Techniques of the Observer

On Vision and Modernity in the Nineteenth Century

JONATHAN CRARY

Chapter 4: Techniques of the Observer

An OCTOBER *Book*

MIT Press
Cambridge, Massachusetts
London, England

Seventh printing, 1996
First MIT Press paperback edition, 1992

This book was set in ITC Garamond by DEKR Corp. and printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Crary, Jonathan.
Techniques of the observer : on vision and modernity in the nineteenth century / Jonathan Crary.
p. cm.
"October books"—Ser. t.p.
Includes bibliographical references (p.
ISBN 0-262-03169-8 (HB), 0-262-53107-0 (PB)
1. Visual perception. 2. Art, Modern—19th century—Themes, motives. 3. Art and society—History—19th century. I. Title.
N7430.5.C7 1990
701'.15—dc20 90-6164
CIP

Illustration credits: Musée du Louvre, Paris (page 44); Städelsches Kunstinstitut, Frankfurt (page 45); Museo Correr, Venice (page 53); The National Gallery, London (page 54); private collection, Paris, photo by Lauros-Giraudon (page 63); National Gallery of Art, Washington (page 65); photos by L. L. Roger-Viollet (pages 117, 123, 130); Tate Gallery, London (pages 140, 144).

4 Techniques of the Observer

Our eye finds it more comfortable to respond to a given stimulus by reproducing once more an image that it has produced many times before, instead of registering what is different and new in an impression.

—Friedrich Nietzsche

The retinal afterimage is perhaps the most important optical phenomenon discussed by Goethe in his chapter on physiological colors in the *Theory of Colours*. Though preceded by others in the late eighteenth century, his treatment of the topic was by far the most thorough up to that moment.[1] Subjective visual phenomena such as afterimages had been recorded since antiquity but only as events outside the domain of optics and they were relegated to the category of the "spectral" or mere appearance. But in the early nineteenth century, particularly with Goethe, such experiences attain the status of optical "truth." They are no longer deceptions that obscure a "true" perception; rather they begin to constitute an irreducible component of human vision. For Goethe and the physiologists who followed him there was

1. Goethe identifies some of these earlier researchers, including Robert W. Darwin (1766–1848), the father of Charles, and the French naturalist Buffon (1707–1788). See *Theory of Colours,* trans. Charles Eastlake (Cambridge, Mass., 1970), p. 1–2. See also Boring, *A History of Experimental Psychology* (New York, 1950), pp. 102–104.

no such thing as optical illusion: whatever the healthy corporal eye experienced was in fact optical truth.

The implications of the new "objectivity" accorded to subjective phenomena are several. First, as discussed in the previous chapter, the privileging of the afterimage allowed one to conceive of sensory perception as cut from any necessary link with an external referent. The afterimage—the presence of sensation in the absence of a stimulus—and its subsequent modulations posed a theoretical and empirical demonstration of autonomous vision, of an optical experience that was produced by and within the subject. Second, and equally important, is the introduction of temporality as an inescapable component of observation. Most of the phenomena described by Goethe in the *Theory of Colours* involve an unfolding over time: "The edge begins to be blue . . . the blue gradually encroaches inward . . . the image then becomes gradually fainter."[2] The virtual instantaneity of optical transmission (whether intromission or extromission) was an unquestioned foundation of classical optics and theories of perception from Aristotle to Locke. And the simultaneity of the camera obscura image with its exterior object was never questioned.[3] But as observation is increasingly tied to the body in the early nineteenth century, temporality and vision become inseparable. The shifting processes of one's own subjectivity experienced in time became synonymous with the act of seeing, dissolving the Cartesian ideal of an observer completely focused on an object.

But the problem of the afterimage and the temporality of subjective vision is lodged within larger epistemological issues in the nineteenth century. On one hand the attention given to the afterimage by Goethe and others parallels contemporary philosophical discourses that describe perception and cognition as essentially temporal processes dependent upon a dynamic amalgamation of past and present. Schelling, for example, describes a vision founded on just such a temporal overlapping:

2. Goethe, *Theory of Colours,* pp. 16–17. Nineteenth century science suggested "the idea of a reality which endures inwardly, which is duration itself." Henri Bergson, *Creative Evolution,* trans. Arthur Mitchell (New York, 1944), p. 395.
3. On the instantaneity of perception see, for example, David C. Lindberg, *Theories of Vision from Al-Kindi to Kepler* (Chicago, 1976), pp. 93–94.

> We do not live in vision; our knowledge is piecework, that is, it must be produced piece by piece in a fragmentary way, with divisions and gradations. . . . In the external world everyone sees more or less the same thing, and yet not everyone can express it. In order to complete itself, each thing runs through certain moments—*a series of processes following one another, in which the later always involves the earlier*, brings each thing to maturity.[4]

Earlier, in the preface to his *Phenomenology* (1807), Hegel makes a sweeping repudiation of Lockean perception and situates perception within an unfolding that is temporal and historical. While attacking the apparent certainty of sense perception, Hegel implicitly refutes the model of the camera obscura. "It must be pointed out that truth is not like stamped coin issued ready from the mint, and so can be taken up and used."[5] Although referring to the Lockean notion of ideas "imprinting" themselves on passive minds, Hegel's remark has a precocious applicability to photography, which, like coinage, offered another mechanically and mass-produced form of exchangeable "truth." Hegel's dynamic, dialectical account of perception, in which appearance negates itself to become something other, finds an echo in Goethe's discussion of afterimages:

> The eye cannot for a moment remain in a particular state determined by the object it looks upon. On the contrary, it is forced to a sort of opposition, which, in contrasting extreme with extreme, intermediate degree with intermediate degree, at the same time combines these opposite impressions, and thus ever tends to be whole, whether the impressions are successive or simultaneous and confined to one image.[6]

4. F. W. J. Schelling, *The Ages of the World* [1815], trans. Fredrick de Wolfe Bolman (New York, 1942), pp. 88–89. Emphasis added.
5. G. W. F. Hegel, *The Phenomenology of Mind,* trans. J. B. Baillie (New York, 1967), p. 98.
6. Goethe, *Theory of Colours,* p. 13.

Goethe and Hegel, each in his own way, pose observation as the play and interaction of forces and relations, rather than as the orderly contiguity of discrete stable sensations conceived by Locke or Condillac.[7]

Other writers of the time also delineated perception as a continuous process, a flux of temporally dispersed contents. The physicist André-Marie Ampère in his epistemological writings used the term *concrétion* to describe how any perception always blends with a preceding or remembered perception. The words *mélange* and *fusion* occur frequently in his attack on classical notions of "pure" isolated sensations. Perception, as he wrote to his friend Maine de Biran, was fundamentally, "une suite de différences successives."[8] The dynamics of the afterimage are also implied in the work of Johann Friedrich Herbart, who undertook one of the earliest attempts to quantify the movement of cognitive experience. Although his ostensible aim was to demonstrate and preserve Kant's notion of the unity of the mind, Herbart's formulation of mathematical laws governing mental experience in fact make him "a spiritual father of stimulus-response psychology."[9] If Kant gave a positive account of the mind's capacity for synthesizing and ordering experience, Herbart (Kant's successor at Königsberg) detailed how the subject wards off and prevents internal incoherence and disorganization. Consciousness, for Herbart, begins as a stream of potentially chaotic input from without. Ideas of things and events in the world were never copies of external reality but rather the outcome of an interactional process within the subject in which ideas (*Vorstellungen*) underwent operations of fusion, fading, inhibition, and blending

7. It should be noted, however, that Hegel, in an 1807 letter to Schelling, criticized Goethe's color theory for being "restricted completely to the empirical." *Briefe von und an Hegel,* vol. 1, ed. Karl Hegel (Leipzig, 1884), p. 94. Cited in Karl Löwith, *From Hegel to Nietzsche: The Revolution in Nineteenth-Century Thought,* trans. David E. Green (New York, 1964), p. 13.

8. André-Marie Ampère, "Lettre à Maine de Biran" [1809], in *Philosophie des Deux Ampères,* ed. J. Barthélemy-Saint-Hilaire (Paris, 1866), p. 236.

9. Benjamin B. Wolman, "The Historical Role of Johann Friedrich Herbart," in *Historical Roots of Contemporary Psychology,* ed. Benjamin B. Wolman (New York, 1968), p. 33. See also David E. Leary, "The Historical Foundations of Herbart's Mathematization of Psychology," *Journal of the History of the Behavioral Sciences* 16 (1980), pp. 150–163. For Herbart's influence on later art theory and aesthetics see Michael Podro, *The Manifold in Perception: Theories of Art from Kant to Hildebrand* (Oxford, 1972); and Arturo Quintavalle, "The Philosophical Context of Riegl's 'Stilfragen,'" in *On the Methodology of Architectural History,* ed. Demetri Porphyrios (London, 1981), pp. 17–20.

(*Verschmelzungen*) with other previous or simultaneously occurring ideas or "presentations." The mind does not reflect truth but rather extracts it from an ongoing process involving the collision and merging of ideas.

> Let a series a, b, c, d, be given by perception; then, from the first movement of the perception and during its continuance, *a* is exposed to an arrest from other concepts already in consciousness. In the meantime, *a,* already partially sunken in consciousness, became more and more obscured when *b* came to it. This *b* at first unobscured, blended with the sinking *a*; then followed *c,* which itself unobscured, fused with *b,* which was becoming obscured. Similarly followed *d,* to become fused with *a, b,* and *c,* in different degrees. From this arises a law for each of these concepts. . . . It is very important to determine by calculation the degree of strength which a concept must attain in order to be able to stand beside two or more stronger ones exactly on the threshold of consciousness.[10]

All the processes of blending and opposition that Goethe described phenomenally in terms of the afterimage are for Herbart statable in differential equations and theorems. He specifically discusses color perception to describe the mental mechanisms of opposition and inhibition.[11] Once the operations of cognition become fundamentally measurable in terms of duration and intensity, it is thereby rendered both predictable and controllable. Although Herbart was philosophically opposed to empirical experimentation or any physiological research, his convoluted attempts to mathematize perception were important for the later quantitative sensory work of Müller, Gustav Fechner, Ernst Weber, and Wilhelm Wundt.[12] He was one of the first to recognize the potential crisis of meaning and representation implied by an autonomous subjectivity, and to propose a framework for its regimentation. Herbart clearly was attempting a quantification of *cognition,* but it nonetheless prepared the ground for attempts to measure the magnitude of sensations, and such mea-

10. Johann Friedrich Herbart, *A Textbook in Psychology: An Attempt to Found the Science of Psychology on Experience, Metaphysics and Mathematics,* trans. Margaret K. Smith (New York, 1891), pp. 21–22.

11. See Herbart, *Psychologie als Wissenschaft,* vol. 1 (Königsberg, 1824), pp. 222–224.

12. For Herbart's influence on Müller, see the latter's *Elements of Physiology,* vol. 2, pp. 1380–1385.

surements required sensory experience that was durational. The afterimage was to become a crucial means by which observation could be quantified, by which the intensity and duration of retinal stimulation could be measured.

