CHAPTER ONE

Introduction

"Edison or Lumière?" was the headline of an article published in the German showman's magazine *Der Komet*, on September 26, 1896. Written by Theodore Bläser, by the date of the article himself an exhibitor, filmmaker, and sales agent for projectors made by Otto Thiele in Geneva, his article contended that Thomas Edison was the real inventor of the new "wonder apparatus" and that the Lumière brothers had merely followed up Edison's invention of the Kinetoscope and turned it into a projection device. The fight over who was the "true" inventor of the cinema had begun, a battle that would last through a century of scholarship, cause many distortions of the historical record, and quickly come to involve issues of national pride and politics.

By the 1930s, several inventors had become fixed in their respective national pantheons as the "true" originator of motion pictures: in America, Thomas Alva Edison; in France, Louis and Auguste Lumière; in Germany, Max Skladanowsky; in Britain, William Friese Greene. At the same time, lively debates were underway on behalf of other inventors whose advocates contended that they had been overlooked as the movies became a worldwide industry and that their contributions as the "true" discoverers of the cinema had been obscured: C. Francis Jenkins, Thomas Armat, and the Latham family (America); Étienne-Jules Marey (France); Oskar Messter (Germany); and Robert William Paul (Britain).

There was never a shortage of candidates for the role of movie inventor (Austria could point to Theodor Reich, Poland to Kasimierz Proszynski, Russia to Ivan Akimovich Akimov), and later research that clarified the work of many of these pioneers seemed at the same time to create another byzantine layer of claims and counterclaims, as the details of the contributions of another whole group of inventors and mechanics was brought into the foreground of the historical record, among them Edison's assistant William Kennedy Laurie Dickson in America, Marey's assistant Georges Demenÿ in France, and Paul's one-time collaborator Birt Acres in England.

Recent writers on the origins of the cinema have tended to avoid many of the most egregious battles of the past and, while telling the story of the first experiments that led to moving pictures in some detail, have suggested that the cinema came to life through the near-simultaneous and independent efforts of many inventors in several countries. If this formulation avoids the sticky problem of naming the "first" inventor, it shares with earlier historical writings an implicitly linear concept of the discovery, introduction, and dissemination of moving pictures just before the turn of the century. The year 1895 is packed with crucial developments in film history, many with clear precedents reaching back over the previous decade, and the six months from November 1895 through April 1896 found moving pictures commercially shown to public audiences and specialist scientific groups in dozens of countries around the world. Getting the chronology of this period sorted out, understanding the mostly Greek- or Latin-based terminology that the inventors affixed to their new devices, and comprehending the relative contributions of the scores of figures involved in the story are together a powerful urge toward a careful linear exposition of the period. Yet a linear approach does not serve the material well: the work of some figures is unbalanced to make it fit the development scheme, other figures are omitted for the sake of neatness, and flattening the image of the period leads to oversimplification and a weakening of the relationships between various participants, denying the robust energy of the era.

Implicit in a linear search for "firsts" is the the question "'First' of what?" The habitual and often unconscious answer to this question projects backward in time the later characteristics of "the movies" drawn from an era well after the period of invention and exploration. This later concept of "the movies" came only with a matured technology and an established business practice that bears little or no relationship to the emerging medium of the 1890s. The beginning *was* the beginning, and few if any of its initial participants had any idea of the scope and impact that the new medium would have in the following century.

Whether this retrospective reading of a stabilized medium into its origins is represented by a search for the first close-up—or the first piece of edited film—as an indication of the origins of film language, or by the quest for the first use of the Maltese cross for giving intermittent movement to the film band in mechanical apparatus, the beginning of moving pictures is retrospectively defined by a context, style, technology, and presentational apparatus that became an emerging practice only after 1900 and stabilized in the next decade. While this search for early examples of either aesthetic or mechanical practice in the cinema is a useful historical endeavor in relation to later developments, it does not adequately reflect the activity of the 1890s, and in preselecting and prevaluing only some developments in the period of invention it begs the question of why certain artifacts, business proceedures, and film subjects were "successful" and others "failed."

The present book is a first attempt to examine the early days of moving pictures from a nonlinear and multidirectional perspective. It attempts to view the birth of moving pictures without privileging later developments from outside the period. While it is broadly organized chronologically, it strongly contends that not only were moving picture entertainments as they have been known throughout the twentieth century invented during this period (movies on celluloid, with a Maltese cross intermittent movement, seen by large audiences in fixed theaters, purveyed as storytelling entertainment or factual record), but also that several other kinds of moving picture were invented as well. It is these alternative proposals for moving pictures—as family portraits, as an instrument of science, as a mechanical variety act, as stereoscopic photography—that make the decade of the 1890s so diverse in its inventions and so resistant to attempts to force its artifacts into a single line of development leading only to the mass entertainment medium of the twentieth century.

