Chapter 6
Magi from the North: Instruments of Fire and Light in the Early Seventeenth Century

Fokko Jan Dijksterhuis

Τοῦ δὲ Ἰησοῦ γενιηθέντος ἐν Βηθλέεμ τῆς Ἰουδαίας ἐν ἡμέραις Ἡρῴδου τοῦ βασιλέως, ἰδοὺ μάγοι ἀπὸ ἀνατολῶν παρεγένοντο εἰς Ἱεροσόλυμα (Matthew 2:1)

When the news of the telescope began to spread through Europe, the old Della Porta once again took up his pen. He wrote an exposition on the telescope, explaining its effects by elaborating on his earlier accounts of refraction and lenses. With this exposition Della Porta not only gave evidence of his intellectual command of the instrument, he also laid claim to its authorship: ' and it pleases me that the idea of the telescope in a tube has been mine; ...'[1] It was a particular way of making a claim. Della Porta did so by mathematical means, showing that he understood the instrument and thus was the intellectual author, even if he had not been the first to actually build it. Della Porta's claim was to no avail: *De Telescopio* was not published, the manuscript did not circulate, and the author died not long after its conception. Whether the claim was justified, is not relevant here; fact is that Della Porta was not considered to be an inventor of the telescope at that time.

A text like *De Telescopio* can be read on several levels. On an earlier occasion I interpreted it as a theoretical exposé, assessing its analytical cogency.[2] In *De Telescopio* Della Porta extended his account of refraction in transparent spheres from *De Refractione* to configurations of lenses in order to explain the workings of the telescope. He quite inventively applied the cathetus to a succession of refracting surfaces in order to explain the magnified image produced by a (Galilean) telescope. From the perspective of Kepler's new theory of image formation 'Della Porta's theory of lenses was fraught with difficulties and mathematically it was riddled with ambiguities', I wrote 15 years ago. Since then it has become clear that a Keplerian perspective is not necessarily appropriate to interpret Della Porta's optics. In particular Arianna Borrelli's recent reading of Della Porta has made clear that this is

[1] Ronchi 1954, 56 and 34. "They know nothing of perspective."

[2] Dijksterhuis 2004, 33–35.

F.J. Dijksterhuis (✉)
University of Twente, Enschede, Netherlands
e-mail: f.j.dijksterhuis@utwente.nl

A. Borrelli et al. (eds.), *The Optics of Giambattista Della Porta (ca. 1535–1615): A Reassessment*, Archimedes 44, DOI 10.1007/978-3-319-50215-1_6

too one-sided and limited.[3] Della Porta explained the properties of lenses in terms of the effects of artefacts on the images as they are perceived. The meticulous way in which Borrelli shows how Della Porta extended his understanding of spheres to the effects of lenses has fundamentally changed my understanding of *De Telescopio* and of the telescope as an instrument of natural magic.

Inspired by this I want to approach optics in early modern natural magic with fresh eyes and reconsider categories of optical instruments. I will do so by looking at practices of natural magic rooted in the Low Countries. The lead will be a letter that was induced by the news of the telescope in the same way as Della Porta's exposé. It claimed Dutch authorship of the telescope and although the claim was justified, of interest here is the way it puts the telescope in a setting of natural magic in the same way as Della Porta does. I will use this letter to reconsider the character of the telescope and other early modern instruments of optics. I want to broaden the term 'optics' beyond the usual dioptrics, to a more general sense of controlling and manipulating light, sight and perception. A detour to the Low Countries brings us to Cornelis Drebbel, another resourceful inventor of optical instruments and in many ways comparable to Della Porta. In addition to historicizing the concept of optical instrument, I will use the northern counterpart to reflect upon the epistemic features of natural magic. Finally I will briefly discuss the reception of Della Porta in the Low Countries. There was a prominent tradition natural magic in the North in which the work of Della Porta also found a modest place.

