Blake's *Newton*, line-drawing, and geometry

"Young, blond, [and] curly-headed," the nude of *Newton* "in some respects . . . resembles a Blakean hero" (fig. 1).[1] His musculature tense, he stares intently at the diagram that is inscribed—in this second state of the scene, printed c. 1805—on the pale scroll still part-unfurled at his feet. As W. T. J. Mitchell notes, "[t]he figure of Newton is a perfect example of what Blake means by linear form," something prized by his aesthetics: "the body is a clear, distinct, almost enamel-like entity, frontally composed (that is, placed parallel to the picture plane, not at an angle), and cleanly demarcated from its surroundings."[2]

Photo of William Blake's color-print *Newton* (c. 1805) removed for copyright reasons. Copyright holder is Tate Gallery.

I am grateful to the Leverhulme Trust and the Centre for Research in Arts, Social Sciences and Humanities (CRASSH), fellowships from which gave me the time to research and write this essay.

[1] Jean H. Hagstrum, "William Blake Rejects the Enlightenment," in *Critical Essays on William Blake*, ed. Hazard Adams (Boston, MA: G K Hall, 1991), 72.

[2] W. T. J. Mitchell, *Blake's Composite Art: A Study of the Illuminated Poetry* (Princeton: Princeton University Press, 1978), 49.

Yet there is a deafening quietness to this scene on the ocean's floor, a stillness, if also a muffled flow, as those two, frond-like anemones posed beneath Newton's seat appear to billow out, caught perhaps in some deep-sea current. Indeed there is a notable dynamism in the depiction of Newton's environment, or at least, of the coralline mass on which he sits. This is manifest in the skilled and felicitous mottling of color and tacky surface generated by Blake's unusual technique of planographic color printing with watercolor additions. Pen and ink point natural historical detail: rock or reef and sea floor; mineral and animal mixed with vegetable. The "coiled spiral" of the scroll might augur some movement yet to come—the slump of its material outwards, or its retraction inwards; it is hard to decide.[3] Whether this dynamism also touches Newton is unclear. As our eyes rove, his focus is intense and exclusive; his torso crunches, bundling forwards, and his gaze is directed downwards, his entire attention engaged by the diagram at his foot.

There is something mysterious about this pristine form: like Keats's urn, present, but as if *sui generis*. It is an interloper, of course, absent from the initial pencil sketch, "Newton" (Fitzwilliam Museum), and the single early pull of the color print still extant (both 1795). In this compositional context, the diagram's presence in 1805 is all the more barefaced. What can it mean, this found object, this "figure composed of lines," this diagram—if it is one, unlettered and apart from proof?[4]

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[3] W. T. J. Mitchell, "Chaosthetics: Blake's Sense of Form," *Huntington Library Quarterly* 58, no. 3/4 (1995), 455, JSTOR.

[4] "[T]he diagram alone is wild and unpredictable," writes Reviel Netz; "the text alone is too difficult to follow. . . . The unit composed of the two is the subject of Greek mathematics." See Netz, *The Shaping of Deduction in Greek Mathematics: A Study in Cognitive History* (Cambridge: Cambridge University Press, 1999), 181. Even though it is unlettered, I will continue to call *Newton*'s figure a "diagram" because in general usage the term toggles suggestively between the use of that figure in proof and its use as illustration (potentially a "visual but non-geometrical concept," in the sense employed by Jesse Norman, *After Euclid: Visual Reasoning and the Epistemology of Diagrams* (Stanford, CA: CSLI, 2006), 152).

Scholars have long been intrigued about what this figure might show, or be: perhaps a diagram from Newton's *Opticks* (1704) or his *Principia* (1687, 1713, 1726),[5] or some design loosely influenced by its English translation? (Andrew Motte's *Principles*, 1729).[6] There is further intrigue surrounding the question of why it only made its appearance in 1805, and the question of what, more broadly, the figure might reveal of Blake's broadly disparaging assessment of Newtonian philosophy. When it comes to the figure, I will argue for two new possible sources, and a probable nexus of influence. The sources are both books that were auctioned in 1821 with the contents of William Hayley's library,[7] and so, depending on when Hayley acquired them, might potentially have been accessible to Blake when he worked side by side with his patron at his Turret House in Felpham between 1800 and 1803.[8] This period also, of course, intervenes between the absence, and superimposed presence, of the geometrical figure in the *Newton* color print. The first possible source is Euclid's *Elements* Book I, Proposition 4 (henceforward I. 4) as it was

[5] John Gage suggests Figure 2 of Newton's *Opticks*, Book I, Part 1; Joseph Fletcher suggests *Opticks*, Book I, Part 1, Figure 10; and Jason Snart looks to triangles in Newton's diagrams in both *Opticks* and the *Principia* as a more general influence. John Mulligan argues contrarily that the *Newton* print rather exhibits a "demonstration of conic sections" in the manner of the "supplementary proofs" to James Milnes' *Sectionum conicarum* (1702). See Gage, "Blake's Newton," *Journal of the Warburg and Courtauld Institutes*, 34 (1971), 373, JSTOR; Fletcher, "Ocean Growing: Blake's Two Versions of *Newton* and the Emerging Polypus," *Blake: An Illustrated Quarterly* 49, no. 3 (Winter 2015-16), § 33, https://blakequarterly.org/index.php/blake/article/view/fletcher493; Snart, *The Torn Book: Unreading William Blake's Marginalia* (Selinsgrove, PA: Susquehanna University Press, 2006), 47-8; Mulligan, "Blake's Use of Geometry in *Newton* (1805)," *Notes and Queries* (June 2016), 225.

[6] Martin K. Nurmi, "Blake's Ancient of Days and Motte's Frontispiece to Newton's Principia," in *The Divine Vision: Studies in the Poetry and Art of William Blake*, ed. Vivian de Sola Pinto (London: Victor Gollancz, 1957), 207-16.

[7] Lot 345 is "Cunn's Euclid, 1767;" lot 462, "[C]unn's Euclid, 1745;" and lot 430, "Chambers's Dictionary of Arts and Sciences, 2 vol. 1738." See R. H. Evans, *A Catalogue of the Valuable and Extensive Library of the Late William Hayley, Esq.* (1821), in A. N. L. Munby, *Sale Catalogues of Libraries of Eminent Persons*, 12 vols (London: Parke-Bernet, 1971), II, 98, 101, 100.

[8] On Blake's working in the Turret House, see G. E. Bentley, Jr., *The Stranger from Paradise: A Biography of William Blake* (New Haven: Yale University Press, 2001), 221.

diagrammed in Samuel Cunn's edition of *Euclid's Elements of Geometry* (1745), translated from Latin by John Keill (fig. 2).

Photo of Euclid's *Elements* I. 4 (detail) in Cunn's Euclid removed for copyright reasons. Copyright holder is British Library.

