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In 1838, Sir Charles Wheatstone, a British physicist who was one of the inventors of the telegraph, published his "Contributions to the Physiology of Vision."[1] This paper announced Wheatstone's explanation of the role of the interocular discrepancy for binocular space perception. Prior to his researches, several individuals had observed an essential component of Wheatstone's innovation: in binocular vision, the two eyes receive slightly different images.[2] Kepler and Descartes had surmised that the muscular sensations arising from the convergence of the eyes in binocular vision might play a role in measuring the proximity of objects.[3] But Wheatstone was the first to propose that the mind fathoms visual space by combining the information from a pair of two-dimensional, monocular pictures.

"It being thus established," Wheatstone wrote, "that the mind perceives an object of three dimensions by means of the two dissimilar pictures projected by it on the two retinae, the following question occurs: What would be the visual effect of simultaneously presenting

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[1]Charles Wheatstone, "Contributions to the Physiology of Vision—Part the First. On some Remarkable, and hitherto Unobserved, Phenomena of Binocular Vision," *Philosophical Transactions of the Royal Society* 128 (1838): 371–94. Also in Nicholas J. Wade, ed., *Brewster and Wheatstone on Vision* (London, 1983), sec. 2.4. Since many of the important papers on this subject by Brewster and Wheatstone have been conveniently collected in Wade's book, page references for articles contained in this volume will be given, wherever it is possible to do so, rather than the original sources. On Wheatstone, see Brian Bowers, *Sir Charles Wheatstone, F.R.S., 1802–1875* (London, 1975).

[2]Antecedents who are often cited include Euclid, Galen, Leonardo da Vinci, Giambattista della Porta, Aguilonius, Joseph Harris, and William Wells.

[3]A. C. Crombie, "The Mechanistic Hypothesis and the Scientific Study of Vision: Some Optical Ideas as a Background to the Invention of the Microscope," in *Historical Aspects of Microscopy*, ed. S. Bradbury and G. L'E. Turner (Cambridge, 1967), pp. 3–112.

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to each eye, instead of the object itself, its projection on a plane surface as it appears to that eye?"[4] Wheatstone's paper introduced an instrument that facilitated this test. The apparatus employed two mirrors mounted in a right angle in order to present the reflection of one perspectival drawing to each eye, thus creating a single perception of marked relief (figs. 1 and 2). Wheatstone called his device "a Stereoscope to indicate its property of representing solid figures."[5]

Since its invention, the stereoscope has served as a tool for the study of vision. Wheatstone's investigation of the mental aspect of depth perception offered a fundamental contribution to experimental psychology, a field that became prominent in American and European universities in the late 19th century.[6] Yet, despite its crucial role in the laboratory, the stereoscope is most immediately recognized as the consummate Victorian amusement. The stereoscope belonged to the class of "philosophical toys," such as the kaleidoscope and the zoetrope, which provided entertainment but also illustrated scientific principles.[7]

The stereoscope occupied a curious cultural position during the second half of the 19th century. As Robert Hunt, a British photographic chemist, noted in 1856: "The stereoscope is now seen in every drawing room; philosophers talk learnedly upon it, ladies are delighted with its magic representations, and children play with it."[8] The instrument was discussed in newspapers and magazines, in art journals, and in scientific treatises. Its widespread prominence affords an opportunity for historians to examine some features of the cultural role and function of technology that would otherwise be inaccessible.

But the popularity of this optical technology creates difficulties, as well as advantages, for historians. Although contemporary discussions of the instrument are plentiful, one may doubt the seriousness and forthrightness of some of these accounts. Since many of these writings

[4]Wheatstone, "Contributions" (1838), in Wade, ed., p. 67.

[5]Ibid., p. 70.

[6]See Wade, ed., p. 322; R. Steven Turner, "Consensus and Controversy: Helmholtz on the Visual Perception of Space," in *Hermann von Helmholtz: Philosopher-Scientist,* ed. David Cahan (in press); Edwin G. Boring, *Sensation and Perception in the History of Experimental Psychology* (New York, 1942).

[7]On "philosophical toys," see Gerard L'E. Turner, *Nineteenth-Century Scientific Instruments* (London, 1983), chap. 16. Additional material on the stereoscope can be found in Robert Taft, *Photography and the American Scene: A Social History, 1839–1889* (New York, 1964; 1st ed., 1938), chap. 10; William C. Darrah, *The World of Stereographs* (Gettysburg, Pa., 1977); Edward W. Earle, ed., *Points of View: The Stereograph in America—a Cultural History* (Rochester, N.Y., 1979); and Moritz von Rohr, *Die Binocularen Instrumente* (Berlin, 1920). The latter two sources contain excellent bibliographies.

[8]Robert Hunt from *Art Journal,* March 1856, p. 11, quoted in Earle, ed., p. 28.

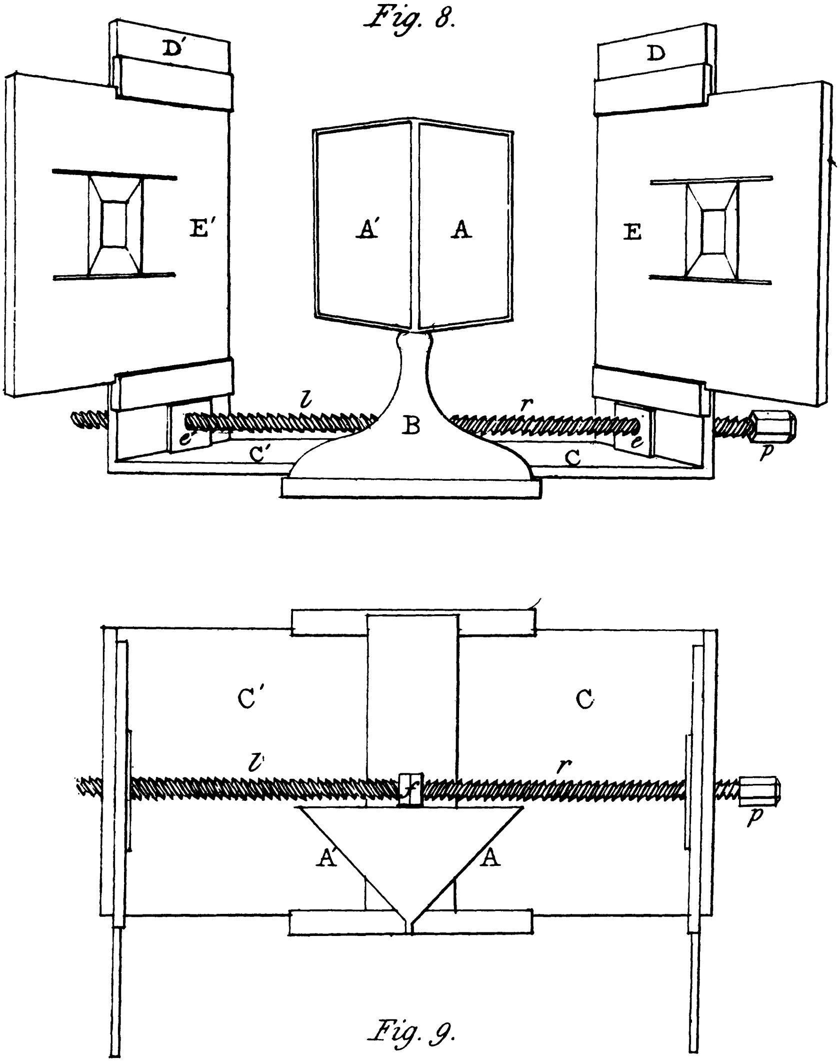

FIG. 1.—Front and top views of Wheatstone's reflecting stereoscope. (Charles Wheatstone, "Contributions to the Physiology of Vision . . .," *Philosophical Transactions of the Royal Society*, vol. 128 [1838], pl. 10.)

were intended to sell stereoscopes and to excite curiosity in their dazzling spectacles, audacious claims for the social value of the stereoscope were not rare. Nevertheless, historians are challenged to assess this verbiage and to try to use it to understand the past. Evaluating the contemporary opinions about the stereoscope becomes