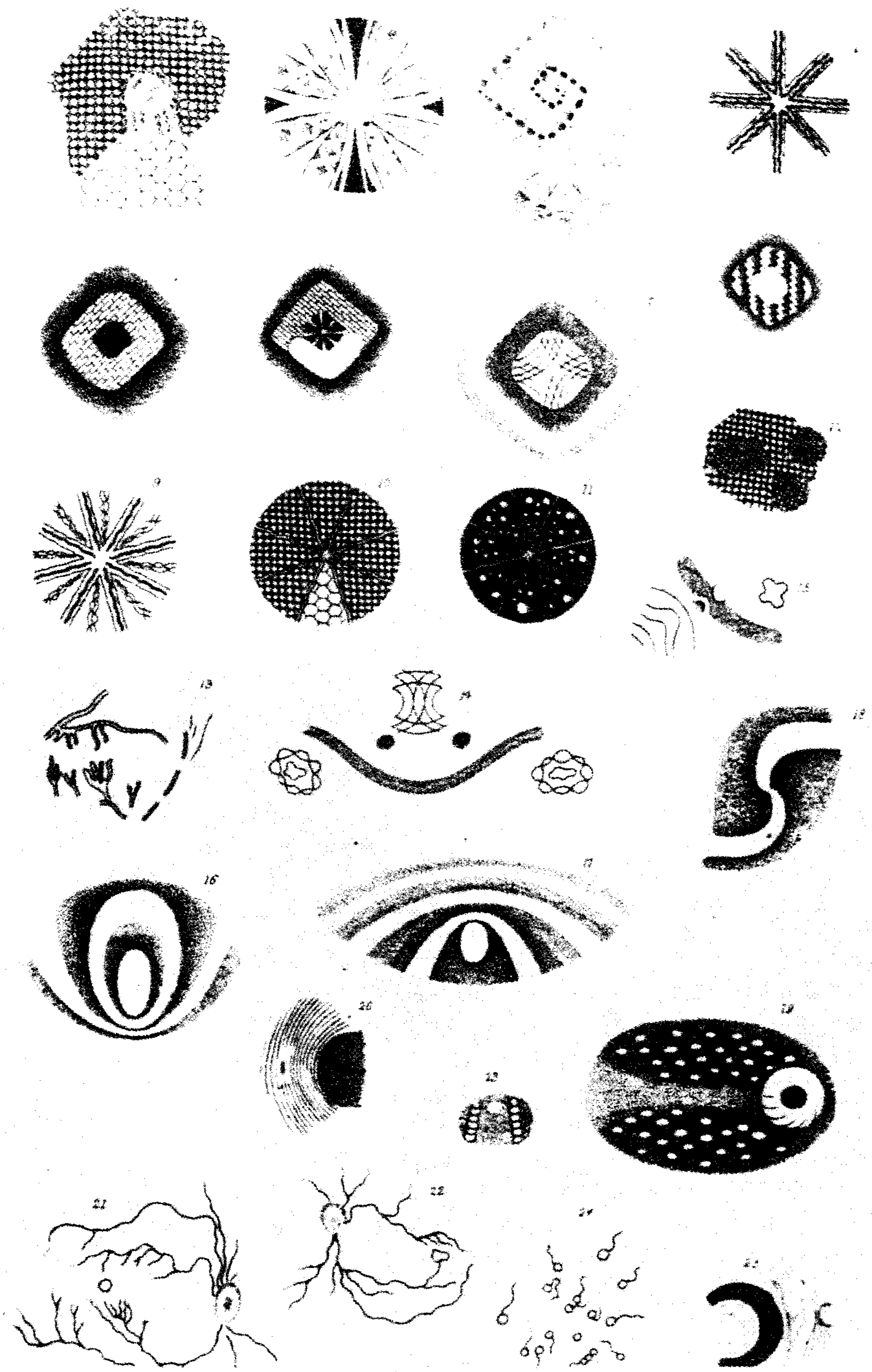
Also it is important to remember that Herbart's work was not simply abstract epistemological speculation but was directly tied to his pedagogical theories, which were influential in Germany and elsewhere in Europe during the mid-nineteenth century.[13] Herbart believed that his attempts to quantify psychological processes held the possibility for controlling and determining the sequential input of ideas into young minds, and in particular had the potential of instilling disciplinary and moral ideas. Obedience and attentiveness were central goals of Herbart's pedagogy. Just as new forms of factory production demanded more precise knowledge of a worker's attention span, so the management of the classroom, another disciplinary institution, demanded similar information.[14] In both cases the subject in question was measurable and regulated in time.

By the 1820s the quantitative study of afterimages was occurring in a wide range of scientific research throughout Europe. Working in Germany, the Czech Jan Purkinje continued Goethe's work on the persistence and modulation of afterimages: how long they lasted, what changes they went through, and under what conditions.[15] His empirical research and Herbart's mathematical methods were to come together in the next generation of psychologists and psychophysicists, when the threshold between the physiological and the mental became one of the primary objects of scientific practice. Instead of recording afterimages in terms of the lived time of the body as Goethe had generally done, Purkinje was the first to study them as part of a comprehensive

13. For Herbart's theories of education, see Harold B. Dunkel, *Herbart and Herbartism: An Educational Ghost Story* (Chicago, 1970), esp. pp. 63–96.

14. See Nikolas Rose, "The Psychological Complex: Mental Measurement and Social Administration," *Ideology and Consciousness* 5 (Spring 1979), pp. 5–70; and Didier Deleule and François Guéry, *Le corps productif* (Paris: 1973), pp. 72–89.

15 Purkinje wrote in Latin, which was translated by others into Czech. For relevant English translations, see "Visual Phenomena" [1823], trans. H. R. John, in William S. Sahakian, *History of Psychology: A Source Book in Systematic Psychology* (Itasca, Ill., 1968), pp. 101–108; and "Contributions to a Physiology of Vision," trans. Charles Wheatstone, *Journal of the Royal Institution* 1 (1830), pp. 101–117, reprinted in *Brewster and Wheatstone on Vision*, ed. Nicholas Wade (London, 1983), pp. 248–262.



Jan Purkinje. Afterimages. 1823.

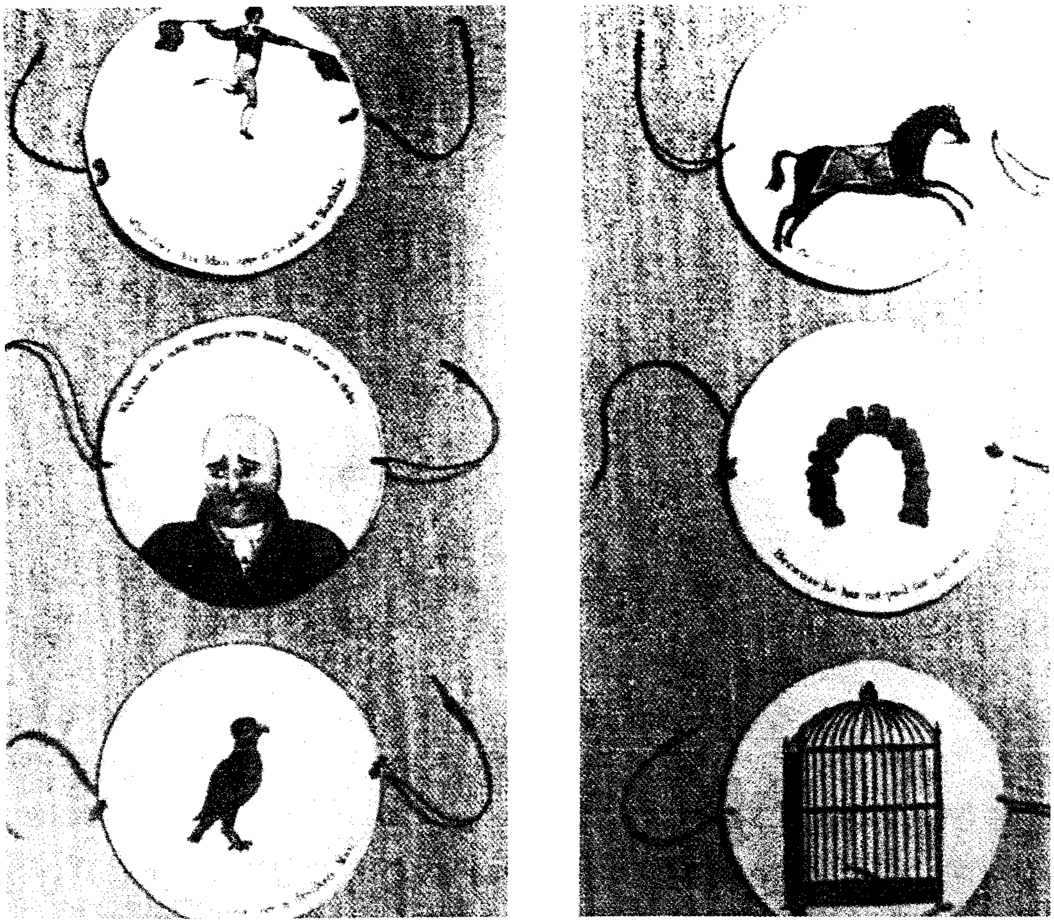
quantification of the irritability of the eye.[16] He provided the first formal classification of different types of afterimages, and his drawings of them are a striking indication of the paradoxical objectivity of the phenomena of subjective vision. Were we able to see the original drawings in color, we would have a more vivid sense of their unprecedented overlapping of the visionary and the empirical, of "the real" and the abstract.

Although working with relatively imprecise instruments, Purkinje timed how long it took the eye to become fatigued, how long dilation and contraction of the pupil took, and measured the strength of eye movements. For Purkinje the physical surface of the eye itself became a field of statistical information: he demarcated the retina in terms of how color changes hue depending on where it strikes the eye, describing the extent of the area of visibility, quantified the distinction between direct and indirect vision, and also gave a highly precise account of the blind spot.[17] The discourse of dioptrics, of the transparency of refractive systems in the seventeenth and eighteenth centuries, has given way to a mapping of the eye as a productive territory with varying zones of efficiency and aptitude.

Beginning in the mid-1820s, the experimental study of afterimages led to the invention of a number of related optical devices and techniques. Initially they were for purposes of scientific observation but were quickly converted into forms of popular entertainment. Linking them all was the notion that perception was not instantaneous, and the notion of a disjunction between eye and object. Research on afterimages had suggested that some form of blending or fusion occurred when sensations were perceived in quick

16. Goethe provides a telling account of the subjectivity of the afterimage in which the physiology of the attentive male eye and its functioning are inseparable from memory and desire: "I had entered an inn towards evening, and, as a well favoured girl, with a brilliantly fair complexion, black hair, and a scarlet bodice, came into the room, I looked attentively at her as she stood before me at some distance in half shadow. As she presently afterwards turned away, I saw on the white wall, which was now before me, a black face surrounded with a bright light, while the dress of the perfectly distinct figure appeared of a beautiful sea green." *Theory of Colours,* p. 22.

17. It should be noted that Purkinje, in 1823, was the first scientist to formulate a classification system for fingerprints, another technique of producing and regulating human subjects. See Vlasilav Krutz, "Purkinje, Jan Evangelista," *Dictionary of Scientific Biography* vol. 11 (New York, 1975), pp. 213–217.



Thaumatropes. c. 1825.

succession, and thus the duration involved in seeing allowed its modification and control.

