Techniques of the Observer

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Near the opening of Goethe's *Color Theory* (1810) we find the following account:

> Let a room be made as dark as possible; let there be a circular opening in the window shutter about three inches in diameter, which may be closed or not at pleasure. The sun being suffered to shine through this on a white surface, let the spectator from some little distance fix his eyes on this bright circle thus admitted.[1]

Goethe, following a long established practice, has made a camera obscura the site of his optical studies. The dark room, of course, had been a crucial feature of the experiments detailed by Newton in his *Opticks* (1704), where it established categorical relations between interior and exterior, between light source, aperture, and screen, and between observer and representation. And as the work of Descartes, Leibniz, Locke, and others attests, the significance of the camera obscura went well beyond the domain of natural science. For nearly two hundred years the camera stood as a sovereign metaphor for describing the status of an observer and as a model, in both rationalist and empiricist thought, of how observation leads to truthful inferences about the world.[2]

But as Goethe continues his recitation, he abruptly and stunningly abandons the order of the camera obscura:

> *The hole being then closed* [Man schliesse darauf die Offnung], let him look towards the darkest part of the room; a circular image will now

1. Johann Wolfgang von Goethe, *Theory of Colours*, trans. Charles Eastlake, Cambridge, Mass., MIT Press, 1970, pp. 16–17; *Gedenkausgabe der Werke, Briefe, und Gespräche*, ed. Ernst Beutler, Zurich, 1949, vol. 16, pp. 35–36.
2. The present essay is adapted from a book forthcoming from the MIT Press on the making of the observer in the nineteenth century in which I discuss the paradigm of the camera obscura at length. I argue that the camera obscura must be understood as part of a larger organization of representation, cognition, and subjectivity in the seventeenth and eighteenth centuries (common to *all* of Europe, not just the North as some have suggested) which is fundamentally discontinuous with a nineteenth-century observer. Thus I contend that the camera obscura and photography, as historical objects, are radically dissimilar. See my "Modernizing Vision," in *Vision and Visuality: Discussion in Contemporary Culture*, ed. Hal Foster, Seattle, Bay Press, 1988.

> be seen to float before him. The middle of the circle will appear bright, colorless, or somewhat yellow, but the border will appear red.
>
> After a time this red, increasing towards the centre, covers the whole circle, and at last the bright central point. No sooner, however, is the whole circle red than the edge begins to be blue, and the blue gradually encroaches inwards on the red. When the whole is blue the edge becomes dark and colorless. The darker edge again slowly encroaches on the blue till the whole circle appears colorless.[3]

Goethe's instruction to seal the hole announces a disordering and negation of the camera obscura as both an optical system and epistemological principle. The closing off of the opening dissolves the distinction between inner and outer space on which the very functioning of the camera (as paradigm and apparatus) depended. But it is now not simply a question of an observer repositioned in a sealed interior to view its particular contents; the optical experience described here by Goethe presents a notion of vision which the classical model was incapable of encompassing.

The colored circles that seem to float, undulate, and undergo a sequence of chromatic transformations have no correlative either within or without the dark room; as Goethe explains at length, they are "physiological colors" belonging entirely to the body of the observer, and they are "the necessary conditions of vision."

> Let the observer look steadfastly on a small colored object and let it be taken away after a time while his eyes remain unmoved; the spectrum of another color will then be visible on the white plane . . . it arises from an image which now *belongs to the eye.*[4]

The corporal subjectivity of the observer, which was *a priori* excluded from the camera obscura, suddenly becomes the site on which an observer is possible. The human body, in all its contingency and specificity, generates "the spectrum of another color," and thus becomes the active producer of optical experience.

The ramifications of Goethe's color theory are manifold and have little to do with the empirical "truth" of his assertions or the "scientific" character of his experiments. Contained within the unsystematized accumulation of statements and findings is a key delineation of subjective vision, a post-Kantian notion that is both a product and constituent of modernity. What is crucial about Goethe's account of subjective vision is the inseparability of two models usually presented as distinct and irreconcilable: a physiological subject who will be described in

3. Goethe, *Theory of Colours*, p. 17. (Emphasis added.)
4. *Ibid.*, p. 21. (Emphasis added.) See Ernst Cassirer, *Rousseau, Kant, and Goethe,* trans. James Gutmann, Princeton, Princeton University Press, 1945, pp. 81–82: In his color theory Goethe aimed "to include nothing but the world of the eye, which contains only form and color."

increasing detail by the empirical sciences in the nineteenth century, *and* an observer posited by various "romanticisms" and early modernisms as the active, autonomous producer of his or her own content. This essay seeks to describe some of the features of this new kind of observer and to suggest how his or her formation in the nineteenth century was immanent to the elaboration of new empirical knowledge of vision and techniques of the visible.

Clearly Kant's "Copernican revolution" (*Drehung*) of the spectator, proposed in the preface to the second edition of the *Critique of Pure Reason* (1787), is a definitive sign of a new organization and positioning of the subject. For Kant, continuing the use of optical figures, it is "a change in point of view," such that "our representation of things, as they are given, does not conform to these things as they are in themselves, but that these objects as appearances, conform to our mode of representation."[5] William Blake put it more simply: "As the eye, such the object."[6] Michel Foucault makes clear that vision in the classical era was precisely the opposite of Kant's subject-centered epistemology, that it was then a form of immediate knowing, "a perceptible knowledge." For example:

> Natural history [in the eighteenth century] is nothing more than the nomination of the visible. Hence its apparent simplicity, and that air of naiveté it has from a distance, so simple does it appear and so obviously *imposed by the things themselves.*[7]

In the aftermath of Kant's work there is an irreversible clouding over of the transparency of the subject-as-observer. Vision, rather than a privileged form of knowing, becomes itself an object of knowledge, of observation. From the beginning of the nineteenth century a science of vision will tend to mean increasingly an interrogation of the makeup of the human subject, rather than of the mechanics of light and optical transmission. It is a moment when the visible escapes from the timeless incorporeal order of the camera obscura and becomes lodged in another apparatus, within the unstable physiology and temporality of the human body.

When Goethe's experiments repeatedly call for either a darkened room or, perhaps more significantly, the closed eye, he is not simply privileging an experience of being severed from contact with an external world. On the one hand he is indicating his conviction that color is always the product of an admixture of light and shadow: "Color itself is a degree of darkness; hence Kircher is perfectly right in calling it *lumen opacatum.*"[8] On the other hand he is also posing conditions in

5. Immanuel Kant, *Critique of Pure Reason,* trans. Norman Kemp Smith, New York, St. Martin's Press, 1965, pp. 24–25.
6. William Blake, "Annotations to Reynolds" [c. 1808], in *Complete Writings,* ed. Geoffrey Keynes, Oxford, Oxford University Press, 1972, p. 456.
7. Michel Foucault, *The Order of Things,* New York, Pantheon, 1970, p. 132. (Emphasis added.)
8. "Die Farbe selbst is ein Schattiges; deswegen Kircher volkommen recht hat, sie *Lumen opaca-*

which the inescapable physiological components of vision can be artificially isolated and made observable by themselves. For Goethe, and for Schopenhauer soon after, vision is always an irreducible complex of elements belonging to the observer's body and of external data. Thus the kind of separation between interior representation and exterior reality implicit in the camera obscura becomes in Goethe's work a single surface of affect on which interior and exterior have few of their former meanings and positions. Color, as the primary object of vision, is now atopic, cut from any spatial referent.

