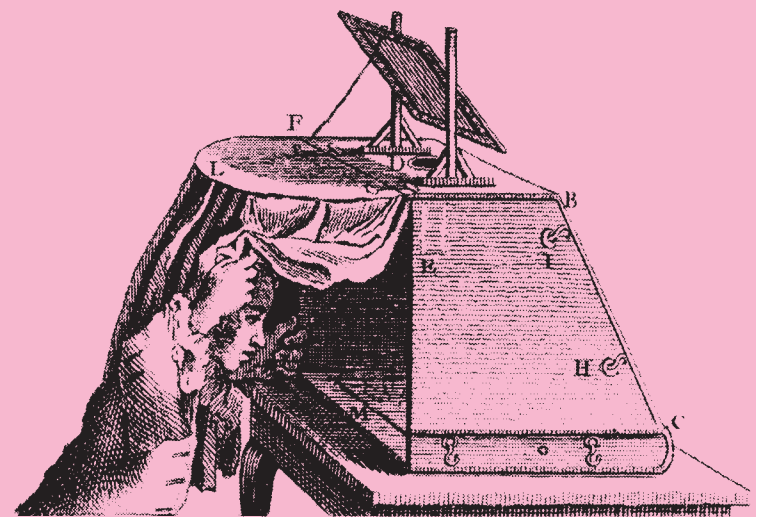
Laurent Mannoni

THE GREAT ART OF LIGHT AND SHADOW

Archaeology of the Cinema



Introduction by Tom Gunning
Preface by David Robinson

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Archaeology of the Cinema

'The dream of being able to project moving illuminated images on a wall or screen is almost as old, in the history of humanity, as the dream of flight.'

Laurent Mannoni

First published in French in 1995 and now translated into English, Laurent Mannoni's account is widely regarded by historians of the early moving picture as the best work yet published on the pre-cinema world, throwing light on a fascinating range of optical media from the twelfth century to the turn of the twentieth: a strange mixture of science, magic, art and deception.

Starting from the earliest uses of the camera obscura in astronomy and entertainment, *The Great Art of Light and Shadow* encompasses, among other devices, the 'invention' and early years of the magic lantern in the seventeenth century, the peepshows and perspective views of the eighteenth century, and the many weird and wonderful ninteenth-century attempts to recreate visions of real life in different ways and forms. Along the way these include the panorama and diorama, early photography, stereography and numerous optical toys and devices of varying shape and size. Finally there is an account of the attempts to fuse these effects together into a medium which would combine the realism of photography with the movement of the phenakistiscope and zoetrope.

Laurent Mannoni is former Curator of the equipment collections of the Cinémathèque Française and the Centre National de la Cinématographie.

Richard Crangle is a freelance researcher and writer, formerly Assistant Director of the Bill Douglas Centre for the History of Cinema and Popular Culture.

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Translated and edited by Richard Crangle

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TRANSLATOR'S NOTE

When, in 1995, I was shown Laurent Mannoni's new book *Le Grand Art de la Lumière et de l'Ombre*—seemingly one of the few copies of the book to have crept across the English Channel—I immediately recognized an essential text. Not only did it take a bold and encyclopaedic sweep through the history of the media which preceded the cinema (an area, as Mannoni himself notes, sadly lacking in reliable historical coverage), it did so with an engaging and lively tone and a storyteller's turn of phrase. Compared to the dry and theoretical works of film studies with which I was used to wrestling, *Le Grand Art* came as a refreshing change.

Later that year, appropriately in a bookshop in Lyon, I succeeded in tracking down my own copy of the French edition, and began to agree with others who had seen it that it would be a good idea if somebody were to translate it into English. It came as something of an extended surprise to find that person to be myself, and also to find an interested publisher in the University of Exeter Press. Some years later, the present volume is the result.

After such an extended process of translation, my first acknowledgement has to be to Simon Baker, Genevieve Davey, Anna Henderson, Rosemary Rooke, and others at University of Exeter Press for their patience, understanding, and continued support for the project. Richard Maltby was also, as ever, a continuing source of support and encouragement. Laurent Mannoni was kind enough to read the draft and help with many of the last-minute questions and Jane Olorenshaw copy-edited the book with a light but assured touch; any errors or misunderstandings remain, of course, my own.

John and Bill Barnes, Michael Bartley, Stephen Bottomore, Tom Gunning, Susan Hayward, Stephen Herbert, Peter Jewell, David Robinson, and Deac Rossell, along with numerous other members of the Magic Lantern Society, have provided invaluable encouragement and great or small acts of assistance along the way. On a more personal level, the way of the translation was smoothed greatly by the good company of good colleagues, among whom were Giacomo Barisone, Kate Bowles, Leo Enticknap, Mark Gant, David Kennedy, Christopher McCullough, Katharine Murphy, Kate Offord, Amy Sargeant, Rebecca Selman, Kate Tyler, and the students of the Exeter MA in the History of Cinema and Popular Culture in 1997–8.

And as in all things, my greatest source of support and sustenance has been Ester Roosmaa; this piece of work is for her.

R.C., Exeter, Spring 2000

Foreword

by David Robinson

The first French edition of *Le Grand Art de la Lumière et de l'Ombre* appeared in 1995. Five years on, it is necessary to revise the original foreword, in order to place this book in the context of the extraordinary and continuing corpus of work that Laurent Mannoni has accomplished in the interim.

It was already clear, at its first appearance, that *Le Grand Art* represented a revolution in the study of the origins and prehistory of moving pictures. There had been a few attempts before at a comprehensive history embracing the whole panorama from camera obscura and peepshow to the arrival of cinema in 1896. None however had come near the regour of Mannoni's insistence on primary sources for his history—texts, documents and above all the two hundred years of patent specifications which, in the field of pre-cinema, he is the first to have extensively and critically explored. The book set challenging new standards for every future scholar.

By chance *Le Grand Art* appeared within a few months of that other fundamental and very different resource, Hermann Hecht's *Pre-Cinema History*, a vast annotated bibliography that encapsulates Hecht's own life-time of reading and research. It seemed fortuitous that in some respects the books were complementary: while both attempt a global survey, Mannoni provides the French perspective on which Hecht, exemplary on his English and German sources, is weakest. Hecht is a reference tool; Mannoni a running narrative. It is the mark of the exceptional scholar that the text, for all its fine detail and digressions, is lucid, unpretentious, personal, witty, a pleasurable read.