6.1 A Telescope in the Lab

Not long after *Sidereus Nuncius* reached the Dutch Republic, a small book was published in the university town of Franeker, in the province of Friesland. *Biolychnium, seu Lucerna, cum vita ejus Cui Accensa est Mystice vivens iugiter*.[4] The treatise discussed a lamp that burned on blood and in so doing revealed the vitality of the owner of the blood. The lamp of life had been invented by Johann Ernst Burggrav († 1629). An earlier edition of the treatise had been published the year before in Leiden, but Burggrav had extended it considerably.[5] The basic idea was that our blood attracts the vital powers of the heavens and thus guides our health. The lamp burned the blood in such a way that the presence of these powers was made visible. The lamp reflected, in other words, universal vitality. *Biolychnium* was much discussed in the early modern period and went through several editions in the seventeenth century.[6] In this way the preliminary matter of the new edition also became widespread, and this is of interest here. Besides preface, panegyric, and

[3] Borrelli 2014. See also Dupré 2005, 2006.

[4] Burggrav 1611.

[5] Burggrav 1610.

[6] Keller 2008, 111 footnote 271.

so on, the book included a long letter to the author, written by Marcellus Vranckheim (1587–1644) from Padua, dated 30 November 1609.

Vranckheim discussed the telescope and other Dutch feats:

> Jacob Metius (the brother of Adriaan Metius, a celebrity because of his remarkable achievements in the mathematical sciences), who invented the spyglass, with which he can measure a tower or any other object from a distance of three Dutch miles, as if he stands right before and eye to eye with it, and with which he can observe England clearly from his beach. He also gives other observations of the surface of the moon, the Milky Way, stars that astronomers have thus far referred to as nebula, and about other stars that are wandering around Jupiter, an unprecedented novelty with regard to earlier generations.[7]

In an overly humanistic style, larded with Greek quotations, Vranckheim continued with disputing the priority of Galileo regarding the telescopic discoveries of *Sidereus Nuncius*. Vranckheim actually had been in Padua when Galileo had started his telescopic observations. Still, the letter was demonstrably antedated and the coincidence of Metius's alleged discoveries with those of Galileo is suspicious to say the least. We have little to no information about the observations Metius made with his instruments, if he ever used them at all. We do know, however, that Vranckheim's claim that Jacob Metius had invented the telescope was right.[8] The Vranckheim letter was reprinted several times and widely read; it was a major source for the attribution to Metius, for example by Descartes in *La Dioptrique*. The idiosyncratic letter of Vranckheim is interesting; not so much for its factual claims regarding inventions and discoveries, but for the context in which it places the early telescope and Metius' authorship.

Marcellus Vranckheim was a young man from Zutphen. After a spell at Leiden, late 1608 he had gone on a *peregrinatio academia* that brought him to Marburg, Basel, and eventually in Venice and Padua in late 1609.[9] In Marburg he had acquainted Burggrav, a well-travelled scholar and medicus. From Marburg they went their own ways. While Vranckheim travelled south to Italy, Burggrav went to England and other places. They met again in Franeker. After his return to the Republic Vranckheim matriculated at the university in September 1610. In Franeker

[7] Burggrav 1611, 53–54. Transcription and translation Dijkstra 2012, 145. 'Sed ecce tibi alterum huic concivem! Iacobus Metius est (frater Adriani Metij, Viri ob singularem in Scientijs Mathematicis praestantiam Clarissimi) qui Perspicillum invenit, quo turrim vel corpus aliud quodlibet tribus milliaribus Hollandicis dissitum, velut pede collato, & ad oculum dimetitur exactis simè, & Angliam è littore suo clarè prospicit, & alia de Lunaeglobo; de Galaxia; de Stellis, quas Nebulosas hactenus dixerunt Astronomi; de alijs circa Iovem erraticis prodit inaudita veterum aevo novitate. 'Quam penè, τάς μηχανάς μετά τον πόλεμον mi Galilee, [Galileus Galileus Matheseos in illustri Patavina Professor] & perspicillum illud tuum cum Observationibus? Et Sidereus Nuncius tuus Callipides erat, nisi inter caesa & porrecta, quod aiunt, nescio quid additum fuisset operae homini Batavo, & adhuc imberbi, qui citiùs Instrumentum tale invenerit, quàm ejus à se reperti famam sparserit, adeo ut rumore de hoc divulgato, ad consimilis Organi inventionem te devenisse confitearis ipsemet, cujus beneficio Observationes εκ τών υπερβερεταίον illas prodidisti in Lunae facie; fixis innumeris; lacteo circulo; stellis nebulosis; & quatuor Planetis, eorundemque circa Iovem periodis. Age verò, dum alteram tibi muralem cedimùs, ne Isthmum Sinapi bibas.'

[8] Zuidervaart 2010, 15–16.