Goethe insistently cites experiences in which the subjective contents of vision are dissociated from an objective world, in which the body itself produces phenomena that have no external correlate. Notions of correspondence, of reflection on which classical optics and theories of knowledge were based, although retained elsewhere by Goethe, have lost their centrality and necessity. The priority previously accorded to Lockean primary qualities over secondary ones becomes inverted. Perhaps most important is his designation of opacity as a crucial and productive component of vision. If discourses of the visible in the seventeenth and eighteenth centuries repressed and concealed whatever threatened the transparence of an optical system, Goethe signals a reversal, and instead poses the opacity of the observer as the necessary condition for the appearance of phenomena.[9] Pure light and pure transparence are now beyond the limits of the visible.[10]

The articulation of subjective vision in the early nineteenth century is part of a shift which Foucault calls "the threshold of our modernity." When the camera obscura was the dominant model of observation it was as "a form of representation which made knowledge in general possible." But at the beginning of the nineteenth century

> the site of analysis is no longer representation but man in his finitude. . . . [It was found] that knowledge has anatomo-physiological conditions, that it is formed gradually within the structures of the body, that it may have a privileged place within it, but that its forms cannot be dissociated from its peculiar functioning; in short, that there is a nature of human knowledge that determines its forms and that at the same time can be manifest to it in its own empirical contents.[11]

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tum zu nennen" (Goethe, *Gedenkausgabe*, p. 45). The reference to Athanasius Kircher (1602–1680), the Jesuit turned magic-lantern showman, recalls a counter-use of classical optical systems. Kircher's career as a conjurer was based on the subversion and making opaque of the "transparency" of the camera obscura and other optical instruments.

9. The thematic of repression is central to Jean-François Lyotard's discussion of Renaissance representation in *Discours, Figure*, Paris, Klincksieck, 1978, esp. pp. 163–189.

10. This point is made in Elaine Escoubas, "L'Oeil du teinturier," *Critique*, vol. 37, no. 418 (March 1982), pp. 231–242.

11. Foucault, *The Order of Things*, p. 319.

Goethe's affirmation of both the subjective and the physiological in perception obviously is echoed in a wide range of well-known philosophical, scientific, and literary developments. One less familiar but significant parallel is the contemporary work of Maine de Biran. During the first decade of the century, the latter outlined a science of the *sens intime* in an attempt to understand more accurately the nature of inward experience. But in seeking to grasp the density and the immediacy of the *sens intime* Maine de Biran began to blur the identity of the very inwardness that was his original object. He employed the term *coenesthèse* to describe "one's immediate awareness of the presence of the body in perception" and "the simultaneity of a composite of impressions inhering in different parts of the organism."[12] Visual perception, for example, is inseparable from the muscular movements of the eye and the physical effort involved in focusing on an object. In a complete reversal of the classical model of the apparatus as a neutral device of pure transmission, the viewer's sensory equipment now is inextricably mixed with whatever object it beholds. Seven years before Goethe published the *Farbenlehre,* Maine de Biran discussed how perception of color was determined by the body's tendency to fatigue (by a physiological modulation over time) and that the very process of becoming tired was in fact perception.[13] For both of them, the absolute values accorded to color by Newtonian theory are displaced by an insistence on color's transient unfolding within the human subject.

Maine de Biran unravels the assumptions of Condillac and others about the composition of perception. Condillac's notion of sensation as a simple unit, a building block out of which clear perceptions were assembled, is no longer adequate to a new multilayered and temporally dispersed perception which Maine de Biran details, making impossible "a soul reduced to pure receptivity." For both Goethe and Maine de Biran, subjective observation is not the inspection of an inner space or a theater of representations. Instead, observation is increasingly exteriorized; the viewing body and its objects begin to constitute a single field on which inside and outside are confounded. Perhaps most importantly, both observer and what he sees are subject to the same modes of empirical study. For Georges Canguilhem, the reorganization of human knowledge at the beginning of the nineteenth century signals an end to the idea of a qualitatively different human order, and he cites the major discovery by Maine de Biran that

12. Maine de Biran, *Considerations sur les principes d'une division des faits psychologiques et physiologiques,* in *Oeuvres des Maine de Biran,* vol. 13, ed. P. Tisserand, Paris, Presses Universitaires de France, 1949, p. 180. An important study is Michel Henry, *Philosophie et phénoménologie du corps: essay sur l'ontologie biranienne,* Paris, Presses Universitaires de France, 1965.

13. Maine de Biran, *Influence de l'habitude sur la faculté de penser* [1803], ed. P. Tisserand, Paris, 1953, pp. 56–60: "When the eye fixes itself on a single color, for a certain length of time, in its manner of becoming fatigued there follows a mixed form of this color and several others, and over time the original color will no longer be contained in this new mixture."

since "the soul is necessarily incarnated there is no psychology without biology."[14]

The models of subjective vision outlined by Goethe and Schopenhauer (which were brought to fulfillment in the physiological optics of Helmholtz in the 1860s), also must be seen against the profound changes which took place in theories of the nature of light. The shift from emission and corpuscular theories to undulatory or wave motion explanations have a major significance for nineteenth-century culture as a whole.[15] The wave theory of light made obsolete any notion of a rectilinear propagation of light rays on which classical optics was based and, in part, the science of perspective. All the modes of representation derived from Renaissance and later models of perspective no longer had the legitimation of a science of optics. The verisimilitude associated with perspectival construction obviously persisted into the nineteenth century, but it was severed from the scientific base that had once authorized it, and it could no longer have the same meanings it had when either Aristotelian or Newtonian optics held sway. Dominant theories of vision, whether of Alberti, Kepler, or Newton (Huygens is the obvious exception), all described in their own fashion how a beam of isolated light rays traversed an optical system, with each ray taking the shortest possible route to reach its destination.[16] The camera obscura is inextricably wedded to this point-to-point epistemological setup. At the same time it must be stressed how deeply theological was the notion that light was radiant (composed of rays) and emanative.

The work of Augustin Jean Fresnel has come to stand for the paradigm shift.[17] By 1821 Fresnel had concluded that the vibrations of which light consisted were entirely *transverse*, which led him and those who followed to build mechanical models of an ether which transmitted such tranverse waves rather than longitudinal rays or waves. Fresnel's work participates in the destruction of classical mechanics and the eventual dominance of modern physics. What had been a discrete domain of optics in the seventeenth and eighteenth centuries now became merged with the study of other physical phenomena, i.e., electricity and magnetism. Above all it is a moment when light loses its ontological privilege;

14. Georges Canguilhem, "Qu'est-ce que la psychologie," *Études d'histoire et de philosophie des sciences*, Paris, Librarie philosophique de J. Vrin, 1968, pp. 374–375.
15. See P. M. Harman, *Energy, Force, and Matter: The Conceptual Development of Nineteenth-Century Physics*, Cambridge, Cambridge University Press, 1982, pp. 19–26; and Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2nd ed., Chicago, University of Chicago Press, 1970, pp. 73–74.
16. See, for example, David C. Lindberg, *Theories of Vision from Al-Kindi to Kepler*, Chicago, University of Chicago Press, 1976; and Gérard Simon, *Le regard, l'être et l'apparence dans l'optique de l'antiquité*, Paris, Seuil, 1988.
17. See Edward Frankel, "Corpuscular Optics and the Wave Theory of Light: the Science and Politics of a Revolution in Physics," *Social Studies of Science*, vol. 6, 1976, pp. 141–184; G. N. Cantor, *Optics After Newton*, Manchester, Manchester University Press, 1983, esp. pp. 150–159; and R. H. Silliman, "Fresnel and the Emergence of Physics as a Discipline," *Historical Studies in the Physical Sciences*, vol. 4, 1974, pp. 137–162.

and during the nineteenth century the very identity of light as an independent entity became increasingly problematic. Goethe's color theory, with its proposal of a qualitative difference between light and color, had implicitly suggested such developments. More importantly here, however, as light began to be seen as an electromagnetic phenomenon, it had less and less to do with the realm of the visible and with the description of human vision. So it is at this moment in the early nineteenth century, when physical optics (the study of light and the forms of its propagation) merges with physics, that physiological optics (the study of the eye and its sensory capacities) comes to dominate the study of vision.