These alternative ideas about moving pictures, about their uses and properties, directly influenced the many technological solutions to the problem of capturing and reproducing motion through photography, and account for the plethora of mechanical and optical apparatus that appeared in the 1890s. For there was no single predetermined and inevitable technical solution to the reproduction of movement for projection on a screen. Many technological solutions were possible—moving pictures on glass plates or on celluloid, with intermittent movement or without—and many were tried. Frequently, the relative success or failure of these alternative solutions is a retrospective judgment made possible only by the later stablilization of the technology within a single social apparatus of exhibition on celluloid in large theaters before mass audiences. To the inventors, showmen, filmmakers, and manufacturers of the late nineteenth century, this particular later resolution of the medium was only one of several possible results of their work, and a consequence that few imagined with any clarity.

This study of the beginnings of the cinema up to 1900 has been heavily influenced by recent writing about the history of technology, especially the work of scholars interested in the social construction of technology. Their work recognizes the influence of a variety of social groups on technology, not only in determining its use and development, but also in influencing the technical design of the artifact itself. The first generation of movie inventors came from a variety of backgrounds, including optics, magic lantern work, photography, scientific research, magic, and electrical manufacture. They lived in a fast-changing era that was characterized by a multiplicity of competing solutions to technological problems. One illustration of multiple solutions to a technical issue is well exemplified in the long process of establishing electrical power generating and distributing systems. As late as 1913, for example, public electrical supply in greater London was provided by 65 separate electrical utilities with 70 generating stations using 49 different types of supply systems on 10 different frequencies, with 32 voltage levels for the transmission of electrical power and 24 for its distribution (Hughes 1983, 227). The rapid and confusing spread of competing electrical systems and the earlier rapid and intensive development of telegraphic communications frame an era that also saw the phonograph begin to replace music boxes in the home, the spread of photography to a mass market, the use of X-rays in medical diagnosis, and experiments with gliders and advanced balloons leading to powered flight. Within this changing world, the first generation of moving picture inventors approached the problems of capturing and recreating natural motion through photography. Their respective experiences and habits of thinking influenced both their concepts of what moving pictures could be, and the specific artifacts they created to fulfil their dreams.

Social influences on the development of technical apparatus are not limited solely to inventors, mechanics, and builders; influence was also exerted through the varying experiences of exhibitors, audiences, officials, and a variety of other social groups, or by exceptional events, contemporary theories and practices, existing social patterns, and problem-solving habits. The exhibition of moving pictures in a large varieté or vaudeville theater in a major city, for example, made demands on the construction of mechanical equipment and its source of illumination that were distinctively different from those required by an itinerant single showman renting storefront spaces in small towns, or exhibiting in hotel and public house venues.

The most useful model of the multiple influences that shape a technological artifact has been suggested by Wiebe E. Bijker in his description of the "technological frame." His model should be "understood as a frame with respect to technology, rather than as the technologist's frame" (Bijker 1987, 172). As such, it is intended to apply not just to groups of inventors, mechanics, and engineers directly involved in applying their skills to an artifact, but also to all social groups who had any involvement with the artifact and who as a consequence influenced the artifact, whether as users, sellers, regulators, observers, or paying customers. Moveover, Bijker explicitly intends the technological frame as a construct "intended to apply to the *interaction* of various actors. Thus it is not an individual's characteristic, nor the characteristic of systems or institutions; frames are located *between* actors, not *in* actors or *above* actors" (1987, 172). The members of a social group attribute various meanings to a technological artifact and in so doing provide an understanding and shared meaning for the artifact, or in Bijker's words, "as it were, a grammar for it" (1987, 173). Various actors or social groups can also have stronger or weaker identifications with a particular technological frame that can additionally determine the degree of their inclusiveness within that frame, and their consequent response to an artifact and their vision for its use.

One example of how a technological frame can be used to illuminate problems in the early history of the cinema can be seen from a brief look at a few of the figures associated with the technological frame including magic lantern work (discussed in more detail in chapter 6). As an important predecessor of the cinema, with its own tradition of "moving" pictures and visual storytelling, its own exhibition patterns and manufacturers of optical apparatus, magic lantern work had an immense influence on the first years of the cinema. The English inventor Robert W. Paul declared that his first projection apparatus was intended "to be capable of attachment to any existing lantern" (Paul 1936, 43), just as Cecil Wray's first apparatus of 1896 was a simple projection mechanism intended to fit wholly within the standard slide stage of a normal magic lantern (Wray, 1896). Both machines were quickly taken up by exhibitors with magic lantern backgrounds, and Wray's device was purchased and marketed by Riley Brothers of Bradford, England, a well-known firm of lantern and slide manufacturers, as Riley's Kineoptoscope.