The book now appears, in retrospect, as the nucleus of Laurent

Mannoni's overall later activity. His subsequent voluminous writings have extended individual aspects of the history. In particular his definitive studies of Demenÿ and Marey* have altered perceptions of those friends who in the end turned into sorry foes. In the case of the latter, his research and documentation has fundamentally altered even his own view of film history, by establishing definitively that Marey had made chronophotographic images on celluloid film as early as the summer of 1889.

Perhaps Mannoni's most remarkable achievement to date has been as the curator of the collections of apparatus of the Cinémathèque Française—a post which he undertook almost at the very moment when *Le Grand Art* came out. The collections were begun in the 1930s by the omnivorous gatherer Henri Langlois, founder of the Cinémathèque, and were notably augmented around 1960 by the acquisition of the Will Day collection. Begun in the first years of the 20th century by the English film pioneer Will Day, this incomparable hoard of documents and artefacts had previously been on loan for forty years to the Science Museum, South Kensington, but the British had never found the incentive or means to purchase what should have been a national treasure.

Mannoni found the collections in a deplorable state, partly in dusty disorder in the cellars of the Palais Chaillot, partly scattered in inadequate warehouses across Paris. Much of the Day collection was still in the boxes in which it arrived at the Cinémathèque in 1960; some boxes even appeared to have remained untouched since Day put his collection in store during the First World War. Unbelievable though it may now seem, single-handed Mannoni sorted, cleaned and arranged the restoration of the thousands of objects, and, no less single-handed, personally repainted the Musée Henri Langlois where the iceberg tip of the collection was displayed.

His efforts were rewarded with thrilling discoveries. For the first time the monumental importance of the Day collection could be assessed. Mannoni found, entirely forgotten among the dirt, the legendary first films of William Friese-Greene and a stack of over one hundred large original drawings by Marey. Day turned out to have acquired many of the most celebrated lantern slides from the Royal Polytechnic. Even Skladanowsky's 1895 camera, mislaid for 40 years in the Cinémathèque,

*Laurent Mannoni, with Marc de Ferrière and Paul Demenÿ, *Georges Demenÿ: Pionnier du Cinéma.* Douai: Editions Pagine, 1997.
Laurent Mannoni, *Étienne-Jules Marey: La Mémoire de L'Oeil.* Paris/Milan Cinémathèque Française/Mazotta, 1999.

came to light and could finally be restored to its rightful owners, the Berlin film museum. Not content with these stirring resurrections, Mannoni has gone on to double the already vast holdings of the Cinémathèque through purchase, gifts and the annexation of other public and private collections.

All this was dramatically threatened on the night of 23 July 1997 when fire swept the upper part of the Palais Chaillot. For 20 hours, an ever more dishevelled Mannoni toiled alongside the firefighters to save his precious charges—a scene, in itself historic, that was fortunately caught by the television news cameras. Since then the collections have been kept under ideal conditions in one of the towers of the new Bibliothèque Nationale.

Work with the collections has developed Mannoni's experiments in museology. His exhibitions 'L'Art Trompeur' (on pre-cinematic shows), and 'Jules-Etienne Marey, La Mémoire de l'Oeil' have been as innovative as his books. Rigorously scientific, lucid in exposition, refusing to patronize the public with facile 'interactive' seductions, but created out of knowledge and passion, they have been visibly more thrilling and attractive to large audiences than modish theme-park methods.

Few would dispute that Laurent Mannoni is the most important single creative personality in the history of the Cinémathèque Française since its formidable founder, Henri Langlois. The fascination is always to know what he will do next, what new vista of the still mysterious lanscape of pre-cinema he will illuminate for us. The passion, knowledge and humanity and the vision of cinema history that have impelled this astonishing achievement are already apparent in *Le Grand Art*, completed when its author was 27, but with a genesis that went back to his teenage years. It is no cold, dry, academic study, but a pulsing, vital chronicle. Mannoni's history has been made by living people, whom he variously admires, loves, pities and sometimes despises, according to their deserts. 'The cinematographic industry, as Demenÿ, the Lathams, and Armat and Jenkins were already aware, did not come into being without a number of acts of betrayal, dubious compromises, and knives in the back'. His uncompromising scholarship in no way excludes a communicated fascination with these human dramas. That larger cultural drama which is the central subject of this book could not be better summarized than in the author's own thrilling evocative image: 'It was as though an eye, whose lids had been lifting, slowly, across the centuries, now opened completely on the world.'

David Robinson

Author's Preface to the 1995 Edition

This book was born out of a meeting, more than ten years ago, with Lotte H. Eisner, the historian and co-director (with Henri Langlois) of the Paris Musée du Cinéma. In her apartment-cum-museum in Rue des Dames, Neuilly, on the outskirts of Paris, this great woman (now sadly departed) showed me a polychrome magic lantern, still shining with its red, blue, green and gold lacquer. This object, if truth be told, had been banished to the top of a cupboard, and Lotte did not seem to attach very great importance to it, preferring her 'Japanese' painting signed by Louise Brooks or her baroque cherubs in gilded wood. However, it was the lantern we discussed: where had this strange and luxurious projector come from? What could it have shown, before the arrival of 'cinema'?

She recommended several recent books to me. This was a depressing experience: not a word, or at best a few lines, on the 'prehistoric' past of the cinema. Even the most serious author, Jacques Deslandes, absolutely refused to travel back further than the nineteenth century. But the dream of being able to project moving illuminated images on a wall or screen is almost as old, in the history of humanity, as the dream of flight.

Most historians accord the realisation of this dream no more than a small note in the margin, and mention no more than a handful of daring technicians: Edison, the Lumière brothers . . . In truth the invention of the cinema was a 'long march' which lasted for several centuries. It was a story filled with crowds of highly ingenious pieces of equipment, infinitely varied images ranging from the popular to the poetic, and researchers who, although occasionally charlatans, were often scientists with a rigorous and very modern approach. Reading other books (such as those by Jurgis Baltrušaitis, Franz Paul Liesegang, and David Robinson), I discovered that the little-explored heyday of 'pre-cinema' displayed an

inexhaustible artistic and technical richness. As for the nineteenth century, there was even more to say about that period.