One of the earliest was the thaumatrope (literally, "wonder-turner"), first popularized in London by Dr. John Paris in 1825. It was a small circular disc with a drawing on either side and strings attached so that it could be twirled with a spin of the hand. The drawing, for example, of a bird on one side and a cage on the other would, when spun, produce the appearance of the bird in the cage. Another had a portrait of a bald-headed man on one side, a hairpiece on the other. Paris described the relation between retinal after-images and the operation of his device:

> An object was seen by the eye, in consequence of its image being delineated on the retina or optic nerve, which is situated on the

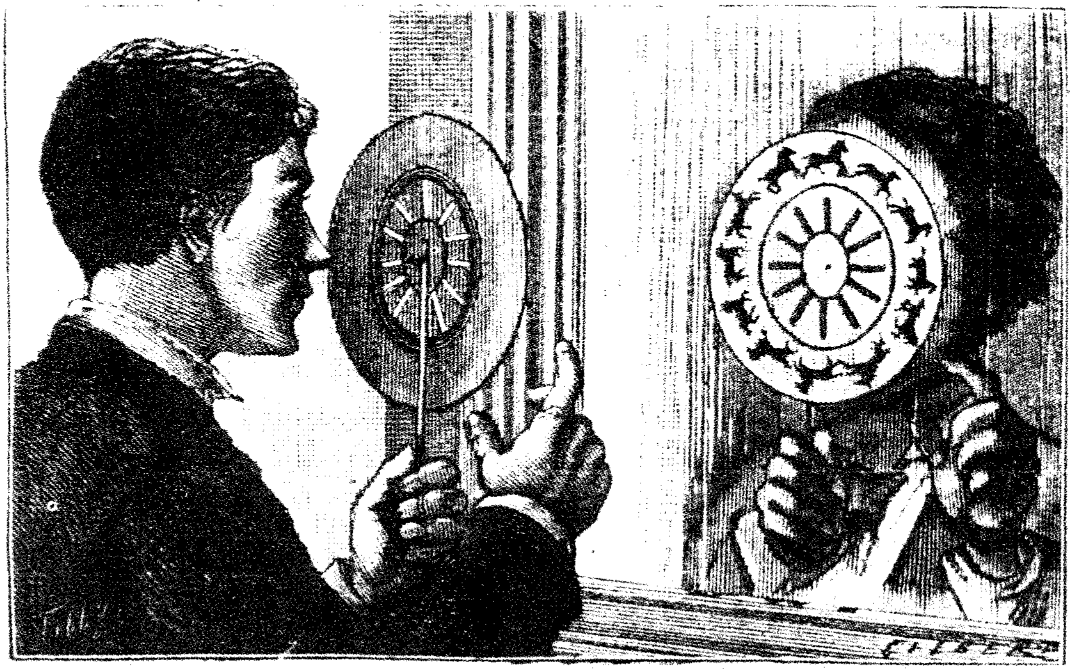
> back part of the eye; and that it has been ascertained, by experiment, that the impression which the mind thus receives, lasts for about the eighth part of a second after the image is removed . . . the Thaumatrope depends upon the same optical principle; the impression made on the retina by the image, which is delineated on one side of the card, is not erased before that which is painted on the opposite side is presented to the eye; and the consequence is that you see both sides at once.[18]

Similar phenomena had been observed in earlier centuries merely by spinning a coin and seeing both sides at the same time, but this was the first time the phenomenon was given a scientific explanation *and* a device was produced to be sold as a popular entertainment. The simplicity of this "philosophical toy" made unequivocally clear both the fabricated and hallucinatory nature of its image and the rupture between perception and its object.

Also in 1825, Peter Mark Roget, an English mathematician and the author of the first thesaurus, published an account of his observations of railway train wheels seen through the vertical bars of a fence. Roget pointed out the illusions that occurred under this circumstance—the spokes of the wheels seemed to be either motionless or to be turning backward. "The deception in the appearance of the spokes must arise from the circumstances of separate parts only of each spoke being seen at the same moment . . . several portions of one and the same line, seen through the intervals of the bars, form on the retina the images of so many different radii."[19] Roget's observations suggested to him how the location of an observer in relation to an intervening screen could exploit the durational properties of retinal afterimages to create various effects of motion. The physicist Michael Faraday explored similar phenomena, particularly the experience of rapidly turning wheels that appeared to be moving slowly. In 1831, the year of his discovery of electromagnetic induction, he produced his own device, later called the Faraday wheel, consisting of two

18. See John A. Paris, *Philosophy in Sport Made Science in Earnest; Being an Attempt to Illustrate the First Principles of Natural Philosophy by the Aid of Popular Toys and Sports* (London, 1827), vol. 3, pp. 13–15.

19. Peter Mark Roget, "Explanation of an optical deception in the appearance of the spokes of a wheel seen through vertical apertures," *Philosophical Transactions of the Royal Society*, 115 (1825), p. 135.

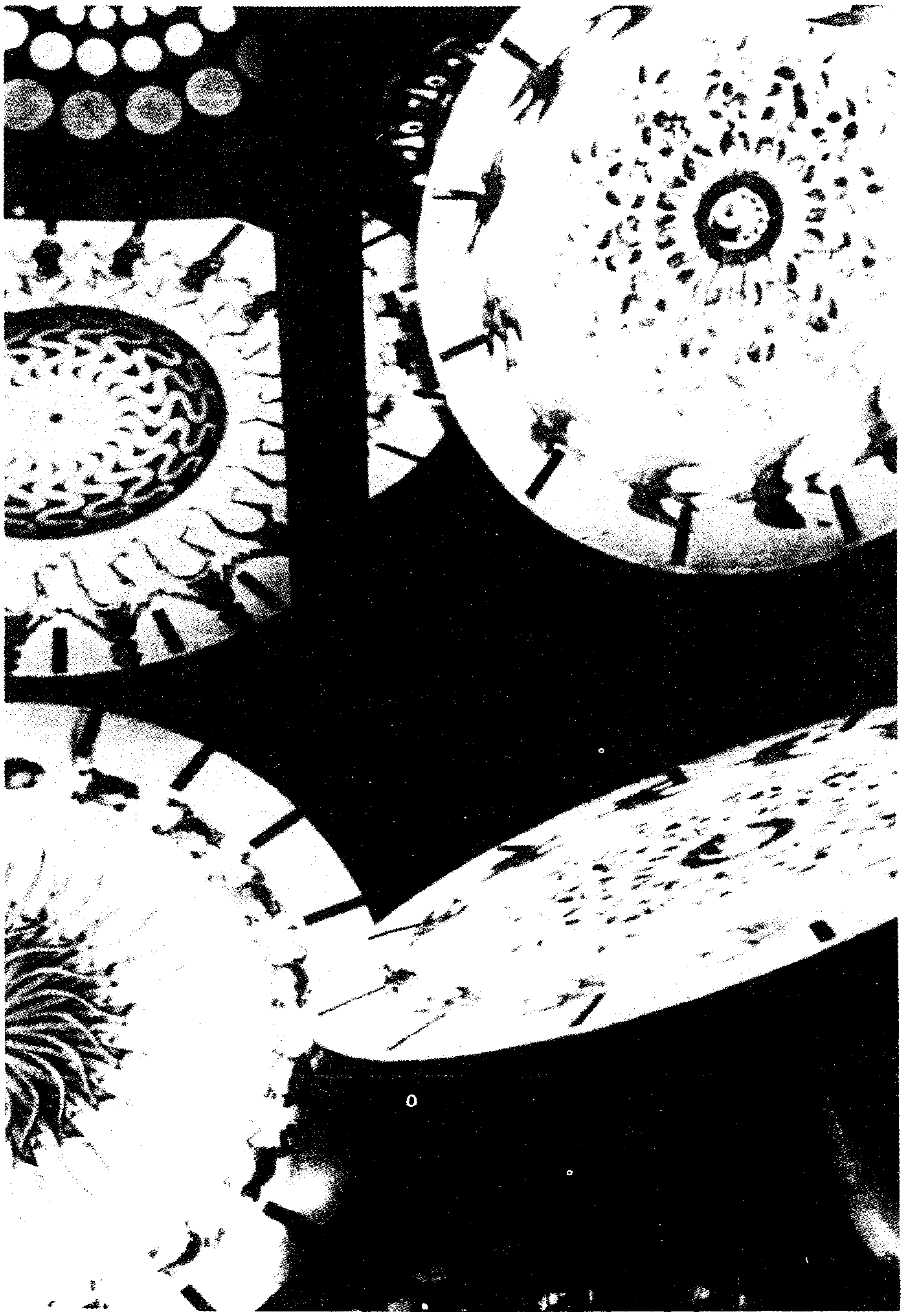


Use of phenakistiscope before a mirror.

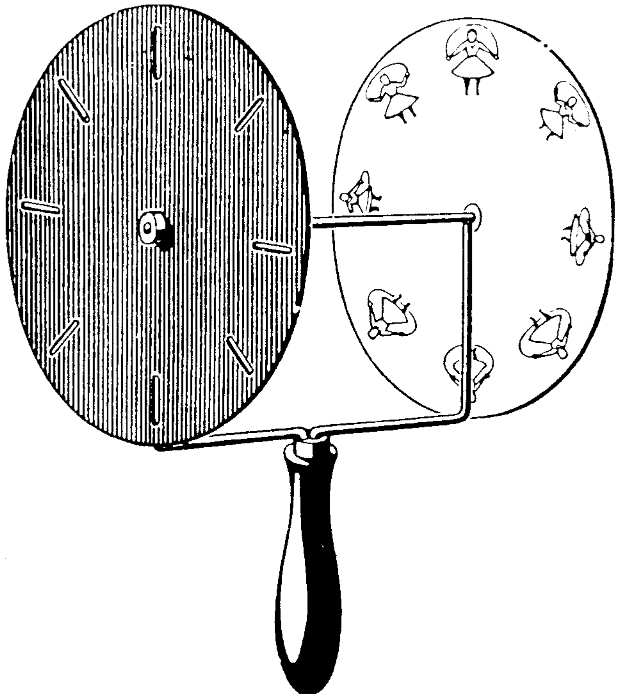
spoked or slotted wheels mounted on the same axis. By varying the relation between the spokes of the two wheels relative to the eye of the viewer, the apparent motion of the further wheel could be modulated. Thus the experience of temporality itself is made susceptible to a range of external technical manipulations.

During the late 1820s the Belgian scientist Joseph Plateau also conducted a wide range of experiments with afterimages, some of which cost him his eyesight due to staring directly into the sun for extended periods. By 1828 he had worked with a Newton color wheel, demonstrating that the duration and quality of retinal afterimages varied with the intensity, color, time, and direction of the stimulus. He also made a calculation of the average time that such sensations lasted—about a third of a second. What is more, his research seemed to confirm the earlier speculations of Goethe and others that retinal afterimages do not simply dissipate uniformly, but go through a number of positive and negative states before vanishing. He made one of the most influential formulations of the theory of "persistence of vision."

> If several objects which differ sequentially in terms of form and position are presented one after the other to the eye in very brief



Phenakistiscopes. 1830s.



Phenakistiscope.

> intervals and sufficiently close together, the impressions they produce on the retina will blend together without confusion and one will believe that a single object is gradually changing form and position.[20]

In the early 1830s Plateau constructed the phenakistiscope (literally, "deceptive view"), which incorporated his own research and that of Roget, Faraday, and others. At its simplest it consisted of a single disc, divided into eight or sixteen equal segments, each of which contained a small slitted opening and a figure, representing one position in a sequence of movement. The side with figures drawn on it was faced toward a mirror while the viewer stayed immobile as the disc turned. When an opening passed in front of the eye, it allowed one to see the figure on the disc very briefly. The same effect occurs with each of the slits. Because of retinal persistence, a series of images results that appear to be in continuous motion before the eye. By 1833, commercial mod-

20. Joseph Plateau, *Dissertation sur quelques propriétés des impressions,* thesis submitted at Liège, May 1829. Quoted in Georges Sadoul, *Histoire générale du cinéma.* Vol. 1: *L'invention du cinéma* (Paris, 1948), p. 25.