Cunn's *Euclid*'s way of diagramming I. 4—with a curved line added over the base of the second triangle—was unusual but not unique; another example, widely available but not listed as owned by Hayley, would have been Robert Simson's *The Elements of Euclid, viz [Books 1-6, 11-12]* (1756), the "standard edition" of Euclid in British schools from the mid-eighteenth to the mid-nineteenth centuries (fig. 3).[9]

Photo of Euclid's *Elements* I. 4 (detail) in Simson's Euclid removed for copyright reasons. Copyright holder is Cambridge University Library.

[9] Matthew Wickman, *Literature After Euclid: The Geometric Imagination in the Long Scottish Enlightenment* (Philadelphia, PA: University of Pennsylvania Press, 2016), 35.

A second possible source that was held by Hayley is Figure 1, "*Line,"* of the fold-out "Tab. Geometry" in the second, two-volume edition of Ephraim Chambers' *Cyclopaedia: or, An Universal Dictionary of Arts and Sciences* (1738) (fig. 4).[10]

Photo of Fig. 1 'Line', 'Tab Geometry' (detail) in Chamber's *Cyclopaedia*, vol. 2, removed for copyright reasons. Copyright holder is Cambridge University Library.

The fold-out is inserted within the text entry for "Geometry" (Vol. 1), but the relevant figure is cross-referenced not here, but in the entry for "Line" (Vol. 2), where—startlingly—it is said to show the generation of straight and curved lines by the apparently spontaneous motion of a point.[11] The table—also included in Abraham Rees' new edition of the *Cyclopaedia* in 1802-20—would have been a handy resource for anyone looking for, or thinking idly about, some graphic symbolic of diagram. I will argue nonetheless in the final part of this essay for its more motivated application in the *Newton* print as a dynamic demonstration of Euclid's *Elements*, I. 4.

Not only these possible sources, then, but also, especially, Blake's use of geometrical figure in *Newton*, enable us to locate him for the first time in his contemporary mathematical-cultural

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[10] See Abraham Rees, ed., *Cyclopaedia*, 45 vols (1802-20), *Plates Volume II: Basso Relievo—Horology* (London: Longman, Hurst, Rees, Orme, & Brown, 1820), "Geometry Plate X: Fig. 1, 'Line'.' Blake would have known about John Flaxman's involvement with Rees' project as early as January 1804, and became involved engraving some of its "Sculpture" plates after "early 1808": see Rosamund A. Paice, "Encyclopaedic Resistance: Blake, Rees's *Cyclopaedia,* and the *Laocoon* Separate Plate," *Blake / An Illustrated Quarterly* 37, no. 2. (Fall 2003): 47 n., http://bq.blakearchive.org/37.2.paice.

[11] This recalls Proclus's definition of line as "flux of a point." See Euclid, *The Thirteen Books of The Elements*, tr. and ed. Thomas L. Heath, 2nd rev. edn, 3 vols (New York: Dover, 1956; repr. 2016), I, 159.

context. That we should find him here, an engaged and even knowledgeable participant, is surprising: in certain of his marginalia and other later writings, Blake objects vociferously to “mathematical demonstration,” to which “God forbid,” he wrote, truth ought not to be confined. His short, late prose piece “On Virgil” (c. 1822) opposes Gothic, or “Living Form,” to Grecian, or “Mathematic Form,” running together a history of art with a history of culture and imperialism. While “Living Form,” it seems, is generative, “Mathematic Form” can only expropriate, reiterate, and so pervert.[12] Such objections, however, are not born of ignorance; far from it. For Blake had a working understanding of Euclidean geometry, in its theory, practice, and application. Furthermore the artisanal emphasis of Blake’s linear aesthetics is in sympathy with those contemporary textbooks of “practical geometry,” such as Thomas Malton’s *Royal Road to Geometry* (1774) and John Bonnycastle’s *Introduction to Mensuration* (1782), which, notwithstanding their investment in utility, are able to speculate about the practical origins of geometry, and even to see in artisanal practices such as drawing the kind of knowledge reserved by some for more speculative pursuits. My argument is in four parts, addressing (i) how and why Isaac Newton appears in Blake’s print in the guise of a geometer; (ii) how Blake vindicates improvisational and hand-drawn lines in an artisanal aesthetics developed seemingly in opposition to geometry; (iii) how his responses to the geometry he may have learned (from John Bonnycastle and Thomas Taylor) nevertheless discloses attitudes typical of practical geometers; and finally (iv) how Blake’s presentation of the compass and diagram in *Newton* may perform a knowing critique of geometrical abstraction, laying bare and potentially celebrating the mechanics (here, superposition) at its heart.

[12] William Blake, [Annotations to Reynolds], in *The Complete Poetry and Prose of William Blake*, ed. David V. Erdman, rev. edn (Berkeley: University of California Press, 1982), E 659, 270. Further references to this edition will appear in the main text.

i. Newton as geometer

Immediately Blake's scene of mathematical encounter summons the geometer-as-technician. Newton's posture is reminiscent (as scholars have noted) of the figure variously identified as Euclid or Archimedes in Raphael's *School of Athens*,[13] and also of Archimedes before his imminent death, "so absorbed in a diagram he was drawing in the dust," in Cicero's words, that "he was unaware even of the capture of his native city."[14] The medium of Archimedes' drawing has been disputed, but significantly, whether sand or dusted surface, ostrakon or wax tablet or "whiteboard," would have been subject to a common material limitation: what the cognitive historian of ancient Greek mathematics, Reviel Netz, identifies as "the inability to erase." According to Netz, this necessitated "the preparation of the diagram prior to the communicative act," that is, the "letter[ing]" of the diagram, "simultaneously with a (possibly oral) dress rehearsal of the text of the proposition." This dress rehearsal, for Netz, is the primal scene of Greek mathematics.[15] The diagram's priority to oral rehearsal is also assumed grammatically by the perfect passive imperatives in Euclid's Greek, such as "let a line be drawn," translating the more precise rendition, "let a line have been drawn." By its inaugural text, then, Greek geometry both anonymises operative activity, and retrojects it from "the

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[13] Anthony Blunt, "Blake's 'Ancient of Days': the Symbolism of the Compasses," *Journal of the Warburg Institute* 2, no. 1 (July 1938), 61, n. 6, JSTOR; Robert Essick, "Blake in the Marketplace, 1992," *BiQ* 26, no. 4 (1993), 159n., http://bq.blakearchive.org/26.4.essick; John Gage, *Color and Meaning: Art, Science and Symbolism* (London: Thames & Hudson, 2000), 144-5.

[14] Cicero, *On Ends*, tr. Harris Rackham, rev. edn, Loeb Classical Library 40 (Cambridge, MA: Harvard University Press, 1914), V. 50 (p. 451). See the engraving after Gustave Courtois at www.math.nyu.edu/~crorres/Archimedes/Death/DeathIllus.html.

[15] Netz, *Shaping of Deduction*, 14-16, 85, 167.