[9] Dijkstra 2012, 142–143.

the two collaborated with the renowned professor of mathematics, Adriaan Metius, the brother of Jacob.

Adriaan Metius was an active writer and purposive marketer. He wrote several textbooks on mathematics that went through numerous editions, making him the widest circulated and best read mathematician of the seventeenth century.[10] In his books Adriaan actively promoted the achievements of his family. Besides the achievements of his father – who was the main engineer in the States Army and a mathematician of note – he would repeatedly mention Jacob's telescope in his textbooks on astronomy. The letter of Vranckheim was a timely exhibit of the priority of his brother and Metius was probably instrumental in the publication of the second edition of Burggrav's *Biolychnium*. The *Arithmeticae* of Metius was published at the same press and Vranckheim had written a carmen for it.[11] The Vranckheim letter fitted Adriaan's ambitions to enhance the reputation of his kin. But why would a renowned mathematician use a chymical treatise as the vehicle for the claim? Part of the answer is that Adriaan Metius had a profound interest in medicine and alchemy. He closely collaborated with the resident of the Franeker castle, Carolus Sternsee. They equipped an alchemical laboratory at the castle where they performed experiments, allegedly aimed at curing Sternsee.[12] Burggrav referred to this laboratory in his preface to *Biolychnium* and probably had come to Franeker for the alchemical activities in the first place.

The book of Burggrav was an excellent place for Vranckheim's letter. It placed the lamp of life among a string of products of Dutch ingenuity. It may seem a strange mix of artifacts to modern eyes but from the perspective of early seventeenth-century natural magic it was not. Prominent were a couple of instruments of Cornelius Drebbel, an engineer working in London in the patronage of king James. Vranckheim elaborately described Drebbel's inventions and particularly praised his perpetuum mobile and light organ. Vranckheim based his account on the first-hand experiences that Burggrav had related to him earlier.[13] There was an important feature Vranckheim's Dutch virtuosi had in common: they all were from the Holland town Alkmaar. The Metii were from Alkmaar, where the father's defense of the town in 1573 had been a turning point in the Dutch Revolt. Drebbel also came from Alkmaar, as were other notable Dutchmen of the time like the astronomer and publisher Willem Blaeu (1571–1638) and the maritime explorer Frederik de Houtman (1571–1627). Vranckheim's letter thus also served to promote the reputation of the home town of his protagonists. The beach that Vranckheim referred to was the North-Sea shore of Holland at Egmond, some 10 km from Alkmaar. Of course one could not see England across the North Sea, not even with the telescope of Jacob Metius. But that is not the point; what matters is that the Alkmaar-Metius circle laid claim to the invention of the telescope and did so successfully – for the time being.

[10] Dijkstra 2012, 89–95.

[11] Dijkstra 2012, 146.

[12] Dijkstra 2012, 152.

[13] Keller 2008, 153–154; 390–392; Keller 2010, 51–52.

The connection of mathematics and chymistry was not specific for Metius. It was quite typical of the circles the Vranckheim letter was set in and in which Metius had circulated during his formative years. He had studied in Franeker, one of the schools established by the Nassau family of the Dutch Stadtholders. He had spent time with Tycho in Hven and taught at several protestant German universities including Marburg. In all these places interest in chymistry was common and linked to mathematical pursuits. The professor of mathematics in Marburg during Metius' sojourn there, was Johannes Hartmann (1568–1631). Ten years later, in April 1609, Moritz the learned of Kassel appointed Hartmann as professor *chymiatrie* at the new Collegium Chymicum.[14] During his stay in Marburg, Burggrav resided with the same Johannes Hartmann. Hartmann may well have referred Burggrav and Vranckheim to Metius in Franeker. The main point is that the combination of the letter of Vranckheim, its publication in Burggrav's book, and the place of publication in Franeker, it all reflects the Lower-German milieu of these circles.

The content and context of Vranckheim's letter and the claim by the Metius circle place the telescope in a definite chymical context. This is less peculiar than it may seem. The telescope is usually regarded as an astronomical instrument but we should bear in mind that it has become astronomical only gradually. Even the term astronomical requires qualification when speaking of the early decades of the history of the telescope. In astronomy the telescope was primarily used and understood as a philosophical instrument; used for observing and inquiring into the physical aspects of heavenly bodies. The telescope of *Sidereus Nuncius* is an instrument of cosmology. It became a quantitative instrument only much later, around 1670, and even then the telescope's feasibility as a measuring instrument was contested by someone like Hevelius.[15] With the geometrical analysis of *Dioptrice* Johannes Kepler may have intended to make the telescope fit for positional astronomy, it did not work out immediately. During the first half century, the telescope was an instrument of image making rather than measuring positions.