Paul was an electrical engineer whose firm manufactured instruments for the growing electrical industry, and whose first contact with film came through the manufacture of reproduction Edison Kinetoscopes; notwithstanding his 1936 statement about the practical dimensions of his first film projector, his degree of inclusion in a technological frame of magic lantern work can be considered small. With the wider contacts of his electrical manufacturing business, his apparatus was taken up quickly not only by lanternists, but also by magicians and travelling showmen, ultimately directly influencing Georges Méliès in France and Oskar Messter in Germany, among many others. Cecil Wray was also an electrical engineer by trade, and also took up film work through the Edison Kinetoscope, patenting a

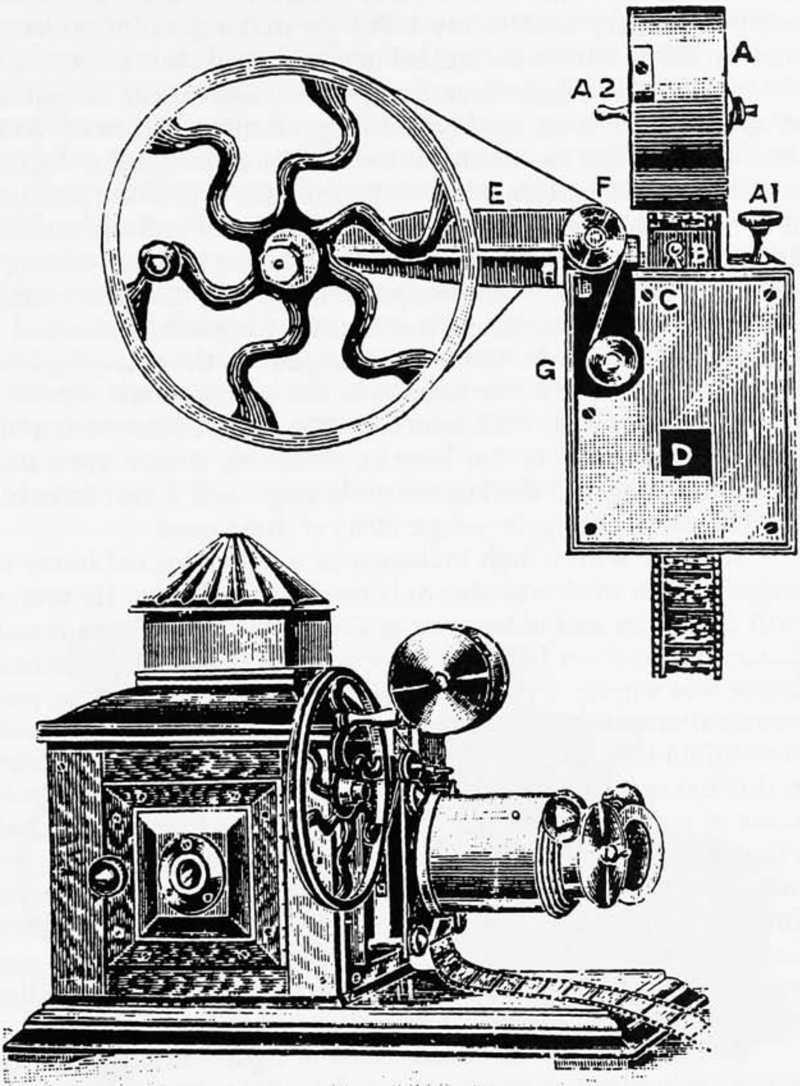

FIGURE 1. The Kineoptoscope projector, patented by Cecil Wray in August, 1896, and manufactured by Riley Brothers of Bradford in 1897, which fit into the slide stage of a normal magic lantern. Above, a front view of the compact apparatus; below, the Kineoptoscope mounted in a magic lantern.

device to turn it into a projection apparatus of dubious workability in January 1895 (Wray 1895). By making a film projector that would fit within a standard magic lantern slide stage, using the lantern's own light source and optics, and selling his patent in spring 1896 to an established magic lantern business, Wray demonstrated his more substantive inclusion in a technological frame of magic lantern work as he thought of moving pictures as a new accessory for the lantern. Physically and technically limited to an existence wholly within existing patterns of magic lantern work, his Kineoptoscope, although popular and widely used in smaller venues in the United Kingdom, remained a regional device and did not have an impact on the emerging new medium in any way comparable to the international reach of Paul's Theatrograph. Within months Wray moved away from his early commitment to the lantern, designing a new apparatus that was not tied to the lantern slide stage, and a year later his third device was largely independent of these roots.

A figure with a high inclusion in a technological frame of magic lantern work was Max Skladanowsky in Berlin. He toured with his father and older brother Emil giving dissolving magic lantern shows from 1879; his Bioscop moving picture projection device was wholly derived from dissolving lantern practice, projecting alternate frames from two intermittently moving bands of celluloid film (discussed in chapter 6). His degree of inclusion in this frame (and his simultaneous inclusion in a technological frame of mechanical varieté showmen) was so high that he had a limited vision of moving pictures as an independent entity, and once he had travelled with his Bioscop double-projector through many of the same venues in Scandinavia and northern Germany that were the sites of his previous lantern and mechanical varieté act appearances, he saw little further utility in his invention.

By illuminating the interactions of figures around an artifact, a technological frame can explain how the environment structures an artifact's design, as was the case for both Paul and Wray, whose machines could instantly enter a market established by magic lantern work. But Wray's Kineoptoscope was designed and marketed wholly within magic lantern practice, unlike Paul's Theatrograph, so it was Paul's machine that broke quickly away from the lantern world and became the second most widely used device across Europe (after the Lumière Cinématographe). Skladanowsky's Bioscop was useful to its maker-exhibitor—he and his brother had previously travelled with a self-made mechanical theater—but was not readily transportable or replicable for other showmen lacking their particular skills, experience, and dedication to the unwieldy apparatus: by the time Skladanowsky gave his last performance in March 1897, with the Bioscop II single-band film projector, events had moved decisively past him and his horizon limited to thinking of his invention as just another mechanical varieté act.