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The retinal afterimage is perhaps the most important optical phenomenon discussed by Goethe in his chapter on "Physiological Colors" in his *Color Theory.* Though preceded by others in the late eighteenth century, his treatment of the topic was by far the most thorough up to that moment.[18] 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 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, the privileging of the afterimage allowed the thought of sensory perception 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. Secondly, and equally crucial for the rest of the nineteenth century, is the introduction of temporality as an inescapable component of observation.[19] Most of the phenomena described by Goethe in the *Color Theory* involve an unfolding over time: "the edge begins to be blue . . . the blue gradually encroaches inward . . . the image then becomes gradually fainter."[20] The virtual

18. 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,* pp. 1–2. See also E. G. Boring, *A History of Experimental Psychology,* New York, Appleton-Century-Crofts, 1950, pp. 102–104.

19. 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, Random House, 1944, p. 395).

20. Goethe, *Theory of Colours,* pp. 16–17.

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.[21] 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 (such as Maine de Biran) which describe perception and cognition as essentially temporal processes dependent upon a dynamic amalgamation of past and present. 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."[22] 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 "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.[23]

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.[24]

21. On the instantaneity of perception see, for example, Lindberg, *Theories of Vision*, pp. 93–94.
22. G. W. F. Hegel, *The Phenomenology of Mind*, trans. J. B. Baillie, New York, Harper and Row, 1967, p. 98.
23. Goethe, *Theory of Colours*, p. 13.
24. It should be noted, however, that Hegel, in an 1807 letter to Schelling, criticized Goethe's

Other writers in the first decade also began to delineate 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 differences successives.*"[25] 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."[26] 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 (*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.

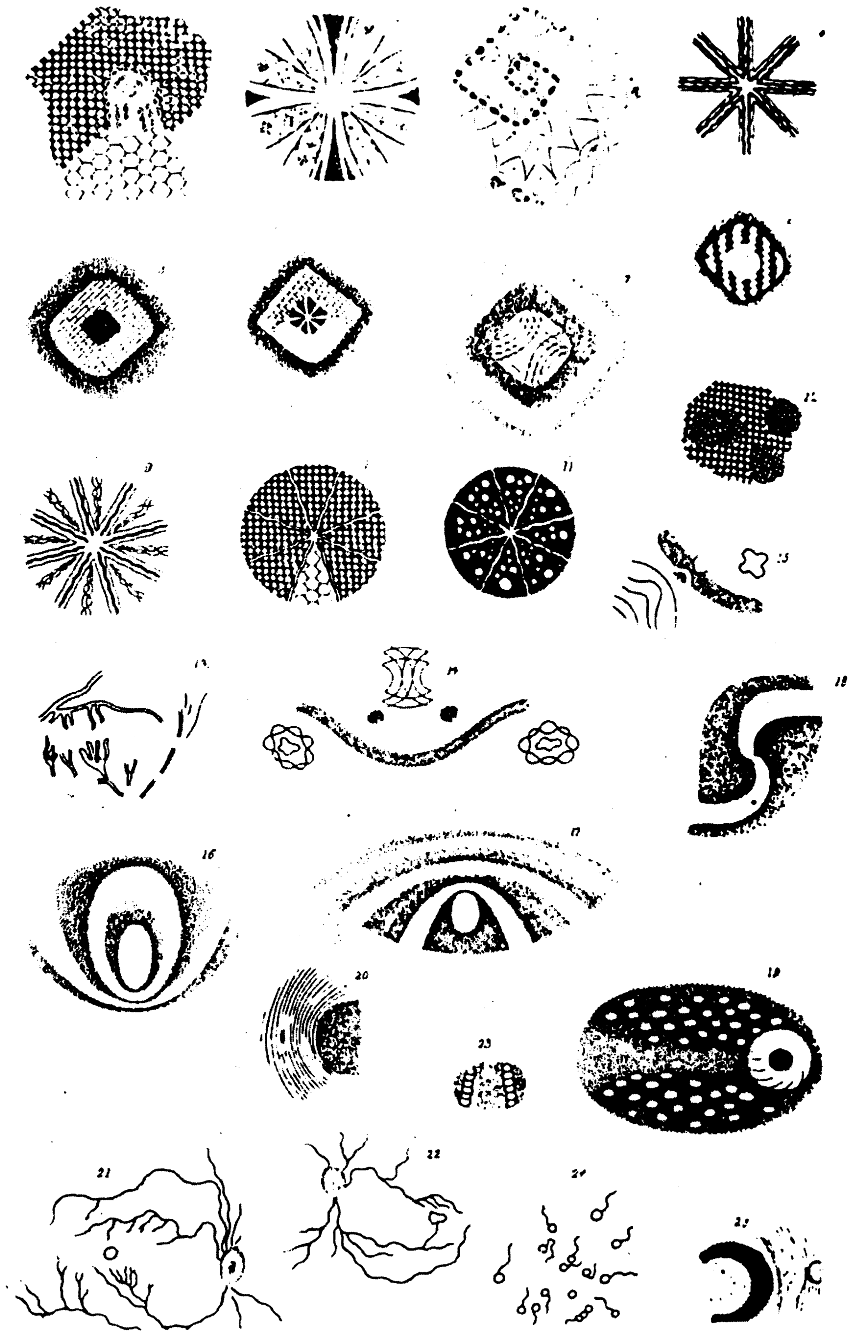
> Let a series a, b, c, d, be given by perception; then, from the first movement of the perception and during its continuance, *a* is exposed to an arrest from other concepts already in consciousness. In the meantime, *a*, already partially sunken in consciousness, became more and more obscured when *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

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, Holt, Rinehart and Winston, 1964, p. 13).

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

26. Benjamin B. Wolman, "The Historical Role of Johann Friedrich Herbart," in *Historical Roots of Contemporary Psychology*, ed. Benjamin B. Wolman, New York, Harper and Row, 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*, vol. 16 (1980), pp. 150–163.

Jan Purkinje. Afterimages. 1823.



order to be able to stand beside two or more stronger ones exactly on the threshold of consciousness.[27]

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.[28] 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 Johannes Müller, Gustav Fechner, Ernst Weber, and Wilhelm Wundt. 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 disciplining and control. Herbart clearly was attempting a quantification of *cognition,* but he nonetheless prepared the ground for attempts to measure the magnitude of sensations, and such measurements 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.[29] Herbart believed that his quantification of 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.[30] 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

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

28. See Johann Friedrich Herbart, *Psychologie als Wissenschaft,* vol. 1, Königsberg, August Unzer, 1824, pp. 222–224.

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

30. See Nikolas Rose, "The Psychological Complex: Mental Measurement and Social Administration," *Ideology and Consciousness,* no. 5 (Spring 1979), pp. 5–70; and Didier Deleule and François Guéry, *Le corps productif,* Paris, Mame, 1973, pp. 72–89.

afterimages: how long they lasted, what changes they went through, and under what conditions.[31] 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 quantification of the irritability of the eye.[32] 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 takes the eye to become fatigued, how long dilation and contraction of the pupil take, 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, and quantified the distinction between direct and indirect vision, and also gave a highly precise account of the blind spot.[33] The discourse of dioptrics, of the transparency of mechanical optical systems in the seventeenth and eighteenth centuries, has given way to a mapping of the human eye as a productive territory with varying zones of efficiency and aptitude.

Purkinje's research, along with that of Johannes Müller and others, inaugurated the comprehensive physiology of vision in the nineteenth century. Part of this study involved establishing quantitative and statistical *norms* of the sense of sight. As Foucault and others have shown, the "scientific" assessment of "normality" in medicine, physiology, and other fields became central to the accumu-

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

32. Goethe provides a telling account of the subjectivity of the afterimage in which the physiology of the attentive (male heterosexual) eye and its operation are inseparable from memory and desire: "I had entered an inn towards evening, and, as a well-favored 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).