'present moment'" of "the reader's encounter with the unfolding proof" to some "unnoticed past," as David Rapport Lachterman asserts.[16]

In the 1805 *Newton* color-print, too, it is as if the diagram has always been there. Newton does wield "dividers or compasses,"[17] it is true, either of which he might have used to measure or to draw.[18] Yet his drawing seems unlikely: for a start, the center of the circle of which the diagram's arc forms a part would surely need to have been fixed beyond the limits of the parchment scroll. His compass legs seem instead to mark the limits of what is already there. In this way, Newton, in the act of attending to the diagram, appears less to be its producer than its product: not drawing but drawn in, "[t]he incredibly powerful and muscular body of the human form . . . rolling itself into the very figure it is measuring with dividers," as Donald Ault observes. It is as if "the powerful imaginative body of the figure has been lured into a mathematical parody of itself."[19] The contrast between geometrical and human figures is plain to see (albeit vexed by the co-presence of the spiralled scroll-edge), the most basic grammar of lines in monochrome opposing tonal color and irregular curve. This makes dissonant a replication of shape (triangles; arcs) that nonetheless maintains visual harmony. Such ambivalence surrounding agency and creation, cause and effect,

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[16] David Rapport Lachterman, *The Ethics of Geometry: A Genealogy of Modernity* (New York; London: Routledge, 1989), 65. Note Netz's disagreement that this necessarily reflects a "*horror operandi*" at *Shaping of Deduction*, 25 n..

[17] "Sector E Plate Illustration," in *Newton*, Object 23, 1795 (Tate Collection), Blake Archive, http://www.blakearchive.org/copy/cpd?descId=but306.1.cprint.01 .

[18] In the tapering of its legs into sharp points, Newton's instrument more resembles a divider (sometimes also called "plain compasses"), used to measure and to copy. A pair of compasses, by contrast, which from *c.* 1550 would have had "interchangeable legs or an insert for a crayon-holder or ink point," could be used to draw as well as to measure. That said, even a bare steel point may be used like a stylus to scratch furrows which were later inked in. See J. F. Heather, *Mathematical Instrument*, rev. edn, 2 vols (London: Crosby Lockwood, 1884), 13; Maya Hambly, *Drawing Instruments 1580-1980* (London: Sotheby's Publications, 1988), 11, 69. The tip of one of Newton's compass legs also seems dark, as if with ink.

[19] Donald Ault, *Visionary Physics: Blake's Response to Newton* (Chicago: University of Chicago Press, 1974), 3.

recalls, within Blake’s oeuvre, the demiurge Urizen, who “formed golden compasses / And began to explore the Abyss” (20: 39-40, E 81). Yet what Urizen encounters and measures is only what he himself has created, through the repeated operation of “division” that is patterned throughout the poem. Within *The [First] Book of Urizen* (1794), the cause of “division” is impossible to ascertain, assigned as it is by flurry of competing narratives to a number of mythical agents, acting alone or in combination. More striking in the *Newton* print, however, is not a vying for authorship but its lack, as the geometer-as-draughtsman is withheld from view. Now found, as if already made, once made but its making now forgotten, the diagram is able by the force of this forgetting to conform the geometer to its image.

Precursors to the color print tend to cast this amnesia as denial, implicating the diagram in Blake’s broader attack on what we might loosely call rational materialism. Conflating geometry with empirical enquiry, the “Application” plate of *There is No Natural Religion*, second series (comp. c. 1788; printed 1795), shows the geometer encaverned, dividers in hand; “He who sees the Infinite in all things sees God,” it says above, “He who sees the Ratio only sees himself only” (E 3) (fig. 5).

Photo of Copy L, Object 10, 'Application: He who sees the Infinite in all things', in William Blake, *There is No Natural Religion* removed for copyright reasons. Copyright holder is Morgan Library and Museum.

Likewise, the accoutrements of Newtonian astronomy singled out by Blake in one of his illustrations to Edward Young's *Night Thoughts* (fig. 6)—the telescope, dividers, and diagram itself—discover a "*Newtonian*" heaven, filled with forces of attraction and repulsion, "circles" and "lines."

Photo of Night IX, p. 91, 'And if he finds', William Blake's illustration to Young's *Night Thoughts* removed for copyright reasons. Copyright holder is Trustees of the British Museum.

"[M]ore curious, than devout," such enquiry leaves Young's speaker "still a stranger to [God's] throne."[20] Not dissimilarly, perhaps, when Isaac Newton, in the "General Scholium" added to the second edition of the *Principia* (1713), discovered "Lord God *Pantokrator*," he found only what his own mathematicized natural philosophy had conditioned him to see.[21]

Blake's identification of Newton as a geometer is a central tenet of his anti-Newtonian critique. It is manifest in his characterisation of Newton as a manipulator of scientific instruments (the compass or divider, the telescope), of machines (the "Water-wheels" that turn "wheel without wheel, with cogs tyrannic / Moving by compulsion" in *Jerusalem* (15: 16, 18-19, E 159), and of

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[20] Edward Young, *Night Thoughts*, ed. Stephen Cornford (Cambridge : CUP, 1989; repr. 2008), 304 (Night IX, ll. 1836, 1844, 1846).

[21] Isaac Newton, *The* Principia*: Mathematical Principles of Natural Philosophy* [3rd edn (1726)], tr. I. Bernard Cohen and Anne Whitman, with Julia Budenz (Berkeley, CA: University of California Press, 1999), 940.

diagrams. It also infiltrates a series of intricate comments about line scattered across his manuscript writings (the *Notebook* rhymes "To Venetian Artists" and "Florentine Ingratitude," and a late letter to George Cumberland, his friend and sponsor).[22] Blake need not have read or looked at any of Newton's writings directly in order to associate him with geometry, of course: the connection was commonplace, thanks in part to what the modern editor of Newton's *Mathematical Papers*, D. T. Whiteside, calls "the Grecian façade of his *Principia*," its pages "heavily adorned with geometrical diagrams," even as "in a number of propositions algebraic reasoning and infinite series occur." Also influential was the suggestion of Henry Pemberton, in *A View of Sir Isaac Newton's Philosophy* (1728), that "Of [the antients'] taste, and form of demonstration Sir Isaac always professed himself a great admirer."[23] It was picked up, for example, by Charles Hutton in *A Mathematical and Philosophical Dictionary* (1795-6), and cited in turn by Thomas Taylor in *Theoretic Arithmetic* (1816).[24] Taylor was known to Blake, as I will discuss later in this essay, and Hutton's *Dictionary* was another of the works auctioned with Hayley's library (lot 1441). It is also possible that Blake encountered Newton's writings more directly. As scholars have long been aware, there are suggestive visual analogues between Blake's compass-wielding demiurges and details of the frontispiece of Motte's *Principia* (1729).[25] Intriguing verbal echoes of Newton's idiom also work their way into Blake's own—notably God as "Pantokrator" or "universal ruler"; mobile "moments";

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[22] I write about these, and the "counter-geometry" that Blake develops, in a longer form of the present essay.

[23] D. T. Whiteside, ed., *The Mathematical Papers of Isaac Newton*, 8 vols. (Cambridge: Cambridge University Press, 1967-1981), IV, 217; Niccolò Guicciardini, "'Gigantic implements of war': images of Newton as a mathematician," in *The Oxford Handbook of the History of Mathematics*, ed. Eleanor Robson and Jacqueline Stedall (Oxford: OUP, 2008), 716.