A technological frame can also explain how an artifact itself structures the social environment in which it operates. Through the end of 1896, both the London magician David Devant and the Berlin operator Karl Pahl recall giving private film showings in the homes of wealthy residents (Barnes 1976, 118; Pahl 1933, 4), continuing a long tradition of private perfor-

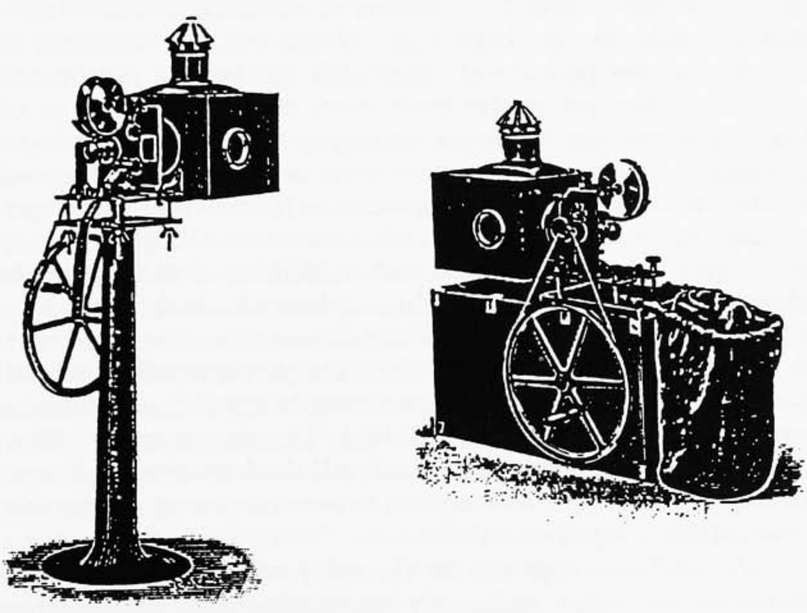

FIGURE 2. Two forms of the second model Theatrograph projector of Robert William Paul from 1896: on the left, the apparatus is mounted on a strong iron stand for use in theaters, and on the right it sits on top of a transportable case used by travelling exhibitors.

mances by magic lantern showmen. The new "wonder apparatus" was also frequently exhibited at upper-class charity events or as a special attraction at middle-class entertainments, such as the summer 1896 Proms concerts in London and the concerts and lectures at Unity Hall in Hartford, Connecticut (Rossell 1995, 210; Musser 1990, 140). After the worldwide publicity given the shocking fire at the Société Charité Maternelle in Paris in March 1897, in which 143 French socialites died, reports of private home screenings or upper-class venues outside strictly theatrical settings are almost nonexistent. The highly flammable celluloid that was an integral part of many moving picture shows meant that some social groups quickly decided to avoid involvement with the new medium. An apparatus that to lanternists was an exciting addition to their repertoire was seen by others as a danger to public safety. These conflicting views of different social groups shaped both the location and the acceptance of the new medium; it was to overcome such conflicts that inventors proposed the variety of alternative technologies that characterize the beginnings of the cinema. Officials in many localities had already regulated the lantern showman's choice of illumination for projection, defining the use of oil lamps, coal gas, oxy-hydrogen limelight, oxygen-ether limelight, or electricity for magic lantern shows, but the authorities took a new look at their licensing procedures for moving picture presentations, which quickly had a direct influence on an exhibitor's choice of location and conditions of exhibition. As interaction within this technological frame built up around the artifacts of cinema, and stable social groups continued to exert their influences on it, some technical options rapidly withered away while others grew in importance. Many of the alternative technologies proposed for moving pictures were a direct response to this characteristic of celluloid movies, and were attempts to bring the sensational new attraction to groups who rejected the dangers of celluloid.

A nonlinear approach to the early history of the cinema accounts for many seemingly conflicting and contradictory developments of the period. In November 1896, when Pierre-Victor Continsouza and René Bünzli patented a new apparatus that substituted a glass plate for the celluloid film band used in other projectors, and predicted the end of celluloid film strip moving pictures, they were not simply proposing another wild device for producing moving pictures (Continsouza and Bünzli 1896). Nor were they just trying to avoid prior patents from other inventors: they envisioned an alternative cinema using nonflammable materials that would be located in the home and be shown to small groups, one that relied on the substantial experience of contemporary photographers in working with glass plates. As later taken up by Leonard Ulrich Kamm, G. Bettini, and others (see chapter 7), such an alternative cinema was not at all out of the question at a time when the normal picture size of a public projection was frequently about three feet in width, or at most four feet, and neither the technology nor the business practices of the cinema had yet stabilized. The proposal of Continsouza and Bünzli is only one reminder that, in Bijker's words, "an historical account founded on the retrospective success of an artifact leaves much untold" (Bijker 1987, 24).

