditas* [among the lost arts].[28]

The tone of this letter is too mischievous to allow its explanations to be taken at face value, and in any case they are hardly credible from a learned mind such as Huygens. 'Signor Padre' was well and truly fooled, and never did show the magic lantern at the Louvre. The Huygens honour was safe. For the next two years, at least on the evidence of his

surviving correspondence, Huygens never once mentioned the magic lantern. On 3 May 1662, shortly before declaring formally to his father and brother that the secret of the device had disappeared from his memory, he wrote to Lodewijk with a curious remark on the magic lantern and retinal persistence:

> You will make of the Lantern as Heaven directs you: the most serious defect will be that of the length of the days, for as long as daylight lasts it is impossible to make these representations unless one places oneself inside a dark room; that arises from the impression which light makes on the eyes, which does not diminish for quite a long time afterwards.[29]

Perhaps to discourage his father and brother from their interest in the lantern, Huygens slightly exaggerated the strength of the phenomenon of the impressions of light on the eye. Almost word for word, his remark recalls della Porta's advice of 1558, concerning the duration of the dazzling caused by outside sunlight on entering the camera obscura.

In August 1662, then, Huygens abandoned the magic lantern in a corner of his cabinet of curiosities. He had removed the lenses, as he later admitted, presumably so that nobody would be able to use it without his permission. We do not know if he continued to sell it in other countries. The device, according to Huygens, now ranked *inter artes deperditas*. This assertion, probably intended for his father Constantin, was soon to be given the lie in no uncertain manner.

Notes

Chapter One: Dark Rooms and Magic Mirrors, p. 3

1. Francesco Maurolico, *Photismi de Lumine et Umbra* (Naples, 1611), and *Theoremata de Lumine et Umbra* (Lyon, 1613).
2. Roger Bacon, 'De Multiplicatione Specerium', in *Opus Majus* (London, 1733), 358.
3. Cited in Pierre Duhem, *Le Système du Monde* (Paris, Hermann, 1915), Vol. III, 505.
4. Cited in Georges Potonniée, *Histoire de la Découverte de la Photographie* (reprinted Paris: J-M. Place, 1989), 28.
5. Cited in Potonniée, op. cit., 20, and in Helmut Gernsheim, *The Origins of Photography* (London: Thames & Hudson, 1982), 10.
6. Leonardo da Vinci, *The Notebooks of Leonardo da Vinci*, Vol. I, trans. Edward MacCurdy (London: Jonathan Cape, 1938, new ed. 1956), 216.
7. Cited in Potonniée, op. cit., 20, and in Gernsheim, op. cit., 10.
8. John Baptista Porta (Giovanni Battista della Porta), *Natural Magick* (London: Thomas Young and Samuel Speed, 1658), 363.
9. Porta, op. cit., 364–5.
10. François d'Aguillon, *Opticorum Libri VI* (Anvers, 1613), 47.
11. L-V. Thiéry, *Guide des Amateurs et des Étrangers Voyageurs à Paris (Paris, 1787), Vol. I, 687.*
12. Jean-François Nicéron, *La Perspective Curieuse* (Paris, 1652), 21–2.
13. Jean Leurechon, *Récréation Mathématique* (Pont-à-Mousson, 1621), 98–9, 103.
14. Nicéron, op. cit., 21–2.
15. Pierre Le Lorrain, Abbé de Valmont, *La Physique Occulte ou Traité de la Baguette Divinatoire* (Amsterdam, 1693), 302.
16. Mario Bettini, *Apiaria Universae Philosophiae Mathematicae*, Vol. I (Bologna, 1642), 38–43.
17. Cited in Potonniée, op. cit., 31.
18. Vincent Chevalier, French Patent of 10 June 1823.
19. Nicéron, op. cit., 21–2.
20. Camera obscuras of this type are discussed in John H. Hammond, *The Camera Obscura* (Bristol: Adam Hilger, 1981), and Michel Auer, *150 Ans d'Appareils Photographiques* (Hermance, Switzerland, 1989).
21. Chérubin d'Orléans, *La Dioptrique Oculaire* (Paris, 1671), 285–8. 'L'oeil artificiel' was also used as a generic term for the camera obscura in the eighteenth century; see P. Ango, *L'Optique* (Paris, 1682), 199.
22. Athanasius Kircher, *Ars Magna Lucis et Umbrae* (Rome, 1646), 811–12.
23. Johann Christoph Sturm, *Collegium Experimentale Sive Curiosum* (Nuremberg, 1676), 161–2.