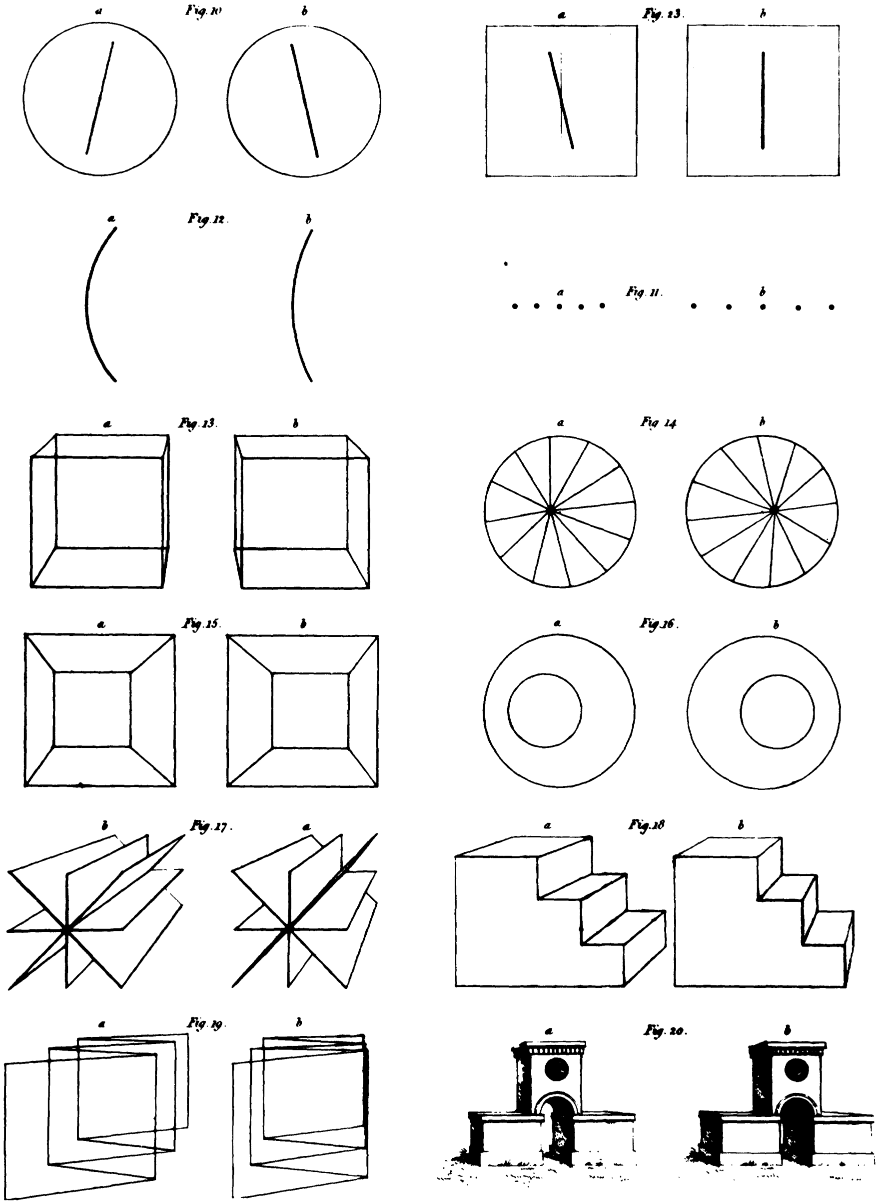

FIG. 2.—Stereoscopic pairs from Wheatstone's 1838 paper. Combined in the stereoscope, such drawings appear as cubes, pyramids, and other solid figures. (Charles Wheatstone, "Contributions to the Physiology of Vision . . .," *Philosophical Transactions of the Royal Society*, vol. 128 [1838], pl. 11.)

part of the larger problem of deciphering the rhetoric of 19th-century popular writing about science and technology. Furthermore, in the case of stereoscopic photography, the terminology and argumentation found in this literature remained surprisingly consistent. Both the "popular" and the "scientific" judgments of the stereoscope shared a coherent nexus of ideas about representation, visual physiology, and the philosophy of human perception.

In the 19th century, the tenets of "natural theology" defined the terms for arguments concerning the machinery of vision, photography, and stereography. This conception exalted the perfect design of the human sense organs as the basis for a truthful representation of nature. The best-known work in this tradition is William Paley's *Natural Theology* (1st ed., 1802), which regarded the eye as the ideal optical instrument, as well as the supreme piece of evidence proving that the universe and its inhabitants were designed by God.[9]

Many other works of the period contained this theme. It was argued with special vigor in the fifth Bridgewater Treatise, *Animal and Vegetable Physiology Considered with Reference to Natural Theology* (1834) by Peter Mark Roget, later of *Thesaurus* fame. "On none of the works of the Creator, which we are permitted to behold," Roget wrote, "have the characters of intention been more deeply and legibly engraved than in the organ of vision." Roget identified the eye as "a refined optical instrument, the perfection of which can never be fully appreciated until we have instituted such a comparison; and the most profound scientific investigations of the anatomy and physiology of the eye concur in showing that the whole of its structure is most accurately and skillfully adapted to the physical laws of light, and that all its parts are finished with that mathematical exactness which the precision of the effect requires, and which no human effort can ever hope to approach,—far less to attain."[10] Although not all writers on visual themes stated natural theological arguments as clearly and as stridently as Paley and Roget, such a teleological conception of the human body and its function was held widely in the 19th century, and it provides a crucial component of the intellectual context required for the historical estimation of the stereoscope.

Art historians such as Michael Baxandall have argued that past methods of making pictures raise an intricate problem in cultural history, one requiring modern students to "read" the various ways

[9]William Paley, *Natural Theology* (London, 1802).

[10]Peter Mark Roget, *Animal and Vegetable Physiology Considered with Reference to Natural Theology*, 2 vols. (London, 1834), 2:445–46.

that pictures, like texts, can generate meaning.[11] However, the present ubiquity of photographs may lead one to believe that the photographic process offers an unambiguous means of depiction—a technique unburdened by intellectual constraints that provides a perfect mirror of the present, as well as a clear window on the past. Hence, one of the goals of the present exploration of 19th-century photographic—and especially stereographic—theory and practice is to recapture the richness of the cultural and scientific assumptions involved in this form of picture making.

The network of natural theological presuppositions that informed both popular and scientific accounts of the stereoscope established the human eyes as the ideal instrumentation for visual representation. This led photographers, scientists, journalists, and art critics to evaluate the hardware of stereoscopic depiction as a substitute for the innate fidelity of the eyes. Nineteenth-century writers also debated the merits of using this technology to surpass the capacity of the human eyes. This discourse embodied contemporary attitudes toward the role of instrumentation in science and the value of technology as a means of studying nature.

The Human Model of Representation

The tremendous popularity of the stereoscope would have been impossible without the aid of photography. The advent of stereoscopic double photographs, called "stereographs," extended dramatically the range of stereoscopic subjects, which had been limited to simple drawings like those contained in Wheatstone's paper. Living in an age when photographic images are ever present, the modern observer can scarcely appreciate the amazement produced by the first photographs. This new medium created permanent images by a purely mechanical process whose detail and accuracy surpassed any effort of art. Daguerre's camera successfully froze reality on its chemically sensitized plates in 1839, the year after Wheatstone introduced the stereoscope. Another photographic pioneer, William Henry Fox Talbot, invented his calotype technique in 1840 and

[11]Michael Baxandall, *Painting and Experience in Fifteenth Century Italy: A Primer in the Social History of Pictorial Style,* 2d ed. (Oxford, 1988; 1st ed., 1972), p. 152. Also see his *Patterns of Intention: On the Historical Explanation of Pictures* (New Haven, Conn., 1985); as well as Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago, 1983); Alan Trachtenberg, *Reading American Photographs: Images as History, Mathew Brady to Walker Evans* (New York, 1989); and Martin J. S. Rudwick, "The Emergence of a Visual Language for Geological Science," *History of Science* 14 (1976): 149–95. The growing interest in visual representation in science has prompted a recent collection, Michael Lynch and Steve Woolgar, eds., *Representation in Scientific Practice* (Cambridge, Mass., 1990).

demonstrated the process in his book *The Pencil of Nature* (1844–46). This title echoed the contemporary attitude that photography was nature revealing herself at the behest of man.[12] Stereoscopic photographs shared this fidelity, but they added the sensation of depth and solidity.

The difficulty involved in aligning photographs in Wheatstone's cumbersome mirror arrangement, along with the cost of the instrument, diminished any chance of popular interest in the reflecting stereoscope.[13] But in 1849, the Scottish physicist (and steadfast opponent of the wave theory of light) Sir David Brewster came up with a convenient and inexpensive lenticular stereoscope.[14] (See fig. 3.) During the spring of 1850, while he was searching for a manufacturer, Brewster showed his device to the Parisian opticians M. Soleil and Jules Duboscq, Soleil's son-in-law. Within a short time, they began producing Brewster's stereoscope and accompanying stereoscopic daguerreotypes.[15]

The Soleil-Duboscq version of Brewster's lenticular stereoscope created a sensation at London's Great Exhibition of 1851. Queen Victoria herself praised Brewster's work, and the craze ensued. An *Illustrated London News* correspondent at the Crystal Palace marveled at the utterly natural precision of stereoscopic productions:

> so long as mere drawings by hand were used, it might be held that the effect, however wonderful, was but some trick of art by which the senses were cheated. But the Daguerréotype admits of no trick; the silvered plate has neither line, nor light, nor shade, but such as the sun gives it: the two plates in the two cameras stand truly for the two eyes, and receive each just such picture, no

[12]On Talbot, see John Ward and Sara Stevenson, *Printed Light: The Scientific Art of William Henry Fox Talbot and David Octavius Hill with Robert Adamson* (Edinburgh, 1986).

[13]See Wade, ed. (n. 1 above), pp. 33–39. The following also discuss the origins of stereoscopic photography: R. S. Clay, "The Stereoscope," *Transactions of the Optical Society* 29 (1927–28): 149–66; A. T. Gill, "Early Stereoscopes," *Photographic Journal* 109 (1969): 546–59, 606–14, 641–51; Darrah (n. 7 above); and two articles by Steven F. Joseph—"Wheatstone's Double Vision," *History of Photography* 8 (1984): 329–32, and "Wheatstone and Fenton: A Vision Shared," *History of Photography* 9 (1985): 305–9.

[14]On Brewster's intellectual development and his commitment to natural theology, see Edgar W. Morse, "Natural Philosophy, Hypotheses, and Impiety: Sir David Brewster Confronts the Undulatory Theory of Light" (Ph.D. diss., University of California, 1972).