33. It should be noted that Purkinje, in 1823, formulated the first classification system for human 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.

lation of knowledge about individuals—whether in medicine, psychiatry, child psychology, the rationalization of labor and education—and thus essential to the exercise of power. My concern here is how the individual as observer became an object of investigation, a locus of knowledge in the first half of the 1800s, and how the nature of vision was thus modified. One feature of this period is the widespread effort by researchers from a variety of fields to establish the bounds of "normative" vision and to quantify forms of optical and other sensory response. The pervasive preoccupation with optical illusions is part of the exploration of the limits and pathology of human vision, defining ever more sharply the shape of the normal. But as Georges Canguilhem has shown, the indication of a norm is not a neutral activity; it never occurs without the specification of technical means to correct, or to produce normativeness.[34]

What is of immediate concern here is how some of the optical devices that spawned a new mass visual culture in the nineteenth century are inseparable from the new normative sciences of the observer and of the seeing body. The comprehensive articulation of subjective vision, which included the conceptual severing of visual experience from referent (in Müller's famous theory of specific nerve energies), and the quantification and study of afterimages, of persistence of vision, peripheral and binocular vision, and thresholds of attention all were directly part of the creation of a new vast domain of visual culture. On one hand there is a new abstraction and mobility of images, on the other is an inverse disciplining of the observer in terms of rigidly fixed relations to image and apparatus, particularly with the stereoscope, the kaleidoscope, the phenakistiscope, and even the diorama.

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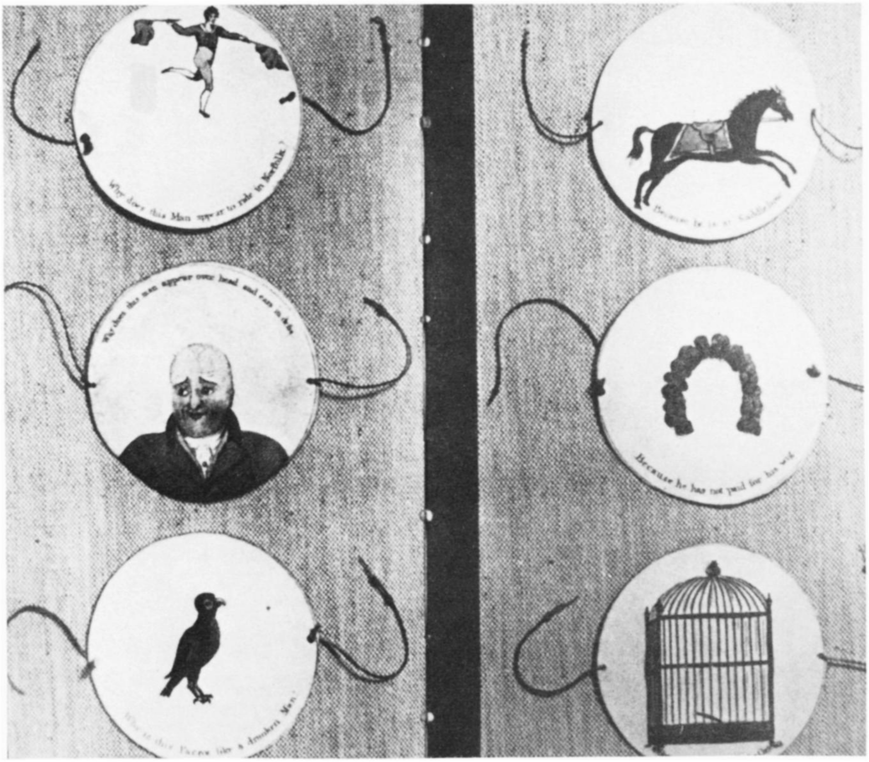
Beginning in the mid-1820s, the experimental study of afterimages was intertwined with the invention of a number of related optical devices and techniques. The boundary separating their use for purposes of scientific observation and as forms of popular entertainment is indistinct. Common to them all 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 succession, and it was the duration involved in seeing that allowed its modification and regulation. The control of time becomes synonymous with new modalities of power.

The details and background of these devices and inventors have been well documented and discussed at length elsewhere, but almost exclusively in the

34. See Georges Canguilhem, *Le normal et le pathologique,* Paris, Presses Universitaires de France, 1966, trans. as *The Normal and the Pathological* by Carolyn Fawcett, New York, Zone Books, forthcoming.

Thaumatropes. c.1825.

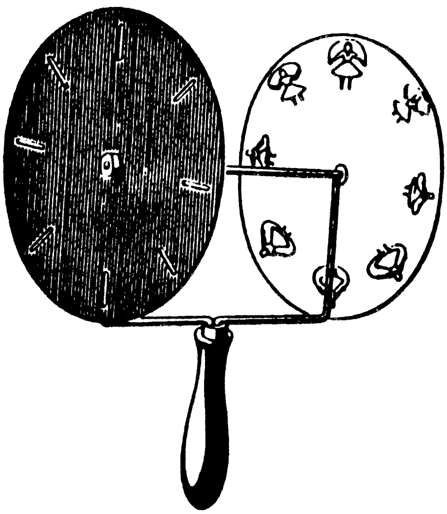


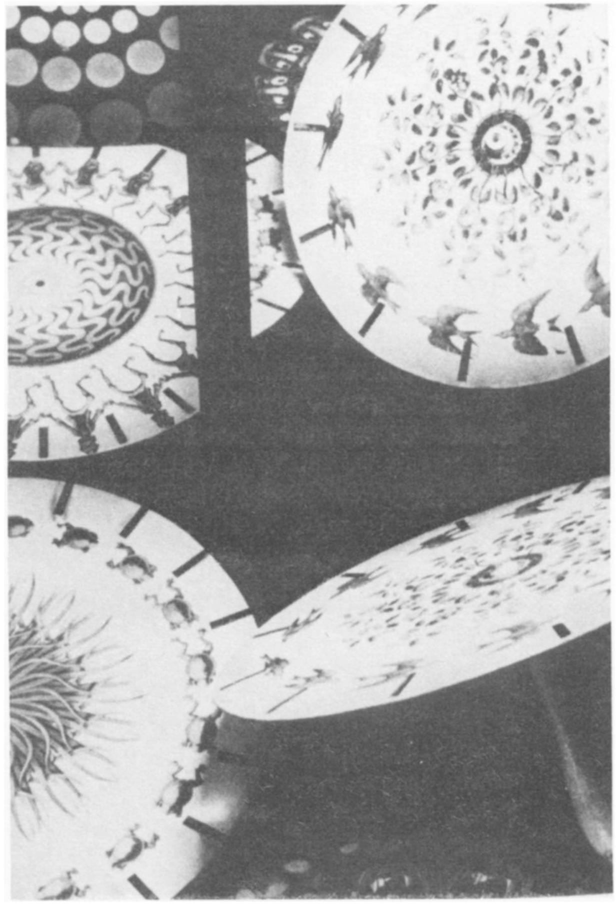
service of a history of cinema.[35] Film scholars position them as the initial forms in an evolutionary technological development leading to the emergence of a single dominant form at the end of the century. Their fundamental characteristic is prematurity; they are not-yet cinema, thus nascent and incomplete 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 verisimi-

35. See, for example, C. W. Ceram, *Archaeology of the Cinema*, New York, Harcourt, Brace and World, 1965; Michael Chanan, *The Dream that Kicks: The Prehistory and Early Years of Cinema in Britain*, London, Routledge and Kegan Paul, 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, Editions Universitaires, 1967, pp. 21–27; and Georges Sadoul, *Histoire générale du cinéma*, vol. 1, Paris, Denoël, 1973, pp. 15–43. See also the brief geneaology in Gilles Deleuze, *Cinema 1: The Movement-Image*, trans. Hugh Tomlinson and Barbara Habberjam, Minneapolis, University of Minnesota Press, 1986, p. 5.