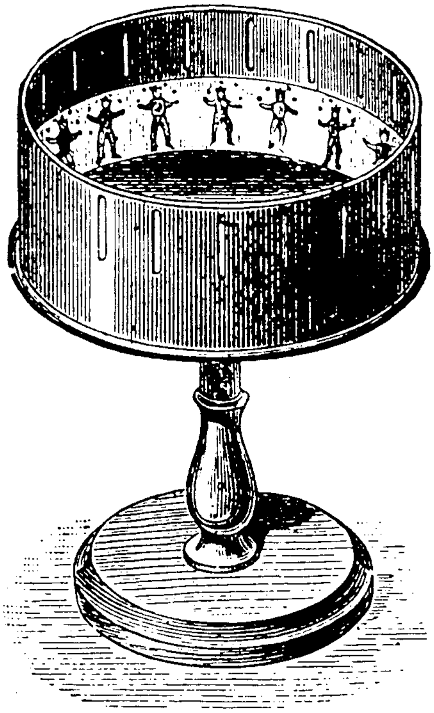
els were being sold in London. By 1834 two similar devices appeared: the stroboscope, invented by the German mathematician Stampfer, and the zoo-trope or "wheel of life" of William G. Horner. The latter was a turning cylinder around which several spectators could view simultaneously a simulated action, often sequences of dancers, jugglers, boxers, or acrobats.

The details and background of these devices and inventors have been well documented elsewhere, but almost exclusively in the service of a history of cinema.[21] Film studies position them as the initial forms in an evolutionary technological development leading to the emergence of a single dominant form at the end of the century. Their fundamental characteristic is that they are not yet cinema, thus nascent, imperfectly designed forms. Obviously there is a connection between cinema and these machines of the 1830s, but it is often a dialectical relation of inversion and opposition, in which features of these earlier devices were negated or concealed. At the same time there is a tendency to conflate all optical devices in the nineteenth century as equally implicated in a vague collective drive to higher and higher standards of verisimilitude. Such an approach often ignores the conceptual and historical singularities of each device.

The empirical truth of the notion of "persistence of vision" as an explanation for the illusion of motion is irrelevant here.[22] What is important are the conditions and circumstances that allowed it to operate as an explanation and the historical subject/observer that it presupposed. The idea of persistence of

21. See, for example, works as diverse as the following: C. W. Ceram, *Archaeology of the Cinema* (New York, 1965); Michael Chanan, *The Dream that Kicks: The Prehistory and Early Years of Cinema in Britain* (London, 1980), esp. pp. 54–65; Jean-Louis Comolli, "Technique et idéologie," *Cahiers du cinéma* no. 229 (May-June 1971), pp. 4–21; Jean Mitry, *Histoire du cinéma,* vol. 1 (Paris, 1967), pp. 21–27; Georges Sadoul, *Histoire générale du cinéma,* vol. 1, pp. 15–43; Steve Neale, *Cinema and Technology: Image, Sound, Colour* (Bloomington, 1985), pp. 9–32; and Leo Sauvage, *L'affaire Lumière: Enquête sur les origines du cinéma* (Paris, 1985), pp. 29–48. For another genealogical model, see Gilles Deleuze, *Cinema 1: The Movement-Image* (Minneapolis, 1986), pp. 4–5.

22. Some recent studies have discussed the "myth" of persistence of vision. They tell us, not surprisingly, that recent neurophysiological research shows nineteenth-century explanations of fusion or blending of images to be an inadequate explanation for the perception of illusory motion. See Joseph and Barbara Anderson, "Motion Perception in Motion Pictures," and Bill Nichols and Susan J. Lederman, "Flicker and Motion in Film," both in *The Cinematic Apparatus,* ed. Teresa de Lauretis and Stephen Heath (London, 1980), pp. 76–95 and 96–105.



Zootrope. Mid-1830s.

vision is linked to two different sorts of studies. One is the kind of self-observation conducted first by Goethe, then by Purkinje, Plateau, Fechner, and others, in which the changing conditions of the observer's own retina was (or was then believed to be) the object of investigation. The other source was the often accidental observation of new forms of movement, in particular mechanized wheels moving at high speeds. Purkinje and Roget both derived some of their ideas from noting the appearance of train wheels in motion or regularly spaced forms seen from a fast-moving train.[23] Faraday indicates that his experiments were suggested by a visit to a factory: "Being at the magnificent lead mills of Messrs. Maltby, two cog-wheels were shown me moving with such velocity that if the eye were . . . standing in such a position that one wheel

23. See Nietzsche, *Human, All Too Human,* trans. R. J. Hollingdale (1878; Cambridge, 1986), p. 132: "With the tremendous acceleration of life, mind and eye have become accustomed to seeing and judging partially or inaccurately, and everyone is like the traveller who gets to know a land and its people from a railway carriage." On the cultural impact and "perceptual shock" of railroad travel, see Wolfgang Schivelbusch, *The Railway Journey: Trains and Travel in the 19th Century,* trans. Anselm Hollo (New York, 1979), esp. pp. 145–160.

appeared behind the other, there was immediately the distinct though shadowy resemblance of cogs moving slowly in one direction."[24] Like the study of afterimages, new experiences of speed and machine movement disclosed an increasing divergence between appearances and their external causes.

The phenakistiscope substantiates Walter Benjamin's claim that in the nineteenth century "technology has subjected the human sensorium to a complex kind of training." At the same time, it would be a mistake to accord new industrial techniques primacy in shaping or determining a new kind of observer.[25] While the phenakistiscope was of course a mode of popular entertainment, a leisure-time commodity purchasable by an expanding urban middle class, it also paralleled the format of the scientific devices used by Purkinje, Plateau, and others for the empirical study of subjective vision. That is, a form with which a new public consumed images of an illusory "reality" was isomorphic to the apparatuses used to accumulate knowledge about an observer. In fact, the very physical position required of the observer by the phenakistiscope bespeaks a confounding of three modes: an individual body that is at once a spectator, a subject of empirical research and observation, and an element of machine production. This is where Foucault's opposition between spectacle and surveillance becomes untenable; his two distinct models here collapse onto one another. The production of the observer in the nineteenth century coincided with new procedures of discipline and regulation. In each of the modes mentioned above, it is a question of a body aligned with and operating an assemblage of turning and regularly moving wheeled parts. The imperatives that generated a rational organization of time and movement in production simultaneously pervaded diverse spheres of social activity. A need for knowledge of the capacities of the eye and its regimentation dominated many of them.

Another phenomenon that corroborates this change in the position of the observer is the diorama, given its definitive form by Louis J. M. Daguerre in the early 1820s. Unlike the static panorama painting that first appeared in the 1790s, the diorama is based on the incorporation of an *immobile* observer

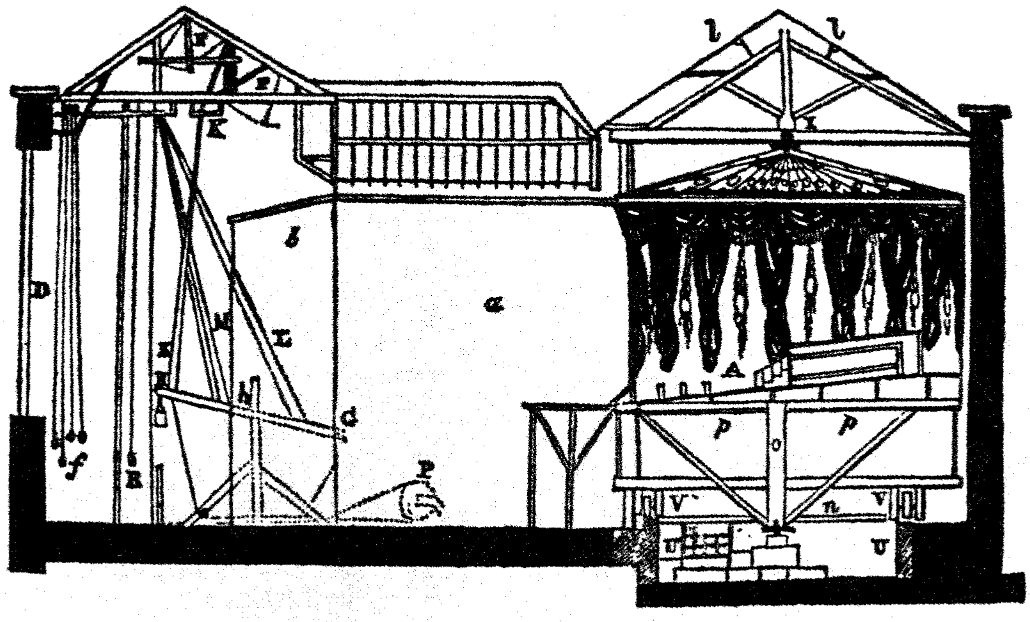
24 Quoted in Chanan, *The Dream that Kicks,* p. 61.
25. Walter Benjamin, *Charles Baudelaire: A Lyric Poet in the Era of High Capitalism,* trans. Harry Zohn (London, 1973), p. 126.

into a mechanical apparatus and a subjection to a predesigned temporal unfolding of optical experience.[26] The circular or semicircular panorama painting clearly broke with the localized point of view of perspective painting or the camera obscura, allowing the spectator an ambulatory ubiquity. One was compelled at the least to turn one's head (and eyes) to see the entire work. The multimedia diorama removed that autonomy from the observer, often situating the audience on a circular platform that was slowly moved, permitting views of different scenes and shifting light effects. Like the phenakistiscope or the zootrope, the diorama was a machine of wheels in motion, one in which the observer was a component. For Marx, one of the great technical innovations of the nineteenth century was the way in which the body was made adaptable to "the few main fundamental forms of motion."[27] But if the modernization of the observer involved the adaptation of the eye to rationalized forms of movement, such a change coincided with and was possible only because of an increasing abstraction of optical experience from a stable referent. Thus one feature of modernization in the nineteenth century was the "uprooting" of vision from the more inflexible representational system of the camera obscura.

Consider also the kaleidoscope, invented in 1815 by Sir David Brewster. With all the luminous possibilities suggested by Baudelaire and later Proust, the kaleidoscope seems radically unlike the rigid and disciplinary structure of the phenakistiscope, with its sequential repetition of regulated representations. For Baudelaire the kaleidoscope coincided with modernity itself; to become a "kaleidoscope gifted with consciousness" was the goal of "the lover of universal life." In his text it figured as a machine for the disintegration of a unitary subjectivity and for the scattering of desire into new shifting and

26. An important study on the relation between the panorama and the diorama is Eric de Kuyper and Emile Poppe, "Voir et regarder," *Communications* 34 (1981), pp. 85–96. Other works include Stephan Oettermann, *Des Panorama* (Munich, 1980); Heinz Buddemeier, *Panorama, Diorama, Photographie: Entstehung und Wirkung neuer Medien im 19. Jahrhundert* (Munich, 1970); Helmut and Alison Gernsheim, *L. J. M. Daguerre: The History of the Diorama and the Daguerreotype* (New York, 1968); Dolf Sternberger, *Panorama of the 19th Century,* trans. Joachim Neugroschel (New York, 1977), pp. 7–16, 184–189; John Barnes, *Precursors of the Cinema: Peepshows, Panoramas and Dioramas* (St. Ives, 1967); and W. Neite, "The Cologne Diorama," *History of Photography* 3, no. 2 (April 1979), pp. 105–109.