[24] Charles Hutton, *A Mathematical and Philosophical Dictionary*, 2 vols (London: Joseph Johnson, G. G. and J. Robinson, 1795-6), II, 153; Thomas Taylor, *Theoretic Arithmetic* (London: Thomas Taylor, 1816), vi-vii.

[25] Nurmi, "Blake's Ancient of Days."

and "fluxions."[26] Even if these echoes originated from Blake's reading of Berkeley's *Siris*,[27] or the widespread diffusion of Newtonian ideas in contemporary magazine articles, encyclopaedia entries, treatises, and textbooks, they evince his interest, and a degree of knowledge. Yet in *Newton* there is more at work than a critique of Newtonianism; there is in excess of this a suggestion of Blake's engagement with—and fascination by—geometry as such, or more precisely, with both Euclidean and practical geometry as they were taught and theorised by his contemporaries. Blake might also have been intrigued by diagrams: their immediate visual-spatial appeal giving access to visual-spatial knowledge; their ancientness; their possible ideality; and their likeness (almost so obvious as to go without saying) to drawings.

ii. Line-drawing

The "description" of lines—their marking or tracing—is integral to graphic art and geometry alike. As William Hogarth notes in *The Analysis of Beauty* (1757), "lines [are used constantly] by mathematicians, as well as painters, in describing things upon paper."[28] Euclidean geometry, especially, is a highly visual medium; diagrams are integral to its proofs. Equally, line, shape, and

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[26] Blake mentions "Newtons Pantocrator" and the "Moment" in *Milton* (4: 11, E 98; 28[30]: 44 - 29[31]: 3, E 126-27), and "fluxions" in the letter to Cumberland of April 12, 1827 (E 783). On the Newtonian source for "Pantocrator," see Paul Miner, "Newton's Pantocrator," *Notes and Queries* 8, no. 1 (January 1961), 15-16; on the Newtonian resonance of "Moment" and "fluxions," see F. B. Curtis, "Blake and the 'Moment of Time': An Eighteenth Century Controversy in Mathematics," *Philological Quarterly* 51, no. 2 (1972), 460-70.

[27] More work deserves to be done on Blake and Berkeley. For a recent assessment, see Chris Townsend, "Visionary Immaterialism: Berkeleian Empiricism in Blake's Poetry," *Studies in Romanticism* 58 (Fall 2019).

[28] William Hogarth, *The Analysis of Beauty*, ed. Ronald Paulson (New Haven; London: Yale University Press, for the Paul Mellon Center of British Art, 1997), 41.

pattern structure graphic art, which since the fifteenth century had been informed by theories of perspective indebted to geometrical ideas. Education in rules of perspective was enshrined in the institutions of art; at the Royal Academy, for instance, the post of Professor of Perspective was created in 1768, and held between 1807 and 1837 by J. M. W. Turner.[29] Education in drawing also penetrated mathematical curricula: attached to the Royal Mathematical School established at Christ's Hospital in 1673, for example, was "a drawing master, who attend[ed] on two afternoons in the week."[30] In 1806 there were two drawing masters among the twenty or so staff at the Royal Military Academy at Woolwich.[31]

Yet for all their common foundation, drawing and geometry are not synonymous; their lines are epistemologically distinct. George Cumberland marked disciplinary distinctions in *Thoughts on Outline* (1788), to which Blake contributed eight plates after Cumberland's designs, acknowledging that:

> Although, mathematically speaking, there is no such thing as Outline, yet, to be more intelligible, we must use that term instead of boundary: for, notwithstanding, I see figure without Outline, I cannot describe it on paper, until I begin with that process.[32]

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[29] Andrea Fredericksen, *Vanishing Point: The Perspective Drawings of J M W Turner* (London: Tate, 2004), 5, 8.

[30] William Trollope, *A History of the Royal Foundation of Christ's Hospital* (London: Pickering, 1834), 78, 188.

[31] Niccolò Guicciardini, *The Development of Newtonian Calculus in Britain, 1700-1800* (Cambridge: CUP, 1989), 109.

[32] George Cumberland, *Thoughts on Outline, Sculpture, and the System that Guided the Ancient Artists in Composing their Figures and Groupes* (London: W. Wilson, 1796), 15.

There is "no such thing as Outline" in Euclid's sense that line is "breathless length," or alternatively, in Proclus' sense that line is the "flux of a point," a point in itself insensible, indivisible.[33] As Newton's great champion, Voltaire, put it, in *The Elements of Sir Isaac Newton's Philosophy* (1738): "A Geometrical Line is a Line in Idea, always divisible in Idea."[34] Blake himself appears to make the connection from geometrical line to Newton's theory of fluxions in his letter of 12 April 1827 to Cumberland:

> a great majority of Englishmen are fond of The Indefinite which they Measure by Newtons Doct[r]ine of the Fluxions of an Atom. A Thing that does not Exist. . . . For a Line or Lineament is not formed by Chance a Line is a Line in its Minutest Subdivision[s] Strait or Crooked It is Itself & Not Intermeasurable with or by any Thing Else. (E 783)

Mary Lynn Johnson glosses this well, writing that "For Blake, a true line can be only the firm, assured stroke of an artist, not some abstraction generated from a random succession of vanishing quantities in motion, as in the popular understanding of Newton's fluxional calculus."[35] "Newton's geometry . . . weakened the authority of the line in art," notes Jean Hagstrum, by subdividing it "infinitely, to non-existence."[36]

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[33] See Euclid, *Elements*, ed. Heath, I, 153, 159. Pertinent here is the related controversy of pseudo-Aristotle's indivisible line. See Paul Miner, "Blake and Aristotle," *Notes and Queries*, 63 (2016), 199-201.

[34] Voltaire, *The Elements of Sir Isaac Newton's Philosophy*, tr. John Hanna (London: Stephen Austen, 1738), 112; Euclid, *Elements*, ed. Heath, I, 153.

[35] Mary Lynn Johnson, "Blake and the 'Fluxions of an Atom': Some Contexts for Materialist Critiques," in *Historicizing Blake*, ed. Steve Clark and David Worrall (Basingstoke: Palgrave Macmillan, 1994), 120.

[36] Hagstrum, "William Blake Rejects the Enlightenment," 72.