But some minor authors, contradicting each other about important facts, kept muddying the waters of my understanding. I decided, therefore, to return systematically to the sources, even the most ancient ones, in search of the truth. Having taken this course, I was overwhelmed by a whirlwind of books, pamphlets, articles, patents, letters, forms, manuscripts, glass slides, and antique equipment.

One day deciphering the folio volume by the German Jesuit Kircher, the next poring over the archives of Georges Demenÿ, the disciple of Marey; rediscovering the entrancing beauty of the works of Christiaan Huygens, then plunging into the great commercial enterprises of 1895; through all such adventures I was struck above all by one great consistency. From the illuminated shows of the Italian della Porta in the sixteenth century, through to the cinematographic projections of the Lumière brothers in 1895, there was certainly plenty of technical difference, but there was one overriding godlike desire: to recreate life, to see a human alter ego, either hand-painted or chronophotographed, living and breathing on the screen.

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Two impassioned researchers, Thierry Lefebvre and Jean-Jacques Meusy, responded to all my questions with great friendship. Maurice Gianati, whose documentation seems inexhaustible, supplied me with a great many priceless pieces of information. François Binétruy allowed me to make close examination of some extremely rare, sometimes unique, devices. Olivier Auboin-Vermorel allowed me the benefit of his fine collection of cameras and projectors. John Barnes, Jean A. Gili, Tom Gunning, Dominique Lebrun, and Jean-Loup Passek always proved warm and encouraging.

Marianne de Fleury and Dominique Païni, before they welcomed me onto their staff, generously opened the reserve collection of the

Archives de la Cinémathèque Française, a magical place where important discoveries are always to be made. Emmanuelle Toulet kindly welcomed the results of my first research, and gave me the opportunity to explore the collections of the Bibliothèque de l'Arsenal. Isabelle Champion, Jean-Pierre Jeancolas, Jean-Pierre Mattei, and Lausa Susini also brought their friendly support to this long undertaking.

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Introduction
by Tom Gunning

More than four centuries of moving images: Mannoni's discovery of cinema

Origins are slippery things, figuratively and literally, and the cinema is possibly the most slippery medium that has ever existed. In his memoirs, Sergei Eisenstein lamented that he had no better luck finding out about the origins of the creative process from his mentor and creative father, theatre director Vsevolod Meyerhold, than he did learning about where babies come from from his biological father. Origins are shrouded in a mixture of forbidding taboos and driving curiosity, and constitute a troubling concoction of claims to power and ownership (often spurious, always simplified): myths of inevitable progress; national pride; and simple misinformation. Faced with the snake-pit of claims and counter-claims, pure egotism and obfuscation that marks accounts of the origins of cinema one might just throw up one's hands and decide to detour around the entire issue. In fact, the famous Brighton Project of the International Federation of Film Archives (FIAF), which took place in 1978 and (at least in some myths of origins) inaugurated a new scholarly investigation of early cinema, specifically targeted the years 1900–06 as its area of investigation, skirting the period of invention and origin. The organizers of the project diplomatically decided that to investigate the invention of cinema would immediately ignite partisanship of the various 'inventors' and pit one national claim against another.

Luckily for film studies—and for cultural history generally—two scholars have recently approached the origins of cinema with not only peerless and patient research, but with a broad perspective, unwilling to become promoters of either a single hero or a particular nation. Most

recently Deac Rossell's *Living Pictures: the Origins of the Movies* (Albany, N.Y.: State University of New York Press, 1998) provides the most reliable handbook of the interlocking attempts to devise motion pictures in the nineteenth century, giving long-overdue attention to the relatively ignored German tradition of Ottomar Anschütz, and a history of the perfection of celluloid as a base. Rossell offers a wonderful sense of the variety of approaches tried out by motion picture technicians and refreshingly refuses to privilege one tradition over another, avoiding especially the writing of history from the perspective of the techniques that later became dominant. Uniquely, Rossell demonstrates the visual qualities of vanished techniques of projection, such as those employing glass images or multiple lenses.

The other great contribution to the rewriting of the origins of cinema you now hold in your hands: Laurent Mannoni's *The Great Art of Light and Shadow*. Although Mannoni himself has since supplemented it with a detailed study of Georges Demenÿ and essays on some of the other figures he discusses herein, this is the work that I believe most thoroughly and imaginatively redefines the shape of early film history, rethinking the issues of origins and thereby defining a new field for research and investigation. This field should no longer be called (as it often was in the 1970s) simply 'proto-cinema,' because it extends through centuries and includes a complex culture of projected and technological images that was not simply waiting for cinema to appear and perfect it. Mannoni extends the profound insight of cinema historian Charles Musser that the history of film cannot be understood unless it is seen as part of a long tradition of 'screen practice', centuries of projected images. But essential as it may be, the screen itself is not necessarily the centre of all these devices. The centre lies, rather, as Mannoni dubs it after Kircher, in 'the great art of *light and shadow*' a tradition which, while it made way for the projected moving image that appeared at the end of the nineteenth century, included many great achievements other than the flicker images of the movies. In our dawning age of new movement media, we can see Mannoni's work as outlining a tradition not simply for cinema but for video, computer-generated images, virtual reality, and a host of new media that pursue the delights that Mannoni chronicles—virtual images made of light and shadow. Mannoni sets out here not a simple pedigree or genealogy for cinema, but a whole complex and neglected visual culture, one of whose forms became the movies in the twentieth century.

Studies such as Mannoni's and Rossell's immediately discredit the metaphor of biological paternity and the family romance of discovering

the true father (or mother) for cinema—that poor shivering foundling abandoned on the doorstep of art and commerce sometime at the end of the nineteenth century. With Mannoni's work, we discard a method which traces offspring back to a single point of origin. He substitutes almost the inverse figure: the device we recognize as motion pictures, when traced backwards, fragments and multiplies, unravelling a skein of influences and practices that move back into centuries-thick layers of culture and history.