Left: Feraday wheel. 1830.

Right: Phenakistiscope. 1832.





litude. Such teleological approaches most often neglect entirely how these devices were expressions of nonveridical models of perception.

One of the earliest was the Thaumatrope (literally, "wonder-turner"), first demonstrated 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 image of a bird on one side and an empty cage on the other would produce when spun the appearance of the bird in the cage. The simplicity of this "philosophical toy" made unequivocally clear the hallucinatory and fabricated nature of the image and the absolute 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 these circumstances in which the spokes of the wheels seemed to be either motionless or to be turning backwards. 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

Zellotrope. Mid-1830s.

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 spoked 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 farther 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 afterimage varied with the intensity, color, time, and direction of the stimulus. He also made a rough 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 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.[36]

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 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 reflected figure on the disc very briefly. The same effect occurs with each of the slits. The images then appear to be in continuous motion before the eye. By 1833, commercial models were being sold in London; by 1834 two similar devices appeared, the Stroboscope invented by the German mathematician Stampfer and the Zootrope or "wheel of life" of William G. Horner.

The empirical truth of the notion of "persistence of vision" as an explanation for the illusion of motion is irrelevant here.[37] What is important are the

36. Joseph Plateau, *Dissertation sur quelques propriétés des impressions,* thesis submitted at Liège, May 1829. Quoted in Georges Sadoul, *Histoire générale du cinéma,* p. 25.
37. Some recent studies have discussed the "myth" of persistence of vision. They tell us, not

conditions and circumstances that allowed it to operate as an explanation and the historical subject/observer that it presupposed. The idea of persistence of 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 industrial 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. 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 appeared behind the other, there was immediately the distinct though shadowy resemblance of cogs moving slowly in one direction."[38] 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 contention that in the nineteenth century "technology has subjected the human sensorium to a complex kind of training."[39] While it was of course a mode of popular entertainment, a leisure-time commodity purchasable by an expanding urban middle class, it nonetheless paralleled the format of the scientific devices used by Purkinje, Plateau, and others for the scientific 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: a body at once a spectator, a subject of empirical research and observation, and an element of machine production. In all three cases 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 multiple spheres of social activity. A need for knowledge of the capacities of the eye and its regimentation pervaded 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

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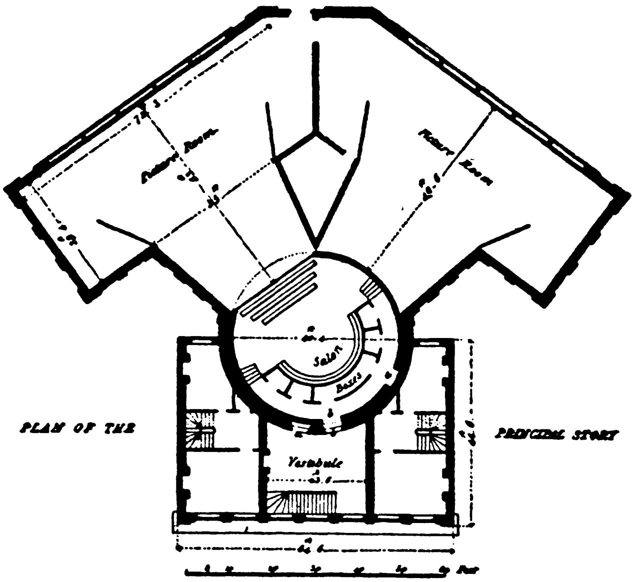
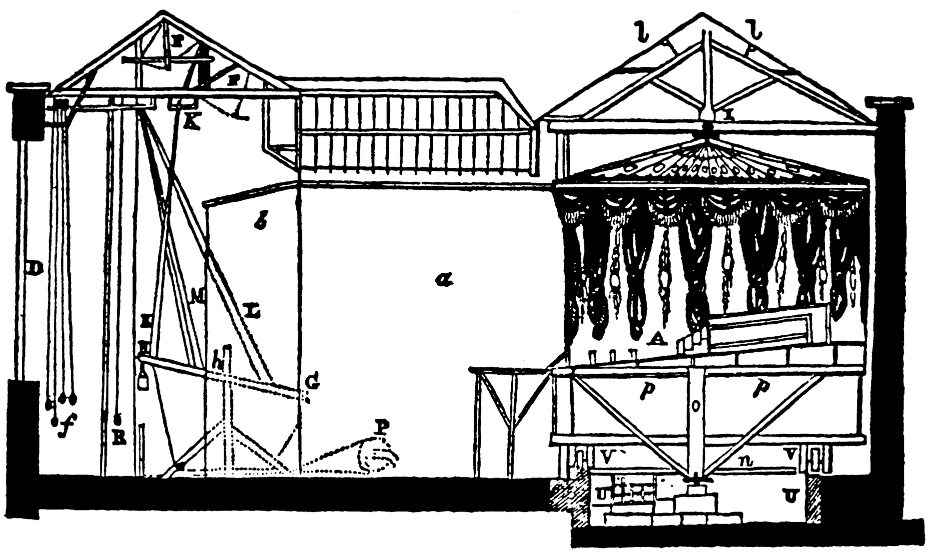
surprisingly, that current neurophysiological research shows nineteenth-century explanations of fusion or blending of images to be an inadequate explanation for the perception of illusory movement. See Joseph and Barbara Anderson, "Motion Perception in Motion Pictures," and Bill Nichols and Susan J. Lederman, "Flicker and Motion in Film," both in *The Cinematic Apparatus,* ed. Teresa de Lauretis and Stephen Heath, London, Macmillan, 1980, pp. 76–95 and 96–105.

38. Quoted in Chanan, *The Dream that Kicks,* p. 61.

39. Walter Benjamin, *Charles Baudelaire: A Lyric Poet in the Era of High Capitalism,* trans. Harry Zohn, London, NLB, 1972, p. 126.



(*a*) Ground plan of the Diorama building, London, by A. Pugin and J. Morgan, 1823



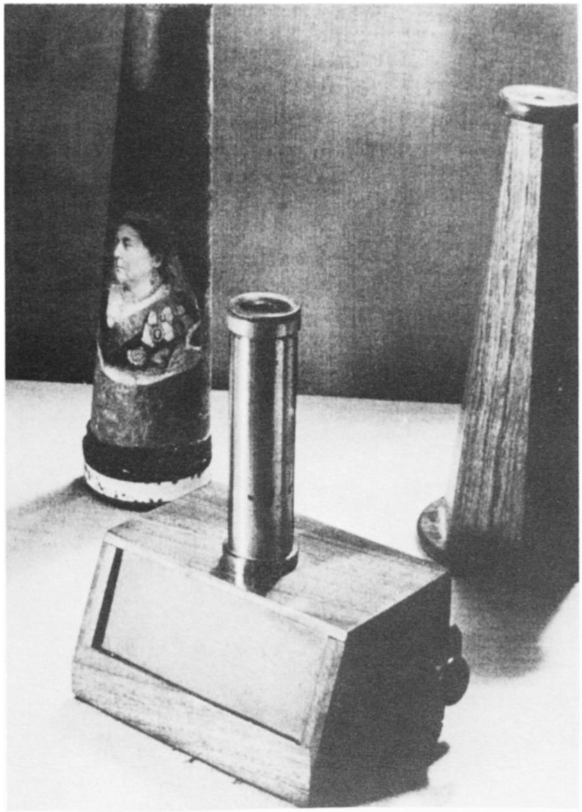
THE DIORAMA.

(*b*) Cross-section of the auditorium and picture emplacement of the Diorama, London early 1820s. Unlike the static panorama painting which first appeared in the 1790s, the Diorama is based on the incorporation of an *immobile* observer into a mechanical apparatus and a subjection to a predesigned temporal unfolding of optical experience.[40] The circular or semi-circular 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 multi-media Diorama removed that autonomy from the observer, 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 and of which the observer was an inflexible 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."[41] But if the remaking 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 a precondition of modernization was the "uprooting" of vision from the delimited and static relations of the camera obscura.