27. Karl Marx, *Capital,* vol. 1, p. 374.



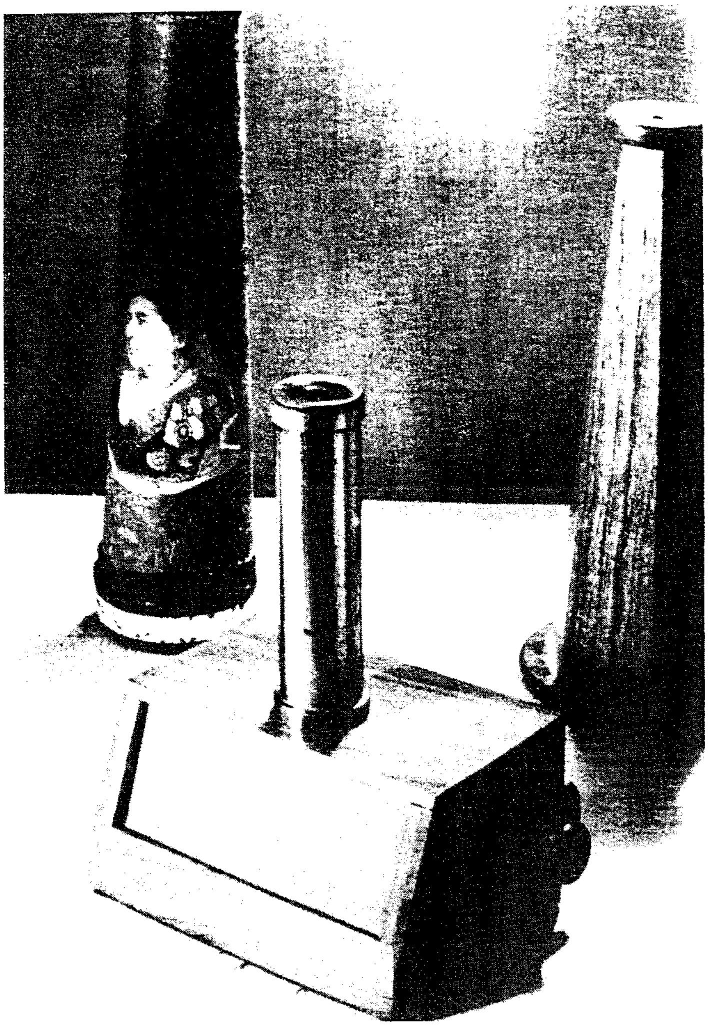
THE DIORAMA.

The London Diorama. 1823.

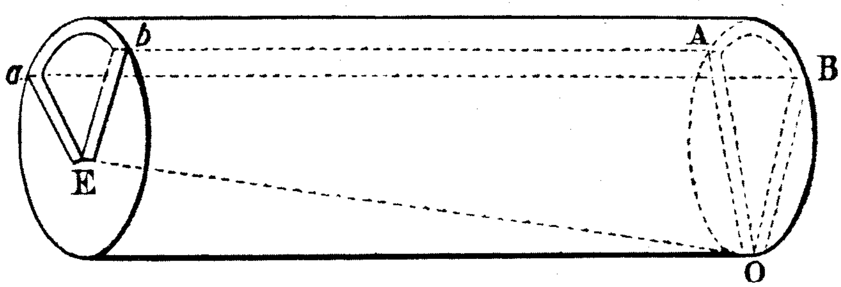
labile arrangements, by fragmenting any point of iconicity and disrupting stasis.

But for Marx and Engels, writing in the 1840s, the kaleidoscope had a very different function. The multiplicity that so seduced Baudelaire was for them a sham, a trick literally done with mirrors. Rather than producing something new the kaleidoscope simply repeated a single image. In their attack on Saint-Simon in *The German Ideology*, a "kaleidoscopic display" is "composed entirely of reflections of itself."[28] According to Marx and Engels, Saint-Simon pretends to be moving his reader from one idea to another, while actually holding to the same position throughout. We don't know how much Marx or Engels knew about the technical structure of the kaleidoscope but they allude to a crucial feature of it in their dissection of Saint-Simon's text. The kaleidoscope presents its viewer with a symmetrical repetition, and the breakup of Marx and Engels's page into two columns of quotations explicitly demonstrates Saint-Simon's maneuver of "self-reflection." The structural underpin-

28. Karl Marx and Friedrich Engels, *The German Ideology*, ed. R. Pascal (New York, 1963), pp. 109–111.



Kaleidoscopes. Mid-nineteenth century.



Position of mirrors inside kaleidoscope.

nings of the kaleidoscope are bipolar and paradoxically the characteristic effect of shimmering dissolution is produced by a simple binary reflective setup (it consists of two plane mirrors extending the length of the tube, inclined at an angle of sixty degrees, or any angle that is a sub-multiple of four right angles). The rotation of this invariant symmetrical format is what generates the appearance of decomposition and proliferation.

For Sir David Brewster, the justification for making the kaleidoscope was productivity and efficiency. He saw it as a mechanical means for the reformation of art according to an industrial paradigm. Since symmetry was the basis of beauty in nature and visual art, he declared, the kaleidoscope was aptly suited to produce art through "the inversion and multiplication of simple forms."

> If we reflect further on the nature of the designs thus composed, and on the methods which must be employed in their composition, the Kaleidoscope will assume the character of the highest class of machinery, which improves at the same time that it abridges the exertions of individuals. There are few machines, indeed, which rise higher above the operations of human skill. It will create in an hour, what a thousand artists could not invent in the course of a year; and while it works with such unexampled rapidity, it works also with a corresponding beauty and precision.[29]

Brewster's proposal of infinite serial production seems far removed from Baudelaire's image of the dandy as "a kaleidoscope gifted with consciousness." But the abstraction necessary for Brewster's industrial delirium is made possible by the same forces of modernization that allowed Baudelaire to use the kaleidoscope as a model for the kinetic experience of "the multiplicity of life itself and the flickering grace of all its elements."[30]

The most significant form of visual imagery in the nineteenth century, with the exception of photographs, was the stereoscope.[31] It is easily forgotten

29. Sir David Brewster, *The Kaleidoscope: Its History, Theory, and Construction* (1819; rpt. London, 1858), pp. 134–136.

30. Charles Baudelaire, "Le peintre de la vie moderne," in *Oeuvres Complètes* (Paris, 1961), p. 1161. In the same volume see Baudelaire's discussion of the stereoscope and the phenakistiscope in his 1853 essay "Morale du joujou," pp. 524–530.

31. There are few serious cultural or historical studies of the stereoscope. Some helpful

Second Empire interior with lenses, magic lantern, and stereoscope.

now how pervasive was the experience of the stereoscope and how for decades it defined a major mode of experiencing photographically produced images. This too is a form whose history has thus far been confounded with that of another phenomenon, in this case photography. Yet as I indicated in my introduction, its conceptual structure and the historical circumstances of its invention are thoroughly independent of photography. Although distinct from the optical devices that represented the illusion of movement, the stereoscope is nonetheless part of the same reorganization of the observer, the same relations of knowledge and power, that those devices implied.

Of primary concern here is the period during which the technical and theoretical principles of the stereoscope were developed, rather than the issue of its effects once it was distributed throughout a sociocultural field. Only after 1850 did its wide commercial diffusion throughout North America and Europe occur.[32] The origins of the stereoscope are intertwined with research in the 1820s and 1830s on subjective vision and more generally within the field of nineteenth-century physiology already discussed. The two figures most closely associated with its invention, Charles Wheatstone and Sir David Brewster, had already written extensively on optical illusions, color theory, afterimages and other visual phenomena. Wheatstone was in fact the translator of Purkinje's major 1823 dissertation on afterimages and subjective vision, published in English in 1830. A few years later Brewster summarized available research on optical devices and subjective vision.

The stereoscope is also inseparable from early nineteenth-century debates about the perception of space, which were to continue unresolved indefinitely. Was space an innate form or was it something recognized through the learning of cues after birth? The Molyneux problem had been transposed to a different century for very different solutions. But the question that troubled the nineteenth century had never really been a central problem before.

---

works are: Edward W. Earle, ed., *Points of View: The Stereograph in America: A Cultural History* (Rochester, 1979); A. T. Gill, "Early Stereoscopes," *The Photographic Journal* 109 (1969), pp. 545–599, 606–614, 641–651; and Rosalind Krauss, "Photography's Discursive Spaces: Landscape/View," *Art Journal* 42 (Winter 1982), pp. 311–319.

32. By 1856, two years after its founding, the London Stereoscopic Company alone had sold over half a million viewers. See Helmut and Alison Gernsheim, *The History of Photography* (London, 1969), p. 191.

Binocular disparity, the self-evident fact that each eye sees a slightly different image, had been a familiar phenomenon since antiquity. Only in the 1830s does it become crucial for scientists to define the seeing body as essentially binocular, to quantify precisely the angular differential of the optical axis of each eye, and to specify the physiological basis for disparity. The question that preoccupied researchers was this: given that an observer perceives with each eye a different image, *how* are they experienced as single or unitary? Before 1800, even when the question was asked it was more as a curiosity, never a central problem. Two alternative explanations had been offered for centuries: one proposed that we never saw anything except with one eye at a time; the other was a projection theory articulated by Kepler, and proposed as late as the 1750s, which asserted that each eye projects an object to its actual location.[33] But in the nineteenth century the unity of the visual field could not be so easily predicated.

By the late 1820s physiologists were seeking anatomical evidence in the structure of the optical chiasma, the point behind the eyes where the nerve fibers leading from the retina to the brain cross each other, carrying half of the nerves from each retina to each side of the brain.[34] But such physiological evidence was relatively inconclusive at that time. Wheatstone's conclusions in 1833 came out of the successful measurement of binocular parallax, or the degree to which the angle of the axis of each eye differed when focused on the same point. The human organism, he claimed, had the capacity under most conditions to synthesize retinal disparity into a single unitary image. While this seems obvious from our own standpoint, Wheatstone's work marked a major break from older explanations (or often disregard) of the binocular body.

The form of the stereoscope is linked to some of Wheatstone's initial findings: his research concerned the visual experience of objects relatively close to the eye.

> When an object is viewed at so great a distance that the optic axes of both eyes are sensibly parallel when directed towards it, the per-

33. See, for example, William Porterfield, *A Treatise on the Eye, the Manner and Phenomena of Vision* (Edinburgh, 1759), p. 285.
34. See R. L. Gregory, *Eye and Brain: The Psychology of Seeing*, 3rd ed. (New York, 1979), p. 45.