The episode sketched above mixes up our disciplinary categories. The letter and context of Vranckheim's letter assembles a range of instruments, ideas, and men in which mathematics, magic, chymistry overlap and coincide. This invites us to reconsider our common understanding of the telescope as a mathematical instrument. We can read it not just as an instrument that creates images but in a more general sense one that manipulates light and sight. In this way the telescope naturally fits the Portean category of natural magic; and it did: the telescope was generally connected to mirrors, cameras, and so on.[16] In the company of Burggrav's lamp of life that transforms blood in such a way to make visible the vital element, Jacob's spyglass can be said to transform the visual perception of the world to bring things

[14] Usually regarded as having been the first university chair in alchemy – although this is a rather presentist term. See for example Salloch 2006, 31–39.

[15] Dijksterhuis 2004, 42–46. See also: McKeon 1986; Winkler & Van Helden 1993.

[16] Reeves 2008.

from afar nearby.[17] We can read Burggrav's instrument as an optical instrument as well; not confined to some category of chymistry, but an instrument that deals with light and vision. It adds a chymical element by the substantial conception of light that can be affected in controlled reactions. In this perspective the Franeker telescope was not misplaced in the medical and chymical laboratory of Sternsee: perhaps it could bring to light some vital element as well. The letter of Vranckheim places both instruments alongside each other, and so the ingenuity of Burggrav and Jacob Metius. In this way it enriches our understanding of 'optical' to a general sense of instruments to create and manipulate light and images.

6.2 The Magical Microscope

Some ten years after the annunciation of the telescope, the microscope was received in this same constellation of instruments of natural magic. In London, Cornelis Drebbel entertained a 'standing spyglass' that brought tiny objects and creatures to life size. At the time of the Vranckheim letter he had been at the start of his virtuoso career and after a brief sojourn at the Prague court he had returned to London where he further developed his instruments. Another Dutchman was also in town: Constantijn Huygens (1596–1687) who participated in a diplomatic mission of the Republic in preparation for his career as secretary to the Stadtholder. In the biographical sketch of his youth that he wrote ten years later as a kind of memento for his wife, Huygens described Drebbel's instrument:

> Not only originating from his hand but also conceived by his remarkable brain is an upright telescope, if I may call it so, fitted with two lenses that are both convex. The lowest of these, closest to the object to be observed, is the size of half a nail of the little finger. Even if Drebbel has achieved nothing else in his life, he would have acquired immortal fame with this miraculous little tube. Namely, particles that we used to consider as atoms because they are completely hidden from human sight, the observing eye gets clearly visible before it, so that people who do not know the instrument first complain that they see nothing, because they see things they have never seen. But soon they scream enthusiastically that their eyes see the most incredible things. It is truly as if one stand before a new stage of nature, as if you are on a different world.[18]

[17] Zuidervaart 2010, 11 footnote 11. 'seekere conste … daer mede men seer verre alle dingen can sien al oft die naer bij waeren bij middel van gesichten van glasen, …'

[18] Worp 1897, 119–120. 'Ab eiusdem non manu solâ sed prodigioso ingenio est perspicillum, ut sic dicam, statarium duobus vitris instructum, quorum convexum utrumque, alterum, quod inferius et obiecto proximum est, amplitudine auricularis digiti medium unguem vix adaequat. Hoc mirabili tubulo, ut nihil omni vitâ aliud praestitisset, nominis immortalitatem Drebbelius non dubie promeruit. Corpora nempe, quorum inter atomos hactenus aestimatio fuit, omnem humanam aciem longe fugientia, inspectanti oculo tam distincte obiecit, ut, cum maxime vident imperiti, quae nunquam videre, nihil se videre questi primo, mox incredibilia oculis usurpare clamitent.' My translation is based on the Dutch translation in Huygens 1987.

