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Picture, Object, Puzzle, Prompter: Devilish Cleverness in Restoration London

Matthew C. Hunter

'A sharking and indigent fellow while he lived in *Oxon*, and a great pretender to the art of Dancing': such are the terms in which a contemporary cast seventeenth-century English poetaster William Hicks.[1] Twister of yarns and turner of jigs, Hicks fashioned doggerel verse from seemingly every ephemeral, urbane amusement he could cram into Homeric couplets. A trifle included in Hicks's miscellaneous *London Drollery* (1673), '*His Answer to Madam* E.C. *Upon her Curious Art in Cutting Figures in Paper; and other her Artificial Curiosities*' is exemplary in form and content. Deftly slicing paper into vegetal and animal forms, the poem's mysterious muse, Madam E.C., performs a strange magic. Before these now-lost cut-paper flowers, we read, Restoration London's jaded tribes of '*Curiosoes*' had been brought up stock still in shocked disbelief; even the 'Painters do confess 'tis done so well, / They thought 'em natural, onely for the smell.'[2]

As the poem unfolds, the muse's cut creations appear more subtly corrosive than these mere tricks of the eye. Inverting the traditional mimetic hierarchy that made art the handmaiden to Lady Nature, Madam E.C.'s wiles even threaten to erase the male artist's position as guardian of patrilineal order.[3] Hicks's narrator puts the point this way:

> 'Tis rare to see a Female Herald; yet you,
> When of your Curiosities I took a view,
> I saw some Coats of Arms so exactly done,
> The Painters Pencils with Scissars Y'ave out-gone.[4]

By the poem's end, this inexorable pruning and cropping of pencils and paper has begun to menace the very loquacious, inky spread that was the stock-in-trade of a hack like Hicks. Putting paid to the presentation of an absent author conventionally attributed to his verse epistle's poetic form, Hicks concludes the work by staking his own art and monstrously magnified agency against that of his muse.[5] The narrator vows

> That I had a thousand Eies,
> On Your Mysterious Art I would fix,
> So long as I am call'd *W. Hicks*.[6]

So completely does this wily, feminine negativity and its fragile paper medium reverse natural and social orders that only a lifetime of surveillance with a five-hundredfold multiplication of human optical power could possibly master its mysteries.

Detail from engraved fold-out with moveable mica window, from Joseph Moxon, *Practical Perspective: or Perspective Made Easy*, 1670 (*plate 6*).

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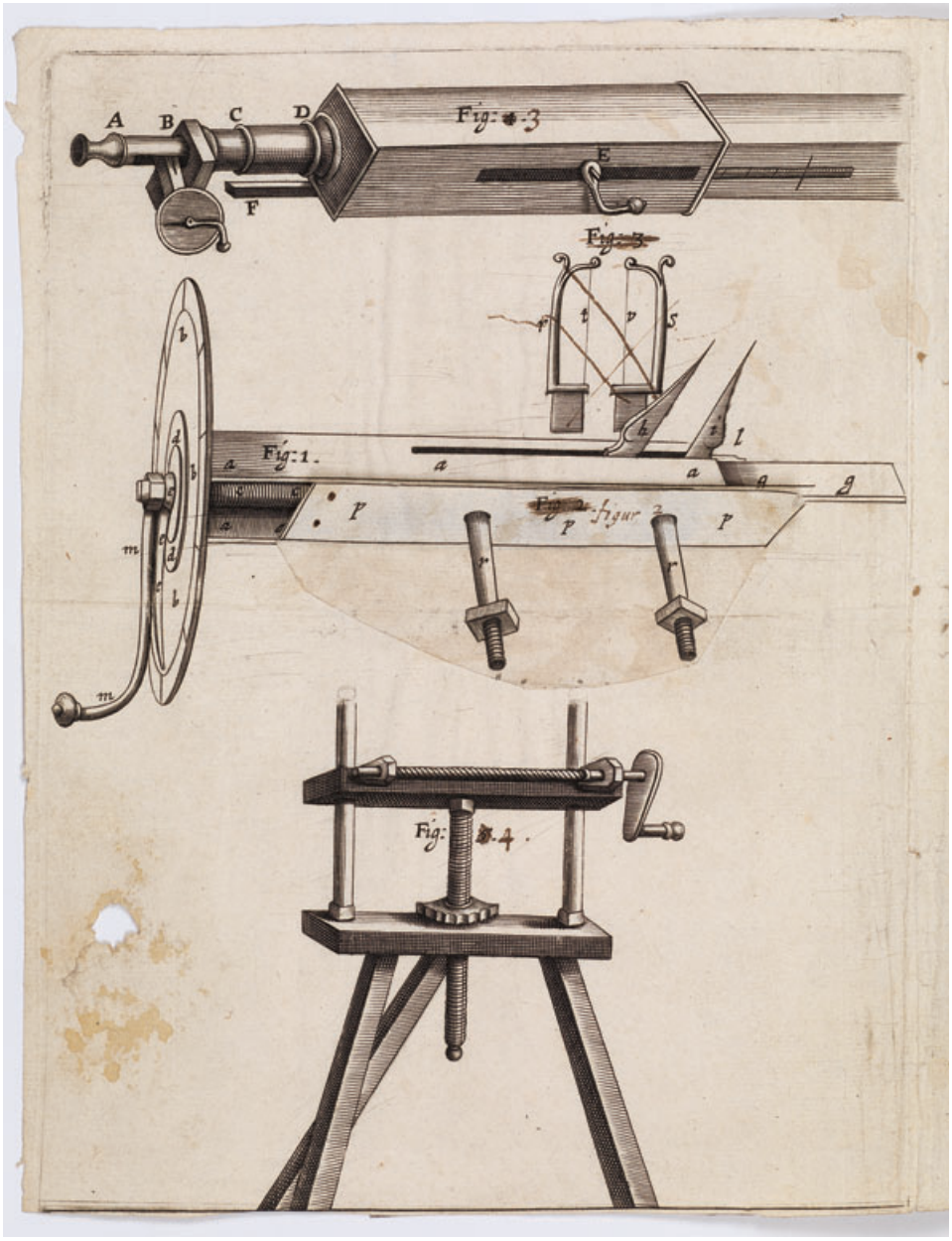
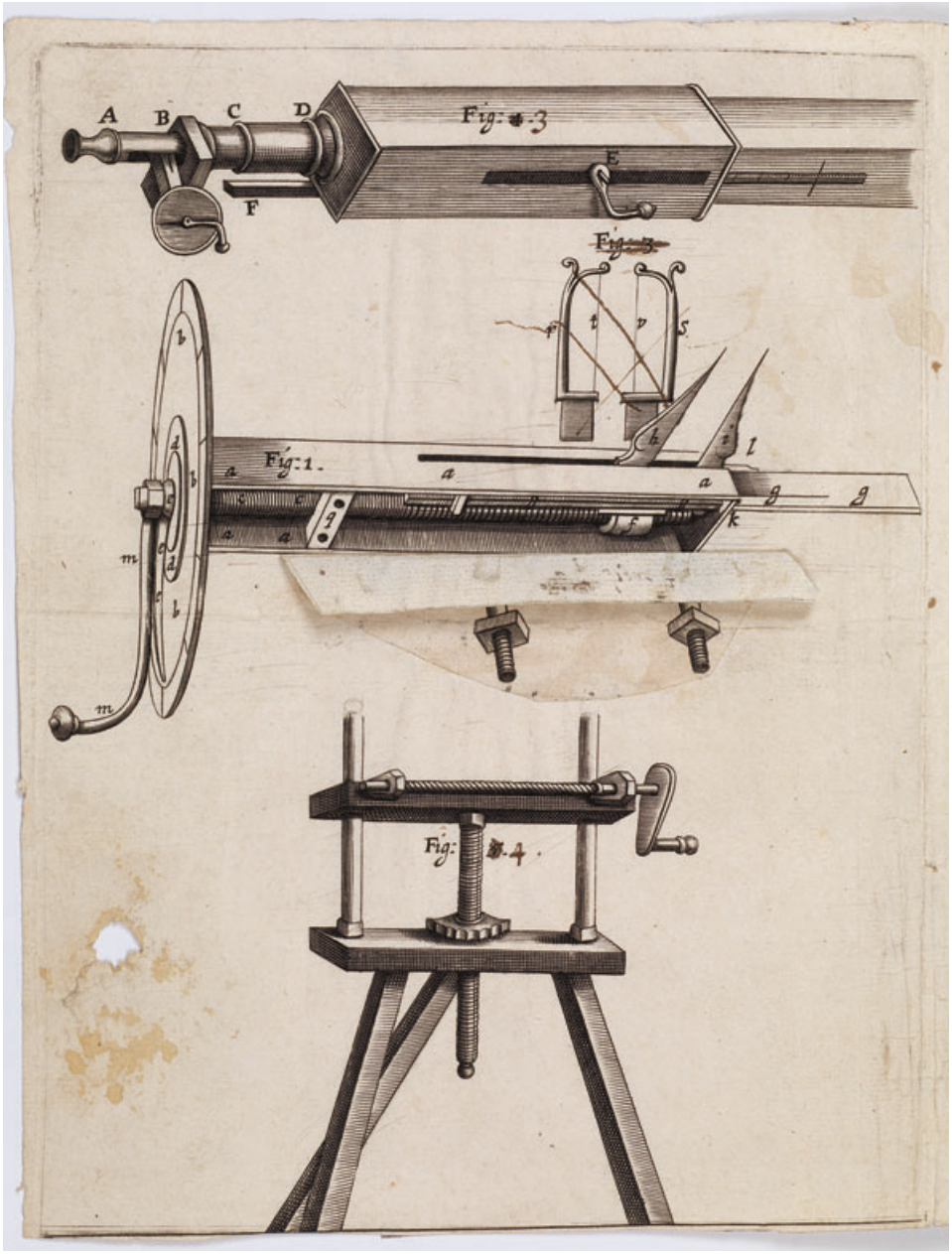


1 Robert Hooke, design for the printed representation of Towneley's micrometer with paper patch closed, from *Philosophical Transactions*, 29, 11 November 1667, n.p., now bound into Register Book (Original), 3, 227–330. 220 × 170 mm. Photo: © The Royal Society.