[15]Gill (n. 13 above), p. 557; A. D. Morrison-Low, "Brewster and Scientific Instruments," in *'Martyr of Science': Sir David Brewster, 1781–1868*, ed. A. D. Morrison-Low and J. R. R. Christie (Edinburgh, 1984), p. 62; Wheatstone privately developed a stereoscope quite similar to the lenticular model well before Brewster's announcement. Brewster's claim for the originality of his stereoscope—as well as his jealousy and scientific conflicts with Wheatstone—fueled their rivalry, which is examined throughout Wade, ed. (n. 1 above).

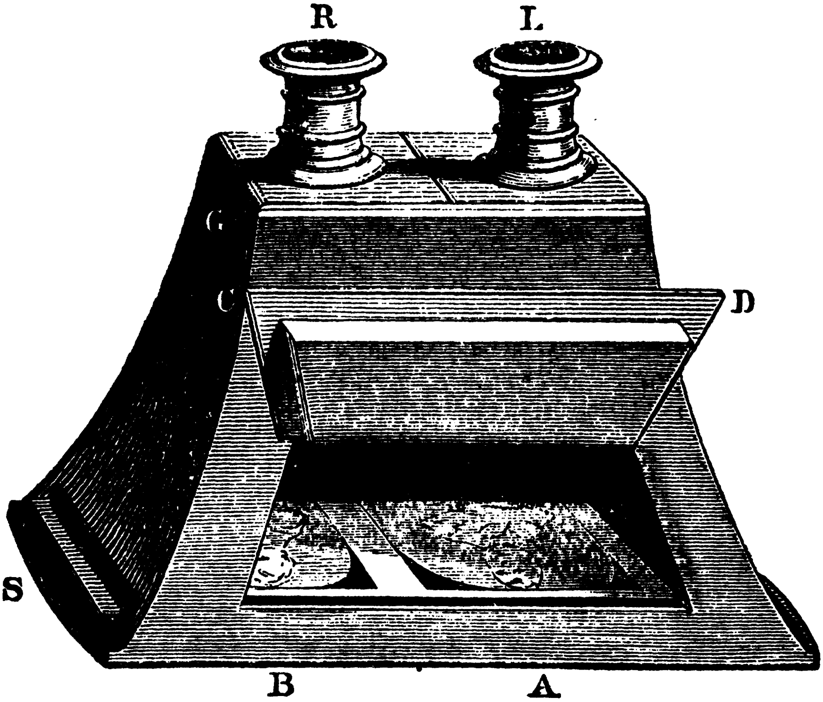

FIG. 3.—Brewster's refracting stereoscope. (David Brewster, *The Stereoscope: Its History, Theory, and Construction with Its Application to the Fine and Useful Arts and to Education* [London, 1856], p. 67.)

> more, no less, as each eye receives. There is, therefore, no further room for doubt as to the need for two eyes; we have taken by the Daguerréotype the very picture from each, and have made them tell their secret. Our double vision is but perfect vision.[16]

Based on sturdy Victorian scientific principles, the stereoscope recreated three-dimensional perception with perfect fidelity.

In the United States, the author and physician Oliver Wendell Holmes became an outspoken champion of the stereoscope. In 1861, he designed a handheld version of Brewster's lenticular stereoscope (fig. 4). The "Holmes Stereoscope" became the overwhelmingly predominant type used in America—indeed, in England it was known as the "American Stereoscope."[17] Holmes also published three enthusi-

[16]"The Stereoscope, Pseudoscope, and Solid Daguerreotypes," *Illustrated London News* 20 (1852): 77–78, on 78.

[17]On Holmes and his stereoscope, see Eleanor M. Tilton, *Amiable Autocrat: A Biography of Dr. Oliver Wendell Holmes* (New York, 1947); Thomas F. Currier and Eleanor M.

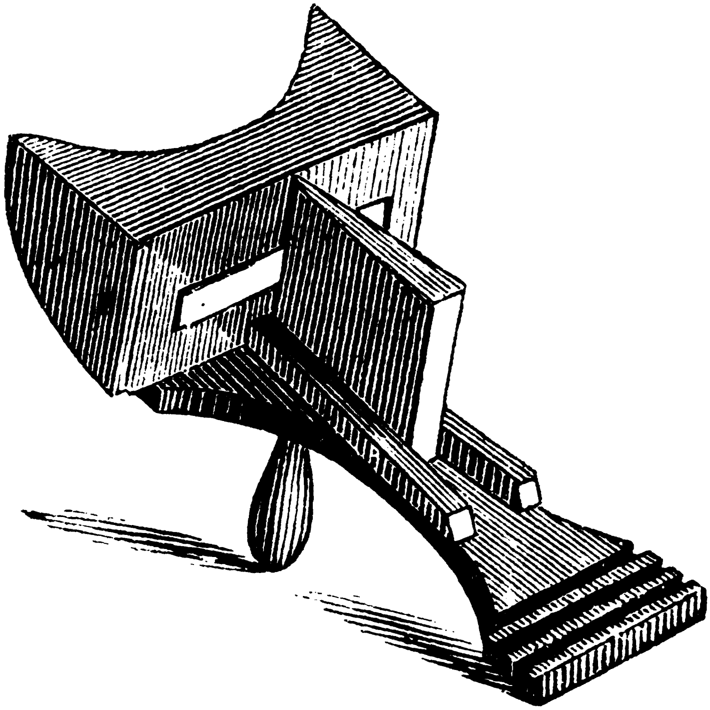

FIG. 4.—Holmes's handheld stereoscope. ("The 'Holmes' Stereoscope," *Philadelphia Photographer* 6 [1869]: 24.)

astic but anonymous essays in the *Atlantic Monthly.* "The Stereoscope and the Stereograph" (1859), "Sun-Painting and Sun-Sculpture" (1861), and "Doings of the Sunbeam" (1863) described the new photographic technology in Promethean terms and trumpeted its most promising application—the stereograph.

Holmes's zeal for the stereoscope's possibilities surpassed mere praise for the stunning representation of the visible world. Through the means of the photograph and the stereograph, he explained, *form* had become an intellectual entity—distinct from physical objects—in the same way that the printing press had liberated *thought.* Thus, the

Tilton, *A Bibliography of Oliver Wendell Holmes* (New York, 1953); "The 'Holmes' Stereoscope," *Philadelphia Photographer* 6 (1869): 23–25; Oliver Wendell Holmes, "History of the 'American Stereoscope,'" *Philadelphia Photographer* 6 (1869): 1–3; Walter LeConte Stevens, "The Stereoscope: Its History," *Popular Science Monthly* 21 (1882): 37–53; William Marder and Estelle Marder, *Anthony: The Man, the Company, the Cameras; an American Photographic Pioneer; 140 Year History of a Company from Anthony to Ansco to GAF* (Plantation, Fla., 1982).

stereoscope could become the "card of introduction to make all mankind acquaintances. . . . *Form is henceforth divorced from matter,*" he observed. "In fact," Holmes continued, "matter as a visible object is of no great use any longer, except as the mould on which form is shaped. Give us a few negatives of a thing worth seeing, taken from different points of view, and that is all we want of it. Pull it down or burn it up if you please." In the age of the stereoscope, the pyramids, the Pantheon, and all other human and natural creations would be expendable: "We have got the fruit of creation now, and need not trouble ourselves with the core. Every conceivable object of Nature and Art will soon scale off its surface for us. Men will hunt all curious, beautiful, grand objects, as they hunt the cattle in South America, for their *skins,* and leave the carcasses as of little worth."[18]

The stereoscope was not a toy, Holmes declared.[19] It would become a priceless tool for communication, education, and art. Perhaps Holmes would have moderated his inflated literary style if the veil provided by his anonymity in the *Atlantic* essays had been lifted. Yet, even his extreme estimate of the instrument's potential hinged on a principle expressed by many others in his day—the unique stereoscopic medium captured the visual essence of nature.

The rationale for Holmes's estimate was articulated by the *Illustrated London News* writer who claimed that the stereoscope duplicated the operation of the human visual organs: the twin cameras "stand truly for the two eyes." Thus, 19th-century photochemistry produced an ironic corollary to Kepler's 1604 discovery that the eye behaves like a lifeless mechanical instrument—a *camera obscura.*[20] By replacing the retina with a sensitive plate, the camera had become an eye. This did not remain a casual metaphor. For students of stereophotography, the camera as eye—or, more exactly, the binocular camera as *pair* of eyes—became a potent leading principle.

In 1849, Sir David Brewster designed a binocular camera to produce photographs for his stereoscope. His camera imitated nature

[18] [Oliver Wendell Holmes], "The Stereoscope and the Stereograph," *Atlantic* 3 (1859): 738–48, on 744, 747, and 748.

[19] [Oliver Wendell Holmes], "Sun-Painting and Sun-Sculpture," *Atlantic* 8 (1861): 13–29, on 28.

[20] On Kepler, see Crombie (n. 3 above); Stephen Straker, "The Eye Made 'Other': Durer, Kepler and the Mechanization of Light and Vision," in *Science, Technology and Culture in Historical Perspective,* University of Calgary Studies in History, no. 1, ed. L. A. Knafla, M. Staum, and T. H. E. Travers (Calgary, 1976), pp. 7–25, as well as his "What Is the History of Theories of Perception the History of?" in *Religion, Science, and Worldview: Essays in Honor of Richard S. Westfall,* ed. M. J. Osler and P. L. Farber (Cambridge, 1985), pp. 245–73; and David C. Lindberg, *Theories of Vision from Al-Kindi to Kepler* (Chicago, 1976), chap. 9.