Early experiences with Drebbel's microscope were of similarly carnal character as Burggrav's lamp of light. It brought to view the worms in the cheese.[19] Rather than inviting a menocchian contemplation of the make-up of the world the experience caused revulsion over this secret of everyday nutrients. For Constantijn it opened entirely new possibilities for artists. He had suggested to the painter Jacob de Gheyn (c. 1565–1629) to employ Drebbel's microscope to depict this uncharted realms and publish a collection of engravings *Novi Orbis*.[20] He continued:

> Therefore nothing will incite us more strongly to worship the eternal wisdom and power of the Creator than entering this treasury of Nature. There, exactly in the smallest and tiniest, we will be confronted with the same devotion of the Architect and everywhere we will come upon the same unspeakable Majesty.[21]

Constantijn expected that with new lenses the tiniest objects could be magnified ad infinitum. According to him bodies are infinitely divisible and all parts have the same properties as the whole.[22]

> I remember that I had very interesting conversations about these matters with Drebbel, who always visited me when I was in London.[23]

Constantijn probably had met Drebbel on his first journey to England in 1618–1619. He mentioned him for the first time in his correspondence during his second stay. Early 1622 he wrote his parents how they had talked about glasses and the English imagining theirs to be better.[24] Constantijn had become a great admirer of Drebbel, whom he regarded together with Francis Bacon as the most significant criticaster of the empty ideas, doctrines and axioms of Antiquity.[25] Unlike Bacon, Drebbel was a pleasant person of modest descent, and he had come miraculously far

---

[19] Constantijn phrases it quite general, but Peiresc around the same time literally viewed cheesemites through it, see below.

[20] Worp, 1897, 120. 'Revera enim istud novo in theatro naturae, alio in terrarum orbe versari est et, si Geinio patri diuturnior vitae usus obtigisset, aggressurum fuisse credo, quo impellere hominem non invitum coeperam, minutissima quaeque rerum et insectorum delicatiore penicillo exprimere compilatisque in libellum, cuius aeri exemplaria incidi potuissent, Novi Orbis vocabulum imponere.'

[21] Worp 1897, 120. 'Infinitam Creatoris Dei sapientiam ac potentiam venerari nullâ re magis adigamur, quam si, satiati obviis cuique hactenus naturae miraculis, quorum, ut fit, frequenti usu ac familiaritate stupor intepuit, in alterum hunc naturae thesaurum immissi, in minimis quibusque ac despectissimis eandem opificis industriam, parem ubique et ineffabilem maiestatem offendamus.' Huygens added in the margin a citation from Aristotle, *De partibus animalium* 1, 5.

[22] Worp 1897, 120–121.

[23] Worp 1897, 121. 'Cum Drebbelio frequenter, quoties Londini essem, ad me visente, memini hac de re praestantissimos sermones fuisse, …'

[24] Huygens 1911, 76 (letter 120, January 1622). 'J'ay parlé van de brillen mesmes avec Drebbel; il se rit de quoy on s'imagine qu'en Angleterre se fassent les meilleures, …'

[25] Worp 1897, 112. 'Veterum, quae dixi, inanium notionum, theorematum, axiomatum censores praestantissimos duos aetate meâ suspexi, Franciscum Baconium, Angliae non ita pridem cancellarium, et disparis loci, non ingenii, Cornelium Drebbelium Batavum.'

in physics.[26] Constantijn listed his inventions, lauded his ingenuity, and praised the way this 'Daedalus' combined hand and mind. He was not uncritical of Drebbel's claims and ideas, though, and gave a remarkably balanced report of his feats. He put Drebbel's claims into perspective but he did not agree with people who called him a mere visionary who never lived up to expectations.[27] The microscope did and it made a lasting impression on Constantijn who would bring one home to entertain his family and friends.[28] Constantijn probably first saw Drebbel's microscope during his first stay in England. His companion Willem Boreel later wrote that he had seen it in 1619.[29] In March 1622 Constantijn listed his debts to his parents, saying that the 'lunette' of Drebbel had eaten 40 florins.[30] This was probably a Drebbel microscope – elsewhere the instrument was also referred to as 'lunette' – and the one that allegedly ended up in Constantijn's The Hague home.[31]