24. Jurgis Baltrušaitis, *Le Miroir* (Paris: Elmayan-Seuil, 1978).
25. Roger Bacon, *De Mirabili Potestate Artis et Naturae* (Paris, 1893), 14.
26. Della Porta, op. cit., 365–6.
27. Giorgio di Sepi, *Romani Collegii Societatis Iesu Musaeum Celeberrimum* (Amsterdam, 1678).
28. Sophie de Hanovre, *Mémoires et Lettres de Voyages* (Paris: Fayard, 1990), 227.
29. Kircher, op. cit., 799. For more on Kircher, see: *Athanasius Kircher: Jesuit Scholar* (Provo, Utah: Friends of Brigham Young University, 1989); J. Fletcher, *Athanasius Kircher und Seine Beziehungen zum Gelehrten Europa Seiner Zeit* (Wiesbaden, 1988); Valerio Rivosecchi, *Esotismo in Roma Barocca* (Rome, 1982); *Enciclopedismo in Roma Barocca* (Venice, 1986); Joscelyn Godwin, *Athanase Kircher* (Paris, 1980); Catherine Chevalley, *'L'Ars Magna Lucis et Umbrae* d'Athanase Kircher', *Baroque* (proceedings of the 10e Session d'Étude du Baroque, Montauban, 1987); and *Dictionary of Scientific Biography*, Vol. VII (Princeton University, 1973).
30. Kircher, op. cit., 818.
31. Jacques Ozanam, *Récréations Mathématiques et Physiques*, Vol. I (Paris, 1694), 252. Ozanam restates the process of using the 'artificial lantern'.
32. Kircher, op. cit., 887.
33. Kircher, op. cit., 892.
34. Nicéron, op. cit. (1638 edition), 77.
35. Kircher, op. cit., 901.
36. Kircher, op. cit., 907–14.
37. Daniel Schwendter, *Deliciae Physico-Mathematicae et Physicae* (Nuremberg, 1638), 287.
38. Gaspar Schott, *Magia Universalis Naturae et Artis*, Part I (Würzburg, 1657), 425–6.
39. Bettini, op. cit., Book IV, 27.
40. Schott, op. cit., 426. With the exception of this somewhat enigmatic reference, there is not the slightest mention of a projection lantern in Schott's *Magia Universalis*.

Chapter Two: Light in the Darkness, p. 28

1. Mathurin Régnier, *Oeuvres Complètes*, Satire XI (Paris, 1911), 124.
2. Jean Prevost, *La Première Partie des Subtiles et Plaisantes Inventions* (Lyon, 1584), 54–5.
3. Prevost, op. cit., 54–5.
4. 'No. 525. A *lanterne tournante*, decorated with various well-painted grotesque figures': E.F. Gersaint, *Catalogue Raisonné d'une Collection Considérable de Diverses Curiosités en Tous Genres Contenues dans les Cabinets de Feu Monsieur Bonnier de la Mosson* (Paris, 1744), 130.
5. Henri Langlois, *300 Années de Cinématographie*, leaflet produced by Glenn Myrent (Paris, Musée du Cinéma, 1984), 19.
6. Omar Khayyám, *The Rubáiyát of Omar Khayyám*, trans. Edward Fitzgerald (London, 1859). The 'Magic Shadow-show' comparison appears in verse XLVI.
7. 'Luminarium nocturnum, quo nemo in Anglia uti potest propter mala quae com illo faciunt latrones.'
8. *Journal d'un Bourgeois de Paris sous le Règne de François Ier*. (Paris, L. Lalanne, 1854), 13–14.
9. Johann Wolfgang van Goethe, *The Sorrows of Werter*, trans. Daniel Malthus (1789; repr. Oxford and New York: Woodstock Books, 1991), 63.