By examining the artifacts of the period symmetrically, that is, looking with equal interest at both "successful" and "failed" artifacts, retrospective distortion of the historical record can be avoided. Symmetrical consideration of the artifacts also rejects the technological determinism in which there is only one "right" solution to a technological problem. It is clear from the early days of moving pictures that there were many possible options of reaching the goal of projected moving pictures, including mechanical and optical intermittent systems, glass and celluloid image carriers, and direct or indirect projections for enlargement. Some of these alternatives provided strikingly superior features to the "successful" technology that has been privileged in most writing about the period. By searching only for predetermined elements of the later, stabilized technology, in particular celluloid film bands and the Maltese cross intermittent movement, assuming that these elements were the sole necessary and inevitable components of the medium, or the technologically "correct" solution, the success of that technology becomes self-justifying, giving no real explanation for its survival. Moveover, there were powerful precinema examples of nonmechanical intermittent movements that produced viable moving pictures, particularly in the Praxinoscope and in the public success of Émile Renaud's Théâtre Optique (see chapter 2) that was based on it. Between 1895 and 1910 over 200 patents in America, France, Germany, and England proposed elements of optical projection systems. Optical systems with continuously running film solved the severe early problems of scratching and tearing the flimsy celluloid band, as well as reducing the irritating flicker of light on the screen that frequently plagued early exhibitions. That these optical solutions were not just a theoretical alternative is exemplified by the later development of the Mechau projector of 1912–34, of which more than 500 examples were made and which proved not only an excellent theatrical projector but also had a revival after 1945 in television work since it was especially well suited to originating film broadcasts. Mechanical intermittents, then, were hardly inevitable, yet technological, social, and economic interests converged to make this the preferred solution.

The several kinds of cinemas that are present in the early days of moving pictures provide a context against which answers to questions about the beginnings of twentieth-century moving picture culture can begin to be approached. The present multidirectional approach to the invention of the movies recognizes that in the beginning very few of its inventors had a vision of what moving pictures might become, or of just what course they might take in developing into a lasting medium. It provides a window on a tumultous, energetic, inventive, and exciting period of history that has long been hidden by extraneous—if sometimes entertaining—disputes both between inventors and between historians. Moving pictures appeared in many different countries at almost the same time; a near simultaneity of invention(s) typically produced by individuals or teams who "inferred from their familiarity with the state of the art the sites, figurative and literal, of critical-problem-solving activity and the nature of the problems" (Hughes 1983, 80). In the last decade of the nineteenth century, the state of the art in projection and visual storytelling was the magic lantern show, and it is with the world of the magic lantern exhibitor that the story of moving pictures begins.

CHAPTER TWO

The Moving Image in the Nineteenth Century

By the second half of the nineteenth century, magic lantern exhibitions had become technologically sophisticated and visually refined productions. The introduction of dissolving views at the Royal Polytechnic Institution in London by Henry Langdon Childe in the early 1840s led to the development of at first double (biunial), then triple (triunial) lanterns capable of subtly blending one image into another, or producing a variety of effects from snow and rain to lightning and billowing smoke. One classic set of widely sold and used dissolving slides showed a pastoral scene, in full color, of a quiet country mill next to its still pond and surrounded by woodlands, its millwheel slowly turning in the late autumn sunlight. Slowly, a gentle snow began to fall; the the landscape was transformed into a bright winter day, with the pond frozen, the wheel still, and a family bundled in winter clothes scurrying down the path to the right of the pond. The scene then transformed again, into a lush green spring, fresh water turning the millwheel on a sparkling day; then a family of swans paddled into view across the the pond, unexpectedly pausing to bend their elegant necks to feed beneath the surface of the water. The apparatus required to exhibit this set of dissolving views was not especially elaborate; its effects could be manipulated by any experienced lanternist. It could be purchased or rented from dozens of suppliers in a range of qualities, determined by the caliber of the glass painting in the set. Its placement in an evening's program might well be set off by the showing of hand-cranked chromatrope slides, also invented by Childe, where abstract painted designs gave a spectacular effect of both depth and motion comparable to looking at the geometrical patterns of a kaleidoscope.

The effects of *The Old Mill* were provided by a combination of rackwork and slipping slides. The basic scene used two glass slides sandwiched together, with the background scene painted on one glass and the millwheel on a separate rotating glass disk mounted in a geared frame that was set in motion by a small crank in the side of the slide's frame. Another geared rackwork slide provided the snowfall for this or any other appropriate image, while the pedestrians and swans were moved across the landscape by levers on their own shards of painted glass in slipping slides. The overall effect of the set was a combination of the quality and precision of the painting on the slides, and the artistic skills of the lanternist were crucial in manipulating the apparatus, dissolving from one view to the next by either adjusting the illumination or by moving a blending shutter in front of the lantern's lenses while at the same time cranking the rackwork handle or tugging at the levers. Other popular dissolving views included the eruption of Mount Vesuvius, St. Paul's Church in London with the effects of a rainbow, historical scenes of battles and ships in harbor, and a variety of Romantic legends, from the tomb of Abelard and Heloise to the ruins of old abbeys and castles.