Blake's own "practical aesthetics" of line-drawing—to borrow a term from Ruth Mack's discussion of Hogarth[37]—take us somewhere very different. The *locus classicus* of his comment on line in the *Descriptive Catalogue* (1809), for instance, describes a "bounding line" with "infinite inflexions and movements": a line with the temporality of the present participle, engaging our minds with the puzzle of compressed paradox ("bounding" as both limiting and leaping); a line that encompasses the work of engraver, painter (E 572), sculptor, and "Sower [of] seed" (E 126); a line —can it be?—that builds houses and plants gardens. "Protogenes and Apelles knew each other by this line," continues Blake, with reference to Pliny's tale in *Natural Histories* of Apelles' virtuosic hand-drawing; "Rafael and Michael Angelo, and Albert Durer, are known by this and this alone" (E 550). Blake imagined himself, too, as having such a distinctive technique, a determinately linear "Blakified drawing," recognizable as such.[38]

The technique manifest in line-drawing is the means by which artists are "known" and by which, like Protogenes and Apelles, they "kn[o]w each other" (*Descriptive Catalogue*, E 550). What artists know is technical practice; their intelligence is a practical intelligence, a *metis*, embracing even the humblest of details.[39] Blake hammers this home in a passage of the manuscript "Public Address" (c. 1809), recalling how his engraving-master James Basire's skill at tool-sharpening was scoffed at by someone whom Blake considered an inferior engraver, William Woollett:

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[37] Ruth Mack, "Hogarth's Practical Aesthetics," in *Mind, Body, Motion, Matter: Eighteenth-Century British and French Literary Perspectives*, ed. Mary Helen McMurran and Alison Conway (Toronto: University of Toronto Press, 2016).

[38] "Flaxman & Stothard . . . / Cry Blakified drawing spoils painter & Engraver," "Blakes apology for his Catalogue," ll. 13-14, E 505.

[39] Marcel Detienne and Jean-Pierre Vernant, *Cunning Intelligence in Greek Culture and Society*, tr. Janet Lloyd (Sussex: Harvester; New Jersey: Humanities, 1978), 2-3. Originally published as *Les ruses de l'intelligence: la mètis des Grecs* (1974).

> Woolett I know did not know how to Grind his Graver I know this he has often proved his Ignorance before me at Basires by laughing at Basires knife tools & ridiculing the Forms of Basires other Gravers till Basire was quite dashd & out of Conceit with what he himself knew. (E 575)

This comment has been hailed as an exception within Blake's writing rather than the rule. As Eaves remarks, "[t]here are no burins in eternity."[40] Yet there are such tools almost everywhere else. The final plate of *Jerusalem*, for example, credits craft as the apotheosis of (in a special sense) 'Human' achievement, and artisanal implements are at its front and centre: a distaff or spindle, whose point resembles a pen; a hammer; and a pair of tongs, or perhaps of plain compasses, "h[eld]" as they are "between thumb and finger." This final example of "iconographic fusion" according to Anne Mellor embodies "the union of imagination and reason in the creative process": "[t]ongs seize and shape molten metal into new images"; plain compasses or dividers are presumed to "circumscribe, dissect, or measure already existing materials."[41] We might understand the work that *Jerusalem* does by this fusion to be redemptive, superadding to an implement used primarily for mensuration the generative potential that it lacks. Then again, a pair of compasses, burin, or grinding-stone would be nothing without the knowledge of the skilled practitioner who draws it into their activity.[42]

iii. Blake's geometry

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[40] Morris Eaves, *The Counter-Arts Conspiracy: Art and Industry in the Age of Blake* (Ithaca: Cornell University Press, 1992), 184-5.

[41] Anne Kostelanetz Mellor, *Blake's Human Form Divine* (Berkeley, LA: University of California Press, 1974), 330-31.

[42] See Tim Ingold, *Being Alive: Essays on Movement, Knowledge, and Description* (Abingdon: Routledge, 2011), 79.

Improvisational, unapologetically hand-made, and particular, the lines of Blake's practical aesthetics have little to do with geometrical diagrams as I have characterised them so far. This characterisation, though, deserves opening up, especially as practical geometry emphasised diagrams' mechanical construction. Geometry was distinguished, during Blake's lifetime, into "*theoretical*, or *speculative*, and *practical*," the first "contemplat[ing] the properties of continuity" and "demonstrat[ing] the truth of general propositions"; the second "appl[ying] those speculations and theorems to particular uses."[43] Blake's earliest documented exposure to geometry encompassed both of these aspects, albeit that the specifics of his sources troubled the distinction between them. For the NeoPlatonist Thomas Taylor, with whom Blake is alleged to have discussed Euclidean geometry, the case is clear: geometry "must be considered as desirable for its own sake, and for the contemplation it affords, and not on account of the utility it administers to human concerns."[44] For the practical mathematician John Bonnycastle, by contrast, geometry's "importance in trade and business," its use by architects, engineers, ship-builders, and surveyors, was "not inferior to its dignity as a science."[45]

Practical geometry belonged to a tradition of vernacular mathematics active in Europe from at least the late sixteenth century. Addressed to the "mechanic Profession[s]," that is, to those employed (as the architectural draughtsman Thomas Malton put it) in "Mensuration, Trigonometry, Navigation, Gunnery, Fortification, Architecture, naval or domestic, Surveying, &c.," books of practical geometry dramatized the intersection of mathematics and art, presenting and celebrating

[43] Ephraim Chambers, *Cyclopaedia; or, An University Dictionary of Arts and Sciences*, 2nd edn, 2 vols (London: D. Midwinter and others, 1738), I.

[44] Taylor, *Theoretic Arithmetic*, xxiv; see also "A Dissertation on the True End of Geometry," in *The Philosophical and Mathematical Commentaries of Proclus on the First Book of Euclid's Elements*, 2 vols. (London: Thomas Taylor, 1788, 1789, and repr.), I, cvii, cix.

[45] John Bonnycastle, *An Introduction to Mensuration, and Practical Geometry* (London: Joseph Johnson, 1782), vi.

geometry as not "abstract knowledge" but "practical action".[46] What practice then had to do with knowledge was moot. Rousseau was one of many who condemned "artisans" and "artists" for their "imitative spirit," which, he wrote in *Emile*, "leads [man and ape] mechanically to want to do everything they see done without quite knowing what it is good for."[47]

Blake was drawn into practical geometry early by an engraving he made after Thomas Stothard in the early 1780s for the title-page of John Bonnycastle's *An Introduction to Mensuration and Practical Geometry* (1782). Bonnycastle was then a mathematics master at the Royal Military Academy, Woolwich, one of the several academies founded on the model of the Royal Mathematical School at Christ's Hospital (f. 1672) to teach not only maths but also drawing to students destined for a career in the navy. The title of Bonnycastle's book situates itself unabashedly in the vernacular tradition. From Egyptian land measurement to "our present . . . mechanical practice," writes Bonnycastle, "the *art of measuring*" is geometry's origin and apotheosis.[48] Whilst addressing "artizan[s]," though, Bonnycastle also addressed "mathematician[s]," espousing the importance of teaching not only construction (or how to make a particular shape) but demonstration too (or how to prove something about all such shapes), that is, he taught principles as well as

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[46] Thomas Malton, *A Royal Road to Geometry; or, An Easy and Familiar Introduction to the Mathematics* (London: Thomas Malton, 1774), iii; Katie Taylor, "Vernacular geometry: between the senses and reason," *BSHM Bulletin* 26 (2011), 148, https://www.tandfonline.com/doi/abs/10.1080/17498430.2011.580137.

[47] Jean-Jacques Rousseau, *Emile*, in *Emile, or On Education, Includes Emile and Sophie, or The Solitaries*, tr. and ed. Christopher Kelly and Allan Bloom (Hanover; London: University Press of New England, 2010), 124-8.