Consider also the kaleidoscope, invented in 1815 by Sir David Brewster.[42] With all the luminous possibilities suggested by Baudelaire, and later by Proust, the kaleidoscope seems radically unlike the rigid and disciplinary structure of the Phenakistiscope, with its sequential repetition of regulated representations. But, for Brewster, the justification for making the kaleidoscope was productivity and efficiency. He saw it as 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

40. An important study on the relation between the panorama and the Diorama is Eric de Kuyper and Emile Poppe, "Voir et regarder," *Communications*, no. 34 (1981), pp. 85–96. Other works include Stephan Oettermann, *Das Panorama*, Munich, Syndikat, 1980; Heinz Buddemeier, *Panorama, Diorama, Photographie: Entstehung und Wirkung neuer Medien im 19. Jahrhundert*, Munich, H. Fink, 1970; and Helmut and Alison Gernsheim, *L. J. M. Daguerre: The History of the Diorama and the Daguerreotype*, New York, Dover, 1968.
41. Karl Marx, *Capital*, vol. 1, trans. Samuel Moore and Edward Aveling, New York, International, 1967, p. 374.
42. For more on this device, see my "Notes on the Kaleidoscope and Stereoscope," *Journal*, no. 5 (Autumn 1985), pp. 38–41.



Kaleidoscope. Mid-19th century.

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.[43]

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."[44]

43. Sir David Brewster, *The Kaleidoscope: Its History, Theory, and Construction* [1819], rpt. London, John Murray, 1858, pp. 134–136.
44. Charles Baudelaire, "Le peintre de la vie moderne," *Oeuvres complètes,* Paris, Gallimard, 1961, p. 1161.

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The most significant form of visual imagery in the nineteenth century, with the exception of photography, was the stereoscope.[45] It is easily forgotten now how pervasive was the experience of the stereoscope and how for decades it defined a principal mode of consuming photographically produced images. This is again a form whose history has thus far been confounded with another phenomenon, in this case, photography. Yet conceptually, structurally, and initially, historically it is independent of the now dominant medium. Clearly, the stereoscope utilized photographic imagery but its invention preceded photography and *in no way required* photographic procedures. Although distinct from the optical devices which represented the illusion of movement, the stereoscope is nonetheless part of the same reorganization of the observer that those devices implied.

Of concern here is the period during which the technical and theoretical principles of the stereoscope were elaborated, rather than its effects once it was distributed in a social-cultural field. Only after 1850 did the wide commercial diffusion throughout North America and Europe of the stereoscope occur.[46] 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 had 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 different solutions.[47] In the eighteenth century, regardless of how the problem was ultimately answered, whether the claim was nativist or empiricist, the testimony of the senses constituted a common surface of order. The

45. There are few serious cultural or historical studies of the stereoscope. Some helpful works are: Edward Earle, ed., *Points of View: The Stereoscope in America: A Cultural History*, Rochester, Visual Studies Workshop, 1979; A.T. Gill, "Early Stereoscopes," *The Photographic Journal*, no. 109 (1969), pp. 546–599, 606–614, 641–651; and Rosalind Krauss, "Photography's Discursive Spaces: Landscape/View," *Art Journal*, no. 42 (Winter 1982), pp. 311–319.
46. 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, Thames and Hudson, 1969, p. 191.
47. The best known formulation of the Molyneux problem is John Locke, *An Essay Concerning Human Understanding*, ed. Alexander C. Fraser, New York, Dover, vol. II, no. ix, p. 8.

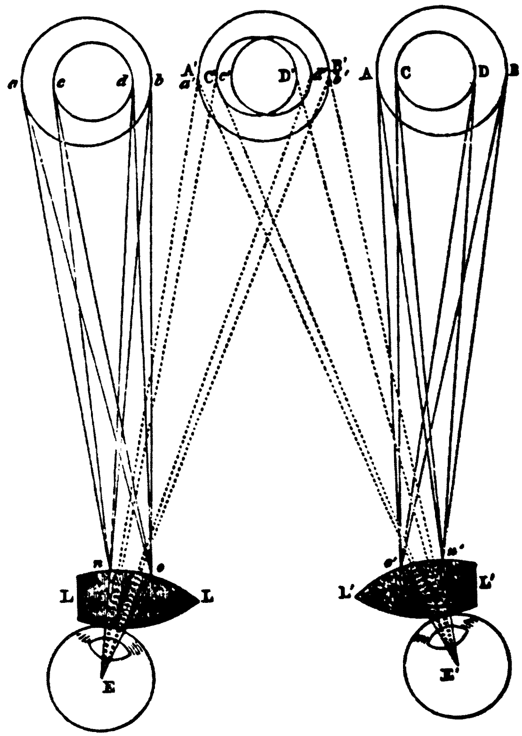
question was how the passage from one domain of sense perception to another occurred, how did the senses "reconvene," that is, come together in a body.[48] But those whose answers to Molyneux were negative—a blind man suddenly restored with sight would *not* immediately recognize the objects before him—and these included Locke, Berkeley, Diderot, Reid, and Condillac, share little with the researchers in the nineteenth century who also, with greater scientific authority, answered negatively. By insisting that knowledge, and specifically knowledge of space and depth, is built up out of an orderly accumulation and cross-referencing of perceptions on a plane independent of the viewer, eighteenth-century thought could know nothing of ideas of pure visibility which would arise in the nineteenth century. From Descartes to Berkeley to Diderot is a continued insistence that vision is grounded in the sense of touch.[49] We could not be further removed from Berkeley's theory of how distance is perceived than with the science of the stereoscope. The quintessentially nineteenth-century device, with which distance (or relief) is perceptible solely through an organization of *optical* cues, eradicates the field on which eighteenth-century knowledge arranged itself.

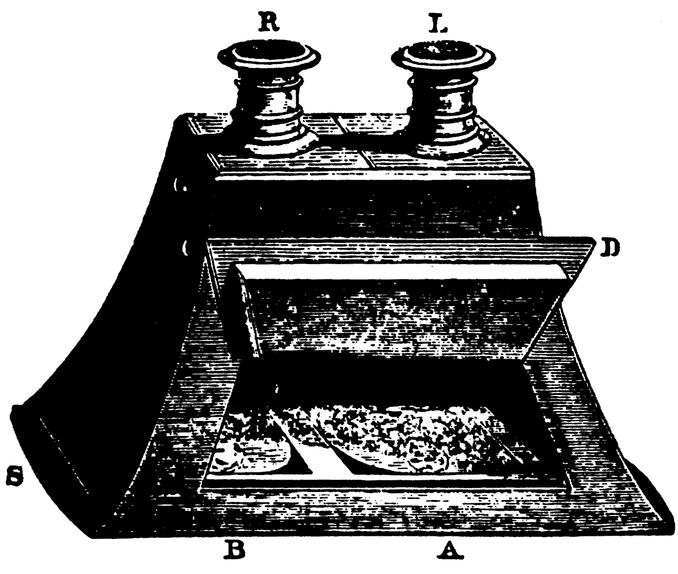
The question that troubled the nineteenth century had never really been a problem before. Binocular disparity, the self-evident fact that each eye sees a slightly different image, had been a familiar phenomenon since antiquity. Only in the 1830s does it become crucial for scientists to define the seeing 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. What 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.[50]

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.[51] But such physiological evidence was relatively inconclusive at that time. Wheatstone's conclusions in 1833 came out

48. See Ernst Cassirer, *The Philosophy of the Enlightenment,* trans. Fritz C. A. Koelln and James Petlegrove, Princeton, Princeton University Press, 1951, p. 108.
49. See Michel Serres, *Hermès ou la communication,* Paris, Minuit, 1968, pp. 124–125; and Maurice Merleau-Ponty, *The Primacy of Perception,* Evanston, Ill., Northwestern University Press, 1964, pp. 169–172.
50. See, for example, William Porterfield, *A Treatise on the Eye, the Manner and Phenomena of Vision,* Edinburgh, Hamilton and Balfour, 1759, p. 285.
51. See R. L. Gregory, *Eye and Brain: The Psychology of Seeing,* 3rd. ed., New York, McGraw-Hill, 1979, p. 45.