If the twin metaphors of biology and invention are deconstructed by such an approach (which, while not discrediting the contributions of Edison, Marey, Muybridge, Demenÿ, Lumière, Paul, etc., no longer isolates them from the energies of a broader cultural history), what about the perhaps more useful metaphor of archaeology which Mannoni uses in his subtitle, again recalling an earlier milestone, C.W. Ceram's classic work *Archaeology of the Cinema*? Mannoni is not investigating a long-vanished civilization whose languages and customs are foreign and difficult to reconstruct, the subject of speculation as much as reconstruction. Instead he is uncovering a continuity of practices which can be systematically reconstructed without uncovering a foot of dirt (although in this contemporary era, of course, oblivion takes many forms and certainly a lot of dust has accumulated!). What Mannoni uncovers and describes here is part of history, not pre-history, and it is the fundamentally historical nature of his work that makes it so valuable. An alternative to the myth of cinema's sudden invention at the end of the nineteenth century by certain men of genius has often been to de-historicize cinema entirely, to situate its origins in pre-history, with analogies to cinema found not only in traditional shadow plays, but buried within the depths of humanity's most archaic origins, locating cinema's ancestors in the attempt to capture motion in cave paintings, the succession of images in Egyptian tombs, or in the shadows cast on the walls of Plato's cave. While this primitive myth is important for the way cinema has been understood (more revealing for film theory than film history), and the phenomenology of shadow and light lies undeniably at the core of cinema, Mannoni quite rightly does not engage in this sort of ahistorical speculation. The great art of light and shadow as Mannoni describes it neither sprang suddenly from the head of Louis Lumière at the end of the nineteenth century, nor is it an eternal factor of human culture. Rather, Mannoni traces it to a particular period of scientific and technological discovery: the sixteenth- and seventeenth-century renaissance of science and technology in Europe.

The great importance of Mannoni's book lies, therefore, not only in

providing the single best and most carefully detailed history of the origins of cinema, but in laying out a multi-century trajectory for the invention of and fascination with illuminated, moving or technological images. Mannoni does not simply tell the story of cinema's 'invention,' but rather describes the intersection of a scientific fascination with elements of visual perceptions—the science of optics—with a delight in the creation of illusions. Thus cinema's history begins in 'Natural Magic,' as typified by a figure such as Giovanni Battista della Porta (1540–1615), who showed how magical illusions could be created through 'natural' means, by a combination of mechanics and optics, the knowledge of lenses and mirrors and a creation of new relations between the perceiving eye and the power of light. The camera obscuras, anamorphic images, parabolic mirrors, and catoptrical theatres of 'Natural Magic' constitute a vital and interconnected realm of visual experiments and devices which finds its most versatile and powerful form in the magic lantern of the seventeenth century. These illusory devices deserve as much cultural investigation as the more respectable offspring of the science of optics, the telescope, microscope and the devices of perspective, have received.

What Mannoni displays is, once again, not a sudden invention, but a rich and varied culture obsessed with the nature of vision and its deformation, and new possibilities of representation through technical devices. From the beginning we find here a delight in illusion which has an entertainment aspect and was promptly exploited as such, intertwined with a desire to demonstrate principles of the science of light and vision. In this fascination with optical devices we find perhaps the strongest cultural expression of the fundamental energy of the era of the Renaissance as it moved towards the Enlightenment. This is the impulse originally condemned by the churchmen of the Middle Ages as a sin, and increasingly liberated and fostered by the new discoveries of the Renaissance: *curiositas*. Visual curiosity drove both the magical amusement offered by this new culture of optical devices and the scientific research which underpinned and was demonstrated by it. In this era of cabinets of curiosities, the new optical devices perfectly embodied a brave new view of the world, a world rendered strange and vivid in its novelty.

Thus Mannoni reveals the key place of visual culture in the dawn of modern sciences. He carefully establishes the importance of Dutch humanist Christiaan Huygens for the perfection of what became known as the magic lantern. Like Musser, Mannoni questions the traditional attribution of this device to the Jesuit Athanasius Kircher, and shows that the magic lantern appeared among a number of visual devices

Huygens developed. Huygens' lack of interest in publicizing or claiming his invention does not prevent Mannoni from demonstrating not only his key role in its invention, but also Huygens' immediate interest in creating an illusion of motion through this projection device, designing a movable glass slide portraying an animated skeleton removing its skull. A fascination with the uncanny aspects of the power of these projected image devices (which were often referred to in their early phases as 'lanterns of fear') and the paradoxical 'animation' of inert images is evident from their origins.

But for Mannoni the great art of light and shadow never restricts itself to the devices and inventions played with by a small number of savants in their laboratories. Like the cinema, the art of projected images is a social practice, involving audiences and showmen. Along with his detailed discussion of the various innovators and inventors, Mannoni describes the fully developed culture of exhibition through which the magic lantern took Europe by storm. Savants and priests, mountebanks and showmen toured magic lantern shows around the world, extending even to China where the Jesuit Claudio Filippo Grimaldi presented an exhibition to the Emperor in Peking in 1671 or 1672 as a marvellous example of Western technology. In the eighteenth century the lantern passed from an entertainment of the elite to a pastime of the people, as travelling showmen wandered the highroads and showed their wonders in towns and villages. At the same time the lantern never lost its ties to science and enlightenment and was seized upon as a particularly modern and effective mode of instruction, dragooned even to teach history and science to the Dauphin on the eve of the French Revolution.

With the passion and attention to sensuous detail of a true collector, Mannoni describes the variety and offshoots of the lantern, the various optical boxes and peepshows, and evokes the beauties of the hand-painted glass slides and their transformation during the eighteenth century. Episodes of history, fairy tales, *diableries* and gags, scatological and even obscene images were projected, along with trick slides of the sort Huygens first envisioned, creating illusions of motion or mythological metamorphoses. The projection possibilities of the magic lantern were also combined with the magnification of the microscope to produce the 'solar microscopes' which could display the mysteries of the unseen world of tiny infusoria cavorting in a drop of water, or enlarge the intricate articulations of a flea's legs. More terrifying to many than the painted devils of the Jesuits, these monstrous creatures with unheard-of dimensions loomed before spectators, creating a new sense of scope

and scale that visualized a world of science more fantastic than the fairy-tales of giants projected for children.