William Hicks's encomium to the arts of cut paper might sound outlandish were it not for a growing body of scholarship that has ratcheted the stakes still higher. Acts of cutting paper apart and pasting it back together were central, it is claimed, to the ways in which men and women in early modern Europe read,[7] travelled through space,[8] integrated information,[9] produced their books,[10] and understood their drawings.[11] Historians of science now study the agency of 'paper-tools' in Enlightenment chemistry while theorists like Bruno Latour have located the very power of Western science in its strange, defining alchemy: 'the transformation of rats and chemicals into paper'.[12] Made from the work of rats like Hicks, this article tells the tale of a specific cut-paper object that came into existence at a nexus of manual skill, technological competition and frankly wild speculation among leading French and English agents of the early Scientific Revolution during a tumultuous, two-year period in the mid-1660s.

A paper model of a telescopic micrometer, this object – my candidate clever object – was designed and drawn by English experimentalist Robert Hooke, working in

collaboration with London book-seller John Martyn and an unknown engraver (*plate 1* and *plate 2*). Although only a few assembled examples of this object survive, any talk of rarity is misleading.[13] The model was made as a multiple, to be printed, cut, pasted and sold by Martyn from his shop in St Paul's churchyard. Elucidating this entity's birth as a picture and its maturation as an object in the hurly-burly of 1660s experimental life, this article aims to elaborate the broader varieties of shape-shifting to which it gave rise and to theorize that materialized intelligence *qua* clever objecthood. My argument has two parts: first, I propose that a crucial component of the cleverness of Hooke's paper micrometer derives from its likeness to a puzzle. This 'positivist' story proceeds by reconstructing the experimental, visual and ethical conflicts in which Hooke's paper model emerged so as to illuminate its elegant, puzzle-solving wit. The second component of my argument turns the situation around; I elucidate how we should understand the relations between what Hooke and his milieu called 'art' and artefacts



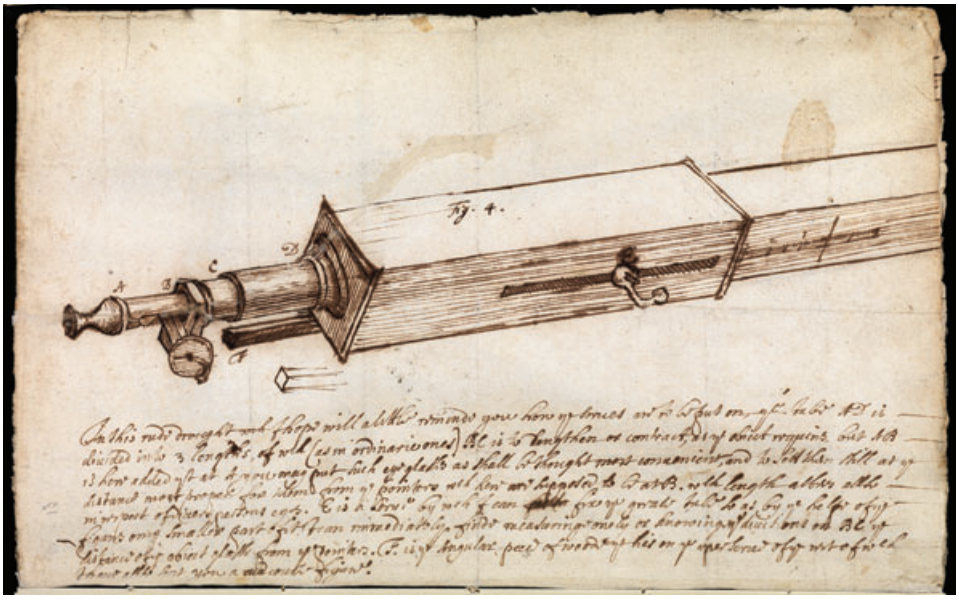
2 Robert Hooke, design for the printed representation of Towneley's micrometer with paper patch opened, from *Philosophical Transactions*, 29, 11 November 1667, n.p., now bound into Register Book (Original), 3, 227–330. 220 × 170 mm. Photo: © The Royal Society.

like the cut-paper micrometer. As opposed to the astonishing creations of Hicks's Madam E.C. or to the devious artistic entrapments contemporaneously narrated by Hooke, I argue, a clever object in later seventeenth-century London is that which could both solve puzzles and also undermine its own authoritative structure, prompting and stimulating new imaginings. Like cut paper itself, the clever object bodied forth by Hooke is literally positive and negative simultaneously; it is both trap and trapdoor.

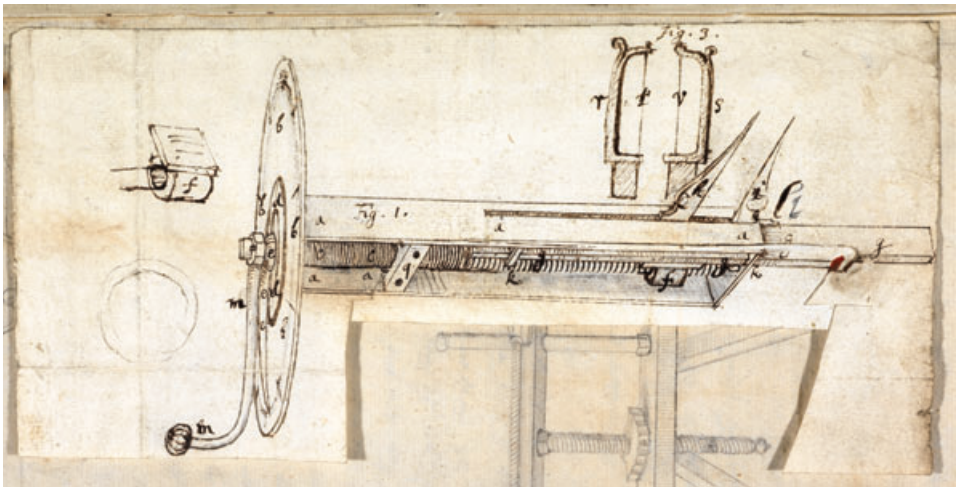
Picture, Object: The Backstory

In late December 1666, astronomer and member of Paris's newly constituted Académie des sciences, Adrien Auzout, wrote to the Royal Society of London, England's leading scientific institution, announcing his new method for dividing 'one foot into 24000. or 30000. parts'.[14] Auzout knew that London's experimental philosophers would quickly recognize the keen advantages to astronomical and terrestrial observation entailed by such a technique. It would allow an observer to measure the size and position of objects sighted through a telescope at incredible precision, thus insuring the exactitude with which planetary orbits or the distance and speed of military targets could be calculated. Within months, Auzout's priority and proclaimed technical supremacy were indeed challenged by English astronomer Richard Towneley. Writing in the wake of London's devastating 1665 plague and fire of 1666 – and on the eve of England's ignominious defeat in the Second Dutch War – Towneley proclaimed that he would be 'look't upon as a great Wronger of our Nation' were he not to advance his achievement.[15]

Using instrumental techniques developed by a fellow Yorkshire mathematician in the 1640s, Towneley claimed to have crafted a telescopic micrometer with a precision far superior to that asserted by Auzout. 'It is small,' Towneley explained, 'not exceeding in weight, nor much in bigness, an ordinary pocket-watch, exactly marking above 40,000 divisions in a foot, by the help of two indexes.'[16] The instrument, as historian of science Allan Chapman elaborates, 'used a pair of fine-pitched screws to move two pointers in the focal plane of a Keplerian telescope. ... By enclosing the object to be measured between the pointers, its angular diameter could now be computed to within a few arc seconds, if one knew the exact focal length of the telescope, and the pitch of the screw that moved the pointers.'[17] What was visualized in the folio-size ink drawing that Towneley sent to the Royal Society in the summer of 1667, though, was



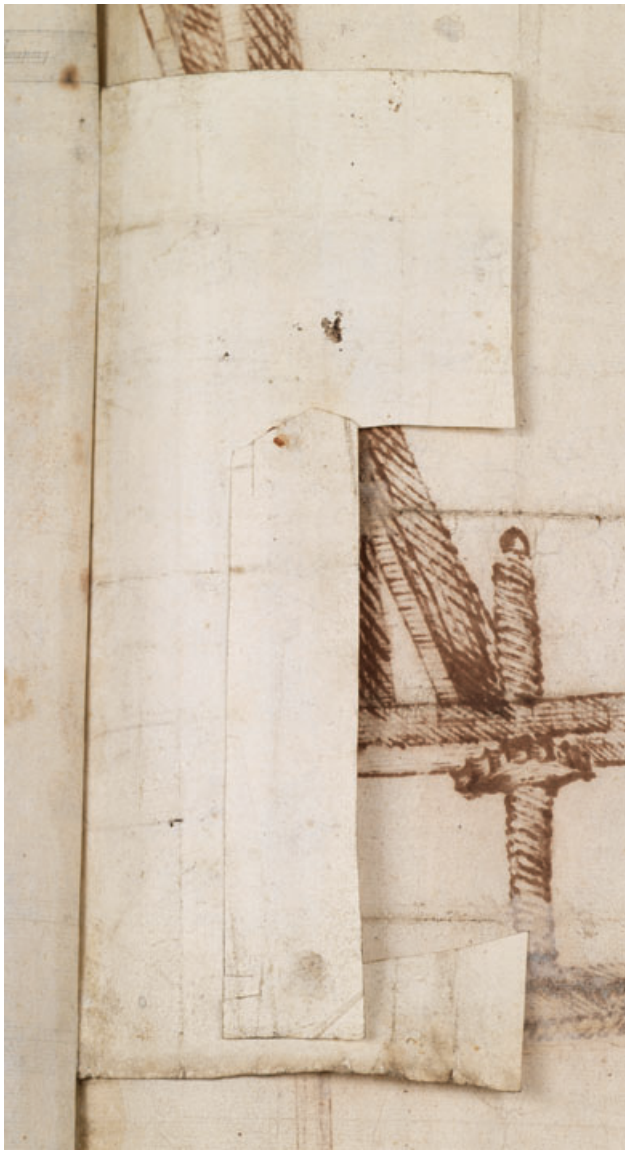
3 Richard Towneley, ink drawing of a telescope installed with a micrometer sent to the Royal Society, 1667. 310 × 196 mm. London: Royal Society (Classified Papers, 2, 13). Photo: © The Royal Society.