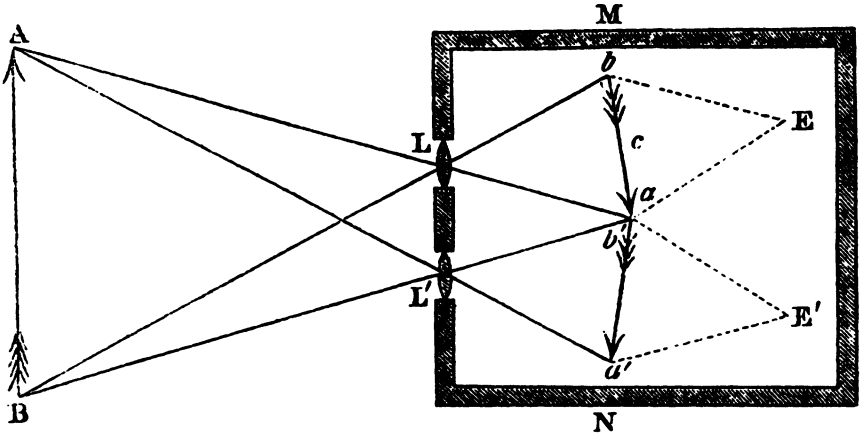

FIG. 5.—Brewster's design for a binocular camera. (David Brewster, *The Stereoscope: Its History, Theory, and Construction with Its Application to the Fine and Useful Arts and to Education* [London, 1856], p. 146.)

by maintaining a lensatic separation of 2½ inches—the average human interocular distance. The result was a pair of images that retained the same parallactic discrepancy present in human binocular vision.[21] (See fig. 5.) Three years after describing his binocular camera, Brewster announced an observation aimed at bolstering his attempt to reproduce mechanically the physical circumstances of human sight. Since the eye provided the model for the correct representation of nature, photographers should employ apertures as small as the pupil of the human eye—approximately ²⁄₁₀ of an inch in diameter.[22]

At the time Brewster wrote this, his apparently innocent recommendation entailed a major change in photographic practice. In the early years of photography, even the most rapid photochemical processes required long exposures. Many portrait photographers employed clamps and braces to help their patrons maintain the

[21]David Brewster, "Description of a Binocular Camera," *Report of the British Association. Transactions of the Sections* (1849): 5. Also see David Brewster, "Account of a Binocular Camera, and of a Method of Obtaining Drawings of Full Length and Colossal Statues, and of Living Bodies, which can be Exhibited as solids by the Stereoscope," *Transactions of the Royal Scottish Society of Arts* 3 (1851): 259–64, reprinted in Wade, ed. (n. 1 above), sec. 3.5; and David Brewster, *The Stereoscope: Its History, Theory, and Construction with Its Application to the Fine and Useful Arts and to Education* (London, 1856), pp. 145–47.

[22]David Brewster, "On the Form of Images Produced by Lenses and Mirrors of Different Sizes," *Report of the British Association. Transactions of the Sections* (1852): 3–7, on 4, and [David Brewster], "Binocular Vision and the Stereoscope," *North British Review* 17 (1852): 165–204, on 183.

desired pose without fatigue. Despite these interminable exposures, photographers required very large apertures, usually ranging from 1 to 6 inches in diameter, which produced a lens area many times greater than Brewster suggested in 1852. Brewster was distressed: "Every addition to the area of the lens introduces parts of the object which have nothing to do with the picture, and when we use lenses of two, four, or six inches in diameter, we obtain, though a common eye may not discover it, monstrous representations of humanity, which no eye and no pair of eyes ever saw or can see."[23] Oversized lenses surveyed more perspective area than the human eye could allow, "and a monstrous portrait of the human bust is thus obtained by the photographer, the monstrosity increasing with the size of the lens."[24] The camera, improperly used, would desecrate, rather than emulate, human sight and human form.

Although photographic studios during the 1850s scarcely enabled subjects to retain a relaxed appearance, Brewster insisted that the size of the lens, rather than the unsteadiness of the sitter, was the primary agent in the "hideousness" of photographic portraits. He advised photographers to improve their art by finding more sensitive photochemical materials and by employing pupil-sized apertures. Only by following the prescriptions of nature and scientific truth might decent, upright photographers create honest representations of their patrons rather than "adding scowls and wrinkles to the noble forms of manhood, and giving to a fresh and vigorous age the aspects of departing or departed life."[25]

In 1855, John F. Mascher—a Philadelphia photographer who in 1853 had obtained the first American patent for a stereoscopic viewer—arrived independently at exactly the same conclusions as Brewster.[26] Cameras with large lenses produced pictures that were "anti-stereoscopic; distortions; disfigurations intolerable in proportion to what the lense, with which it is taken, exceeds in diameter the size of the human eye. Such pictures will do for owls to look at! . . . We might with the same propriety call the hide of an ox, when spread upon a flat surface, a portrait of that animal, as to call a picture, taken in a camera with such large lenses, a portrait of the 'human face divine.'"[27]

[23][Brewster], "Binocular Vision," p. 183.

[24]Brewster, "On the Form of Images," p. 5.

[25]Ibid.

[26]J. F. Mascher, "On Taking Daguerreotypes without a Camera," *Journal of the Franklin Institute* 59 (1855): 344–47. On Mascher's stereoscopic case, see Darrah (n. 7 above), p. 15.

[27]Mascher, pp. 345–46.

Mascher cited divine intelligence as the origin for the arrangement of man's visual organs, thus making proper stereophotography a moral imperative: "In the human eye we find, as in all other parts of the body, the most extraordinary wisdom displayed, and it is only the hand of Omnipotence that could have designed and constructed such a wonderful organ. Not only do we find a single eye perfect in all its parts, but we also find the two eyes arranged in such a manner as to give the greatest possible amount of effect to binocular vision. Who can devise anything better? To imitate and equal, it ought to challenge our undivided attention."[28] Mascher thus revealed the natural theological dimension of his method for producing stereoscopic photographs. Although he experimented with apertures at least as small as $\frac{1}{66}$ of an inch in diameter, and he discussed a "theoretical eye," which "occupies no more room than a *mathematical point*," Mascher selected the human visual apparatus as the ideal.[29]

For many 19th-century scientists and photographers, the eye had become the archetype for the camera. This analogy was particularly appealing to those who investigated the stereoscope and binocular vision, in which the relationship between the picture-making machinery and the human model was especially close. Brewster employed a geometrical analysis of the images created by various apertures, and Mascher conducted an empirical study, but both agreed that the dimensions of the human eyes led to photographic truth.

In several descriptions of stereographic apparatus, the double camera nearly became living tissue. An essay in *Harper's Magazine*, "The Eye and the Camera," described the anatomy and function of these analogous devices. An "ordinary camera resembles a single eye," the writer claimed, and a stereoscopic camera

> is like a forehead with two eyes in it. The two round tubes in front contain the lenses, and the brass caps which fit over them when the exposure is complete are the eyelids. The diaphragm, which is inserted in each of these tubes to regulate the size of the aperture, is like the pupil of the eye that contracts and expands according to the degree of light. And this double instrument makes two pictures at the same instant, which differ from each other just as the images received by one eye differ from those received by the other in an observer standing at the same place.[30]

[28]Ibid., p. 347.

[29]Ibid., p. 345. When Mascher became aware of Brewster's researches on the subject, he praised the Scottish physicist and recognized his priority. See J. F. Mascher, "On the Cause of Distortions in Photographic Pictures—a Disclaimer," *Journal of the Franklin Institute* 60 (1855): 65–66.

[30]Austin Abbot, "The Eye and the Camera," *Harper's Magazine* 39 (1869): 476–82, on 480 and 481.

The appearance of a photographer at work encouraged the connection between man and camera and the anthropomorphic description of the photographic instrument. With the artist's head beneath the camera's hood, the human and the machine seem fused. Optically, both survey the same scene, sharing the camera's lens. The emblem adopted in 1870 by New York's great photographic supply house, the E. and H. T. Anthony Company, accentuated this symbiosis: the actively engaged photographer's skinny, bent legs mimic the angles of his tripod.[31] (See fig. 6.) A *Punch* cartoonist mistook a photographer with a camera for a new species of urban wildlife.[32] (See fig. 7.) Another contemporary illustration nearly forms a visual pun.[33] (See fig. 8.) A pair of cameras stereograph a woman's countenance—but it is a statue, not a living face. Two representations of human eyes gaze at each other. One has the correct external features; on the inside, however, there is lifeless stone and not flesh. The opposing figure possesses none of the softness of the human form; yet its dual cameras nearly copy the optical relations of human sight. Whether for humor or for irony or by accident, the two pairs of "eyes" together contain the physical equipment for sight, but none of the intellectual works. Both stare blindly into empty eyes.

Oliver Wendell Holmes's account of his visit to a stereoscopic studio included a description of an anthropomorphized binocular camera. In his report, the human photographer has been reduced to subservience—a "waiting slave." In contrast, the binocular camera has come to life as a "shrouded sorcerer," a veiled figure whose "two great glassy eyes" stared at Holmes for thirty seconds and stole his double image.[34]

The analogy between the eye and the camera owed much of its power to the notion that the divinely constructed human form offered the model for the most efficient application of physical principles. The eye was the natural theologian's favorite illustration of the perfection of God's design, and the specifications of nature—delineated in the human frame—dictated the standard for truthful representation. Because it duplicated the optical circumstances of binocular vision, the stereoscopic camera functioned like a pair of surrogate eyes and created correct pictures of the world.