> spective projections of it, seen by each eye separately, and the appearance to the two eyes is precisely the same as when the object is seen by one eye only.[35]

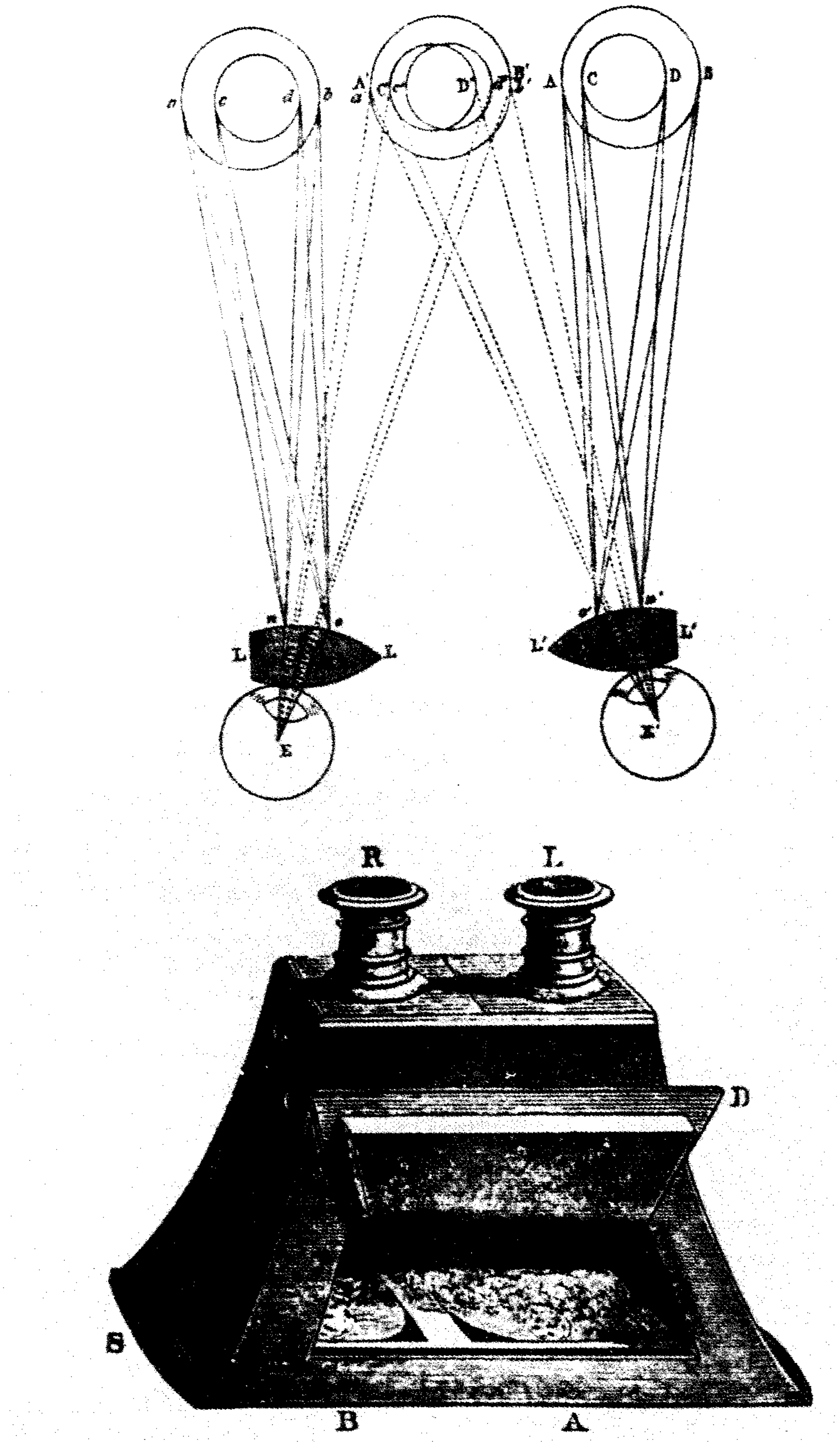
Instead Wheatstone was preoccupied with objects close enough to the observer so that the optic axes had *different* angles.

> When the object is placed so near the eyes that to view it the optic axes must converge . . . a different perspective projection of it is seen by each eye, and these perspectives are more dissimilar as the convergence of the optic axes becomes greater.[36]

Thus physical proximity brings binocular vision into play as an operation of reconciling disparity, of making two distinct views appear as one. This is what links the stereoscope with other devices in the 1830s like the phenakistiscope. Its "realism" presupposes perceptual experience to be essentially an apprehension of differences. The relation of the observer to the object is not one of identity but an experience of disjunct or divergent images. Helmholtz's influential epistemology was based on such a "differential hypothesis."[37] Both Wheatstone and Brewster indicated that the fusion of pictures viewed in a stereoscope took place over time and that their convergence might not actually be secure. According to Brewster,

> the relief is not obtained from the mere combination or superposition of the two dissimilar pictures. The superposition is effected by turning each eye upon the object, but the relief is given by the play of the optic axes in uniting, in rapid *succession,* similar points of the two pictures. . . . Though the pictures apparently coalesce, yet the relief is given by the subsequent play of the optic

35. Charles Wheatstone, "Contributions to the physiology of vision—Part the first. On some remarkable, and hitherto unobserved, phenomena of binocular vision," in *Brewster and Wheatstone on Vision,* ed. Nicholas J. Wade (London, 1983), p. 65.
36. Wheatstone, "Contributions to a physiology of vision," p. 65.
37. Hermann von Helmholtz, "The Facts in Perception," *Epistemological Writings,* ed. Moritz Schlick (Boston, 1977), p. 133: "Our acquaintance with the visual field can be acquired by observation of the images during the movements of our eyes, provided only that there exists, between otherwise qualitatively alike retinal sensations, some or other perceptible difference corresponding to the difference between distinct places on the retina."



David Brewster's lenticular stereoscope. 1849.

> axes varying themselves *successively* upon, and unifying, the similar points in each picture that correspond to different distances from the observer.[38]

Brewster thus confirms there never really is a stereoscopic image, that it is a conjuration, an effect of the observer's experience of the differential between two other images.

In devising the stereoscope, Wheatstone aimed to simulate the actual presence of a physical object or scene, not to discover another way to exhibit a print or drawing. Painting had been an adequate form of representation, he asserts, but only for images of objects at a great distance. When a landscape is presented to a viewer, "if those circumstances which would disturb the illusion are excluded," we could mistake the representation for reality. He declares that up to this point in history it is impossible for an artist to give a faithful representation of any *near* solid object.

> When the painting and the object are seen with both eyes, in the case of the painting two similar objects are projected on the retina, in the case of the solid object the pictures are dissimilar; there is therefore an essential difference between the impressions on the organs of sensation in the two cases, and consequently between the perceptions formed in the mind; the painting therefore cannot be confounded with the solid object.[39]

What he seeks, then, is a complete equivalence of stereoscopic image and object. Not only will the invention of the stereoscope overcome the deficiencies of painting but also those of the diorama, which Wheatstone singles out. The diorama, he believed, was too bound up in the techniques of painting, which depended for their illusory effects on the depiction of distant subjects. The stereoscope, on the contrary, provided a form in which "vividness" of effect increased with the apparent proximity of the object to the viewer, and the impression of three-dimensional solidity became greater as the optic axes of each diverged. Thus the desired effect of the stereoscope was not simply

38. Sir David Brewster, *The Stereoscope: Its History, Theory, and Construction* (London, 1856), p. 53 (emphasis in original).
39. Charles Wheatstone, "Contributions to the Physiology of Vision," in *Brewster and Wheatstone on Vision,* p. 66.

Stereoscopes in use. Second Empire.

likeness, but immediate, apparent *tangibility*. But it is a tangibility that has been transformed into a purely visual experience, of a kind that Diderot could never have imagined. The "reciprocal assistance" between sight and touch Diderot specified in *Letters on the Blind* is no longer operative. Even as sophisticated a student of vision as Helmholtz could write, in the 1850s,

> these stereoscopic photographs are so true to nature and so lifelike in their portrayal of material things, that after viewing such a picture and recognizing in it some object like a house, for instance, we get the impression, when we actually do see the object, that we have already seen it before and are more or less familiar with it. In cases of this kind, the actual view of the thing itself does not add anything new or more accurate to the previous apperception we got from the picture, so far at least as mere form relations are concerned.[40]

No other form of representation in the nineteenth century had so conflated the real with the optical. We will never really know what the stereoscope looked like to a nineteenth-century viewer or recover a stance from which it could seem an equivalent for a "natural vision." There is even something "uncanny" in Helmholtz's conviction that a picture of a house could be so real that we feel "we have already seen it before." Since it is obviously impossible to reproduce stereoscopic effects here on a printed page, it is necessary to analyze closely the nature of this illusion for which such claims were made, to look through the lenses of the device itself.

First it must be emphasized that the "reality effect" of the stereoscope was highly variable. Some stereoscopic images produce little or no three-dimensional effect: for instance, a view across an empty plaza of a building facade, or a view of a distant landscape with few intervening elements. Also, images that elsewhere are standard demonstrations of perspectival recession, such as a road or a railroad track extending to a centrally located vanishing point, produce little impression of depth. Pronounced stereoscopic effects depend on the presence of objects or obtrusive forms in the near or middle ground; that is, there must be enough points in the image that require sig-

40. Helmholtz, *Physiological Optics,* vol. 3, p. 303.

nificant changes in the angle of convergence of the optical axes. Thus the most intense experience of the stereoscopic image coincides with an object-filled space, with a material plenitude that bespeaks a nineteenth-century bourgeois horror of the void; and there are endless quantities of stereo cards showing interiors crammed with bric-a-brac, densely filled museum sculpture galleries, and congested city views.

But in such images the depth is essentially different from anything in painting or photography. We are given an insistent sense of "in front of" and "in back of" that seems to organize the image as a sequence of receding planes. And in fact the fundamental organization of the stereoscopic image is *planar*.[41] We perceive individual elements as flat, cutout forms arrayed either nearer or further from us. But the experience of space between these objects (planes) is not one of gradual and predictable recession; rather, there is a vertiginous uncertainty about the distance separating forms. Compared to the strange insubstantiality of objects and figures located in the middle ground, the absolutely airless space surrounding them has a disturbing palpability. There are some superficial similarities between the stereoscope and classical stage design, which synthesizes flats and real extensive space into an illusory scene. But theatrical space is still perspectival in that the movement of actors on a stage generally rationalizes the relation between points.

In the stereoscopic image there is a derangement of the conventional functioning of optical cues. Certain planes or surfaces, even though composed of indications of light or shade that normally designate volume, are perceived as flat; other planes that normally would be read as two-dimensional, such as a fence in a foreground, seem to occupy space aggressively. Thus stereoscopic relief or depth has no unifying logic or order. If perspective implied a homogeneous and potentially metric space, the stereoscope discloses a fundamentally disunified and aggregate field of disjunct elements. Our eyes never traverse the image in a full apprehension of the three-dimensionality of the entire field, but in terms of a localized experience of separate areas. When we look head-on at a photograph or painting our eyes remain at a single angle of convergence, thus endowing the image surface with an optical unity. The reading or scanning of a stereo image, however, is an accumulation of dif-

41. See Krauss, "Photography's Discursive Spaces," p. 313.

ferences in the degree of optical convergence, thereby producing a perceptual effect of a patchwork of different intensities of relief within a single image. Our eyes follow a choppy and erratic path into its depth: it is an assemblage of local zones of three-dimensionality, zones imbued with a hallucinatory clarity, but which when taken together never coalesce into a homogeneous field. It is a world that simply does not communicate with that which produced baroque scenography or the city views of Canaletto and Bellotto. Part of the fascination of these images is due to this immanent disorder, to the fissures that disrupt its coherence. The stereoscope could be said to constitute what Gilles Deleuze calls a "Riemann space," after the German mathematician Georg Riemann (1826–1866). "Each vicinity in a Riemann space is like a shred of Euclidian space but the linkage between one vicinity and the next is not defined. . . . Riemann space at its most general thus presents itself as an amorphous collection of pieces that are juxtaposed but not attached to each other."[42]

A range of nineteenth-century painting also manifests some of these features of stereoscopic imagery. Courbet's *Ladies of the Village* (1851), with its much-noted discontinuity of groups and planes, suggests the aggregate space of the stereoscope, as do similar elements of *The Meeting (Bonjour, M. Courbet)* (1854). Works by Manet, such as *The Execution of Maximillian* (1867) and *View of the International Exhibition* (1867), and certainly Seurat's *Sunday Afternoon on the Island of La Grande Jatte* (1884–86) also are built up piecemeal out of local and disjunct areas of spatial coherence, of both modeled depth and cutout flatness. Numerous other examples could be mentioned, perhaps going back as early as the landscapes of Wilhelm von Köbell, with their unsettling hyperclarity and abrupt adjacency of foreground and distant background. I am certainly not proposing a causal relation of *any* sort between these two forms, and I would be dismayed if I prompted anyone to determine if Courbet owned a stereoscope. Instead I am suggesting that *both* the "realism" of the stereoscope and the "experiments" of certain painters were equally bound up in a much broader transformation of the observer that allowed the emergence of this new optically constructed space. The stereoscope and Cézanne have far more in common than one might assume. Paint-

42. Gilles Deleuze and Félix Guattari, *A Thousand Plateaus,* p. 485.

ing, and early modernism in particular, had no special claims in the renovation of vision in the nineteenth century.