4 Robert Hooke, ink and pencil drawing of Towneley's micrometer, autumn 1667. 310 × 196 mm. London: Royal Society (Classified Papers, 2, 13). Photo: © The Royal Society.

not this mechanism, but the micrometer put into action (*plate* 3). From the darkened inlet of an hour-glass-shaped eyepiece at left (labelled A), Towneley's telescope spans the horizontal axis of the page, progressing from a sequence of moveable, circular stems to the square, adjustable shaft of the focal plane. Inward from the eyepiece and just below the letter B, we are shown the outward-turned face of the micrometer. Rupturing the image's perspectival construction in its emphatic frontal address to the picture-plane, this minutely calibrated face and the upward-slanting, hatched casement are all Towneley shows us of his micrometer. As would have been required for its use, the device's intricate pointers have disappeared into the telescope's focal field. Like its detailed inscription and the depiction of the instrument stand sent along with it, Towneley's drawing presents the micrometer as one component among several broader improvements to telescopic technique.[18]

Profiting from collaboration yet keen to assert priority, depicting his instrument without divulging its essential design, Richard Towneley's representations of his telescopic micrometer register the tectonic pressures impinging upon authorship at the intersections of art, science and technology in the early Enlightenment.[19] In his case, Towneley's bet-hedging precautions were entirely justified. Already pre-empted by Auzout, Towneley found a new claimant upon his micrometer in the person of Robert Hooke (then Curator of Experiments to the Royal Society) who closely shadowed the instrument's development. When note of Towneley's device was first published in Henry Oldenburg's *Philosophical Transactions of the Royal Society of London* in May 1667, Hooke responded with a short piece in the same volume entitled, bluntly, 'More Wayes For the Same Purpose'.[20] When it appeared in the Royal Society's Register Book (the institution's central mechanism for archiving significant research and allocating inventive priority) in mid-November 1667, the micrometer was likewise noted as 'being contrived and sent by Mr. Richard Towneley to the R. Society, and this following description of it being made by Mr. Hook was read before the Society.'[21] And as he printed visualizations of the micrometer on 11 November 1667 (see *plate* 1), Oldenburg credited 'the ingenuity of Mr. Hook' not only for negotiating between the far-flung Towneley and local engravers, but for 'the draught of the figures, representing the new instrument it self, and the description of the same'.[22] While it is clear that two of the graphic images published by Oldenburg – and contemporaneously copied into the Royal Society's register – derive directly from Towneley's original drawings, the image that alone depicts the mechanical features of the micrometer in any detail is that which sprang from Mr Hooke's formidable cleverness.[23]



5 Verso of Robert Hooke's drawing of Towneley's micrometer revealing where and how it has been cut and pasted back together, autumn 1667. 90 × 199 mm. London: Royal Society (Classified Papers, 2, 13). Photo: © The Royal Society.

In the pencil and ink draft he made for this engraved figure, Robert Hooke's cunning can be observed as if in slow motion (*plate* 4). Hooke's drawing has fundamentally altered our point of view; Towneley's micrometer is now seen from the side, its face appearing like a flywheel in oblique perspective. By rotating the handle at extreme left, we can infer, the axle-like screw at the instrument's core turned, moving the wing-like pointer (marked with a cursive h in the drawing) threaded to it. Protruding upward through an incision in the micrometer's casement, this index would have been visible through the telescope's focal plane where it could measure features of observed targets relative to its stationary twin at right. Yet, Hooke's drawing not only alters the pictorial schemata and point of view through which we see Towneley's device; it manifests a restlessness with existing form, a desire to mutate the object itself. Directly above the micrometer's wing-like sights in the drawing is a small figure labelled 'fig. 3'. As Hooke explains, this figure denotes an alteration proposed by 'some ingenious men' to enhance the micrometer's functionality: 'two sights fitted with hairs … may be conveniently used in the place of the solid edges of the sights.'[24] Omitted from the version of Hooke's drawing copied into the Royal Society's official register, Hooke's pictorial additions betray his regard for the Towneley micrometer as an evolving design rather than as a static, authorized object – a view clearly not shared within the Royal Society.[25]

Far more radical volatilities were subtending Robert Hooke's engagement with the micrometer, however. As the material facture of his preparatory drawing demonstrates, Hooke was deeply ambivalent about how to represent Towneley's precision instrument. Must a depiction of such a device confine itself to detailed denotation of the instrument's exterior? Or should the delicate, moveable mechanics (parts that would have been concealed both by the casement and through their insertion into the telescopic tube when in use) be shown by pictorial means? At the outset, Hooke clearly preferred the first option; he began to depict the micrometer from the side with its lower casement panel and threaded attachment screws projecting perspectivally outward toward the beholder, much in the manner as the device appears in the *Philosophical Transactions* engraving (see *plate* 1). But, Hooke fundamentally revised this approach *in media res*. Using a razor or knife, he cut away the portion of his drawing depicting the lower casement and screws. The damage inflicted upon the existing page is substantial; nearly a quarter of its surface has been removed (*plate* 5 and see *plate* 4). Then, with red wax – material that remains visible at the far right corner of the incision – Hooke attached a patch to the back of his dissected drawing. On the recto of this thin strip, he drew a detailed representation of the micrometer's interior mechanics, drafted so as to appear continuous with the existing image. As its surviving form suggests, the pictorial continuity of front and back, wounded page and patch, is nearly seamless.

Robert Hooke's incision into his micrometer drawing might be dismissed as an incidental exigency, a practical remedy to a graphic error or, as it is known to connoisseurs of drawing, a *repentance*.[26] After all, Hooke's drawing was to be seen only by the engravers, a pragmatic lot for whom the excess expenditure of labour required to redraw fine details of micrometer-innards would have been unnecessary. Yet, when preparing the engraving of his drawing for the *Philosophical Transactions* in mid-November 1667, Hooke effectively reversed the surgery he had performed upon his own drawing, insisting upon the beholder's haptic encounter with the representation. He devised an engraved pictorial patch showing the outer casement and screws of the micrometer, which was to be cut and pasted on top of the printed image of the micrometer's interior. Through this pasted paper addendum, the beholder could toggle between views of the interior or exterior of the micrometer (see *plate 1* and *plate 2*). In an explanatory text from the *Philosophical Transactions*, Hooke stipulated that 'Fig. 2. represents the moveable cover containing the screws, to be by the bookseller cut off by the pricked line (x x x) from the paper, and to be fitly placed on Figure 1.'[27] Consequently, the depicted micrometer *qua* paper instrument could be seen in two distinct ways: 'By the taking off, as it were, or folding up of this cover, the inward contrivance of the screws and sights may appear.'[28] Inside and outside could be seen effortlessly, at will.

6 Engraved fold-out with moveable mica window, from Joseph Moxon, *Practical Perspective: or Perspective Made Easy*, London, 1670, 7. Dimensions variable. Photo: © The British Library Board (BL 786.1.24).

In one of his dialogues, Greek satirist Lucian tells the tale of a simpleton named Momus who is elected to judge a trial of skill between three gods. Neptune makes a bull, Minerva crafts a horse, Vulcan fashions a man, and their referee inspects them. Giving proof of his incompetence in judging and judgment, Momus finds Vulcan's work most wanting 'for not making a door in his man's breast, to open and let us know what he willed, and thought, and whether he spoke the truth or not.'[29] Instead of demonstrating any particular cleverness, so a sceptic might protest here, Robert Hooke's patched micrometer commits a folly similar to Momus's door. By privileging concretized visibility, it distorts both key relations within its target and the criteria proper to assessing them.[30] Intoxication by such virtuosic but ultimately obfuscating visualization was certainly not unusual in Restoration London. No more powerfully was it demonstrated in Royal Society circles than by the strange assemblage of printed page, glue and mica crafted by Hooke's friend Joseph Moxon as a model of the principles of pictorial perspective (*plate 6*).[31] As with Moxon's belated, seemingly excessive perspectival demonstration, we might ask, why would Hooke have made an object like this? What, if anything, is especially clever about it? And how can it illuminate the category of the 'clever object' more broadly conceived?

Seeing, Violently

Robert Hooke's cut-paper micrometer was assembled, and assembled quickly, in the first weeks of November 1667. But, as I argue in this section, the puzzles it resolved – the constitutive contexts that make its cleverness manifest – had been unfurling for the better part of a decade.[32] Beginning concertedly in the summer of 1662, several different programmes of experimental research in England had been moving closer together, converging upon a workable account of respiration.[33] From the days of their collaborative experiments on the physics of air in the later 1650s, Hooke and Robert Boyle had played an important role in that conversation. Working from the evidence of birds and small mammals that sickened or died in the vacuum chamber of Hooke's air-pump, Boyle explained the influx of air into the lungs through a decrease in pressure as the bellows-like construction of the chest dilated.[34] As Boyle and Hooke collaborated to identify chemical components in air essential to life, physicians like William Croone in London and Walter Needham in Oxford were co-developing a powerful programme of experimental vivisection. Their trials demonstrated that withholding air from a creature would cause its vital signs to diminish rapidly; but should air be promptly pumped back into its lungs, the asphyxiated beast could often be resuscitated and restored to full health.[35] What these overlapping chemical, anatomical and experimental studies were seeking was as much an understanding of respiration as of observable relationships between systems – how the respiratory and circulatory systems connected to one another and, specifically, whether any 'visible passage' could be identified between them.[36]

The programme of experimental anatomy that Robert Hooke perfected in London between autumn 1664 and summer 1668 amounted to a radical visualization of relations between these systems.[37] Hooke's method was as simple as it was brutal. Removing the animal-subject's rib cage and the tissue encasing its heart, he would sever its wind-pipe, replacing natural respiration with a supply of air fed into the lungs by a tube connected to bellows. Mechanically controlling the influx of air into the beast's body, visible effects upon vital organs caused by the privation or artificial provision of air could be observed directly. This is how Henry Oldenburg, Secretary of the Royal Society, reported Hooke's paradigmatic trial of this experiment in early November 1664:

> By means of a pair of bellows (when the thorax was laid quite open, and ye whole *venter infirmus* also) and a certain cane thrust into the wind pipe of ye Animal, ye heart continued beating for a long while, at the least an houre, even after the diaphragme had been cutt away in great part, and ye pericardium removed from the heart. ... ye motion of ye heart seemed very brisk and lively, after an houres time from ye first displaying ye diaphragm; and upon removing ye bellows, ye lunges would presently begin to sink, and ye heart begin to have irregular, thick, and convulsive motions: but upon renewing ye motions of ye bellows, ye heart recovered its former motion, and the irregular one ceased.[38]

Here, we are in the thick of experiment in its historically novel, 'Baconian' sense.[39] No longer an illustration or exposition of *a priori* principles, experiment had become the privileged means for producing new facts by putting nature to the rack of the torturous 'vexations of art'.[40]

If both scientifically productive and morbidly fascinating, these experiments revolted philosophers like Robert Hooke. In a letter to Boyle written soon after the experiment's first trial in November 1664, Hooke staked out a conflict between the visual interests at the core of his trials and a disgust at their violence.[41] Acknowledging the pre-eminent place of vision in his thoughts, Hooke promised to analyse 'refractions also of the parts of the eye & of each of which as fast as I can make them'.[42] From this dry, 'ballistic' account of vision, the letter quickly turned to the uncomfortably liquid body of his anatomized dog.[43] 'The other experiment (which I shall hardly confess make again because it was cruel),' Hooke writes, 'was with a dog which by means of a pair of bellows wherewith I filled his lungs and suffered them to empty again.'[44] Where Oldenburg narrated this event in neat, passive-voiced constructions, Hooke is unequivocal in stating his agency. 'I was able,' he claims, 'to preserve [the dog] alive as long as I could desire, after I had wholy open'd the thorax and cutt off all the ribs and open'd the belly nay I kept him alive above an houre after I had cutt off the pericardium and the mediastinum.' Nor was Hooke ambiguous about the pain and suffering to which his test-beast had been subjected. 'I shall hardly be induced to make any further tryalls of this kind,' he pledges, 'because of the torture of the creature.'[45]

Hooke's recognition of wickedness – of cruelty, 'torture' – in his treatment of animals is striking.[46] A sympathetic reader of René Descartes and a noted practitioner of mechanical philosophy, Hooke might well be expected to have understood animals after the model of machines (*plate 7*).[47] Commenting on the sole target of his 1660s vivisection experiments that he actually drew, Hooke indeed deployed the language of machines as a term of praise. 'The contrivance for erecting and retracting, or sheathing the teeth' disclosed in this English viper, Hooke wrote, was 'very pretty, and like all other articular motions of the body very mechanical.'[48] Because he possessed this conceptual framework for understanding beasts as machines, it is tempting to think that any qualms induced by his experiments' violent literalizations – their concrete fusions of beast-machines and mechanical devices like bellows – could have been peremptorily dismissed.[49]

7 Robert Hooke, ink drawing of the head of an 'English Viper', 23 November 1664. 50 × 80 mm. London: Royal Society (Register Book [Original], 3, 65). Photo: © The Royal Society.

Yet, as his mentor Boyle had earlier done, Robert Hooke systematically developed a range of prophylactic

measures in the mid-1660s by which to shear his visual excavations from their hideous violence.[50] In *Micrographia* (1665), Hooke advocated for the microscope specifically on the grounds that it enabled the philosopher to see deeply and invasively but without destroying the target of inspection. The microscope proves miraculous, Hooke writes, 'for the discovery of Nature's course in the operations perform'd in Animal bodies, by which we have the opportunity of observing her through these delicate and pellucid teguments of the bodies of Insects acting according to her usual course.'[51] The advantage to the student of Lady Nature over conventional vivisection was undeniable:

> Whereas, when we endeavour to pry into her secrets by breaking open the doors upon her, and dissecting and mangling creatures whil'st there is life yet within them, we find her indeed at work, but put into such disorder by the violence offer'd, as it may easily be imagin'd, how differing a thing we should find, if we could, as we can with a *Microscope*, in these smaller creatures, quietly peep in at the windows, without frighting her out of her usual bias.[52]

Because of the transparency of insects' protective exoskeletons, microscopic observation could provide visual access to interacting bodily systems in ways utterly foreign to the violent methods of the gross anatomist. And although no comparable optical technique could then allow the philosopher to 'quietly peep in' to the bodies of the larger beasts of his experimental trials, Hooke was eager to defray the cruel cost of their visualization by anesthetic techniques contemporaneously developed by colleagues like Christopher Wren.[53] 'Certainly,' Hooke noted of his ongoing vivisections, 'the inquiry would be very noble if we could any way find a way to so stupify the creature as that it might not be sensible wch I fear there is hardly any opiate will performe.'[54]

Influential accounts of early modern visuality by Svetlana Alpers and Barbara Maria Stafford have asserted the delight taken in probing, dissecting, flaying and otherwise anatomizing targets of observation especially among artists and experimentalists of Northern Europe.[55] What I would emphasize here is the extremity of Robert Hooke's struggle to stabilize such rupturing sight by means of instrumental and psychotropic supports. Against conventional vivisection, Hooke had argued, microscopic seeing would enable a beholder to look inside organic bodies without either ruining them or implicating the experimentalist's disfiguring presence in the scene of violent observation. Prying into interacting organs of living animals or peering through their window-like bodies were thus ignoble enterprises if, and only if, the target beast was 'sensible' of its inspection. If an animal could be sufficiently 'stupefied' or anaesthetized, then the experimental vivisectionist would not only be freed from implication in torture, but the trial could be elevated to true nobility. By transporting the animal into an opiate-induced torpor, that is, the probing investigator would spare the creature sentience of its physical violation and nullify the charge of cruelty against himself.

Whatever we make of Hooke's tortured ethical reasonings, the crucial point is this: by early years of the Restoration, experimentalists in England had come abreast of a conflict between a desire to see into the very depths of organic life and a repulsion at the stain caused by indulgence of such morbid seeing. In the first instance, I argue in the next section, the cleverness of the paper micrometer that Robert Hooke crafted in the late autumn of 1667 – a moment coincident precisely with the resumption of his experimental vivisection trials – derives from its ability to address this conflict, to transform its menacing dynamics into a puzzle.[56]

Puzzling

Like many acts of cunning, Robert Hooke's paper micrometer came together through some quick-witted, ruthless opportunism.[57] On 24 October 1667, approximately three weeks before Hooke's patched print off went to press, mathematician and then-recent Fellow of the Royal Society John Collins donated a collection of books to the institution's library. Among this donation (and signed by Collins himself) was an incredible specimen of anatomical representation: Johannes Remellin's *Catoptrum Microscopium* (1639).[58] In a series of prints of formidable complexity, Remellin's engraver Stepan Michelspacher had depicted full-length male and female bodies as figures that a beholder could open in a 'paper dissection' to reveal upwards of eleven layers of printed, cut and pasted viscera (*plate* 8 and *plate* 9).[59] Given the highly public nature of Collins's donation and the bibliophilic Hooke's intimate connection to the Royal Society library, it is impossible to escape the conclusion that Hooke would have become aware of Remellin's work in late October 1667.[60]

Before exploring how Hooke cleverly put Remellin to work, the immediate chronology of events needs to be recapitulated. It is this: in the spring of 1667, Richard Towneley sends word and then images of his newly revamped micrometer to London, contesting the claims of Adrien Auzout. Robert Hooke takes keen interest in Towneley's device; by the early autumn of 1667, he produces a pencil and ink drawing depicting the micrometer at close range with its interior mechanics concealed, likely based upon first-hand knowledge of the instrument. With the onset of the cooler autumn weather preferred across Europe for anatomies, Hooke simultaneously recommences a programme of fascinating but repulsive vivisection experiments as Johannes Remellin's volume is publicly donated to the Royal Society. Because Hooke is already conceptually equipped to think of beasts as machines, the arrival of Remellin's fold-out depictions of human anatomy in late October 1667 suggests a way to turn the analogy around, to represent machines after the manner of organic bodies.[61] Thus, by the second week of November 1667, having cut apart his existing machine drawing and repaired it with a pictorial patch, Hooke designs a fold-out print inspired by Remellin. Not only did this resulting paper object show Towneley's device open and closed at the user's pleasure, but it could, as it were, nobly gratify a morbid, penetrative desire to see – a desire Hooke possibly shared with contemporaneous painters in the Northern European tradition, but one that had explicitly haunted his colleagues' experimental work since the 1650s. Responsive to broader artistic and experimental currents yet reducible to neither, the cleverness of Hooke's object devolves, in this first instance, upon its ability to liquidate visual and ethical conflicts through opportunistic, conceptual flux or, as I will argue momentarily, to solve a puzzle. Pilfering shamelessly from Remellin and sacrificing the physical integrity of his own micrometer drawing, Hooke's object could ingeniously represent its mechanical target while simultaneously delivering provocative visual fantasy in an unthreatening, paper form.

Now, as theorists of various intellectual stripes remind us, modern science – that enterprise traditionally seen as inaugurated by Robert Hooke and his colleagues – is veritably defined by its ability to reduce the buzzing, blooming chaos of the natural world to radically simplified forms.[62] The efficacy of 'normal' or paradigmatic science is contingent, so Thomas Kuhn famously put it, precisely upon its targeting of only those problems reducible to the conditions of the puzzle. Because solutions to such problems are guaranteed to exist, the investigator can confidently proceed in the conviction that 'if only he is skilful enough, he will succeed in solving a puzzle that no one before has solved or solved so well.'[63] Hooke's paper object surely deserves to be seen as puzzle-like in this sense.[64] It is innovative neither in its conceptualization of the machine/animal

analogy nor in the practical terms of how to represent interior and exterior views of a target simultaneously; these solutions were guaranteed by the paradigmatic works of Descartes and Remellin, respectively. However, Hooke's paper micrometer concretizes these conceptual and practical models in an elegant, highly efficient way. What had been unmanageable and obstructive in two discrete domains becomes luciferous when ingeniously combined. As with a Kuhnian puzzle or other pursuit where the existence of a successful resolution is guaranteed, moreover, the criteria for assessing these intentional, 'positivist' ends of Hooke's object would effectively be aesthetic.[65] What matters is neither the intrinsic interest of the question to be solved nor its originality as a problem, but the economy, grace, and ingenuity by which the solution is achieved in practice.[66]

Noting the economy and efficiency with which it fulfils its puzzle-solving ends, might we not simply think of Robert Hooke's paper micrometer as an *artistic* object of

8 Stephan Michelspacher, engraving of female anatomy with paper patches closed, from Johannes Remellin, *Catoptrum Microscopium*, Ulm, 1639, n.p. 490 × 370 mm. Photo: © The Royal Society.