Nowhere is the great art of light and shadow's ambiguous relation with the world of the fantastic better demonstrated than in Mannoni's thorough discussion of the phantasmagoria of Philidor and Robertson. This form of magic lantern entertainment has become part of our language, a term describing an impossible—yet fully convincing—illusion. Beyond its use to describe any experience in which the senses seem to be stimulated to the point of hallucination, 'phantasmagoria' was used by Marx and others to describe the non-reality of modern culture under capitalism, in which the spell of the commodity enwraps the masses in a sort of illusory wonder, obscuring the actual conditions of production. The lantern entertainment at its most complex became a metaphor for the peculiarly modern experience of a loss of a sense of reality, a world in which appearances could be so completely controlled that the possibility of seeing through them to an underlying actuality seems to be in peril.

Mannoni not only provides the most complete account of the phantasmagoria in its various forms, but clearly situates it in the crisis point of the age of Enlightenment: the French Revolution and its aftermath. The phantasmagoria balanced itself on the cutting edge of the art of light and shadow, exploring the ambiguous realm between phantom and substance. By a variety of projection devices (moving the lantern to create effects of enlarging or shrinking of the image, projection of a wavering and uncanny image on billows of smoke, effects of transformation through mechanical slides or anamorphic lenses), the images themselves were endowed with a sense of protean energy. As insubstantial projections seemingly came to life, these ambiguous images could be presented as manifestations of spirits and ghosts. As Mannoni shows, the presentation of these images set the stage for the modern magic show. Phantasmagoria showmen would invoke the spirits of the dead, display images of recent victims of the guillotine or newly deceased celebrities like Benjamin Franklin, yet at the same time proclaim their allegiance to the regime of reason and announce that there was nothing produced in their shows that could not be scientifically explained.

The greatest phantasmagorical showman, Étienne-Gaspard Robertson, held his seances on the grounds of a ruined Capuchin monastery, on the very site of the old religion overturned by the Revolution, yet still haunting the consciousness of the public. The visual and psychological effects of the ruins combined with the special decor of skulls and Egyptian hieroglyphics to produce a receptive and possibly fearful

attitude on the part of the viewers. As Freud has demonstrated, the experience of the uncanny derives from the lingering of an irrational belief, often even unconscious, after the conscious has dismissed the old belief as nonsense. As the magic lantern had embodied the marvels of the new science in the seventeenth century, so at the close of the eighteenth it acted out the contest between superstitions and reason, with a form of illusion which could invoke both simultaneously. The attraction of the phantasmagoria, which soon became a world-wide form of entertainment, literally enacted the new consciousness of modernity: torn between doubt and credulity, fascinated by the ways its senses could be entertained as its logic sought, not always successfully, for explanations.

In the nineteenth century this rich visual culture became industrialized and found a truly mass audience. The creation of a commercial visual culture was at least a century old before the cinema appeared and appropriated it. Throughout the nineteenth century new technologies of visual reproduction and new sources of light appeared and supplied improved means to shape and fix its shadows, ushering in a new era of visual illusions. These included entertainments of light and shadow that created not a simple image, but rather a total environment. Secularizing and rationalizing the fearsome spectacles of Robertson's phantasmagoria and its creepy setting, the panorama and diorama sought to create a situation in which the viewer would be totally immersed in the illusion. While the panorama and diorama developed partly from landscape and history paintings, they sought to transform the very nature of perspective-based easel painting since the Renaissance, the enframed image seen from a single view point, as if viewed through a window. The 360 degree space of the panorama engulfed the viewer, using perspective to turn space inside out, so that the viewer constituted the vanishing point of a mobile, rotating point of view. Light itself was essential to the illusion, with the specially designed panorama exhibition spaces using the new architecture of glass to illuminate the painting from unseen sources with the actual light of nature itself, changing with meteorological conditions. But light played a much stronger role in the panorama's offspring, Daguerre's diorama, which sacrificed the 360 degree space for a more careful technological control of light projected through semi-transparent canvases, which could transform from one view to another or more subtly create changing effects of light and shadow, compressing time, for instance, by moving through the cycles of the day and night.

Daguerre, as a painter of stage sets, understood the theatrical effects

of new technological control over light and shadow, but was equally drawn to the problem pursued since the beginning of the century: of actually securing, fixing for ever, the shadows cast by nature. Extending the research of Niépce, Daguerre turned from the massive scale of the diorama to the miniature image of the daguerreotype, offering a means to capture an image created by light itself as it affected sensitive chemicals. Although the intimacy and small scale of the daguerreotype seem to set it apart from the 'great' art of light and shadow, the pursuit of a technologically caused image would eventually intersect with the magic lantern and open new realms of visual pleasure. A new realm of investigation of the nature of visual perceptions and the possibility of tricking the human eye would pave the way for this, as the savants once more take took centre stage.

The optical illusions which cluster around the old-fashioned term 'persistence of vision' were a subject of investigation in the eighteenth century, although some related effects had been remarked as early as the writings of Aristotle. But it was primarily in the nineteenth century that scientists such as d'Arcy, Roget, Brewster, Faraday, Plateau, Stampfer and Babbage made careful observations of the way the eye could be tricked into creating visual superimpositions, or even illusions of motion, by viewing rapidly changing images. The various devices, known as 'philosophical toys', designed to demonstrate and exploit these frailties of human vision occupy the centre of Mannoni's account: the thaumatrope, anorthoscope, phenakistiscope, stroboscope, etc. Perhaps even more than the original projecting devices of the seventeenth and eighteenth centuries, these toys combined the fascination of illusion with the demonstrations of science. But, picking up a cue from Jonathan Crary's brilliant discussion of optical devices in his work *The Techniques of the Observer*, we could point out an important difference. The projected images of the original magic lantern amazed viewers because in some sense they did not know whether to take them for substance or shadow, image or reality. Careful observation and familiarity with the projection techniques could dispel these illusions, revealing them as figures merely composed of light and shadow. But in the optical toys of the nineteenth century (and we could add here Crary's main example, the stereoscope), the illusion of motion was no longer based on credulity: the viewer actually *saw* the images superimposed or the succession of motions or the illusion of three-dimensionality. In other words, the senses themselves were fooled; even understanding the nature of the device could not dispel the illusions. As Crary shows, in the nineteenth century the subject of investigation became not simply optics in the sense of the

properties of lenses and light, but rather the actual human sensorium, the nature of perception and its physical basis in the eye. These new optical toys continued the long tradition of visual fascination through a combination of magical-seeming illusions and scientific demonstrations, but now the scientific interest was rooted in a new investigation of the human body as a perceptual device itself.