The stereoscope as a means of representation was inherently *obscene,* in the most literal sense. It shattered the *scenic* relationship between viewer and object that was intrinsic to the fundamentally theatrical setup of the camera obscura. The very functioning of the stereoscope depended, as indicated above, on the visual priority of the object closest to the viewer and on the absence of any mediation between eye and image.[43] It was a fulfillment of what Walter Benjamin saw as central in the visual culture of modernity: "Day by day the need becomes greater to take possession of the object—from the closest proximity—in an image and the reproduction of an image."[44] It is no coincidence that the stereoscope became increasingly synonymous with erotic and pornographic imagery in the course of the nineteenth century. The very effects of tangibility that Wheatstone had sought from the beginning were quickly turned into a mass form of ocular possession. Some have speculated that the very close association of the stereoscope with pornography was in part responsible for its social demise as a mode of visual consumption. Around the turn of the century sales of the device supposedly dwindled because it became linked with "indecent" subject matter. Although the reasons for the collapse of the stereoscope lie elsewhere, as I will suggest shortly, the simulation of tangible three-dimensionality hovers uneasily at the limits of acceptable verisimilitude.[45]

If photography preserved an ambivalent (and superficial) relation to the codes of monocular space and geometrical perspective, the relation of the stereoscope to these older forms was one of annihilation, not compromise. Charles Wheatstone's question in 1838 was: "What would be the visual effect of simultaneously presenting to each eye, instead of the object itself, its pro-

43. See Florence de Mèredieu, "De l'obscénité photographique," *Traverses* 29 (October 1983), pp. 86–94.
44. Walter Benjamin, "A Small History of Photography," in *One Way Street,* trans. Edmund Jephcott and Kingsley Shorter (London, 1979), pp. 240–257.
45. The ambivalence with which twentieth-century audiences have received 3-D movies and holography suggests the enduring problematic nature of such techniques. Christian Metz discusses the idea of an optimal point on either side of which the impression of reality tends to decrease, in his *Film Language* (New York, 1974), pp. 3–15.

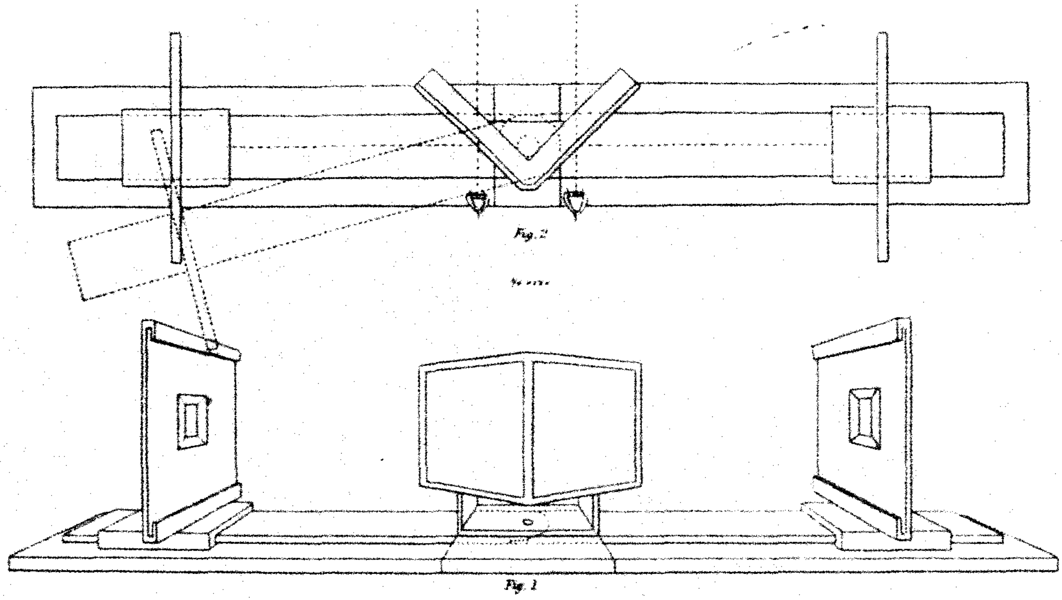


Diagram of the operation of the Wheatstone stereoscope.

jection on a plane surface as it appears to that eye?" The stereoscopic spectator sees neither the identity of a copy nor the coherence guaranteed by the frame of a window. Rather, what appears is the technical reconstitution of an already reproduced world fragmented into *two* nonidentical models, models that precede any experience of their subsequent perception as unified or tangible. It is a radical repositioning of the observer's relation to visual representation. The institutionalization of this decentered observer and the stereoscope's dispersed and multiplied sign severed from a point of external reference indicate a greater break with a classical observer than that which occurs later in the century in the realm of painting. The stereoscope signals an eradication of "the point of view" around which, for several centuries, meanings had been assigned reciprocally to an observer and the object of his or her vision. There is no longer the possibility of perspective under such a technique of beholding. The relation of observer to image is no longer to an object quantified in relation to a position in space, but rather to two dissimilar images whose position simulates the anatomical structure of the observer's body.

To fully appreciate the rupture signified by the stereoscope it is important to consider the original device, the so-called Wheatstone stereoscope. In order to view images with this device, an observer placed his eyes directly in front of two plane mirrors set ninety degrees to one another. The images to be viewed were held in slots on either side of the observer, and thus were spatially completely separated from each other. Unlike the Brewster stereoscope, invented in the late 1840s, or the familiar Holmes viewer, invented in 1861, the Wheatstone model made clear the atopic nature of the perceived stereoscopic image, the disjunction between experience and its cause. The later models allowed the viewer to believe that he or she was looking forward *at* something "out there." But the Wheatstone model left the hallucinatory and fabricated nature of the experience undisguised. It did not support what Roland Barthes called "the referential illusion."[46] There simply was nothing "out there." The illusion of relief or depth was thus a subjective event and the observer coupled with the apparatus was the agent of synthesis or fusion.

Like the phenakistiscope and other nonprojective optical devices, the stereoscope also required the corporeal adjacency and immobility of the observer. They are part of a nineteenth-century modulation in the relation between eye and optical apparatus. During the seventeenth and eighteenth centuries that relationship had been essentially metaphoric: the eye and the camera obscura or the eye and the telescope or microscope were allied by a conceptual similarity, in which the authority of an ideal eye remained unchallenged.[47] Beginning in the nineteenth century, the relation between eye and optical apparatus becomes one of metonymy: both were now contiguous instruments on the same plane of operation, with varying capabilities and features.[48] The limits and deficiencies of one will be complemented by the capacities of the other and vice versa. The optical apparatus undergoes a shift comparable to that of the tool as described by Marx: "From the moment that the tool proper is taken from man, and fitted into a mechanism, a machine

46. See Roland Barthes, "The Reality Effect," in *The Rustle of Language,* trans. Richard Howard (New York, 1986), pp. 141–148.

47. On the telescope as metaphor in Galileo, Kepler, and others see Timothy J. Riess, *The Discourse of Modernism* (Ithaca, 1980), pp. 25–29.

48. "In Metonymy, phenomena are implicitly apprehended as bearing relationships to one another in the modality of part-part relationships, on the basis of which one can effect a *reduction* of one of the parts to the status of an aspect or function of the other." Hayden White, *Metahistory: The Historical Imagination in Nineteenth Century Europe* (Baltimore, 1973), p. 35.

Manufacture of stereographs. Paris, late 1850s.

takes the place of a mere implement."[49] In this sense, other optical instruments of the seventeenth and eighteenth centuries, like peep shows, Claude glasses, and print viewing boxes had the status of tools. In the older handicraft-based work, Marx explained, a workman "makes use of a tool," that is, the tool had a metaphoric relation to the innate powers of the human subject.[50] In the factory, Marx contended, the machine makes use of man by subjecting him to a relation of contiguity, of part to other parts, and of exchangeability. He is quite specific about the new metonymic status of the human subject: "As soon as man, instead of working with an implement on the subject of his labour, becomes merely the motive power of an implement-machine, it is a mere accident that motive power takes the disguise of human muscle; and it may equally well take the form of wind, water, or steam."[51] Georges Canguilhem makes an important distinction between eighteenth-century utilitarianism, which derived its idea of utility from its definition of man as toolmaker, and the instrumentalism of the human sciences in the nineteenth century, which is based on "one implicit postulate: that the nature of man is to be a tool, that his vocation is to be set in his place and to be set to work."[52] Although "set to work" may sound inappropriate in a discussion of optical devices, the apparently passive observer of the stereoscope and phenakistiscope, by virtue of specific

49. Karl Marx, *Capital,* vol. 1, trans. Samuel Moore and Edward Aveling (New York, 1967), p. 374.

50. Marx, *Capital,* vol. 1, p. 422. J. D. Bernal has noted that the instrumental capacities of the telescope and microscope remained remarkably undeveloped during the seventeenth and eighteenth centuries. Until the nineteenth century, the microscope "remained more amusing and instructive, in the philosophical sense, than of scientific and practical value." *Science in History, Vol. 2: The Scientific and Industrial Revolutions* (Cambridge, Mass., 1971), pp. 464–469.

51. Marx, *Capital,* vol. 1, p. 375.

52. Georges Canguilhem, "Qu'est-ce que la psychologie," *Etudes d'histoire et de philosophie des sciences* (Paris, 1983), p. 378. See also Gilles Deleuze and Félix Guattari, *A Thousand Plateaus,* p. 490: "During the nineteenth century a two-fold elaboration was undertaken: of a physioscientific concept of Work (weight-height, force-displacement), and of a socioeconomic concept of labor-power or abstract labor (a homogenous abstract quantity applicable to all work and susceptible to multiplication and division). There was a profound link between physics and sociology: society furnished an economic standard of measure for work, and physics as 'mechanical currency' for it. . . . Impose the Work Model upon every activity, translate every act into possible or virtual work, discipline free action, or else (which amounts to the same thing) relegate it to 'leisure,' which exists only by reference to work."

physiological capacities, was in fact made into a producer of forms of verisimilitude. And what the observer produced, again and again, was the effortless transformation of the dreary parallel images of flat stereo cards into a tantalizing apparition of depth. The content of the images is far less important than the inexhaustible routine of moving from one card to the next and producing the same effect, repeatedly, mechanically. And each time, the mass-produced and monotonous cards are transubstantiated into a compulsory and seductive vision of the "real."