[48] For histories of geometry's origin, see David Fowler, *The Mathematics of Plato's Academy: A New Reconstruction* (Oxford: Clarendon Press, 1999), 279; for his corresponding scepticism, see 281, and compare Thomas L. Heath, *A History of Greek Mathematics*, 2 vols. (Oxford: Clarendon Press, 1921), I, 121-8. On geometry's origins, plural, see Ian Hacking, "Husserl on the Origins of Geometry," in *Science and the Life-World: Essays on Husserl's Crisis of European Sciences*, ed. David Hyder and Hans-Jorg Rheinberger (Stanford University Press, 2010), 67.

practice. By this means, he writes, "those who would wish not to take things upon trust" could "be acquainted with the grounds and *rationale* of the operations they perform."[49]

If the body of Bonnycastle's book presented geometry as artful practice, so too did the vignette selected for its title page (which is after all the only part of the book we can be sure Blake saw) (fig. 7).

Photo of William Blake after Thomas Stothard, title-page vignette for Bonnycastle's *Introduction to Mensuration* removed for copyright reasons. Copyright holder is William Blake Archive (Collection of R. N. Essick).

Attributed to Thomas Stothard, this design, especially the "plump child who leans over and points with a stick," is said to have influenced that "important Blakean motif, the man leaning down with dividers."[50] Stothard's scene, though, is more thickly populated. *Putti* proliferate, their hands pointing like manicules to the several different versions of the Pythagorean theorem on display. Most prominent is the set of inscribed lines which faces us squarely, on an up-ended tablet. This figure (nearly) describes the simplest version of the theorem as it may have been investigated

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[49] Bonnycastle, *Mensuration*, v, vii, ix.

[50] Essick, "Blake in the Marketplace, 1992," 159.

generally by Pythagoras himself, using an isosceles, right-angled triangle.[51] More difficult to make out—cut against the grain of its background, and intricate—is the figure on the floor below: an unlettered version of the diagram at *Elements* Book I, Proposition 47, the recording of Pythagoras's theorem by Euclid. This *putto* is a recognisably Archimedean figure: re-tracing a diagram in the dust at his feet whilst—as in Raphael's convivial scene—he perhaps talks his interlocutor through the proof, the interlocutor able at once to listen and to look. The *putto* third from right has a more solitary experience with a printed book. The final pair of *putti*, meanwhile, talk around the model of a dodecahedron posed on a column to the right—the Pythagorean theorem can be used to help calculate this solid's area, and is assumed by Euclid in his construction of the same in *Elements* Book XIII. Three-dimensional geometrical models were used in teaching of geometry at the time,[52] and were imagined by the chemist and physician Thomas Beddoes, in his *Observations on the Nature of Demonstrative Evidence* (1793), to have the benefit, he writes, of "rendering the elements of geometry palpable": "if a child had something to handle and to place in various postures, he might learn many properties of geometrical figures," Beddoes continues. "[The child] would have no difficulty in transferring the properties of the palpable to merely visible figures," he thinks, "nor in generalizing the inferences." The exhibition of such sensible, in Beddoes' word "experimental" methods, is however no part of Stothard's concern.[53] His vignette gives us *putti* at play, not mathematicians at work. Tools have been downed (note the carpenter's rule at the base of the

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[51] "[T]he truth of the theorem in this particular case would easily appear from the mere construction of a figure" (Heath, at Euclid, *Elements*, I, 352, which includes two ancient Indian figures in support of his suggestion).

[52] For example, a wooden set made by George Adams, c. 1750, on display in the Whipple Museum, Cambridge (Wh.0368).

[53] Thomas Beddoes, *Observations on the Nature of Demonstrative Evidence* (London: Joseph Johnson, 1793), vii-viii.

tablet); hands point not palpate. Scenes such as this functioned to domesticate geometrical enquiry. Their cost was the euphemizing of geometry's banausic inheritance.[54]

Blake's sympathy with practical geometry is again manifest in his reported encounter with Thomas Taylor. According to William George Meredith (1804-31), the nephew of Taylor's patron William George Meredith (?1756-1831), Taylor "'gave Blake, the artist, some lessons in mathematics & got as far as the 5th propositn wc[h] proves that y two angles at the base of an isosceles triangle must be equal.'" When these meetings might have taken place is unknown, although it is possible that Taylor first met Blake in the 1780s through their common friend, John Flaxman. Blake's appreciation of geometry seems not to have been primarily mathematical. "'Taylor was going thro the demonstration,'" continues Meredith, "'but was interrupted by Blake, exclaiming 'ah never mind that—what's the use of going to prove it. Why I see with my eyes that it is so, & do not require any proof to make it clearer'.'"[55] We cannot know the particularities of what Blake would have been seeing, of course. Taylor's own text about Euclid, his edition and translation *The Philosophical and Mathematical Commentaries of Proclus, on the First Book of Euclid's Elements* (1788, 1789), was not designed for teaching, and in fact calls for the use of a supplementary textbook. This may have been Simson's *The Elements of Euclid* (1756) (see fig. 3), a text Taylor certainly knew. However his references to Simson tend to be disparaging—Simson was too much "a professor of experimental philosophy," he thought, "who considers the useful as inseparable from practice." Taylor himself learned geometry from Barrow, to whose edition of

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54 See J. L. Heilbron, "Domesticating Science in the Eighteenth Century," in *Science and the Visual Image in the Enlightenment*, ed. William R. Shea (Canton, MA: Science History Publications, 2000); Steven Shapin, "The Invisible Technician," *American Scientist* 77, no. 6 (Nov/Dec 1989), JSTOR. On geometry and "banausic anxiety," see further Netz, *Shaping of Deduction*, 60-1, 303-6.

55 James King, "The Meredith Family, Thomas Taylor, and William Blake," *Studies in Romanticism* 11, no. 2 (1972), 157, 154; Kathleen Raine, "Thomas Taylor in England," in *Thomas Taylor, the Platonist: Selected Writings* (Princeton, NJ: Princeton University Press, 1969; repr. 2019), 13

Euclid he often refers.[56] Not only the editor, but also the date, of any textbook would also have shaped what one saw. Swept up in wider changes across the polite book production industry, mathematical diagrams, like scientific illustrations, came over the course of the eighteenth century to be engraved on copper rather than cut in wood. Diagrams that in the first English edition of Barrow's *Euclide's Elements* (1705) appeared embedded within their proposition texts, for example, were by 1751 culled and coralled on to separate, fold-out plates (even if they might always be brought to bear on individual propositions by a reader or teacher's drawing them out).

Blake's reported response to Taylor's teaching—almost but not quite a dismissal—singles out the immediate visual appeal of geometrical figure, its enablement of taking "a synoptic view." Take *Elements* Book I, Proposition 4, which has always been somewhat of a touchstone for philosophical theories of knowledge, and according to certain practical geometers was the "corner-stone" of geometrical reasoning.[57] We would nowadays call I. 4 the side angle side (SAS) theorem of the congruence, or equality, of triangles. With reference to Barrow's *Euclide* (fig. 8),

Photo of Euclid's *Elements* I. 4 in Barrow's Euclid removed for copyright reasons. Copyright holder is Cambridge University Library.

one could well believe that the similar look of the triangles alone assures us of their equality, or at the very least, that one need not laboriously point out the equality of each side, angle, and side respectively in order to prove it—and in fact, this seems to have been an eighteenth-century

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[56] Taylor, *Commentaries*, I, 141 fn; *Commentaries*, II, xix.