9 Stephan Michelspacher, engraving of female anatomy with paper patches partially opened, from Johannes Remellin, *Catoptrum Microscopium*, Ulm, 1639, n.p. 490 × 370 mm. Photo: © The Royal Society.

paradigmatic science? After all, Hooke not only trained as a painter, but no shortage of critical commentary has asserted an aesthetics of 'plain style' as a crucial desideratum shared between experimental philosophy, literature and the visual arts in seventeenth-century England.[67] Albeit in very different terms, categorizing Hooke's paper micrometer as an art-object will indeed find still further support as we take into account the varieties of imaginative play to which it gave rise. Nonetheless, as I argue in the next section, what is most interesting – and most instructively understood as *clever* – about Hooke's cut-paper creation is the traffic between puzzling and prompting enabled through it. By considering the kinds of power that Hooke and his contemporaries attributed to artists and their works, these cognitive actions and the ontology of their objective props will appear better apprehended by altogether different criteria.

Aesthetics of Entrapment and the Artist's Intelligence

If a puzzle-solving capacity of Robert Hooke's paper micrometer may be allowed, attribution of intelligence or cleverness to such an artefact is an admittedly precarious business. In the mid-1660s, Hooke himself was using relations between animals and machines to elaborate just such a point. 'When we find Flies swarming, about any piece of flesh', he observed, we should not explain their behaviour by crediting any intelligence to the flies. Instead, we should attribute their ability to detect food or identify a suitable habitat to what Hooke called 'the excellent contrivance of their machine, to excite and force them to act after such and such a manner'.[68] Through the intelligence ostensibly manifest in a huntsman's trap, Hooke elucidated the point this way:

> In the contrivance killing a Fox or Wolf with a Gun, the moving of a string, is the death of the Animal; for the Beast, by moving the flesh that is laid to entrap him, pulls the string which moves the trigger, and that lets go the Cock which on the steel strikes certain sparks of fire which kindle the powder in the pann, and that presently flies into the barrel, where the powder catching fire rarifies and drives out the bullet which kills the Animal; in all which actions, there is nothing of intention or ratiocination to be ascrib'd either to the Animal or the Engine, but all to the ingeniousness of the contriver.[69]

We mistake effect for cause, patient for agent, when we assign intelligence to the trap rather than to the trapper, to the beast-machine rather than the divine creator who contrived it. Yet, few places in Robert Hooke's work elaborate this persistent, dangerous slippage between agents and the effects of their intelligence more potently than his discussions of artists and artworks. In turning to such passages, what I want to stress is how the products of early modern artistic intelligence can be seen as possessing a hold on mind and body instructively different from that of the paper micrometer. For if, as Hooke and William Hicks's meditations on cut-paper creations seem to suggest, art is a trap, a clever object always retains a trapdoor.[70]

Cognizant as only a true iconophile can be of the power of images, Robert Hooke frequently cautioned his colleagues about art's dangerous capacities to ensnare and to mislead the active imagination.[71] 'Instead of giving us a true Idea', he warned in a lecture from 1694, prints in travel books were all too frequently the baseless products of what he called 'Mr. Engraver's Fancy'.[72] These bogus images 'misguide our Imagination, and lead us into Error, by obtruding upon us the Imaginations of a Person, possibly, more ignorant than our selves.'[73] A telling registration of what one recent scholar has called the special 'authority of print' in early modern Europe, Hooke clearly extended his reservations to works of art more broadly conceived.[74] 'Pictures of things which only serve for Ornament or Pleasure,' so he would adjure in the *General Scheme* of *c.* 1666–68, 'is rather noxious than useful, and serves to divert and disturb the Mind, and sways it with a kind of Partiality or Respect.'[75] Even the comparatively staid visual experience of reading literature presents a menacing aspect to the experimental imagination.[76] 'Read the Book it self,' Hooke implores in the preface to a history of Ceylon penned by a former prisoner in south Asia, 'and you will find your self taken Captive indeed, but used more kindly by the Author, than he himself was by the Natives.'[77] Where contemporaneous Fellows of the Royal Society could celebrate art's optical deceptions as 'the *Magic*, and innocent *Witch-craft* of lights and shades', Robert Hooke thus perceived manipulations that were less benign, far more capable of deluding and ensnaring.[78]

That said, Hooke's writings betray a curious fascination with artistic power. At beginning of an undated lecture on the effects of music, Hooke sets out a beguiling tale of artistic enchantment. 'A certaine excellent & skilfull Musitian', we read, had circulated tell of his musical powers far and wide. When summoned to perform before the Danish king, 'the artist ... did by various notes, Strains, & moods, soe excite, [forme] & change the passions not only of the King, but of all the auditors that they were sufficiently satisfied both of the Power of Musick, and of this artist's skill.'[79] Not content at simply entertaining his audience, the musician uses his royal audience to demonstrate the true potency of his art. Music and musician 'soe powerfully wrought upon the attentive king, that it did put him into a violent Phrensy; Wherein he fell upon not only fell upon his dear freinds, & councellors, beating and kicking them, but went on to kill severall of them.'[80] Hooke attributed similarly efficacious powers to visual practitioners in a 1668 article on techniques of optical projection. Through a magic lantern-like contrivance, he explained, pagan priests and other shady dealers would have command of 'Apparitions of Angels, or Devils, Inscriptions and Oracles on Walls; the Prospect of Countryes, Cities, Houses, Navies, Armies; the Actions and Motions of Men, Beasts, Birds, &c. the vanishing of them in a cloud, and their appearing no more after the cloud is vanisht.'[81] Crucially, the effect of seeing such wondrous displays would be no less overwhelming than that of the Danish musician's bewitching performance. 'Spectators, not well versed in Opticks,' Hooke observes, '... would readily believe them to be supernatural and miraculous, and would as easily be affected with all those passions of Love, Fear, Reverence, Honor, and Astonishment, that are the natural consequences of such belief.'[82] With passions stirred irresistibly, the unwitting spectator of these artful contrivances would be entirely entrapped, docile before the artist's wicked machinations.

What is perhaps Hooke's most direct meditation on artistic entrapment appears at the head of five stories gathered at the end of the famous journal he kept between 1672 and 1682.[83] Leading off these roguish tales of confidence schemes, thefts and deceptions, the artist's story begins with a 'coulerman' (a dealer in dyes and pigments) who lived on Snowhill Street on the western edge of the City of London. Also identified by Hooke as a 'deputy', this merchant had come to suffer from a grievous toothache. Shrewdly sizing up the vulnerable situation of his professional acquaintance, 'a Waggish Painter' instructed the deputy to return home, start a fire and await the painter's arrival. What happens then is this:

> Bringing with him a little fair water a hammer and some nailes the painter perswades the deputy to goe with him and not to think much of his Directions though they might seem extravagant. In fine he perswades him to let downe his breeches and leane his breech against the fire[.] He in the mean time tacking up his shirt to the mantletree with his nailes. Then bidding him fill his mouth with the water & keep it in till such a time as it began to scald his mouth he advised him to have patience and hold by his breech soe till he found the effect. In the mean time he [the painter] pretends to step downe for somewhat and slipt away.[84]

Bound and effectively gagged, his mouth and buttocks already burnt by the painter's contrivance, the plight of the deputy only worsens as a visitor arrives at the house. Hearing a knock at the door, the merchant can neither move to answer nor cry out for help. Instead, 'to save his water til it boyled', we are told, the colour-man 'stamped at the wench and mummd with his mouth full of water'. The terrified maid then runs to the mistress of the house, convinced that the master has gone insane. When his wife

arrives, the bare, burned official again 'stamps & mumms at her but she in great passion fearing he was mad indeed kept soe great a coyle as made him spit out his water.' As the suffering man tries vainly to soothe his pain, the painter enjoys the cruel ruse he has played at the expense of the merchant upon whom his own art depended.

Although more deserves to be said about these strange stories, it is crucial to stress that Robert Hooke was hardly alone in seeing early modern artists and art-objects as capable of wielding formidable, malevolent power over the mind and body of the beholder.[85] Artists themselves often trafficked in such sentiments. Witnessing copyists torturing themselves below his Sistine ceiling, Michelangelo reputedly exclaimed: 'Oh, how many men this work of mine wishes to destroy.'[86] Among recent interpreters, an influential tradition led by Louis Marin and Michael Fried has done much to emphasize how the experience of beholding early modern art constituted a violent assault – 'a poke in the eye' – before which the 'stupefied' observer would be transfixed, unable to look away.[87] But, if this lacerating, overwhelming experience echoes the boggling affect attributed to cut-paper creations both by contemporaries such as Hicks and imagined by recent theorists of the technologized image like Gell and Latour, these terms singularly fail to illuminate the object constructed by Robert Hooke in late 1667. What I want to foreground in conclusion is the relative weakness or, better, the *lightness* of an object like Hooke's cut-paper micrometer and the cognitive advantages its unsublimated fragility could have offered to his experimental philosophy's peculiar, devious cleverness.