David Brewster's lenticular stereoscope. 1849.





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 (or often disregard of) the older explanations 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 perspective 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.[52]

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.[53]

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 epistemology was based on such a "differential hypothesis."[54] 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

52. Charles Wheatstone, "Contributions to the Physiology of Vision," in *Brewster and Wheatstone on Vision*, p. 65.
53. *Ibid.*
54. Hermann von Helmholtz, "The Facts in Perception," in *Epistemological Writings*, ed. Paul Hertz and Moritz Schlick, Boston, Boston Studies in the Philosophy of Science, 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."

> 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 axes varying themselves *successively* upon, and unifying, the similar points in each picture that correspond to different distances from the observer.[55]

Brewster then 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.[56]

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 as the object represented appeared closer to the viewer, and the impression of three-dimensional solidity became greater as the optic axes of each eye diverged. Thus the desired effect of the stereoscope was not simply 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. 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

55. Sir David Brewster, *The Stereoscope: Its History, Theory, and Construction*, London, John Murray, 1856, p. 53. (Emphasis in original.)
56. Charles Wheatstone, "Contributions to the Physiology of Vision," p. 66.

> 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.[57]

No other form of representation in the nineteenth century had so conflated the real with the optical, an object with its image.

The stereoscope as a means of representation was inherently *obscene.* 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 on the visual priority of the objects closest to the viewer and on the absence of any mediation between eye and objects viewed.[58] It was a fulfillment of what Walter Benjamin saw as part of 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 the image."[59] It is no coincidence that the stereoscope became increasingly synonymous with varieties of 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 close association of the stereoscope with pornography was in part responsible for its social demise; around the turn of the century sales of the device supposedly dwindled because of its link 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.[60]

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 projection 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.

57. Hermann von Helmholtz, *Handbook of Physiological Optics,* vol. 3, trans. George T. Ladd, New York, Dover, 1962, p. 303.
58. See Florence de Mèridieu, "De l'obscénité photographique," *Traverses,* no. 29 (October 1983), pp. 86–94.
59. Walter Benjamin, "A Short History of Photography," *Artforum,* no. 15 (February 1977), p. 49.
60. The ambivalence with which twentieth-century audiences have received 3-D movies and holography suggests the enduring problematic nature of such techniques.

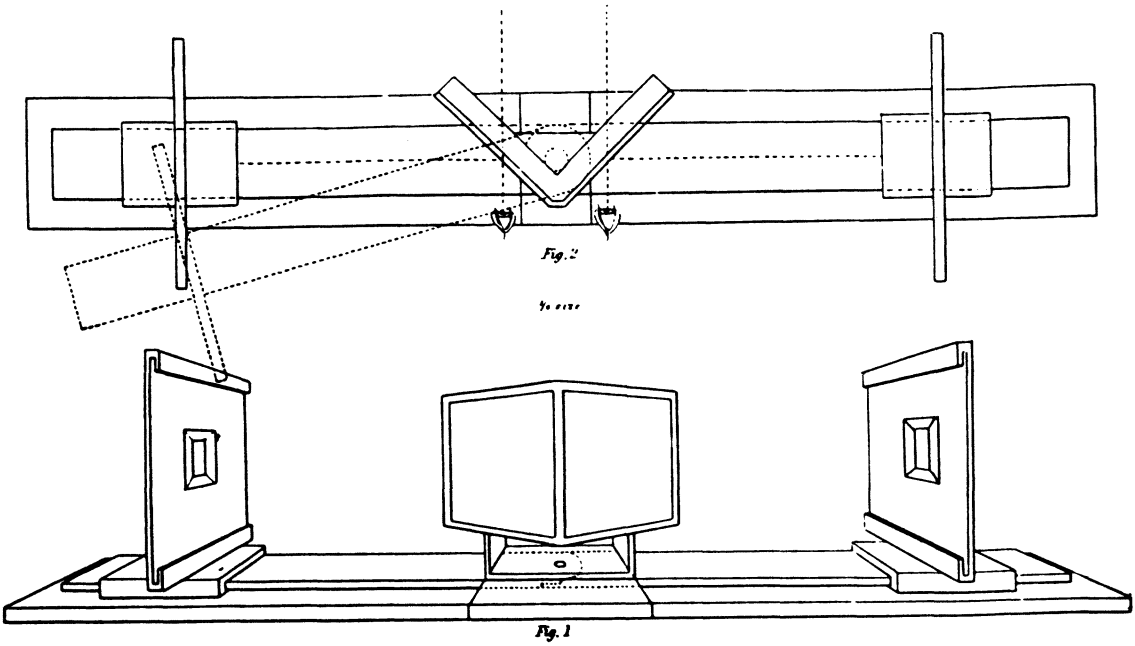


Diagram of the operation of the Wheatstone stereoscope.

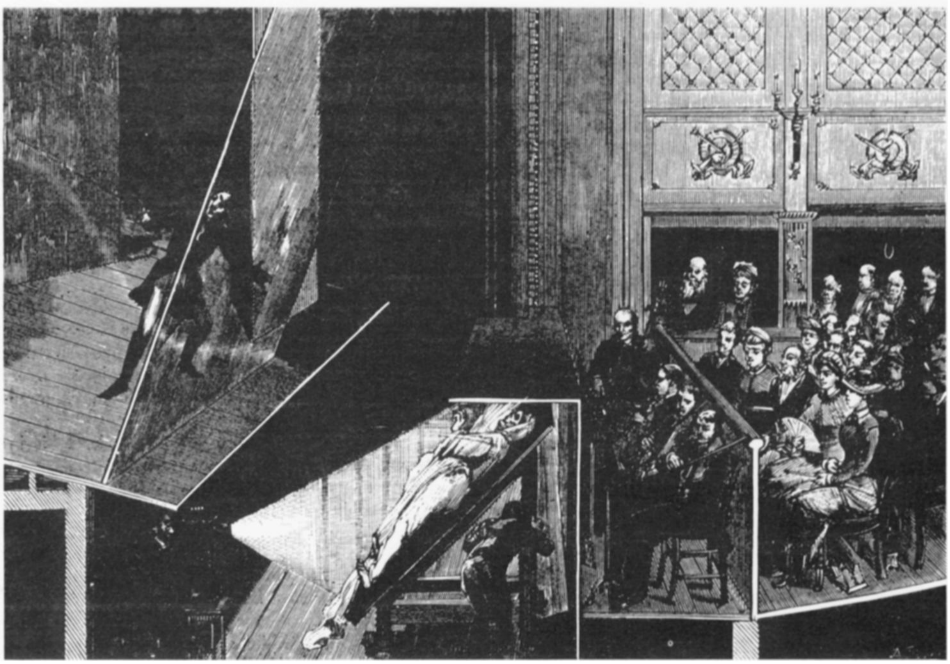
Rather, what appears is the technical reconstitution of an already reproduced world fragmented into *two* nonidentical models, models that precede any experience of their subsequent perception as unified or tangible. It is a radical repositioning of the observer's relation to visual representation. The institutionalization of this de-centered 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 modernist 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. Perspective is not even a possibility under the terms of this technique of beholding. An observer no longer sees an image that has an intelligible or quantifiable location in space, but rather a hallucinatory composite of two dissimilar images whose positions refer to the anatomical structure of the observer's body.