At London's Royal Polytechnic Institution, like the Eden Musee in New York one of the established centers of lantern exhibitions intended for both instruction and entertainment, a battery of giant lanterns using elaborately painted slides as large as 8½ inches wide and 6½ inches high and served by a team of operators provided even more elaborate shows. *The Optical Magic Lantern Journal* reported on one new production in 1894, *Gabriel Grubb*, painted by W. R. Hill, a former apprentice to Childe, in which the story's churchyard scene alone required one view and fifteen effects:

> There are goblins coming out of graves, leaping over tombstones, streaming out of windows, standing on their heads

> and sinking into the ground. Illumination of windows and clock faces. Gabriel himself in a number of different positions of surprise and terror, and at the close of the scene the whole picture moves, and we appear to travel down through the earth to the goblins' cave, passing through the various strata of unmentionable objects such as we might expect to find in churchyard mould. In the same set Mr. Hill also introduced a panorama, the glass of which is 38 inches by 8 inches, illustrating Gabriel's walk from the village to the old abbey church. (Barnes 1985, 4)

A panorama slide from *Gabriel Grubb* measuring more than three feet in length is preserved at the Cinémathèque française.

Many professional touring lanternists painted their own slides, and the quality can frequently be astonishing. The reputation of a lanternist depended as much on the merit of his brushwork and visual interpretation as on an ability to manipulate special effects in the lantern. The travelling lecturer and showman Paul Hoffmann toured the capitals of central Europe giving talks on themes as diverse as "Polar Expeditions from 1845 to 1859," "A Trip through Central Africa," and "Earthquakes, Volcanoes, and the Destruction of Pompeii." Over half of the seventy-one slides in his presentation of "The Divine Comedy of Dante Alighieri" were modelled on the engravings of Gustave Doré, and for a presentation of "The Niebelungenring" forty-four surviving slides were painted from the original stage designs commissioned by Richard Wagner for the first complete cycle of his operas at Bayreuth (Hoffmann and Junker 1982). Other sources for Hoffmann's slides included illustrated scientific works on geology and astronomy, woodcuts by the painter Friedrich Preller, and the watercolors of English architect T. W. Atkinson. At the same time, Hoffmann's erudite shows capitalized on the current interests of his audiences: he launched his Dante program in 1868, three years after the Europewide celebrations of the poet's 600th anniversary, and his Wagner program in 1876, the year the Festspielhaus in Bayreuth was completed and the presentation there of the complete cycle of Wagner's four operas became a national event.

The images produced on the screen by Hoffmann's slides, now preserved at the Historisches Museum in Frankfurt, and by those in use at the Polytechnic institution in London, the Eden Musee in New York, and by many professional lanternists were rock-steady, clear, and subtle pictures superior to those in the illustrated books of the day and often comparable to the genre paintings, woodcuts, and engravings that could be seen in gal-

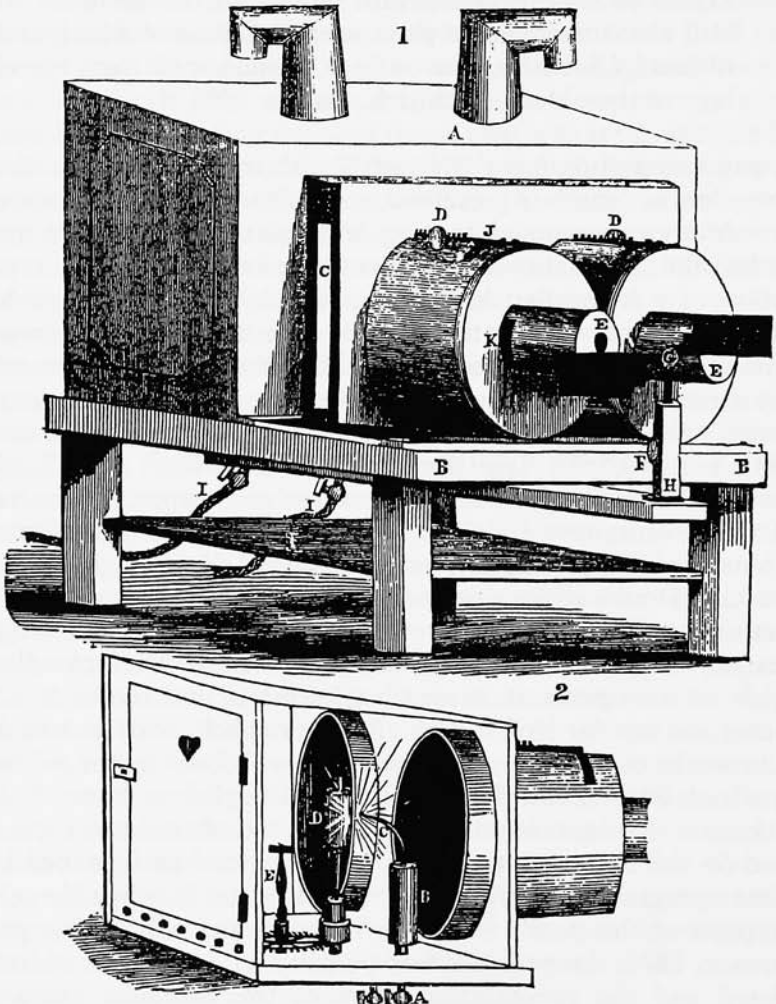

FIGURE 3. A pair of side-by-side dissolving view lanterns as used at the Royal Polytechnic Institution, London, in 1843.