Prompting, Paper

Throughout Robert Hooke's writing, bare beholding is repeatedly staged as debased brutality. Man is elevated above all other creatures, so we read in the opening lines of *Micrographia*, because 'we are not only able to *behold* the works of Nature ... but we have

10 Robert Hooke, ink drawing representing processes of felt hat-making, c. February 1666. 185 × 293 mm. London: Royal Society (Classified Papers, 20, 96). Photo: © The Royal Society.

also the power of *considering*, *comparing*, *altering*, *assisting*, and *improving* them to various uses.'[88] If this altering or 'thinkering' with materials is clearly instantiated in the paper micrometer's cut-and-pasted form, a more capacious approach is needed to theorize the radical availability of such an artefact to the labile re-imaginings that Hooke saw as a uniquely human prerogative.[89] To this project, the 'pretense theory' of representation advanced by philosopher Kendall Walton is especially useful. In Walton's terms, the paper object made by Robert Hooke might be understood as a representation insofar as it prescribes a game of make-believe.[90] As a 'prop' that possesses a 'principle of generation', the paper micrometer authorizes a public and socially comprehensible game in which the beholder pretends that inked markings on cut-and-pasted paper are Richard Towneley's telescopic micrometer.[91] Privately (and perhaps unconsciously) for Robert Hooke and his close affiliates, I have suggested, the paper micrometer also functioned as a game of make-believe in which opening and closing a haptic representation solved the puzzle of how to manage a morbid desire to see inside living bodies. But, while his appeal to game-playing felicitously overlaps with these concerns for puzzle-solving, Walton's approach is particularly instructive for understanding the range of ad hoc imaginings by which Hooke's authorized game was swamped.

What I mean is this: in early 1666, Robert Hooke presented a lecture to the Royal Society on the interrelated trades of paper- and felt-making (*plate 10*).[92] Assisted by his own heavily annotated drawing of a felt-maker's workshop, Hooke explained how craftsmen in both trades processed and laboriously refined fermented cloth rags. In procedural sequence from left to right, Hooke depicts raw lamb's wool oscillated with a bowstring on a slotted table called a hurdle. As the artisan in the central foreground works the basoning table where thick batts of wool are pressed together and heated from below by a pan of burning charcoal, a workman at centre right squeezes excess urine and wine-lees from hot, matted wool on the 'waking plank'.[93] Signalled by the vanishing point at centre right, Hooke has clearly tried to impose a perspectival, pictorial construction onto this composition. But the density of visual information he had amassed ruptures spatial form, spilling outward into a sequence of details dominating the right-hand border of the page and mandating extensive corrections at left.[94]

Struggling to bring this plenum of artisanal knowledge into order on paper as Hooke was in 1666, the condensation of animal and machine bodies at work with the paper micrometer in the fall of 1667 seems to have made the object and substrate of his studies newly available as what Walton calls a 'prompter' to imaginings of a very different kind. For, in a portion of a major theoretical text likely composed in spring 1668, Hooke encouraged his audience to imagine the following proposition: 'Suppose we compare Paper or Hats with the Skin of an Animal.'[95] Identifying positive analogy between the two systems, Hooke uses exploration of the paper-making process he had studied so intensively in 1666 to illuminate the obscure, taboo target of his long-standing fascination. He puts it this way:

> Because the Texture of the two seems of much Affinity with this, we shall find the Method of Nature prettily explicated by them: For in both those Artificial Products we find that the Artists endeavor first to cut, grind, or beat into small parts the Materials they are to use, then to make them soft, light, and supple with Water or other Liquor, then to dispose, place, or put it into such Forms or Moulds as they may shape it into what Form they design it, then they there so work and order it, that the Moisture may by degrees waste, and the solid Parts unite more closely together, adding to it such glutinous Matter as may

> make it fit to stick, hold and grow stiff, firm, and strong together; and lastly, by several ways they smooth and color or beautify the Surface. ... Now Nature in preparing the Matter that does repair the Skin or Flesh of the Body, seems to proceed much after the same method, the food is chosen, then ground or chewed, then digested or brought into the Form of a Milk or Froth, then dispersed over the Body, by degrees thickened, and lastly polished.[96]

Students of technology have often aligned 'dreaming with' materials and making reference to practices external to a craft as the damning hallmarks of the amateur.[97] To Hooke's way of thinking, though, paper was not only a useful surface upon which to prop public, authorized games of make-believe and to resolve semi-private visual/ethical puzzles. It was simultaneously a made thing whose production history, physical properties and even poetic dimensions could prompt generative, ad hoc imaginings of their own.[98]

Precisely this persistent suggestiveness of paper's materiality and the consequent drift of active, experimentalist imagination away from the central, authorized representational games played upon it need to be seen as potentially advantageous epistemic features of Robert Hooke's clever object. Recent work on the 'autonomy' and non-mimetic, fictionalized dimensions of scientific modelling has done much to illuminate just this point. Indifferent to their putative creators' intentions, this literature argues, models are subservient neither to theory nor observation, but gain cognitive value by resistant mediation between them.[99] 'Model systems are interesting', philosopher of science Roman Frigg writes, 'exactly because more is true of them than what the initial description specifies; no one would spend time studying models if all there was to know about them was the explicit content of the initial description.'[100] Or as Tarja Knuuttila and Atro Voutilainen pithily put it: 'A model has an existence of its own. For this reason we cannot be totally in charge of it, however purposefully fabricated it may be.'[101]

Now, exactly *how* it is that experimentalists could learn from these fabricated imaginings and unintended discoveries is currently a matter of lively debate in the philosophy of science.[102] And while I think that Robert Hooke's generative, inductive play with his paper micrometer might be seen as an important, historical complement to the deductive, logical procedures he was contemporaneously calling 'philosophical algebra', my point here is an analytic one.[103] That is, unlike overpowering artistic works that would mystify their material means and entrap stupefied beholders, Hooke's paper micrometer commanded a different kind of hold on eye and mind. What had struck a period theorist like Giorgio Vasari as 'absolutely astonishing' in Michelangelo's marble sculpture was that 'a stone, formless in the beginning, could ever have been brought to the state of perfection which Nature habitually struggles to create in the flesh.'[104] Puzzling through technical competition, visual desire and ethical conflict, the transformation of materials enacted by the paper micrometer's game of make-believe was of a crucially different, lighter kind; the properties of paper remained available for both physical manipulation and for guiding ad hoc imaginative promptings. Intended publicly as a representation of a machine and deployed semi-covertly as a substitute visualization of animal bodies, Hooke's object opened a cognitive space wherein the materials for graphic representation had become available as resources for modelling the targets *of* that representation – where thinking on paper could be pursued by thinking with paper. What is more, by leading Hooke back to its dark, wet roots, paper also enabled him to *change the question*. Instead of acting only as dry, white support to pictorial visualization

of animal/machine interior systems, paper-as-made-thing had now become a conceptual model for exploring how organic tissue comes into being in the first place. This is not Madam E.C.'s stupefying cut-paper 'art'; it is clever objecthood.

Under-developed as a critical term, 'cleverness' is often imagined as a skilful act done in a competitive milieu that accomplishes its end by ensnaring a rival in its claws. Jan van Eyck's *Arnolfini Portrait*, so Linda Seidel argues, constitutes 'a clever commission of a shrewd banker', because it stunningly visualizes a significant financial transfer of the Cenami bridal dowry while simultaneously binding the family of the Arnolfini groom to its future return.[105] Likewise, a skilled physician after Bernard Mandeville's model in the early eighteenth century used practical know-how to trick self-indulgent patients into health just as 'the clever politician derives general good from private passions.'[106] In its pilfered form and purloined target – in its cunning transformation of forbidden, flayed animal into a manageable paper machine – Robert Hooke's object does nothing to dispel this agonistic atmosphere. What it does compel us to reckon with, though, is a shiftiness, a willingness of the clever object to liquidate its authorized meanings, to solicit new imaginings, to pry a trapdoor into art's trap. Picture, object, puzzle, prompter: a clever object in Restoration London was all of those, in that order.

Notes

1 Anthony à Wood, *Athenae Oxonienses. An Exact History of All the Writers and Bishops who have had their Education in the most Ancient and Famous University of Oxford*, London, 1692, Vol. II, 157.
2 W.H. [William Hicks], *London Drollery: Or, The Wits Academy*, London, 1673, 60.
3 On this theme in Restoration literature more broadly, see J. Douglas Canfield, 'Women's wit: Subversive women tricksters in Restoration comedy', in W. G. Marshall, ed., *The Restoration Mind*, Newark, DE, 1997, 147–76.
4 Hicks, *London Drollery*, 61.
5 See Jay Arnold Levine, 'The status of the verse epistle before Pope', *Studies in Philology*, 59: 4, October 1962, esp. 667–8.
6 Hicks, *London Drollery*, 61.
7 Adam Smyth, ' "Rend and Teare in Peeces": Textual fragmentation in seventeenth-century England', *Seventeenth Century*, 19:1, 2004, 36–52.
8 Lucia Nuti, ' "To Make the Whole Progress a Lineall Visible Demonstration": The journal of Edward Dummer', *Word & Image*, 15: 3, 1999, 292–305.
9 Ann Blair, 'Reading strategies for coping with information overload ca. 1550–1700,' *Journal of the History of Ideas*, 64: 1, 2003, 11–28; and Blair, *Too Much to Know: Managing Scholarly Information Before the Modern Age*, New Haven and London, 2010.
10 Martin Rudwick, 'George Cuvier's paper museum of fossil bones', *Archives of Natural History*, 27: 1, 2000, 51–68.
11 Kristel Smentek, 'The collector's cut: Why Pierre-Jean Mariette tore up his drawings and put them back together again', *Master Drawings*, 46: 1, Spring 2008, 36–60.
12 Ursula Klein, 'Techniques of modelling and paper-tools in classical chemistry', in Mary S. Morgan and Margaret C. Morrison, eds, *Models as Mediators: Perspectives on Natural and Social Science*, Cambridge, 1999, 146–67; Bruno Latour, 'Drawing things together', in Michael Lynch and Steve Woolgar, eds, *Representation in Scientific Practice*, Cambridge, MA, 1990, 22.
13 John Evelyn's personal copy of the early *Philosophical Transactions* (now British Library EVE.A.149), for example, contains this assembled instrument. I thank Meghan Doherty for kindly pointing this out to me.
14 See [Adrian Auzout], 'An Extract of a Letter Written Decemb. 28. 1666. By M. Auzout to the Publisher, Concerning a Way of His, for Taking the Diameters of the Planets ... ', *Philosophical Transactions*, 21: 1, 1667, 373–5.
15 [Richard Towneley], 'An Extract of a Letter, Written by Mr. Richard Towneley to Dr. Croon, Touching the Invention of Dividing a Foot into Many Thousand Parts, for Mathematical Purposes', *Philosophical Transactions*, 25: 2, 6 May 1667, 457. For the broader context, see Steven Pincus, *Protestantism and Patriotism: Ideologies and the Making of English Foreign Policy, 1650–1668*, New York and Cambridge, 1996.
16 Towneley, 'An Extract', 458.
17 Allan Chapman, 'England's Leonardo: Robert Hooke (1635–1703) and the art of experiment in Restoration London', *Proceedings of the Royal Institution of Great Britain*, 67, 1996, 265.
18 For these drawings, see Royal Society Classified Papers [henceforth CP] Vol. II: 13. Towneley's inscription on the drawing reads: 'In this rude draft which I hope will a little reminde you how the screws are to be put on the Tube[,] A D is divided into 3 lengths of which (as in ordinarie ones) BC is to lengthen or contract, as the object requires, but AB is now added that at A you may put such eye glasses as shall be thought most convenient, and to sett them still at the distance most proper for them from the pointers which here are supposed to be at B, which length alters also in respect of divers persons eyes. E is a screw by which I can fix the great Tube so as by the help of the figures on the smaller part of it I can immediately find a measuring only or knowing the divisions on BC the distance of the object glasses from the pointers. F is the angular piece of wood, that lies upon the screw of the wood, of which I have also sent you an uncouth figure.'
19 See Rob Iliffe, ' "In the warehouse": Privacy, property and priority in the early Royal Society', *History of Science*, XXX, 1992, 29–68; Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making*, Chicago, IL, 1998; and Mario Biagioli and Peter Galison, eds, *Scientific Authorship: Credit and Intellectual Property in Science*, New York, 2003.
20 See 'More Wayes For the same Purpose, Intimated by M. Hook', *Philosophical Transactions*, 25: 2, 6 May 1667, 459.
21 [Richard Towneley and Robert Hooke], 'A Description of an Instrument for dividing a foot into many thousand parts, and thereby measuring the diameters of planets to a great exactness, &c. The instrument itself and being contrived and sent by Mr. Richard Towneley to the R. Society, and this following description of it being made by Mr. Hook was read before the Society Novemb. 14, 1667', Register Book (Original) [henceforth RBO] Vol. III: 227.
22 [Robert Hooke], 'A Description of an Instrument for dividing a foot into many thousand parts, and thereby measuring the diameters of planets to a great exactness, &c. as it was promised in Numb. 25', *Philosophical Transactions*, 29: 2, 11 November 1667, 542.