[31]Ibid., p. 476; Marder and Marder (n. 17 above), p. 198; *Anthony's Photographic Bulletin* 1 (1870): cover.

[32]*Punch* 44 (June 20, 1863): 249.

[33]Gaston Tissandier, *A History and Handbook of Photography*, ed. J. Thomson, 2d rev. ed. (London, 1878); the illustration follows p. 312.

[34][Holmes], "The Stereoscope and the Stereograph" (n. 18 above), p. 734.

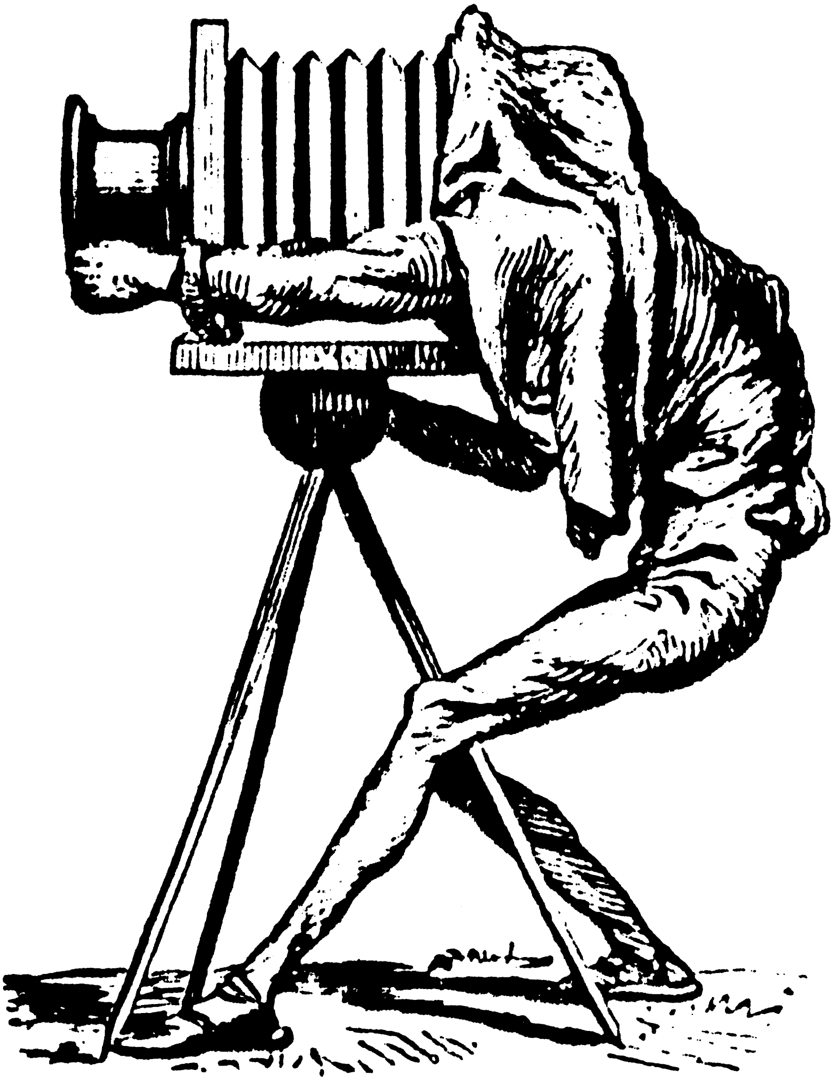

FIG. 6.—The emblem of the E. and H. T. Anthony Company. (*Anthony's Photographic Bulletin* 1 [1870]: cover.)

Instrumental Distortion and Enhancement

The twin lenses of the stereoscopic camera were often praised as infallible scribes which could etch reality on their photographic tablets. However, a contemporaneous debate challenged the veracity of the photographic medium. Such complaints were made especially

Front and Back view of a very Curious Animal that was seen going about loose the other day. It has been named by Dr. Gunther " Elephans Photographicus."

Fig. 7.—A *Punch* cartoonist noticed how photographers combine with their cameras to create bizarre new creatures. (*Punch* 44 [June 20, 1863]: 249.)

by art critics and theorists who refused to rank photography among the "fine arts." For both the supporters and the detractors of the new medium, the relationship between photography and human vision stood at the core of the issue. Photography's critics, however, asserted that this means of depiction entailed an inherent flaw: it misrepresented human vision and therefore produced distorted images.

Lady Elizabeth Eastlake's well-known contribution on this matter, which appeared anonymously in a *Quarterly Review* for 1857, portrayed photography as a necessarily unfaithful means of depiction:

> Far from holding up the mirror to nature, which is an assertion usually as triumphant as it is erroneous, it holds up that which, however beautiful, ingenious, and valuable in powers of reflection, is yet subject to certain distortions and deficiencies for which there is no remedy. The science therefore which has developed the resources of photography, has but more glaringly betrayed its defects. For the more perfect you render an imperfect machine

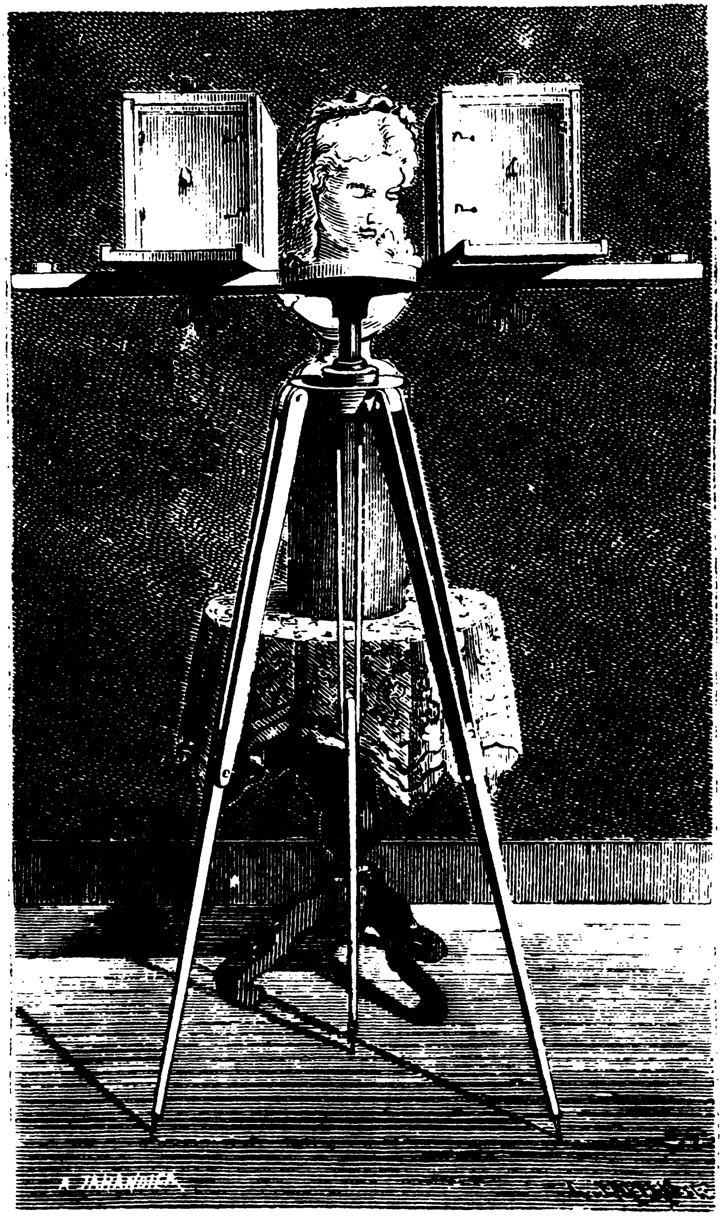

FIG. 8.—The eyes of the photographic camera face the eyes of the statue; the analogy between the eye and the camera remains prevalent today. (Gaston Tissandier, *A History and Handbook of Photography,* ed. J. Thomson, 2d rev. ed. [London, 1878], following p. 312.)

> the more must its imperfections come to light: it is superfluous therefore to ask whether Art has been benefited, where Nature, its only source and model, has been but more accurately falsified.[35]

Photography's principal inadequacy was observed in the alleged incompatibility between the mechanical camera and human sensibilities. As an essay in the American art journal *Crayon* explained, "the camera, although obedient to the laws of physical nature, is quite indifferent to the laws of our intellectual nature; it is, in fact, a falsifying agent of that which we know to be true in nature."[36] As a mere mechanical process, photography could not exercise the tasteful judgment of the human artist. "Paradoxical as it may appear," *Crayon* reported, "it would seem as if light, like man, lost its moral power, and wrought out deeds of evil, when it condescends to work in the dark of the camera."[37]

In his *Salon de 1859,* the French critic Charles Baudelaire disparaged the philistine crowd who would elevate photography—which possessed a coarse exactitude and lacked the invigorating touch of human imagination—above *true* art. As soon as the substitution was made, "our squalid society rushed, Narcissus to a man, to gaze at its trivial image on a scrap of metal."[38] These fanatics became "new sun worshippers," and "[a] little later a thousand hungry eyes were bending over the peepholes of the stereoscope, as though they were the skylights [*lucarnes*] of the infinite."[39]

Such arguments were part of a Romantic tradition in literature and art that emphasized the mental and emotional aspects of vision. William Blake, William Wordsworth, and Ralph Waldo Emerson, among others, insisted that vision was the product of an active intellect as well as optics.[40] By contrast, Oliver Wendell Holmes and the advocates of stereophotography considered an imitation of the mechanics of sight sufficient to liberate the visual essence from its

[35][Lady Elizabeth Eastlake], "Photography," *Quarterly Review* 101 (1857): 442–68, on 460.