Lanternists were quick to try to combine these new illusions of motion with projectors which could display them to larger audiences. Mannoni painstakingly details dozens of such devices, now unjustly forgotten, which reveal that audiences watched projections of motion for decades before the innovation of modern motion pictures. But these special effects of motion were basically a sideshow to the key role the magic lantern took on, in much of nineteenth-century Europe, as the mass medium of visual information. The lantern show was adapted to every possible task of entertainment and instruction, and adopted by a huge range of institutions and practices from travelling entertainments, to temperance lectures, to the promotion of the principles of both religion and science and the conveying of distant lands and current events to masses of people. As a mass medium, the magic lantern was industrialized in both the manufacture of lanterns (for professional exhibition as well as home use) and of the slides themselves, including the adaptation of photography to mass reproduction via photographs printed on glass slides. The magic lantern was the first medium to contest the printed word as a primary mode of information and instruction.

Mannoni maintains the dual focus needed for a vivid account of this new visual culture, balancing the popular with the scientific, as the new visual culture increasingly understood itself as participating in the key myth of the nineteenth century: the inevitable advance of science, industry and 'civilization'. Thus, as the showmen were adapting the new observations about the visual illusion of motion, physiologists such as Étienne-Jules Marey, fully aware of the manner in which the human senses were unreliable, sought new technological means of observation, quicker and more permanent than simple visual observation. Cued by the photographs of animal and human motion of photographer Eadweard Muybridge, Marey and his assistant Georges Demenÿ saw the usefulness (as well as the limitations) that photography might offer as a means of analysing the body in motion. Two new factors have entered into the mix here: a further perfection of photography in terms of time and a new attitude towards the body.

Daguerre and Niépce were concerned about fixing the photographic

image, overcoming the gradual darkening that all previous photographic experiments had found inevitably obscured the images they obtained. They were less concerned about capturing an instant of time, and their original exposures took many minutes. Throughout the nineteenth century, however, the focus in photography began to shift from the fixing of the image to fixing of an instant through shorter exposure times. By the second half of the century (and especially towards its end), instantaneous photography could claim not only to capture an instant, but to seize a fraction of a second in a manner no human eye was capable of. Thus Muybridge could freeze a horse in full gallop and display the positions of its hooves, or Marey could capture the beating of a bird's wings. Chronophotography exploited the possibility of instantaneous photography not only to seize instants of time, but to place these instants into a series, dissolving the continuous motion of the world into singular points, creating a series of images which could trace the successive positions of the human or animal body in motion.

A whole new world of observation was opened up, and the physical body and its behaviour became subject to a new regime of not only visualization, but discipline. Georges Demenÿ arrived at Marey's Station Physiologique with a strong interest in the body-building possibilities of certain forms of gymnastics, which could possibly be demonstrated and taught through chronophotography. Mannoni makes clear that this is not an isolated instance, but part of a broad scientific culture interested in the way chronophotography could deliver the smallest increment of time for analysis and observation. The frozen sequence of images constituted the major form of chronophotography for a host of European and American scientists and photographers.

But for Marey and most of these scientists, it was the frozen image, or rather the succession of frozen images (which could analyse motion in a manner human eyesight could not) that embodied the great scientific possibilities of chronophotography—not the illusion of motion. Chronophotography allowed the breakdown of motion into bits of information. The reconstitution of motion, the synthesis of these separate images into a continuous illusion, served only a secondary purpose, that of demonstrating that these separate images could be reassembled as stages of a continual motion, a sort of guarantee of the accuracy of the frozen images themselves. Marey, Muybridge and other chronophotographers did devise projectors that allowed such reassembly and illusion of motion, but they were less important than the cameras and the images they captured. Mannoni details the various supports Marey employed for his chronophotography, from glass to paper to celluloid.

But it was the Phonoscope, first devised by Demenÿ to aid the teaching of lip-reading to deaf children, which became one of the first forms of photographic motion pictures to gain commercial backing as a device of entertainment. Like Anschütz's Tachyscope, it consisted of a wheel of glass slides created by chronophotography which, when spun, would produce a moving image. This commercial undertaking infuriated Marey, who felt not only that his work was being exploited, but that scientific research was being contaminated by entertainment profits. As Mannoni shows, however, the display of motion pictures was by the end of the century proceeding on all fronts with different combinations of the devices that had been appearing throughout the nineteenth century. Émile Reynaud combined his Praxinoscope with a projection device and created the first animated films, using hand-painted images on long bands of celluloid which were being projected by his Théâtre Optique at the Musée Grevin by 1892. In 1894 Edison finally launched his Kinetoscope, supplying celluloid bands of motion photographs which could be viewed by a single viewer through a peep-show device, which received a brief but world-wide success. More importantly, Edison showed the world how simple the mechanics of displaying photographic motion pictures could be, especially with the use of flexible celluloid. Each of these devices embodied a different combination of the various practices of motion pictures that had been developing through the nineteenth century. Not only were there many researchers and entrepreneurs busy working on these new forms of entertainment—rather than the sudden *Eureka!* of the isolated genius —but also the rich visual culture of illusions that was now centuries-old supplied a vast array of practices and devices to draw from.

Once the fateful year of 1895 was reached, the possibility of commercial exhibition of photographic motion pictures arose in an environment already saturated with technical devices and, as Mannoni shows, a complex and highly competitive entertainment industry (born, as he says, in an atmosphere of treachery and stabs in the back) came into being. Mannoni threads his way through claims of priorities and refuses to pay homage to the established figures of the 'invention of cinema'. Thus the later commercial career of Demenÿ and his various devices plays as strong a role in his account of the coming of cinema as do the Lumière brothers or Edison, as well as a host of other figures, whether machinists like Henri Joly or Jules Carpentier, or entrepreneurs like George William de Bedts or Ludwig Stollwerck. Mannoni ends his account with the well-known achievements of the Lumières, but urges us to see them as

only one link in a long chain of devices and practices, a centuries-long tradition of images made of light and shadow.

It is precisely this approach, one which understands origins in terms of a broad range of cultural practices and the *longue durée* of centuries of history, rather than a founding father or mythical culture hero, that makes this book so uniquely valuable. Besides the treasure trove of information and facts that Mannoni has so carefully snatched from oblivion and assembled, it is his basic lesson that endures: that cinema is only part of a broad visual culture that stands at the intersection of modern science and modern media. This intersection still defines our media of information and entertainment and allows us, I believe, to rethink what the nature of modernity and its roots really are.