To fully appreciate the rupture signified by the stereoscope, it is important to consider one of its earliest forms, 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 90 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 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."[61] There simply was nothing "out there." The illusion of relief and of 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 corporal 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 the eye remained unchallenged.[62] 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.[63] 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 takes the place of a mere implement."[64] In the older, handcraft-based work, he explained, a workman "makes use of a tool," that is, the tool had a metaphoric relation to the innate powers of the human subject.[65]

61. See Roland Barthes, "L'effet de réel," *Communications*, no. 11 (1968), pp. 84–89; trans. as "The Reality Effect" by Richard Howard, in *The Rustle of Language*, New York, Hill and Wang, 1986, pp. 141–148.
62. On the telescope as metaphor in Galileo, Kepler, and others, see Timothy J. Reiss, *The Discourse of Modernism*, Ithaca, N.Y., Cornell University Press, 1980, pp. 25–29.
63. "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, Johns Hopkins University Press, 1973, p. 35).
64. Karl Marx, *Capital*, vol. 1, p. 374. 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.
65. *Ibid.*, 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., MIT Press, 1971, pp. 464–469).

Phantasmagoria.



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.[66] Georges Canguilheim makes a crucial 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."[67] Although "set to work" may sound inappropriate in a discussion of optical devices, the apparently passive observers of the stereoscope and Phenakistiscope were in fact made into producers, by virtue of specific physical capacities, of forms of verisimilitude.

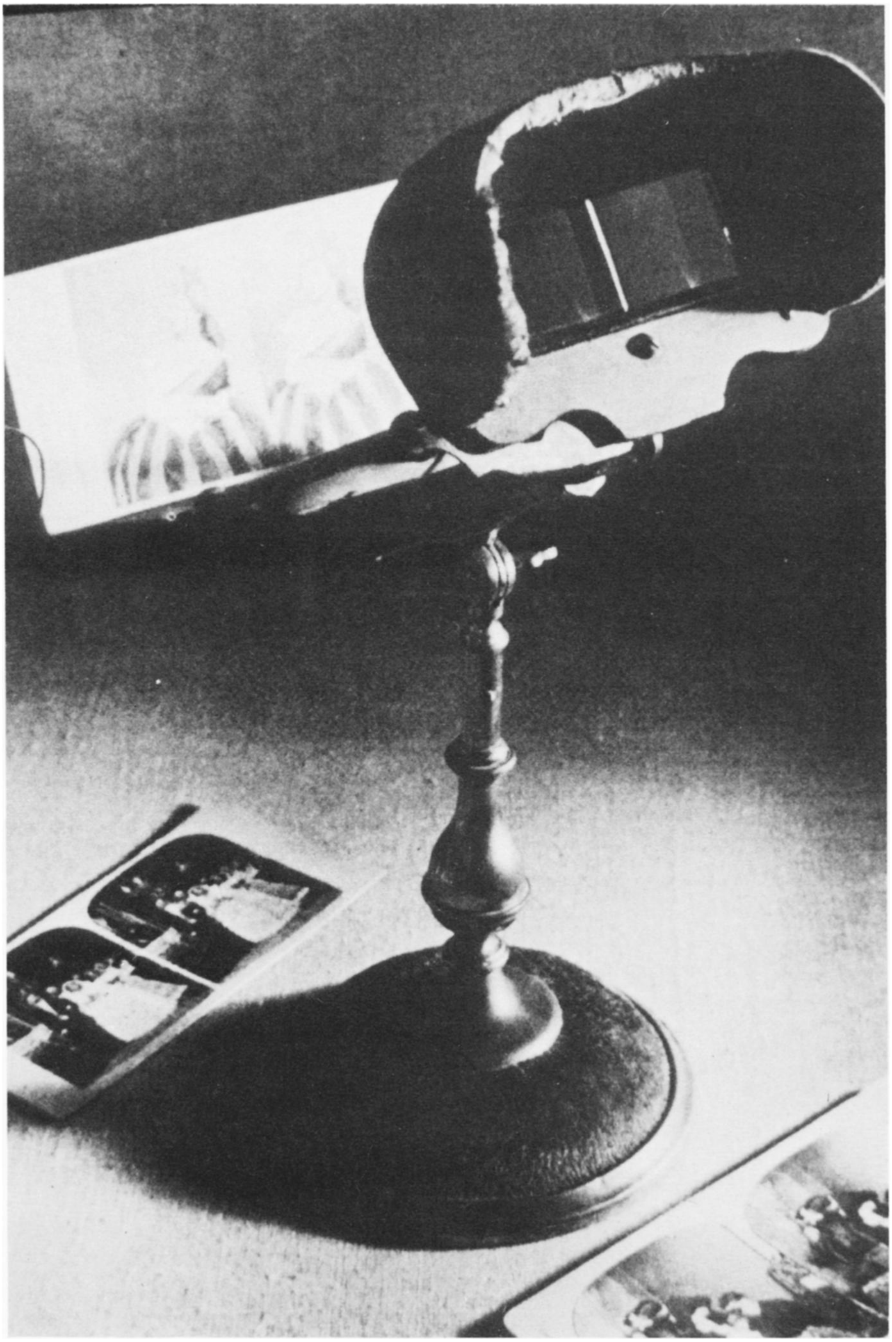
A crucial feature of these optical devices of the 1830s and 1840s is the undisguised nature of their operational structure and the form of subjection they entail. Even though they provide access to "the real," they make no claim that the real is anything other than a mechanical production. The optical 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 which 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, which 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.[68]

But the effacement or mystification of a machine's operation was precisely what David Brewster hoped to overcome with his kaleidoscope and stereoscope. He

66. Marx again indicates the new metonymic status of the human subject: "As soon as man, instead of working with an implement on the subject of his labor, 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" (*Capital*, vol. 1, p. 375).
67. Canguilhem, "Qu'est-ce que la psychologie," p. 378.
68. Theodor Adorno, *In Search of Wagner*, trans. Rodney Livingstone, London, Verso, 1981, p. 85. On Adorno, Wagner, and phantasmagoria, see Andreas Huyssen, *After the Great Divide: Modernism, Mass Culture, Postmodernism*, Bloomington, University of Indiana Press, 1986, pp. 34–42.



Holmes stereoscope. 1860s.

optimistically saw the spread of scientific ideas in the nineteenth century undermining the possibility of phantasmagoric effects, and he presented a cursory history of civilization in terms of the development of technologies of illusion and apparition.[69] 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 really occur.[70] Clearly the stereoscope was dependent on a physical engagement with the apparatus which became increasingly inconvenient and unacceptable, but more importantly, the abstract and synthetic nature of the stereoscopic image could never be fully effaced. An apparatus openly based on a principle of disparity, on an awkward "binocular" body, and on an illusion patently derived from the binary referent of the stereoscopic card of paired images, inevitably would give way to a form that preserved the referential illusion more fully than anything before it. Photography also defeated the stereoscope as a mode of visual consumption 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).[71] 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.[72]

69. Sir David Brewster, *Letters on Natural Magic*, New York, J. J. Harper, 1832, pp. 15–21.
70. This device is described by its inventor in Oliver Wendell Holmes, "The Stereoscope and the Stereograph," *Atlantic Monthly*, vol. 3, no. 20 (June 1859), pp. 740–752.
71. For the disruptive effect of Muybridge and Marey on nineteenth-century codes of "naturalistic" representation, see Noël Burch, "Charles Baudelaire Versus Doctor Frankenstein," *Afterimage*, nos. 8–9 (Spring 1981), pp. 10–13.
72. On the problem of modernism, vision and the body, see the recent work of Rosalind Krauss, for example, "Antivision," *October*, no. 36 (Spring 1986), pp. 147–154; and "Where's Poppa," forthcoming in, *Marcel Duchamp Centennial Conference at Nova Scotia School of Art*, Thierry de Duve, ed., Cambridge, Mass., MIT Press.