Around the same time two of Drebbel's sons-in-law, Abraham and Gilles Kuffler, demonstrated his instruments on the continent. On Tuesday 22 May 1622, the polymath Nicolas-Claude Fabri de Peiresc drew up a lengthy report of a demonstration in the petit Luxembourg in Paris.[32] The 'lunette' of 'Drebellius' consisted of a three-piece tube of some 10 in. in length and one inch in diameter. The lid on one end had a tiny hole behind which a small glass sphere was mounted. The tube on the other end was about a third inch in diameter, holding a lens with a flat side facing the inner lens and the convex side turned to the object on the outside. The convex face was covered with brass, leaving a tiny opening for observation. The demonstrators purported that the glass of the objective lens was of special make, enhancing the clarity of view. Peiresc noted that the image remained remarkable clear and sharp when the instrument was adjusted. The tube was mounted on an adjustable brass tripod. Through the instrument they saw numerous marvelous things, such as the build and color of individual cheesemites, a flea (as well as the fabric of the blotting paper on which it was mounted) that resembled tiny shrimps or crayfish the size of an elver, its egg like a chicken's kidney, and so on with fruit flies, spiders, etc. Like Constantijn they were impressed by the perfection of this tiny life and the way it replicated the structures of the visible world.

---

[26] Worp 1897, 116. 'De Drebbelio, quem cum Baconio copulavi, parcior sermo exit; apposita nempe hac soil luna in physicam praecipue attendebam, qua hunc de plebe Batavum borealem, Alcmariae civem, minim in modem valuisse oculatus testis assero, multa familiaritate hominem perspeetum habens eidemque perspectus.'

[27] Worp 1897, 116. 'Cavillati aliqui cum Jacobo Rege sunt, vix operae quicquam edidisse perpetuum inventorem, cuius utilitate impensa rependeretur'.

[28] Jorink, 2010, 181–184.

[29] Borel 1655, 36. This, however, is not an entirely reliable source as it is also contained the infamous but persistent claim that Sacharias Jansen had invented the telescope. Boreel was also in London in 1622.

[30] Huygens 1911, 91 (letter 141, March 1622). "La lunette de Drebbel en a mangé quarante".

[31] Peiresc. Ruestow 1996 7–11.

[32] Humbert 1951 has made a full transcription. He says that the manuscript is in Peiresc's hand. Jaeger 1922, 133–135 made a full transcription but did not publish the observations.

The Peiresc report is verbal, but in 1631 Isaac Beeckman in Dordrecht made a sketch of a 'perspectivum dr^{j}' that fits the description.[33] The context is illuminating: Beeckman added it to a copy he made of a 1613 letter of Drebbel to King James. This was the moment he returned to London, after his sojourn at the Prague court. Apparently to reapply for patronage Drebbel presented his various inventions. Among these were telescopes with unrivalled properties but not a microscope. This strongly suggests that Drebbel developed his microscope after his return in London, somewhere between 1613 and 1618. Whether Drebbel has actually 'invented' the microscope has been a matter of debate but does not need to concern us here.[34]

The microscope was but one of Drebbel's optical devices. In the course of his career he developed a line of instruments that created images and perceptions in various kinds of ways. With a common trope from the early days of the telescope he told James that he could make telescopes with which letters could be read at 7 miles. He did not claim to have invented the instrument, but he said that his lenses were extraordinary and could not be replicated.[35] Drebbel had first heard of the telescope shortly after its annunciation. Around the time Vranckheim was promoting Jacob Metius's authorship, Drebbel inquired with his acquaintances in his home town after the new invention. 'You have until now remained silent over the 'far seeing' found by the son of Mr. Adriaen Thonissen. Please let me know what he has done. In these I have also found excellent things that seem so incredible and are estimated to be magic'.[36] Drebbel then explained how he would stand in a room in front of an audience and magically change his appearance: first the color and fabric of his clothes, and then taking on the shape of tree, animals and so on. Although the letter is not very explicit, it probably was an early version of the camera obscura that Constantijn Huygens described in critical detail later. 'It's an instrument of simple make, where one can project in a carefully closed room objects that are held outside in front of it right out in the sun.' Drebbel fit a lens in the opening, an idea that he may have come up with himself but was not original, Constantijn continued. What was original, he wrote, was a white screen parallel to the wall that could be moved to and from and turned around. Apparently Drebbel used the camera to make himself

[33] Beeckman 1939–1953, 439–442 (appendix II). Jaeger denies this similarity but gives no further arguments. Jaeger 1922, 134 footnote 1.