PART ONE

The dreams of the eye

1

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

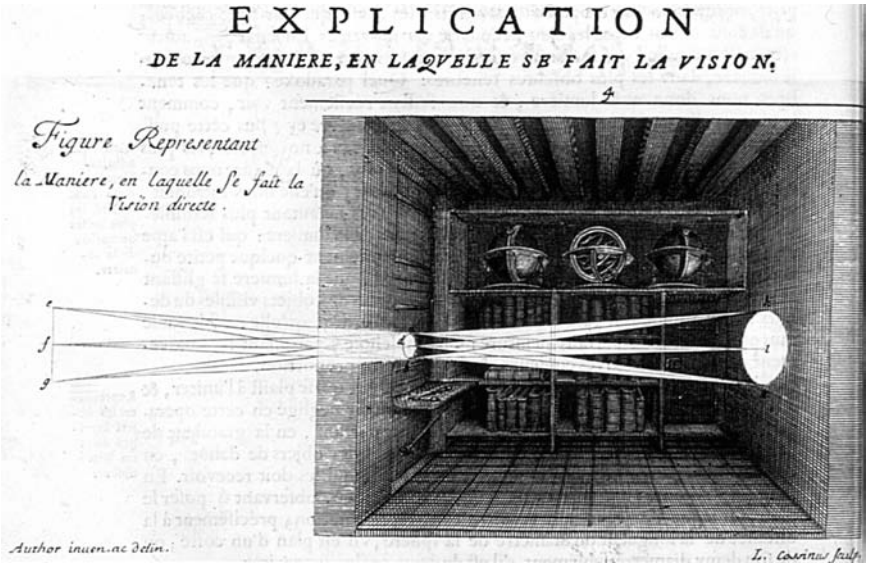

Fig. 1. Chérubin d'Orléans, *La Dioptrique Oculaire* (Paris, 1671). Collection: Bibliothèque Nationale.

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

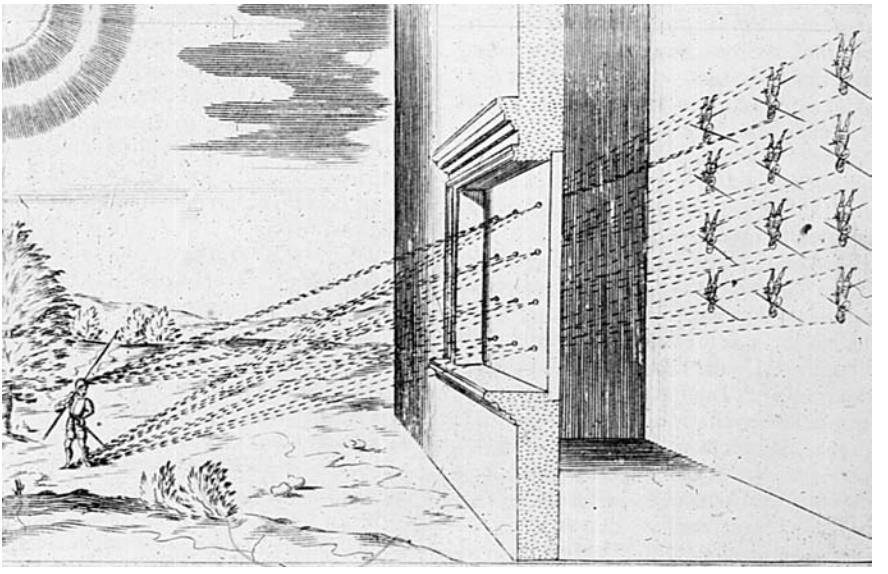

Fig. 2. Mario Bettini, *Apiaria Universae Philosophiae Mathematicae* (1642). Collection: Bibliothèque Nationale.

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

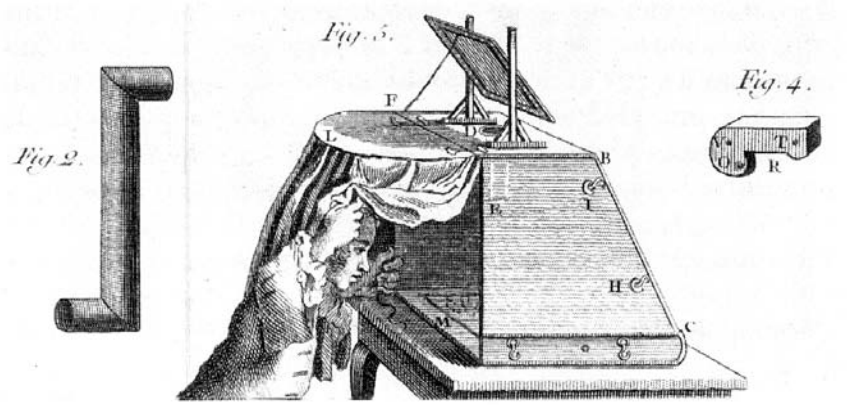

Fig. 3. Camera obscura, after van s'Gravesande.
Collection: Bibliothèque Nationale.

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

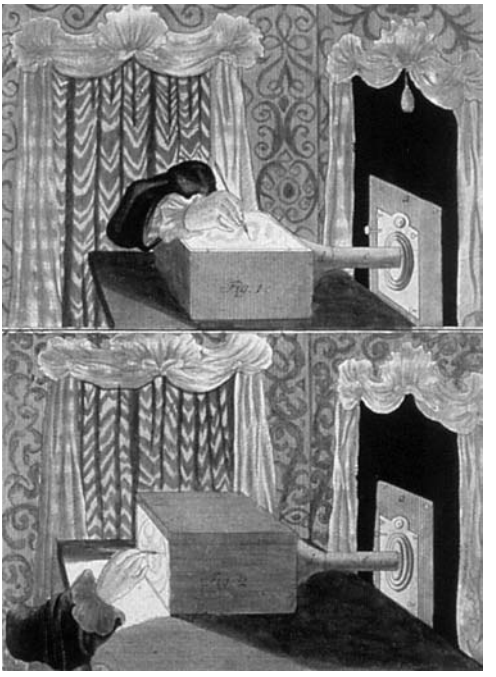

Fig. 4. Two camera obscuras, after Johann Sturm. Illustrated in Martin Frobene Ledermuller, *Amusements Microscopiques* (1768). Collection: Bibliothèque Nationale.