23 For these images, see RBO Vol. III, 227–30.
24 Hooke, 'A Description', 543. With regard to implementation of this improvement to Towneley-based telescopic micrometers, John Flamsteed (later Astronomer Royal) reported the following to Henry Oldenburg in 1671: 'Not findeing yt Mr. Townly's micrometer is so devised as to be convenient for some observations I intend, I have devised a new one in which I can have thread sights or other as I please and parallel threads disposed perpendicular to ye ostensors like a kind of rete [i.e. a net] which is very convenient'; John Flamsteed to Henry Oldenburg, 2 December 1671, in A. R. Hall and M. B. Hall, eds, *The Correspondence of Henry Oldenburg*, Madison, WI and London, 1971, Vol. VIII, 390.
25 Beyond the omission of Hooke's amended pointers from copy of his drawing in the Register Book, an offprint of the engraving of the micrometer from the *Philosophical Transactions* now bound into that Register Book shows Hooke's enhanced pointers crossed out with three inky slashes (as in my *Plate* 1); RBO Vol. III, f 227–30.
26 For an interesting treatment of this concept, see Françoise Viatte, 'Weaving a rope of sand', *Yale French Studies*, 89, 1996, 85–102.
27 Hooke, 'A Description', 543. On the category of the 'paper instrument', see Catherine Eagleton and Boris Jardine, 'Collections and projections: Henry Sutton's paper instruments', *Journal of the History of Collections*, 12: 1, 2005, 1–13.
28 Hooke, 'A Description', 543.
29 Lucian, *Hermotimus* in *Lucian VI: Loeb Classical Library*, trans. K. Kilburn, Cambridge, MA, 1999.
30 By this I mean, first, that Towneley's micrometer would not actually have opened in the way that Hooke had represented. Secondly, and more importantly, the exchanges between Auzout and Towneley demonstrate that the criteria for assessing a micrometer had to do with its precision mensuration capabilities, not the relations between internal mechanics and exterior housing exemplified by Hooke.
31 This image appears in Joseph Moxon, *Practical Perspective: or Perspective Made Easy*, London, 1670, 7. For a discussion of this image in the context of Restoration print culture, see Matthew C. Hunter, 'The theory of the impression according to Robert Hooke', in Michael Hunter, ed., *Printed Images in Early Modern Britain: Essays in Interpretation*, Aldershot, 2010, 167–90.
32 As argued below, I am using puzzle in an analytic sense rather than a strictly historical sense. However, for 'puzzle jugs' and other period artefacts that instantiate the interests in witty problem-solving elucidated here, see R. L. Hobson, 'Early Staffordshire wares illustrated by pieces in the British Museum', *Burlington Magazine*, 2: 4, June 1903, 64–9. I thank Lia Markey and, especially, Jason LaFountain for pushing me on this point.
33 For an authoritative account of these traditions, see Robert G. Frank Jr., *Harvey and the Oxford Physiologists: A Study of Scientific Ideas*, Berkeley and Los Angeles, CA, 1980, esp. 140–63.
34 Robert Boyle, *New Experiments Physico-Mechanicall, Touching the Spring of the Air* (1660) in Michael Hunter and Edward B. Davis, eds, *The Works of Robert Boyle: Vol. I*, London, 1999, 278–9. More broadly, see Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life*, Princeton, NJ, 1985.
35 See Thomas Birch, *History of the Royal Society of London*, London, 1756–7, Vol. I, 433, 444.
36 Birch, *History*, Vol. I, 475.
37 Although they should not be considered an exhaustive record, six related trials are listed in the Royal Society's Register Books; see RBO Vol. III, 64 (9 November 1664); 65–6 (23 November 1664); 203–5 (24 October 1667); 265–7 (19 December 1667); 297 (14 May 1668); and 307–8 (4 July 1668).
38 Henry Oldenburg to Robert Boyle, 10 November 1664, in A. R. Hall and M. B. Hall, eds, *The Correspondence of Henry Oldenburg Vol. II: 1663–1665*, Madison, WI and London, 1966, 296–7.
39 For a classic study of this 'Baconian' tradition of experiment, see Thomas Kuhn, 'Mathematical versus experimental traditions in the development of physical science', in *The Essential Tension: Selected Studies in Scientific Tradition and Change*, Chicago, IL, 1977, 31–65.
40 See Francis Bacon, *The Advancement of Learning* (1605) in *Francis Bacon*, Chicago, IL, 1989, Book II: Section 1: Chapter 6, 34.
41 While the original manuscript of this letter has been lost, an eighteenth-century copy survives in the British Library; see BL Add. MS 6194: f 27–8.
42 BL Add. MS 6194: f 27v.
43 For this opposition of the dry and wet, see Jeff Wall, 'Photography and liquid intelligence', in Thierry de Duve, Arielle Pelenc, Borys Groys and Jean-François Chevrier, *Jeff Wall*, London, 1996, 90–3.
44 BL Add. MS 6194: f 27v.
45 BL Add. MS 6194: f 28r.
46 Other contributions that have noted this include: Andreas-Holger Maehle and Ulrich Tröhler, 'Animal experimentation from antiquity to the end of the eighteenth century: Attitudes and arguments', in Nicolaas Rupke, ed., *Vivisection in Historical Perspective*, New York, 1987, 14–47; and Janice Neri, *The Insect and the Image: Visualizing Nature in Early Modern Europe, 1500–1700*, Minneapolis, MN, 2011, 105–38.
47 A widely read statement of Descartes' view of animals is 'Part Five' of *Discours de la Méthode* (1637); see John Cottingham, Robert Stroothoff and Dugald Murdoch, eds, *The Philosophical Writings of Descartes: Vol. 1*, New York and Cambridge, 1985, 131–40. For an argument stressing the infrequency with which the animal/machine doctrine was actually used to justify vivisection, see Anita Guerrini, 'The ethics of animal experimentation in seventeenth-century England', *Journal of the History of Ideas*, 50: 3, 1999, 391–407.
48 See R. T. Gunther, *Early Science at Oxford: The Life and Work of Robert Hooke*, Oxford, 1930, Vol. VI, 210.
49 On 'violent literalization', see Jeremy Biles, 'I, insect, or Bataille and the crush freaks', *Janus Head*, 7: 1, 2004, 115–31.
50 For Boyle, see Malcolm R. Oster, 'The "Beame of Diuinity": Animal suffering in the early thought of Robert Boyle', *British Journal for the History of Science*, 22: 2, July 1989, 151–79.
51 Robert Hooke, *Micrographia: or, Some Physiological Descriptions of Minute Bodies made by Magnifying Glass*, London, 1665, 186.
52 Hooke, *Micrographia*, 186.
53 For Wren's innovative work on intravenous drug injection and its application to vivisection, see W. C. Gibson, 'The bio-medical pursuits of Christopher Wren', *Medical History*, 14: 4, October 1970, 331–41.
54 BL Add. MS 6194: f 28r.
55 See Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century*, Chicago, IL, 1983; and Barbara Maria Stafford, *Body Criticism: Imaging the Unseen in Enlightenment Art and Medicine*, Cambridge, MA and London, 1991. See also Catherine Wilson, 'Visual surface and visual symbol: The microscope and the occult in early modern science,' *Journal of the History of Ideas*, 49: 1, 1988, 85–108.
56 On the importance of the rupture in this chronology, see Guerrini, 'Ethics of animal experimentation', 400–2.
57 A classic account is Marcel Detienne and Jean-Pierre Vernant, *Cunning Intelligence in Greek Culture and Society*, trans. J. Lloyd, Atlantic Highlands, NJ, 1978.
58 For Collins's donation of a range of materials including 'Remmelini's anatomical cuts', see Birch, *History*, Vol. II, 202.
59 For more on Remellin's prints, see Andrea Carlino, *Paper Bodies: A Catalogue of Anatomical Fugitive Sheets 1538–1687*, trans. N. Arikha, London, 1999, esp. 71–3.
60 On Hooke's relationship to the Royal Society Library, see Linda Levy Peck, 'Uncovering the Arundel Library at the Royal Society: Changing meanings of science and the fate of the Norfolk donation', *Notes and Records of the Royal Society of London*, 52: 1, 1998, 3–24.
61 To be clear, I am not claiming that Remellin's volume was the only source Hooke knew in which flaps were utilized. My point is that Remellin's volume arrived precisely and publicly at this crucial moment in Hooke's experimental activities, enabling him to redeploy the flap technique to solve a puzzle. For more on flaps in architectural publications, see Anthony Gerbino and Stephen Johnston, *Compass and Rule: Architecture as Mathematical Practice in England 1600–1750*, New Haven and London, 2009, esp. 57–9. More broadly, see Suzanne Karr Schmidt and Kimberly Nichols, *Altered and Adorned: Using Renaissance Prints in Daily Life*, Chicago, IL, 2011, esp. 73–91; and Susan Dackerman, *Prints and the Pursuit of Knowledge in Early Modern Europe*, Cambridge, MA, 2011.
62 For a range of approaches to this problem, see Roman Frigg and Matthew Hunter, eds, *Beyond Mimesis and Convention: Representation in Art and Science*, New York, 2010.
63 Thomas Kuhn, *The Structure of Scientific Revolutions*, Chicago, IL, 1965, 38. For interesting readings of Kuhn's thinking on puzzle-solving,