leries and museums. They bore little resemblance to the flickering, blurred, and frequently scratched black-and-white offerings of the first celluloid moving pictures. For a decade after film projection swept the world in 1896, many critics lamented the public enthusiasm for what they saw as a distinctly inferior medium. Cecil Hepworth, a lanternist and son of a lanternist but in later years an outstanding British filmmaker, was heavily critical of the film image in 1896, decrying the "animated palsyscopes" and questioning how long it would be before the public "gets tired of the uncomfortably jerky photographs. Living photographs are about as far from being things of beauty as anything possibly could be" (Bottomore 1996, 137).

Along with high-quality painted slides and cheaper color-lithographed or transfer slides widely sold to a mass market after about 1870, mechanical moving slides were also an important part of the magic lantern repertoire. The earliest seem to have been produced in at least 1697, when the Jena physicist Erhard Weigel made slides of "goats butting, and a bear rising and attacking with his paws a man dressed in a Swiss outfit" (Lange-Fuchs 1995a, 14); Pieter van Musschenbroek, a professor of natural philosophy and mathematics at Utrecht, published illustrations of five moving slides, including four different lever slides and a hand-cranked windmill slide in his *Essais de physique* in 1739.

But from about 1866, with the introduction of the Choreutoscope by J. Beale, an engineer in Greenwich, England, a new kind of movement entered lantern shows. In the Choreutoscope, a version of which was also patented by O. B. Brown in 1869 in the United States, a disk with images of sequenced movement was rotated intermittently by a pin-and-slot gearing similar to a Maltese cross, with a slotted shutter rotated synchronously in front of the lantern's lens. The interchangeable disks held painted representations of tumblers or dancers, and in use gave the impression of continuous movement on the screen. This lantern accessory, popularized by the lantern maker James Henry Steward in London and improved in 1884 by William Charles Hughes in his Giant Choreutoscope, melded nineteenth-century persistence of vision devices with magic lantern projection: "The object of my invention," wrote Brown of his device, "is to combine the principle of the phan-

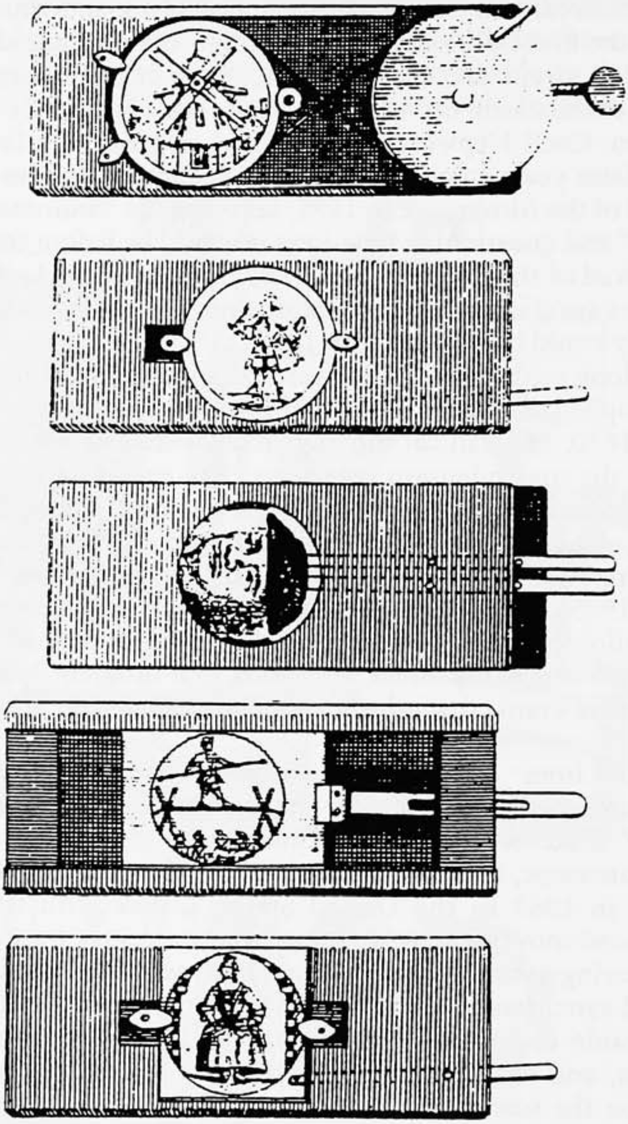

FIGURE 4. Five moving slides for the magic lantern. Top to bottom: the windmill sails revolve, a man drinks, a man rolls his eyes, a tightrope walker moves across his rope, and a woman jumps. From Pieter van Musschenbroek, *Essais de physique*, 1739.

tasmascope, or phenakistoscope with that of the phantasmagoria, or magic-lantern, in an instrument . . . by means of which figures may be represented upon a wall or screen so as to produce the appearance of objects in motion" (Brown 1869, 1).