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

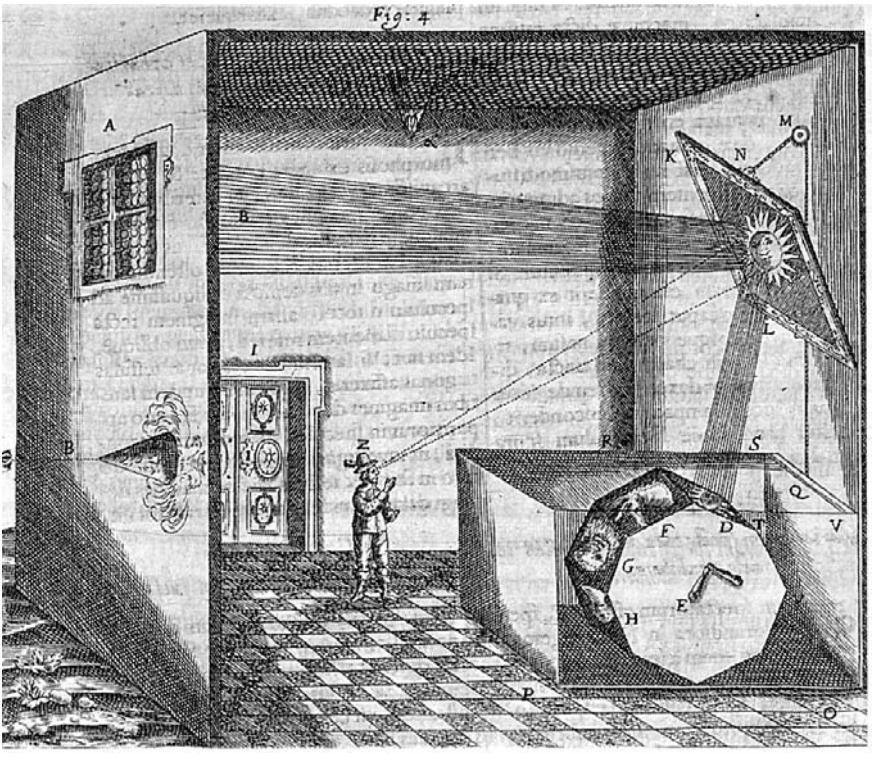

Fig. 5. Metamorphosis machine, illustrated in Athanasius Kircher, *Ars Magna Lucis et Umbrae* (1646). Collection: Bibliothèque Nationale.

> 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

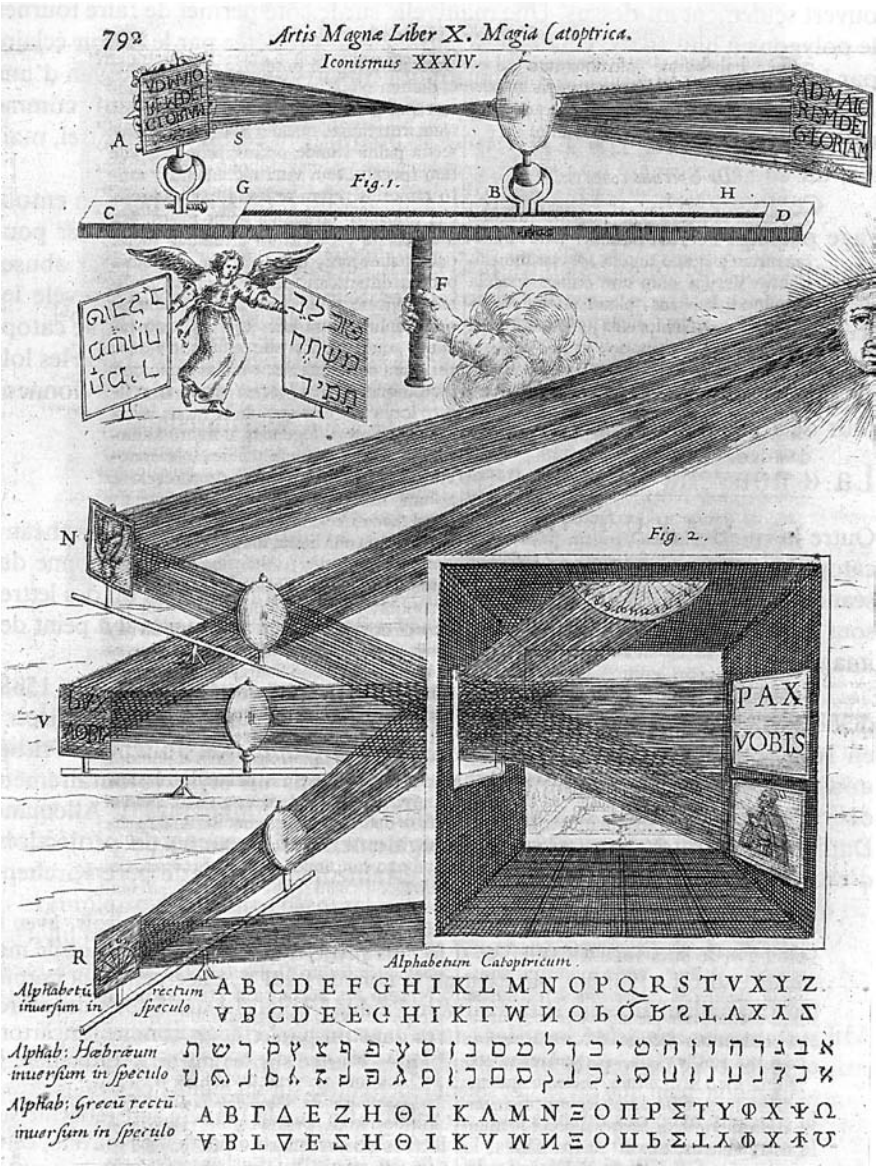

Fig. 6. Optical building for solar projection using engraved mirrors, illustrated in Athanasius Kircher, *Ars Magna Lucis et Umbrae* (1646). Collection: Bibliothèque Nationale.

> 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.