see Thomas Nickles, 'Kuhnian puzzle solving and schema theory', *Philosophy of Science*, 67: II, September 2000, S242–55; and Thomas Leddy, 'Is the creative process a form of puzzle solving?', *Journal of Aesthetic Education*, 24: 3, Autumn 1990, 83–97.

64 Although it is beyond the scope of this essay, examination of relations between Hooke's paper micrometer and early modern games might well draw out additional features through which to expand the meanings of this puzzle analogy. For an approach that goes in this general direction, see James Elkins, *Why Are Our Pictures Puzzles? On the Modern Origins of Pictorial Complexity*, New York, 1999.

65 For this definition of a puzzle, see Kuhn, *Structure*, 37.

66 For a particularly instructive reading of the force of 'elegance' in contemporary string theory, see Peter Galison, 'Theory bound and unbound: Superstrings and experiment', in Friedel Weinert, ed., *Laws of Nature: Essays on the Philosophical, Scientific and Historical Dimensions*, New York, 1995, 369–408.

67 For a brief overview of Hooke's artistic training and its place in his draughtsmanship, see Matthew C. Hunter, 'Hooke's figurations: A figural drawing attributed to Robert Hooke', *Notes and Records of the Royal Society of London*, 64, March 2010, 251–60. On 'plain style', see Richard Foster Jones, 'Science and English prose style in the third quarter of the seventeenth century', *Proceedings of the Modern Language Association*, 45, 1930, 977–1009; Laura Lunger Knoppers, 'The politics of portraiture: Oliver Cromwell and the plain style', *Renaissance Quarterly*, 12: 22, 1998, 1281–319; and Ann Bermingham, *Learning to Draw: Studies in the Cultural History of a Polite and Useful Art*, New Haven and London, 2000, esp. 64–73.

68 Hooke, *Micrographia*, 190.

69 Hooke, *Micrographia*, 190.

70 On brilliant reading of artworks as traps, see Alfred Gell, 'Vogel's net: Traps as artworks and artworks as traps', in Eric Hirsch, ed., *The Art of Anthropology: Essays and Diagrams*, London, 1999, 187–214.

71 For a broader account of Hooke's anxieties about visual art and its relation to his theories of perception and cognition, see Hunter, 'Theory of the impression', 164–93.

72 Robert Hooke, 'An Instrument of Use to Take the Draught, or Picture of Any Thing', in William Derham, ed., *Philosophical Experiments and Observations of the Late Eminent Dr. Robert Hooke*, London, 1726, 294.

73 Hooke, 'An Instrument', 294.

74 William B. MacGregor, 'The authority of prints: An early modern perspective', *Art History*, 22: 3, September 1999, 389–420.

75 Robert Hooke, *A General Scheme, or Idea of the Present State of Natural Philosophy*, in Richard Waller, ed., *The Posthumous Works of Dr. Robert Hooke*, London, 1705, 64.

76 On this point, see Johns, *Nature of the Book*, 380–443.

77 Robert Knox, *An Historical Relation of the Island of Ceylon in the East Indies*, London, 1681, sig. A 6.

78 John Evelyn, *Sculptura: Or The History, and Art of Chalcography and Engraving in Copper*, London, 1662, 107.

79 Robert Hooke, 'A Curious Dissertation Concerning the Causes of the Power & Effects of Music', CP Vol. II, 31 (f 1). For a transcription and commentary on this lecture, see Penelope Gouk, 'The role of acoustics and music theory in the scientific work of Robert Hooke', *Annals of Science*, 37, 1980, 573–605.

80 Hooke, 'Curious Dissertation', CP Vol. II, 31 (f 1 V).

81 [Robert Hooke], 'A Contrivance to make the Picture of any thing appear on a Wall, Cub-board, or within a Picture-frame …', *Philosophical Transactions*, 4: 38, 17 August 1668, 743.

82 Hooke, 'A Contrivance', 742.

83 Curiously, these stories were omitted from the 1935 published edition of Hooke's diary. For an illuminating discussion of this edition, see Felicity Henderson, 'Unpublished material from the memorandum book of Robert Hooke, Guildhall Library MS 1758', *Notes and Records of the Royal Society of London*, 61, 2007, 129–75, esp. 129–35.

84 For this story and all subsequent citations from it, see Guildhall Library, London; MS 1758: f 131 V.

85 For a recent history of intellectual response to these problems, see Stuart Clark, *Vanities of the Eye: Vision in Early Modern European Culture*, New York and Oxford, 2007.

86 Giovanni Battista Armenini, *On the True Precepts of the Art of Painting*, ed. and trans. E. J. Olszewski, New York, 1977, 138. On the sinister dimensions of artistic creativity more broadly, see Ernst Kris and Otto Kurz, *Legend, Myth, and Magic in the Image of the Artist*, New Haven and London, 1979; and Claudia Swan, *Art, Science and Witchcraft in Early Modern Holland: Jacques de Gheyn II (1565–1629)*, New York and Cambridge, 2005.

87 Louis Marin, *To Destroy Painting*, trans. M. Hjort, Chicago, IL, 1995, esp. 160–4; and Michael Fried, *Realism, Writing, Disfiguration: On Thomas Eakins and Stephen Crane*, Chicago, IL, 1987, esp. 64–5.

88 Hooke, *Micrographia*, sig. a i.

89 See Michele and Robert Root-Bernstein, 'Thinkering', *Psychology Today*, 21 August 2008: http://www.psychologytoday.com/blog/imagine/200808/thinkering [accessed 16 September 2012].

90 See Kendall Walton, *Mimesis as Make-Believe: On the Foundations of the Representational Arts*, Cambridge, MA, 1990.

91 I would stress that, while members of the Royal Society may have objected to the way in which Hooke represented discrete features of Towneley's micrometer, they had no problem understanding his contrivance as a representation of that machine. For Walton's definition of these terms, see Walton, *Mimesis as Make-Believe*, 38–9.

92 See Robert Hooke, 'The Way of Making Felts', CP Vol. XX, 96. For a description and dating of this lecture to 21 February 1666, see H. B. Wheatley, ed., *The Diary of Samuel* Pepys, New York, 1946, Vol. II, 155.

93 All citations that follow regarding this image are from CP Vol. XX, 96 (f 223). For the full extent of Hooke's notations on felt-making, see CP Vol. XX, 96 (f 223R–227V).

94 Although Hooke explicitly gives instructions to an engraver here (i.e. 'This Draught must not be inverted'), I have been unable to locate any evidence suggesting that a print was ever actually made from this drawing.

95 Hooke, *General Scheme*, 57.

96 Hooke, *General Scheme*, 57.

97 See Erin O'Connor, 'Embodied knowledge in glassblowing: The experience of meaning and the struggle towards proficiency', *Sociological Review*, 55: Supplement 1, May 2007, 126–41.

98 Although I do not know of any further instances in which Hooke used features of paper to pursue similar kinds of conceptual modelling, he was clearly interested in other aspects of its physical properties such as its ability to absorb fluids. In *Micrographia*, he explains the deficiencies of printed images in part by noting 'the *uneven surface* of the *paper*, which at best appears no smother then a very course piece of *shag'd cloth*'. Like most early modern intellectuals, he also collected recipes for making ink. See Hooke, *Micrographia*, 3; Hooke, 'Ink for the Rolling-Press', in Derham, *Philosophical Experiments and Observations*, 188–90. See also: 'An Experiment of a Way of Preparing a Liquor, That Shall Sink into, and Colour the Whole Body of Marble, Causing a Picture, Drawn on a Surface, to Appear Also in the Inmost Parts of the Stone', *Philosophical Transactions*, 1, 1665–6, 125–7.

99 See Morgan and Morrison, *Models as Mediators*.

100 Roman Frigg, 'Models and fiction', *Synthese*, 172, 2010, 258.

101 Tarja Knuuttila and Atro Voutilainen, 'A parser as an epistemic artifact: A material view on models', *Philosophy of Science*, 70, December 2003, 1489.

102 For a range of interpretations of this problem, see Frigg and Hunter, *Beyond Mimesis and Convention*.

103 For a broader reading of this object's cognitive efficacy, see Matthew Hunter, *Wicked Intelligence: Visual Art and the Science of Experiment in Restoration London*, Chicago, IL, 2013, Chapter 2.

104 Giorgio Vasari, *The Lives of the Artists*, trans. J. C. Bondanella and P. Bondanella, New York, 1991, 425.

105 Linda Seidel, ' "Jan van Eyck's Arnolfini Portrait": Business as usual?', *Critical Inquiry*, 16: 1, 1989, 71.

106 Harold J. Cook, 'Bernard Mandeville and the therapy of "the clever politician"', *Journal of the History of Ideas*, 60: 1, January 1999, 122–3.