The Phenakistoscope had been a popular toy for three decades when it was adapted for projection. A disk of heavy paper with printed sequences of drawn movement separated by slots around its circumference, when it was held with the printed side towards a mirror and spun, a viewer looking through the slots at the image reflected in the mirror saw figures of men playing leapfrog or a bouncing ball in continuous, if repetitive, motion. The near-simultaneous invention of Simon Stampfer in Austria in December 1832, who called it a "stroboscopic disk," and of Joseph Plateau in Belgium in January 1833, versions of the Phenakistoscope were marketed in Germany, Austria, France, and England by mid-1833.

An improvement on the Phenakistoscope was suggested the same year by Stampfer and in 1834 by William George Horner in England, where the images were painted on a long band that was placed inside a deep cylinder with a slotted top; looking at the band through the slots when the cylinder was spun produced the same effect of movement without requiring a mirror. This device, named the Zoetrope, was widely manufactured and sold from the mid-1860s, when new patents for it appeared in both America and Europe (Hallett, 1867; May 1867; Lincoln 1867).

The Phenakistoscope and the Zoetrope both relied on the nineteenth-century concept of "persistence of vision," where it was thought that a still image was retained briefly on the human retina so that if more than about sixteen impressions per second of phased movement were received by the eye, it could not discriminate between them. The eye, therefore, perceived the separate drawings (later, photographs) as continuous movement. This idea of the persistence of vision is an incorrect description of the physiological process of how the rods and cones in the retina actually perceive and digest motion (see Chanan 1996, 54–69), but it is still a useful guideline to the mechanical thresholds necessary for the reproduction of movement in nineteenth-century devices and, later, in celluloid movies. Just as Newtonian physics is a functional description of

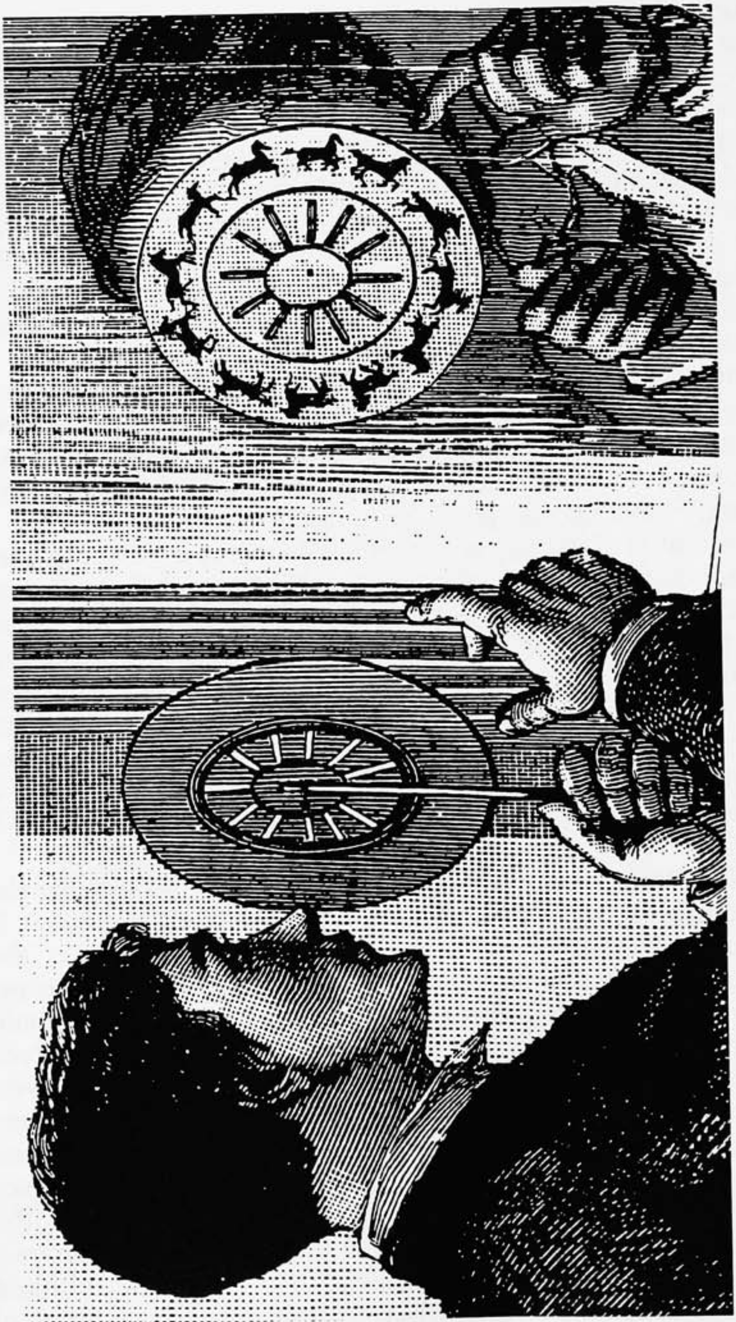

FIGURE 5. The Phenakistoscope in use before a mirror.