A crucial feature of these optical devices of the 1830s and 1840s is the undisguised nature of their operational structure and the form of subjection they entail. Even though they provide access to "the real," they make no claim that the real is anything other than a mechanical production. The optical experiences they manufacture are clearly disjunct from the images used in the device. They refer as much to the functional interaction of body and machine as they do to external objects, no matter how "vivid" the quality of the illusion. So when the phenakistiscope and the stereoscope eventually disappeared, it was not as part of a smooth process of invention and improvement, but rather because these earlier forms were no longer adequate to current needs and uses.

One reason for their obsolescence was that they were insufficiently "phantasmagoric," a word that Adorno, Benjamin, and others have used to describe forms of representation after 1850. Phantasmagoria was a name for a specific type of magic-lantern performance in the 1790s and early 1800s, one that used back projection to keep an audience unaware of the lanterns. Adorno takes the word to indicate

> the occultation of production by means of the outward appearance of the product . . . this outer appearance can lay claim to the status of being. Its perfection is at the same time the perfection of the illusion that the work of art is a reality *sui generis* that constitutes itself in the realm of the absolute without having to renounce its claim to image the world.[53]

53. Theodor Adorno, *In Search of Wagner*, trans. Rodney Livingstone (London, 1981), p. 85. On Adorno and the phantasmagoria, see Andreas Huyssen, *After the Great Divide: Modernism, Mass Culture, Postmodernism* (Bloomington, 1986), pp. 34–42. See also Rolf

But the effacement or mystification of a machine's operation was precisely what David Brewster hoped to overcome with his kaleidoscope and stereoscope. He optimistically saw the spread of scientific ideas in the nineteenth century undermining the possibility of phantasmagoric effects, and he overlapped the history of civilization with the development of tehnologies of illusion and apparition.[54] For Brewster, a Scottish Calvinist, the maintenance of barbarism, tyranny, and popery had always been founded on closely guarded knowledge of optics and acoustics, the secrets by which priestly and higher castes ruled. But his implied program, the democratization and mass dissemination of techniques of illusion, simply collapsed that older model of power onto a single human subject, transforming each observer into simultaneously the magician and the deceived.

Even in the later Holmes stereoscope, the "concealment of the process of production" did not fully occur.[55] Clearly the stereoscope was dependent on a physical engagement with the apparatus that became increasingly unacceptable, and the composite, synthetic nature of the stereoscopic image could never be fully effaced. An apparatus openly based on a principle of disparity, on a "binocular" body, and on an illusion patently derived from the binary referent of the stereoscopic card of paired images, gave way to a form that preserved the referential illusion more fully than anything before it. Photography defeated the stereoscope as a mode of visual consumption as well because it recreated and perpetuated the fiction that the "free" subject of the camera obscura was still viable. Photographs seemed to be a continuation of older "naturalistic" pictorial codes, but only because their dominant conventions were restricted to a narrow range of technical possibilities (that is, shutter speeds and lens openings that rendered elapsed time invisible and recorded

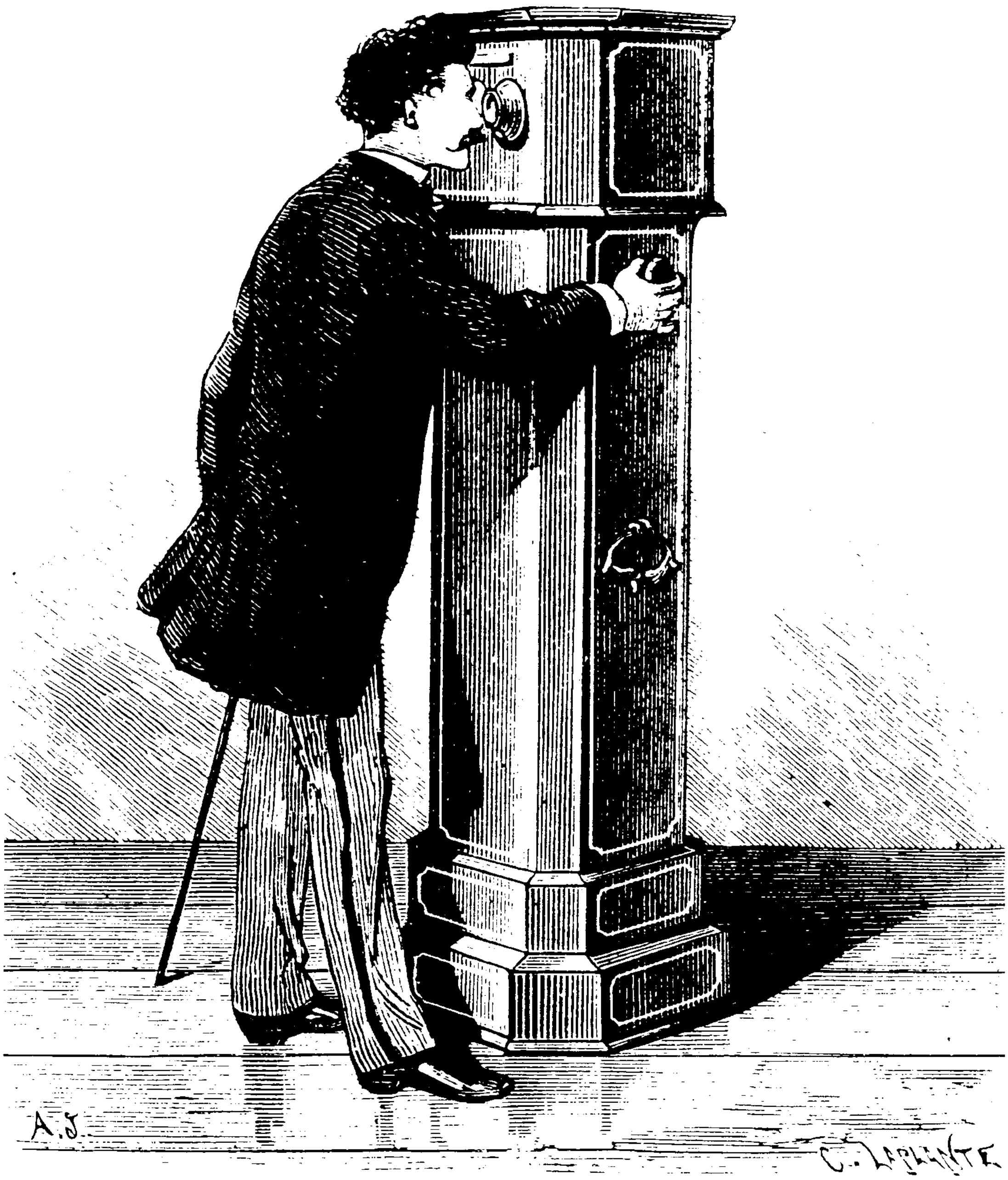
---

Tiedemann, "Dialectics at a Standstill: Approaches to the Passagen-Werk," in *On Walter Benjamin: Critical Essays and Recollections,* ed. Gary Smith (Cambridge, Mass., 1988), pp. 276–279. For the technical and cultural history of the original phantasmagoria, see Terry Castle, "Phantasmagoria: Spectral Technology and the Metaphorics of Modern Reverie," *Critical Inquiry* 15 (Autumn 1988), pp. 26–61; Erik Barnouw, *The Magician and the Cinema* (Oxford, 1981); and Martin Quigley, Jr., *Magic Shadows: The Story of the Origin of Motion Pictures,* pp. 75–79.

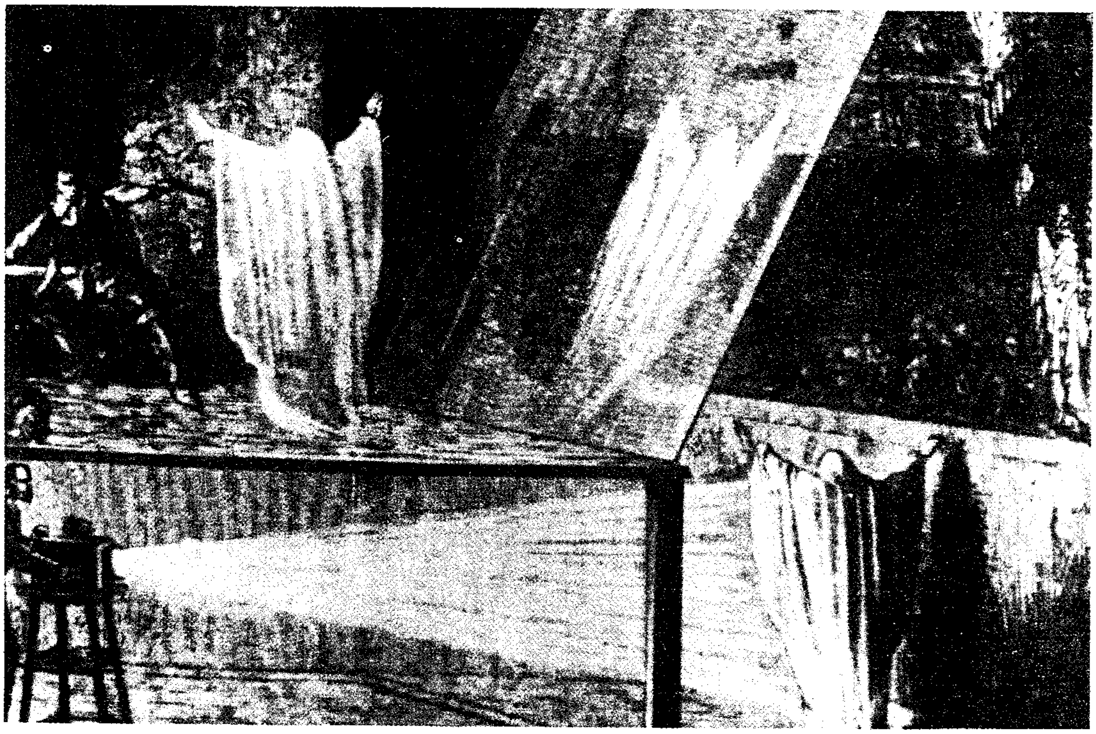
54. Sir David Brewster, *Letters on Natural Magic* (New York, 1832), pp. 15–21.

55. This device is described by its inventor in Oliver Wendell Holmes, "The Stereoscope and the Stereograph," *Atlantic Monthly* 3, no. 20 (June 1859), pp. 738–748.

Holmes stereoscope. 1870s.



Column stereoscope. 1870s.



Phantasmagoric effects: Mid-nineteenth century theatrical performance.

objects in focus).[56] But photography had already abolished the inseparability of observer and camera obscura, bound together by a single point of view, and made the new camera an apparatus fundamentally independent of the spectator, yet which masqueraded as a transparent and incorporeal intermediary between observer and world. The prehistory of the spectacle *and* the "pure perception" of modernism are lodged in the newly discovered territory of a fully embodied viewer, but the eventual triumph of both depends on the denial of the body, its pulsings and phantasms, as the ground of vision.[57]

56. For the disruptive effect of Muybridge and Marey on nineteenth-century codes of "naturalistic" representation, see Noël Burch, "Charles Baudelaire versus Doctor Frankenstein," *Afterimage* 8–9 (Spring 1981), pp. 4–21.

57. On the problem of modernism, vision, and the body, see the recent work of Rosalind Krauss: "Antivision," *October* 36 (Spring 1986), pp. 147–154; "The Blink of an Eye," in *The States of Theory: History, Art, and Critical Discourse,* ed. David Caroll (New York, 1990), pp. 175–199; and "The Impulse to See," in *Vision and Visuality,* ed. Hal Foster (Seattle, 1988), pp. 51–75.