[36]"The Photographic Portrait," *Crayon* 4 (1857): 154–55, on 155.

[37]Ibid., p. 155.

[38]Charles Baudelaire, "The Modern Public and Photography," part 2 of "The Salon of 1859," pp. 149–55 in *Art in Paris, 1845–1862,* trans. and ed. Jonathan Mayne (London, 1965). According to Mayne, the *Salon* was originally published in four installments between June 10 and July 20 in the *Revue Française.* It is reprinted in Charles Baudelaire, *Variétés Critiques,* 2 vols. (Paris, 1924), 1:111–96. The quotation is from the Mayne edition, pp. 152–53.

[39]Baudelaire, Mayne ed., p. 153. The translation given here differs slightly from Mayne's.

[40]See M. H. Abrams, *The Mirror and the Lamp: Romantic Theory and the Critical Tradition* (Oxford, 1953), and his *Natural Supernaturalism: Tradition and Revolution in Romantic Literature* (New York, 1971).

material bondage. According to Romantic writers, however, *perception* involved more than the simple geometrical duplication of the eyes. The bodily organs of sight by themselves were insufficient for complete vision, as the great 19th-century aesthetic theorist John Ruskin pronounced: "You do not see *with* the lens of the eye. You see *through* that, and by means of that, but you see with the soul of the eye."[41] To such an attitude, instrumental means of picture making seemed inherently offensive. Thus, photography could offer nothing but a perversion of human sight.

There is an element of irony in this strain of criticism. Despite their idealistic rhetoric, Eastlake and Baudelaire did not deny the value of photographic resemblances to fulfill the needs of "historic interest," which demanded "mere manual correctness."[42] The flaws disclosed in their essays related only vaguely and abstractly to the absence of a conscious component in photography. Instead, the authors pointed to the failure of photography to replicate the experience of human perception. For example, the monochromatic medium could never provide an accurate representation of color, nor could the long photographic exposures preserve the fleeting expressions of human emotion.[43] Therefore, Eastlake and other art critics agreed essentially with the natural theological judgment: human vision provided the model for proper depiction. Errors and distortions were created by departures from this standard.

However, not everyone in the 19th century agreed that only falsity could arise from the transgression of ocular orthodoxy. Many writers praised the potential of photographs and stereographs to surpass the limitations of unaided sight. Like the telescope or microscope, the stereoscope could be regarded as an instrument that created a more valuable representation of the physical world than the human eyes produced.

In an essay on his binocular camera, Sir David Brewster suggested a way to expand the capability of natural human sight. Brewster recognized that large objects—he mentioned buildings and "colossal statues"—must be viewed from an extended distance. Because human

[41]John Ruskin, *The Eagle's Nest: Ten Lectures on the Relation of Natural Science to Art,* in *The Complete Works of John Ruskin,* ed. E. T. Cook and Alexander Wedderburn, 39 vols. (London, 1903–12), 22:194. There is a wealth of secondary literature on Ruskin. In particular, see John D. Rosenberg, *The Darkening Glass: A Portrait of Ruskin's Genius* (New York, 1961); Robert Hewison, *John Ruskin: The Argument of the Eye* (Princeton, N.J., 1976); Elizabeth K. Helsinger, *Ruskin and the Art of the Beholder* (Cambridge, Mass., 1982).

[42][Eastlake] (n. 35 above), p. 465. See Baudelaire's similar comment in Mayne, ed. (n. 38 above), p. 154.

[43]See [Eastlake], pp. 461–62; "The Photographic Portrait" (n. 36 above), p. 155.

eyes are close together, viewing a large statue from afar allows for very little binocular parallax, and, therefore, a diminished sense of stereoscopic relief. "As we cannot increase the distance between our eyes, and thus obtain a higher degree of relief for bodies of large dimensions," Brewster asked, "how are we to proceed in order to obtain drawings of such bodies of the requisite relief?"[44]

Brewster resolved this quandary by contradicting his own rule concerning the consistent use of 2½ inches of separation between the lenses of a binocular camera. In the case of large objects, the interval should be expanded, he said. In the stereoscope, two images procured in this fashion will create the impression of viewing a reduced copy of the oversized structure. Brewster claimed that this method provided "a better and more relieved representation of the work of art than if we had viewed the colossal original with our own eyes, either under a greater, equal, or a less angle of apparent magnitude."[45]

Brewster's essay was one of the earliest discussions of a deliberate attempt to manipulate normal visual perception with the stereoscope. The arrangement of stereoscopic cameras became a hotly debated subject among photographers. While these arguments encompassed a variety of opinions, the discourse can be characterized as a confrontation between two aesthetic theories. One side maintained that the separation of the human eyes should be duplicated unwaveringly by the photographer. Appeals to nature, as one might gather, provided the most potent rhetorical device for those who maintained this stance. Proponents of this view often warned that widely separated cameras would make objects appear like "models" that would seem "distorted" or even "monstrous" if the exaggeration became extreme.[46]

On the other hand, many photographers—including some who agreed that art should emulate nature—rather enjoyed the enhanced perspective and model-like appearance. The technique of separating

[44]Brewster, "Account of a Binocular Camera," in Wade, ed. (n. 1 above), p. 220.

[45]Ibid., p. 221.

[46]In the 1850s, the problem of the "stereoscopic angle" was debated in many books and periodicals, such as the *Photographic Journal, Photographic Notes, Photographic News,* and *Notes and Queries.* A typical exchange involved the editor of *Photographic News,* who claimed, "When we view the duplicate pictures in a stereoscope, we see as it were a MODEL of the object, smaller than, but similar to it, and presenting to our vision the same effect of solidity that the object itself would present to a monstrous animal, having an eye at each of the stations occupied by a camera" ("On the Stereoscope," *Photographic Notes* 1 [1856]: 56–57, on 57). W. J. Read, a correspondent, opposed this view and claimed that, with the editor's technique, "all objects are dwarfed to ridiculously diminutive proportions" (*Photographic Notes* 1 [1856]: 190–91, on 191).

the lenses of the stereoscopic camera by more than the human interocular distance—a practice that more recent stereographers call "hyperspace"—became standard among landscape photographers. (The camera separation for landscapes was usually on the order of several feet.) The stereograph purchaser could observe deeper valleys and more dramatic cascades than existed in reality. Antoine Claudet's stereodaguerreotypes, which accompanied Brewster's stereoscope at the Great Exhibition, were produced in this manner. Several of his works depicting the interior of the Crystal Palace, as an *Illustrated London News* writer remarked, revealed even remote items with "as full roundness and relief as those at hand."[47] These representations showed "a view as if the pictures were taken from a small model of the building brought sufficiently near for the whole to be within the distance influenced by the angle of the eyes. In fact, instead of seeing the object itself, you see a miniature model of it brought close to the eyes; so that, in this instance, the stereoscopic Daguerréotypes actually surpass the reality. No one has ever seen the interior of the Exhibition from end to end with such clearness as it is seen in M. Claudet's pictures."[48] The stereoscope brought before the eyes images that unaided sight could never have achieved.

An 1854 correspondent to the *Photographic Journal* expressed disgust over the proliferation of "painfully exaggerated specimens, so repulsive to truth or good taste, ordinarily shown in the beautiful invention of Wheatstone."[49] This correspondent might have been even more dismayed (and a little embarrassed) to learn that Wheatstone himself could be seduced by the charms of stereoscopic enhancement. The second installment of Wheatstone's discussion of binocular vision described how stereoscopic pictures could be produced to show "their true relief" (2½-inch camera separation), but he also noted that "the mind is not unpleasingly affected" by the exaggerated relief in photographs taken by cameras at a greater separation.[50]

In 1857, Hermann von Helmholtz devised an instrument that produced this effect for observing natural, rather than photo-

[47]"The Stereoscope, Pseudoscope, and Solid Daguerreotypes" (n. 16 above), p. 78.

[48]Ibid.

[49]John Leighton, "Binocular Photographs," *Photographic Journal* 1 (1853/54): 211–12, on 212.