10. Pierre Le Lorrain, Abbé de Valmont, *La Physique Occulte ou Traité de la Baguette Divinatoire* (Amsterdam, 1693), 301.
11. Balthazar de Monconys, *Voyages*, Vol. I (Paris, 1695), 73.
12. J.A. Worp, *De Briefwisseling van Constantin Huygens*, Vol. I (1911), 88.
13. Worp, op. cit., 94.
14. Christiaan Huygens, *Correspondance*, Vol. I (The Hague: Société Hollandaise des Sciences, 1888), 357.
15. For more on this subject see the fascinating book by David S. Landes, *L'Heure qu'il est* (Paris: Gallimard, 1987).
16. Marin Mersenne, *Correspondance*, Vol. XII (Paris: C. de Waard and B. Rochot/ Éditions du CNRS, 1972), 10, 29.
17. Mersenne, op. cit., Vol. XIV (1980), 534.
18. Huygens, *Correspondance*, Vol. 2, Supplement 18a.
19. *Catalogus Variorum* [. . .] (The Hague, 1695). Five of Kircher's books could be found in Huygens' library: *Magnes, Sive de Arte Magnetica* (1641), *Musurgia Universalis* (1650), *Obeliscus Pamphilius* (1650), *Iter Extaticum II* (1660), and *Sphynx Mystagoga* (1676), as well as a complilation by Johann Kestler, *Physiologia Kircheriana Experimentalis* (1680). Of course Huygens also owned all the classic texts of optics, by Al-Hazen, della Porta, d'Aguillon, Hooke, Tacquet, Nicéron, Dechales, Grimaldi, Schott, Molyneux, Ango, and others.
20. Huygens, *Oeuvres Complètes*, Vol. XXII, 197. The original drawing is preserved at the Library of the University of Leiden (ms. Hug. 10, f.76v.).
21. Huygens, *Correspondance*, Vol. I (1888), 16–17.
22. Huygens, *Correspondance*, Vol. III (1890), 47.
23. H.L. Brugmans, *Le Séjour de Christiaan Huygens à Paris, Suivi de son Journal de Voyage à Paris et à Londres* (Paris, 1935). See also *Huygens et la France*, colloquium of the CNRS (Paris: Vrin, 1982).
24. Huygens, *Correspondance*, Vol. IV, 102.
25. Huygens, *Correspondance*, Vol. IV, 109.
26. Huygens, *Correspondance*, Vol. IV, 111. The identity of 'cousin Micheli' and the nature of his service for the Duc d'Aumale are unknown.
27. Huygens, *Correspondance*, Vol. XXII, 82.
28. Huygens, *Correspondance*, Vol. IV, 197.
29. Huygens, *Correspondance*, Vol. IV, 125.

Chapter Three: The 'Lantern of Fear' Tours the World, p. 46

1. Balthazar de Monconys, *Voyages*, Vol. IV (Paris, 1695), 437 and 460.
2. Samuel Pepys, *The Illustrated Pepys: Extracts from the Diary*. Selected and edited by Robert Latham (London: George Rainbird, 1979), 161.
3. de Monconys, op. cit., 458.
4. Huygens, *Correspondance*, Vol. IV, 266.
5. Huygens, *Correspondance*, Vol. V, 161.
6. Claude-François Milliet Dechales, *Cursus seu Mundus Mathematicus*, Vol. II (Lyon, 1674), 665.
7. Kircher, *Ars Magna Lucis et Umbrae* (Amsterdam, 1671), 768.
8. Oligerus Jacobaeus, *Musaeum Regium, seu Catalogus Rerum*, 2nd ed. (Copenhagen, 1710), A II 2.
9. Robert Hooke, 'A contrivance to make the Picture of any thing appear on a Wall, Cub-board, or within a Picture-frame, &c. [. . .]', *Philosophical Transactions*, 38 (17