[57] Beddoes, *Observations*, 20.

commonplace.[58] So “self-evident” does I. 4 appear to Thomas Malton, in *A Royal Road*, that it tests his pedagogical resolve. For:

> [a]re not all these, and several more, obvious and clear, from a bare inspection of the Figure? nay even without it; ’tis clear enough to be told they have such properties, and not to lose time trying the patience of the Student, with a tedious and puzling [sic] Demonstration.

After all, writes Malton, the “know[ledge]” that “any two sides of a Triangle, are greater than the third is implanted in us by Nature; every common Porter knows it, or practices it every Day. Who ever saw one of them traverse two sides of a Square, when he could cross the Diagonal?”[59] Here, innate ideas (ideas “implanted in us by Nature”) dovetail a tacit bodily knowledge entrained by habitual action (walking across a square). Mathematically, though, any grasp of diagram that does not recognize it as part of proof stops short of true understanding. It is necessary to run through each step of a proof in order to surmount what modern philosophers of mathematics call “the *generality problem*,” in order, that is, to understand that “properties seen to hold in the diagram [can be] taken to hold of *all* the configurations of the given type”[60] (which indeed is one reason that Malton, like Bonnycastle, persisted in relaying Euclidean demonstrations to artisans and mechanics). Perhaps, then, by Meredith’s report, Blake displays misunderstanding or impatience; perhaps he deliberately short-circuits geometry’s claim to truth. His emphasis on what “I see with

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[58] “[T]he fourth proposition of the first book of the Elements, is thought by many to be more evident without the demonstration than with it”: William Ludlam, *The Rudiments of Mathematics* (Cambridge: J. Archdeacon, 1785), 142.

[59] Malton, *Royal Road*, vii.

[60] Sun-Joo Shin, Oliver Lemon, and John Mumma, “Diagrams,” *The Stanford Encyclopedia of Philosophy* (Winter 2018 Edition), Edward N. Zalta (ed.), https://plato.stanford.edu/archives/win2018/entries/diagrams.

my eyes" also works as a refusal to disallow sensible experience from informing geometrical knowledge.

iv. Geometry's furniture

When it came to mathematical demonstration, Beddoes felt impatient with those who supposed mathematical reasoning "to be something independent of experience." Even Euclidean geometry had its origin in practice, he thinks: thus even "if a Greek writer happens to have written a demonstration a mile long, [this] demonstration can be nothing but a concatenation of the results of observation and experiment."[61] It is something like an experimental construction of *Elements* I. 4 that I would argue we can see in Blake's *Newton*.[62]

Central to the operation of I. 4 is the method of superposition, a term which describes the actual moving or placing of one figure upon another in order to effect a comparison of its size. In I. 4, it is by marking the "coinciden[ce]" of select sides and angles of two triangles that the proof of their "equality" consists.[63] The congruence effected is simultaneous and rigid; the triangle moved does not itself change, despite the shift of place or space. Superposition has historically been the source of some controversy because so apparently mechanical a practice. The Scottish mathematician and geologist John Playfair's *Elements of Geometry* (published in 1795) treads with care, conceding that "supraposition involves the idea of motion," but denying that "the evidence derived from this method is like that which arises from the use of instruments, and of the same kind

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[61] Beddoes, *Observations*, 25.

[62] By "experiment" I do not mean the kind of hesitant, inconsequential process that the word seems to have summoned for Blake (E 513). Instead, I mean "experiment" as mechanical dexterity or ingeniousness (of the kind Stukeley saw in Isaac Newton's boyhood knack for mechanics).

[63] Euclid, *Elements*, ed. Heath, I, 247-8.

with what is furnished by experience and observation." The demonstration of I. 4 is rather "a process of pure reasoning," depending on "the idea of equality" as established *a priori* on the basis of axiom, the axiom that "Things which coincide with one another are equal to one another."[64] Blake's treatment of superposition, though, more resembles that of empirically-minded mathematicians of the previous century, such as Barrow, Hobbes, and even Newton himself. For them, the mechanical generation of geometrical objects had special prominence insofar as it provided a knowledge of causes.[65] Newton, for instance, was aware that the mobility of superposition might appear to furnish him with a classical precedent for what was in truth his own innovation of treating motions as if they, like magnitudes, were geometrical objects, existing in absolute time and space. Thus he claimed, in a revised manuscript "Preface" to the *Principia*, that although "the geometry of the ancients had . . . primarily to do with magnitudes," "propositions on magnitudes were from time to time demonstrated by means of local motion: as, for instance, when the equality of triangles in Proposition 4 of Book I of Euclid's Elements were demonstrated by transporting either one of the triangles into the other's place."[66]

Barrow, in the more generalist of his mathematical writings, *Mathematical Lectures* (*Lectiones mathematicae*, 1665), yet more frankly embraced superposition's mechanical implications, framing it as the simplest of five degrees of congruity—"the most elegant Utensil that belongs to the Furniture of Geometry," according to Willebrord Snell, whom Barrow quotes, approvingly. Those who despise congruity "as savouring too much of mechanical Bungling," writes

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[64] John Playfair, ed., *Elements of Geometry* (Edinburgh: Bell & Bradfute, and G. G. and J. Robinson, 1795), 354; Euclid, *Elements*, ed. Heath, I, 248, 155.

[65] See Helena M. Pycior, *Symbols, Impossible Numbers, and Geometric Entanglements* (Cambridge: CUP, 1997), 135-6; Niccolò Guicciardini, *Isaac Newton on Mathematical Certainty and Method* (Cambridge: MIT Press, 2011), 313-14, 324-6

[66] Whiteside, ed., *Mathematical Papers*, VIII, 455, cited and discussed by Guicciardini, *Mathematical Certainty*, 303-4.

Barrow, "do endeavour to overthrow the very Basis of Geometry, but without either Wisdom or Success." This is because, Barrow says:

> Geometricians do not perform their *Congruity* by the Hand but the Thought, not by the Sense of the Eye but the Judgment of the Mind. . . . Here is no need of Rule or Compasses, no Labour of the Hands, but the Whole is the Work, the Artifice, the Device of the Reason.[67]

In attributing skill and mechanical contrivance ("Artifice" and "Device") to "Reason," Barrow persists in a mechanical strain. This is quite deliberate, first, because he believes that "sensible Observation" has explanatory power, able by appealing to "the common Conceptions of men" to convince non-mathematicians of "the Possibility of Mathematical Hypotheses" (which word "Possibility" is an essential curb on sensation's power).[68] Second, it is significant that "what the Mind demands to be understood, the Hand can execute in Part" because equality is not self-evident —not "implanted in us by Nature," that is (contra Malton and others, then)—but rather "result[ing] from an instituted Comparison of Things" on the basis of defined criteria.[69]

We have already seen Barrow's version of I. 4 as it appears in the first English edition of his Euclid (fig. 8). By the later edition of 1751, diagrams had been dis-embedded from their proposition texts and collected onto separate plates. In Samuel Cunn's *Euclid*, too, in one of the editions sold with Hayley's library (1745), the diagrams were printed without their texts, floating together on fold-out plates, cast off from propositions, albeit visible close by when the plates are opened out

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[67] Isaac Barrow, *The Usefulness of Mathematical Learning Explained and Demonstrated: Being Mathematical Lectures Read in the Publick Schools at the University of Cambridge*, tr. John Kirkby (London: Stephen Austen, 1734), 187-8.