[50]Charles Wheatstone, "Contributions to the Physiology of Vision—Part the Second. On some Remarkable and hitherto Unobserved Phenomena of Binocular Vision," *Philosophical Transactions of the Royal Society* 142 (1852): 1–17; reprinted in Wade, ed. (n. 1 above), sec. 2.10, on pp. 157 and 158.

graphed, subjects.[51] (See fig. 9.) Helmholtz noticed that stereoscopic pictures with artificially enhanced depth gave "a much clearer representation of the form of a landscape than the view of the landscape itself."[52] This increased appreciation for the layout of the terrain explained "why models of mountains with exaggerated heights please us better than such as represent the elevations on a correct scale."[53] Helmholtz's "telestereoscope" employed a system of mirrors to present images from two widely separated points to the eyes. While using the telestereoscope to study a landscape, Helmholtz observed that the resulting impressions "assume the same bodily appearance as in the stereoscope, and retain at the same time the whole richness of the natural colors, so that images of surprising beauty and elegance are obtained."[54]

The stereography of the moon offered the ultimate example of augmented relief. Two telescopic photographs, taken several months apart, could exploit the moon's libration, in order to provide the parallactic discrepancy necessary for a solid-looking combination (fig. 10). Stereographs of the moon, and of the sun as well, allowed astronomers to discern previously unrecognized details of the surfaces of these bodies. The first successful stereograph of the moon was taken in 1858 by Warren De la Rue, at the Cranford Observatory.[55] De la Rue realized that not everyone would approve of his "unnatural" productions, because they transcended the capabilities of human vision. In his own defense, he reiterated Sir John Herschel's opinion that "the view is such as would be seen by a giant with eyes thousands of miles apart: after all, the stereoscope affords such a view as we should get if we possessed a perfect model of the moon and placed it at a suitable distance from the eyes, and we may be well satisfied to possess such a means of extending our knowledge

[51]Hermann von Helmholtz, "On the Telestereoscope," *Philosophical Magazine,* 4th ser., 15 (1858): 19–24 (from *Annalen der Physik* 101 [1857]: 494–96, and 102 [1857]: 167–75). Also see Helmholtz's *Physiological Optics,* 3 vols., trans. and ed. James P. C. Southall (New York, 1962; first English ed., 1924–25; originally, vol. 1, 1856; vol. 2, 1860; vol. 3, 1866), in 3:310–12. Walter Hardie of Edinburgh independently contrived an essentially identical instrument several years earlier. It is found in his "Description of a New Pseudoscope," *Philosophical Magazine,* 4th ser., 5 (1853): 442–46. Hardie pointed out his priority in "The Telestereoscope," *Philosophical Magazine,* 4th ser., 15 (1858): 156–57.

[52]Helmholtz, "On the Telestereoscope," p. 20.

[53]Ibid.

[54]Ibid., p. 22.

[55]Darrah (n. 7 above), p. 147.

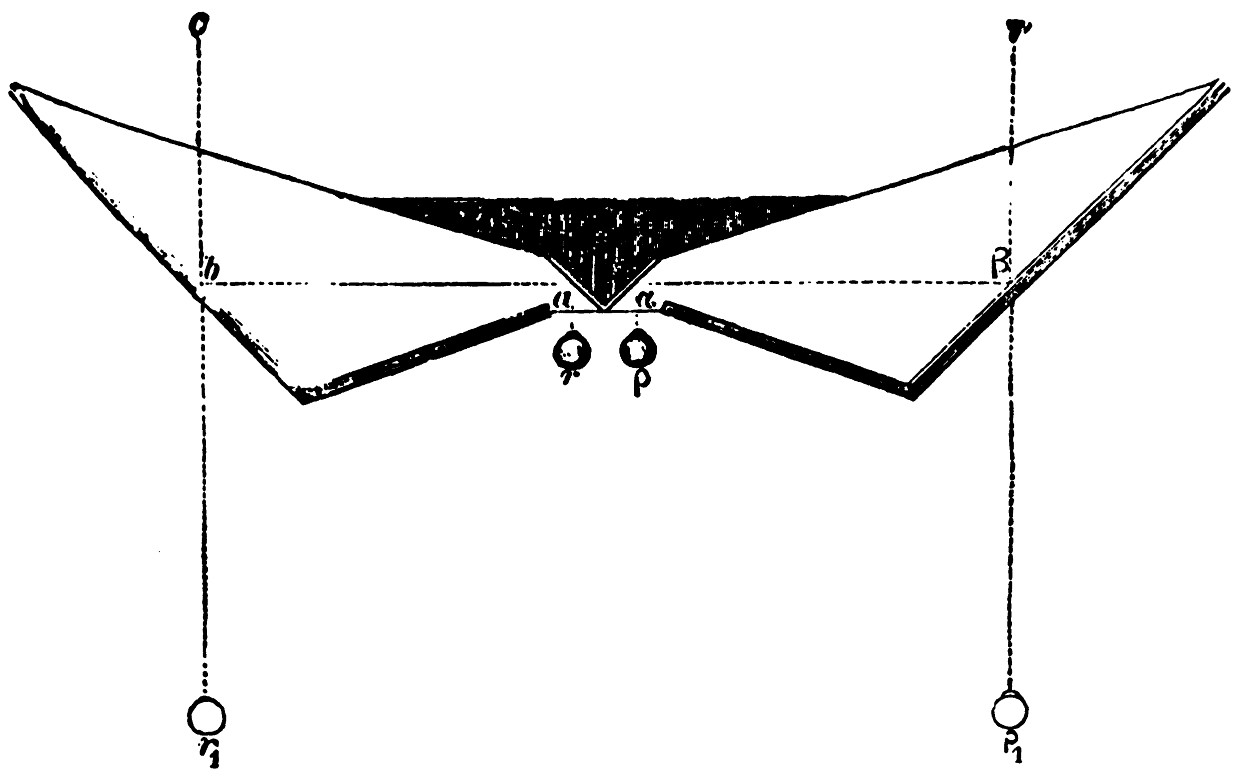

Fig. 9.—In Helmholtz's telestereoscope, mirrors *a*, α and *b*, β allow the user's eyes (*r*, ρ) to see what they would view if they were as widely separated as r_1 and ρ_1. (Hermann von Helmholtz, *Physiological Optics*, trans. and ed. James P. C. Southall [New York, 1962], 3:311.)

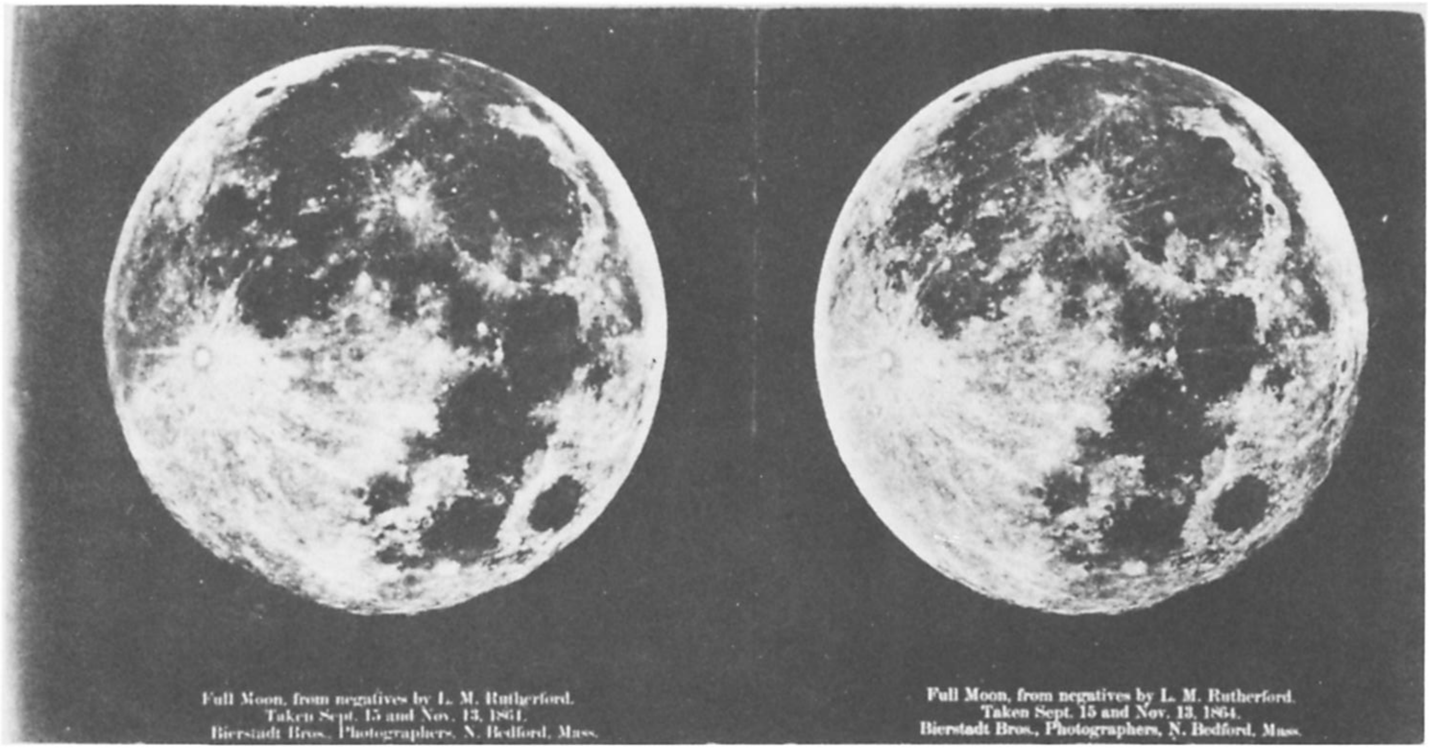

FIG. 10.—A stereograph of the moon taken by Lewis M. Rutherfurd in 1864. (William C. Darrah, *The World of Stereographs* [Gettysburg, Penn., 1977], p. 147.)

respecting the moon, by thus availing ourselves of the giant eyes of science."[56]

Most persons delighted in gazing through these magnificent oculi. As De la Rue feared, however, not everyone admired such gigantic means for examining the moon. The author of the entry on the stereoscope in *Chambers's Encyclopaedia* (1883), somewhat disgusted by the exaggerated rotundity, mentioned that the lunar surface showed "conspicuous relief" in the stereograph, which "no human eyes" could perceive.[57] The writer displayed little patience for attempts to enhance reality, wishing that stereographers "would be content to adopt that exact relation of the two retinal pictures which subsists in ordinary binocular vision."[58]

Some of those who voiced an opinion on "proper" stereoscopic technique adhered rigidly to the standard defined by the human eyes. Yet most accounts contained startling inconsistencies between the recommendations of nature and the advantages gained by surpassing these limits. Augmented stereographic landscapes thrilled an *Edinburgh Review* essayist, even though the productions were "untrue," since no pair of eyes could receive the widely separated aspects unless one's head had been expanded to "Brobdingnagian dimensions."[59] The urges to copy and to enhance the experience of human vision often went hand in hand.

This sort of self-contradiction became most blatant in Sir David Brewster's writings. A single chapter of his 1856 book, *The Stereoscope,* shows the full spectrum of his views. Here, he complained that exceeding a 2½-inch lens separation gave "unreal and untruthful pictures, for the purpose of producing a startling relief."[60] He then challenged Antoine Claudet, whose recommendations for stereoscopic photography were flexible and who believed that "there cannot be any rule for fixing the binocular angle of camera obscuras. *It is a matter of taste and artistic illusion.*"[61] Brewster declared that "no question of science can be a matter of taste, and no illusion can be artistic which

[56] Warren De la Rue, "Report on the Present State of Celestial Photography in England," *Report of the British Association* (1859): 130–53, on 143. Herschel's comment may be found in "The Stereoscopic Angle," *Photographic News* 1 (1858): 110 (this letter is signed simply "J. F. W. H."). Also see Note (I) on Article (473) of Herschel's *Outlines of Astronomy* (London, 1875), p. 700. On De la Rue, see *Dictionary of Scientific Biography,* s.v. "De la Rue, Warren"; and John Darius, *Beyond Vision* (New York, 1984), pp. 28–29.

[57] See *Chambers's Encyclopaedia,* American rev. ed., s.v. "stereoscope," 9:117.

[58] Ibid., p. 116.

[59] "Binocular Vision," *Edinburgh Review* 108 (1858): 437–73, on 469.

[60] Brewster, *The Stereoscope* (n. 21 above), p. 147.

[61] Ibid., p. 147.

is a misrepresentation of nature."[62] Later in the chapter, however, he gave his advice for accommodating colossal statues and other large objects. Within a single internally inconsistent paragraph, he conceded that there may be a "special purpose" that would demand a distant placement of the cameras; yet, the addition of "artificial relief is but a trick which may startle the vulgar, but cannot gratify the lover of what is true in nature and art."[63]

A contrivance that created extreme alterations of the visible world was Wheatstone's pseudoscope, which inverted binocular relief by means of a pair of prisms.[64] Wheatstone devised the pseudoscope in order to study the relationship between binocular and monocular cues, as well as the role of experience and tactile information, in space perception. Although he created the instrument to explore the psychology of vision, he was also delighted by the appearance of "another visual world" through the pseudoscope, "in which external objects and internal perceptions have no longer their habitual relation with each other."[65]

Wheatstone appreciated the paradoxes of seeing the inside of a teacup rendered solid and convex, or a terrestrial globe transformed into a concave hemisphere, with the map on the inside. He claimed to know "nothing more wonderful, among the phenomena of perception, than the spontaneous successive occurrence of these two very different ideas in the mind, while all external circumstances remain precisely the same."[66] If more people had shared Wheatstone's excitement for these perplexing sights, the pseudoscope might have fulfilled the expectations of another writer who assumed that the device "will, no doubt, soon to be had of every optician, as, from the infinity of its illusions, it is sure, even as a toy, to become popular."[67] There is no indication, however, that the pseudoscope ever gained widespread appeal. The pseudoscope may not have enriched the view obtained by the unaided eye as much as it offered a frustrating glimpse of a world turned inside-out.

Pseudoscopic distortions perhaps marked the limit of instrumental manipulation to produce amusing visual effects. However, like other "philosophical toys" of the era—such as the kaleidoscope—the stereoscope could transform the circumstances of unaided sight to create a pleasing visual impression.

[62]Ibid., pp. 147–48.

[63]Ibid., p. 157.

[64]Wheatstone introduced the pseudoscope in his 1852 paper, "Contributions . . . Part the Second" (n. 50 above), p. 162.

[65]Ibid., p. 164.

[66]Ibid., p. 165.

[67]"The Stereoscope, Pseudoscope, and Solid Daguerreotypes" (n. 16 above), p. 78.

Conclusion

In the history of depiction, 19th-century discoveries in the fields of photochemistry and binocular vision combined to produce a fantastically popular visual medium—one which also permitted an unprecedented correspondence to the physiology of sight. Modern historians, philosophers, and scientists have debated whether or not such tools as perspective painting, the photographic camera, and the stereoscope do, in fact, duplicate the human visual field and, furthermore, whether these techniques constitute a means for producing indisputably correct portraits of the world, or merely a set of representational *conventions*.[68] In the 19th century, this problem was solved by the dictates of natural theology since this framework accepted the human visual organs as perfectly designed instruments that provided the template for an ideal representation of nature. Animated by the capacity to preserve images, the photographic plates became surrogate retinae and the stereoscopic camera was transformed into a pair of external eyes.

Although this notion formed the basis for the 19th-century discourse on photography and the stereoscope, there existed a difference of opinion regarding the proper implementation of this technology. There was a marked tension (even in the opinions of a single individual) between the position that altering the conditions of sight entailed a transgression of divine authority and the belief that such an alteration provided a valuable extension of one's ability to understand nature. This tension was inherent in many of the technological projects of the 19th century. Since stereoscopic enhancement and distortion could both arise from a single process—varying the placement of the cameras—one may ask whether *distortion* was a meaning-

[68]See Nelson Goodman, *Languages of Art,* 2d ed. (Indianapolis, 1976; 1st ed., 1968). E. H. Gombrich has written several pieces on this theme: *Art and Illusion* (Princeton, N.J., 1984; 1st ed., 1960), esp. chap. 11; "The 'What' and the 'How': Perspective Representation and the Phenomenal World," in *Logic and Art: Essays in Honor of Nelson Goodman,* ed. Richard Rudner and Israel Scheffler (Indianapolis, 1972), pp. 129–49, "Mirror and Map: Theories of Pictorial Representation," *Philosophical Transactions of the Royal Society* (B) 270 (1975): 119–49, "Standards of Truth: The Arrested Image and the Moving Eye," *Critical Inquiry* 7 (1980): 237–73, and "Image and Code: Scope and Limits of Conventionalism in Pictorial Representation," in *Image and Code,* ed. Wendy Steiner (Ann Arbor, Mich., 1981). Joel Snyder has explored photography's relation to modes of picture making: "Picturing Vision," *Critical Inquiry* 6 (1980): 499–526; and Joel Snyder and Neil Walsh Allen, "Photography, Vision, and Representation," *Critical Inquiry* 2 (1975): 143–69. On the development of perspective, see G. Ten Doesschate, *Perspective: Fundamentals, Controversials, History* (Nieuwkoop, 1964); M. H. Pirenne, *Optics, Painting, and Photography* (Cambridge, 1970); Samuel Edgerton, *The Renaissance Discovery of Linear Perspective* (New York, 1976); and Lindberg (n. 20 above), chap. 8.

ful category, or merely a term applied to representational modes that were *unfamiliar* and *unconventional.*

This has been a continuing problem in the history of instrumentation. Galileo, for example, identified the eye as an optical instrument, although not an ideal one. He recognized that the eye is not an immediate source of information about nature, and that one's conception of the physical world is dependent on the means used to study it.[69] When Galileo suggested that the visual capacity of the naked eye could be improved with a telescope, he had to show that the new information available with his device was not a distortion. Similar conflicts surrounded other novel types of scientific instruments that challenged the prevailing conventions for the representation of nature. In the 17th century, advocates of the air pump and the dispersion prism—like proponents of more recent mega-instruments such as the radio telescope or particle accelerator—had to convince other researchers that the phenomena manifested by their apparatus were not artificial aberrations.[70] There is no way to separate the new phenomena from the tools used to study them.

Techniques for the representation and study of nature are always embedded in a social, aesthetic, and scientific matrix. Such tools never provide a neutral mediation between observers and the world. Rather, an instrument embodies an approach to nature, as well as a means for constructing knowledge. By appreciating the complex function of these systems of mediation, historians may use them to learn about the past. This approach is particularly helpful in the case of the stereoscope, because the debates concerning the design and role of binocular devices reflected the spectrum of attitudes regarding the status of the human frame as the supreme model for learning about nature. Whether it copied the 2½-inch separation rule for truthful depiction or whether it created visual effects beyond the capacity of any human, the stereoscope became a mechanical analogue for the 19th-century mind. It delineated both the human standard of accurate representation and the potential of technology to improve or distort the perception of nature.

[69]Harold I. Brown, "Galileo on the Telescope and the Eye," *Journal of the History of Ideas* 46 (1985): 487–501.

[70]Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, N.J., 1985); Simon Schaffer, "Glass Works: Newton's Prisms and the Uses of Experiment," in *The Uses of Experiment,* ed. David Gooding, Trevor Pinch, and Simon Schaffer (Cambridge, 1989), pp. 67–104; Timothy Lenoir and Yehuda Elkana, eds., "Practice, Context, and the Dialogue between Theory and Experiment," *Science in Context,* vol. 2, no. 1 (Spring 1988).