[68] Ibid., 74-5, 201.

[69] Ibid., 188, 198-9.

(fig. 2). The diagram for Cunn's I. 4 has an additional peculiarity: note the curved line added over the base *EF* of the second triangle. We had best understand this line as a diagrammatic aid; its tacit appeal is beyond the proposition to a prior interpolation (which is not Euclid's own, but which is included as an "axiom" or "postulate" by most subsequent editors), the interpolated assumption that "two straight lines cannot enclose a space."[70] All the aid (the arc) is supposed to do is to is to confirm for us that these two triangles are indeed equal.

"Cunns Euclid" (1759) was used "[s]ome time after 1817" by the artist J. W. M. Turner as he was preparing diagrams to use in his lectures as Professor of Perspective at the Royal Academy, a post he had held from 1807. Turner's description of I. 4 evidently follows Cunn in including the diagrammatic aid and posing it above the triangle's baseline (fig. 9).

Photo of W. M. Turner, 'Lecture Diagram: "Euclid's Elements of Geometry," Book 1, Propositions 1 and 4' (detail) removed for copyright reasons. Copyright holder is Tate Gallery.

Yet his diagram is also more painterly, rendered "in bold strokes of red and black watercolor over indications of pencil."[71] Turner's precise choice of materials weighs heavily. His use of color makes

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70 Euclid, *Elements*, I, 225 n..

71 Fredericksen, *Vanishing Point*, 6.

his triangles substantial rather than simply spatial: it means they differ by virtue of pigment, not merely position. It also adds the illusion of depth, something reinforced by Turner's suggestion that the red-painted lines are in the foreground, breaking or obscuring the black ones, even the arc or aid. This, and Turner's running together of the triangles, troubles geometrical space, forcing the issue of mobility which had dogged superposition from its inception. Turner's diagram makes time relative too, displaying the "same" triangle in two, and perhaps three, positions at once: two positions, as if anticipating the triangles' perfect congruence, or three, if our familiarity with conventional representations of the diagram is such that we can also imagine the triangle *ABC*'s position further to the left of triangle *DEF*, before Turner got his hands on it. As conceded by Lessing's *Laocoon* (1766), it was possible in this way to temporize painting; the artist might "fin[d] his advantage in exhibiting . . . two moments at one and the same time."[72] The convention of using sanguine for preliminary drawings further works to temporize even what Euclid's proposition assumes as given, the two triangles now implied by Turner's coloring to have been generated one after another.

Blake's *Newton* seems similarly to catch superposition in the act. Look again at Newton's body, as not "lured into . . . mathematical parody" but drawn into activity. Look again at his compasses, as not "alienated instruments" but "extensions of his hand."[73] When we bring these compasses into play, when we treat them dynamically, as not only demonstrating but enacting congruity, triangles beginning to overlap in Turner's diagram in Blake's might share a common base, with the sides and vertex of one triangle marked by the compasses, and the sides and vertex of the other marked below, on the parchment scroll.[74] Practical geometry had long been explicit about the role of instruments in construction, not simply as they were used to measure and transfer line-

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[72] G. E. Lessing, *Laocoon*, ed. and tr. Robert Phillimore (London: Macmillan, 1874), §18, 172-73.

[73] Mitchell, "Chaosthetics," 455.

[74] Thanks to Rod Haggarty for his discussion of this point.

lengths, but also, on occasion, as they were literally made manifest in proof. By Beddoes' "experiment[al]" demonstration of I. 4, for example, one might work superposition either literally, with "a model of each triangle cut out in pasteboard," or "imagin[atively]," "if the triangles be only traced upon a surface." Beddoes' demonstration is founded on "experiment[al]" construction, which "shew[s what angles and lines are]": "a carpenter's rule may be opened and shut to various angles," writes Beddoes, "and one carpenter's ruler may be placed over another." In Blake's color print, the substantialness of the compasses is heightened by his use of tone, shadow, and lustre. These add to the illusion of depth, created too by the foreshortening of the figure on the scroll, and its apparent folding in and out of the picture-plane. The triangles' two vertices map the moments of its movement, folding between dimensions, and keeping the plastic (the three-dimensional model) as well as the projective (the two-dimensional drawing) in play. Such dynamism was exploited by geometrical textbooks: Henry Billingsley and John Dee's first English edition of Euclid's *Elements* (1570), printed by John Day, used folding diagrams and cut-outs to illustrate solid geometry and its constructions, and the practice persisted in the eighteenth century in John Lodge Cowley's geometrical origami (*An Appendix to the Elements of Euclid*, 1758). It would be possible to mis-read the diagram of *Elements* I. 8, too ("the side side side (SSS) theorem of the congruence of triangles"), as showing just such a fold (fig. 10).

Photo of Euclid's *Elements* I. 4 and I. 8 (detail) in Cunn's Euclid removed for copyright reasons. Copyright holder is British Library.

But the diagram in Blake's *Newton* seems set in its resemblance to I.4, the right hand of the geometer working like a manicule to remind us of the axiom that two straight lines cannot enclose a space. Perhaps this insinuates Blake's association of Isaac Newton with the more axiomatic, that is, the more speculative or abstract, parts of geometry. But it could also be *by* geometry—by the *practice* of geometry—that Newton might be redeemed, if not (in this case) by his drawing of lines, then by the action of placing his compasses, drawing in the diagram thus palpably to proof.

In this way the *Newton* print might temporize geometry's very origin, exhibiting demonstration as practical intelligence rather than act of pure thinking. It might also allow geometry to coexist with artistry,[75] especially as the folding and unfolding triangle inscribes the plural origin of painting in Pliny's *Natural History*, in an anecdote about Boutades' daughter we know Blake knew.[76] In Pliny, painting begins once "in tracing lines round the human shadow," and once (or more) again, in the action of the potter Boutades, filling with clay an outline drawn by his daughter of her beloved. There is a fold, here, between practice and theory, palpation and projection, mechanics and an appeal to the mind's eye—a dialectic of anteriority, at the fountain-head of practical geometry and poiesis alike.

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[75] Thanks to the first *SiR* reader for suggesting a link to Boutades.

[76] See William Blake, "Design for a fan (?), The Corinthian maid, the origin of painting" (c. 1795), British Museum, BM 1874,1212.147.

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