[34] Borel introduced the claim that Sacharias Jansen invented the telescope and the microscope (Borel 1655). Within a few decades Christiaan Huygens had refuted the claim (see below); Zuidervaart 2010 shows how it persisted until the present day. Ruestow 1996, 7 repeats the claim that Drebbel obtained one from Jansen. Harting in his historical exposition also denied Drebbel's authorship: Harting 1850, 24–28.

[35] Beeckman 1939–1953, 440.

[36] Letter to IJsbrandt van Rietwijck in Alkmaar, around 1608–1609. Transcription Jaeger 1922, 110. 'UE. heeft mij voor desen geswegen 't verre sien gevonden bij den zoon van Mr. *Adriaen Thonissen*. lck bidde laat mij weten wat daerin gedaen heeft. lck hebbe oock vele excellente dingen daerin gevonden, soo ongelooflijke schijnen ende als tooverij geestimeert werden, waervan UE. hier een weinich wil gedencken.' The 'son' is often mistaken for Adriaan, including Keller 2008, 124; but in 390 footnote 397 Jacob is referred.

metamorphose by projecting colors and images on his robe.[37] The only thing that remained, he wrote, was that Drebbel would find a way to erect the images.[38] Huygens also brought a camera back home and would entertain visitors with the moving images on the screen.[39]

By this time, Drebbel had developed a whole family of visual instruments. Later he would be regarded as a model optics inventor alongside Galileo, Fontana and Rheita.[40] The Peiresc report describes all kinds of ways to cast images and light and view objects, like Archimedes-style mirrors to set fire at a distance and create floating images. Drebbel had developed a kind of spotlight: a configuration of multiple lenses with which candle light could be projected over a distance to make objects visible at night. The Peiresc report described an instrument 'that multiplied the light of a star in such a way that a letter can be read at night'.[41] Together with the camera and the microscope, instruments like these create the impression of a Drebbel dabbling with the set-ups and effects of his instruments. Combining and recombining the projection of images through a pinhole, the telescopic effects of the tube of long vision; reversing imagery and vision, inwards and outwards. Although the sources do not allow a full genealogy we can see Drebbel's microscope as the off-spring of the phantasmagoria camera and the telescope, and next of kin to the spotlight.

6.3 Quarters of the Magia Naturalis

With Drebbel too, terms like image, light and optical acquire a much broader meaning than the restricted dioptrical domain. Like Burggrav's lamp of light, Drebbel built all kinds of instruments that manipulated and utilized light. Peiresc described an artificial sun, 'that is to say a perpetual fire that always burns and lights.'[42] In Drebbel's ontology fire and light were equal, and fire was the quoin of the round of

[37] Jaeger 1922, 111 calls the instrument in the 1609 letter a magic lantern or camera lucida but this interpretation is very problematic for several reasons: the description is evidently camera obscura like and no 'slides' are projected on an outer screen; it is chronologically implausible.

[38] Worp 1897, 119. '…; levis operae instrumentum, quo quae foris obiiciuntur, sole valido illustrata, in cubiculum exquisite occlusum speciem sui intromittunt. Aperto tenui foramine maiores utebantur; primum Drebbelium applicasse fenestellam vitream orbicularem creditum fuit, sed et hanc superiorum industriae debet, nisi nescium veteris inventi dicas per se, quasi iam recentis, autorem extitisse, quod accidere non raro sciunt, qui, quo candore decet, omnium saeculorum laudes ex aequo librant. Illud constat, candidae tabellae cum pariete παραλληλισμόν, motum item et accessum et recessum et in omnem plagam facilem obversionem solius Drebbelii esse; perfectâ nunc iucundissimi longe atque utilissimi spectaculi machinâ, si, quas decussatis specierum radiis inversas imagines dat, erigat tandem Drebbelius meus et contractum diu nomen aliquando solvat.'

[39] Worp 1897, 83–84.

[40] Keller 2008, 39–40.

[41] Humbert 1955, 155. 'de multiplier la lumière d'une estoille en sorte qu'elle puisse faire lisre une lettre de nuict'

[42] Jaeger 1922, 132.

transformations of the four elements.[43] In his dynamics of atmospheric evaporations and condensations fire was the principal power of change; as an active agent rather than a substance. Drebbel recreated these processes in instruments like the famous perpetuum mobile and the self-regulating oven. Light was more directly involved in the clock that readjusted itself to the sun and the harpsichord that played to the light of the sun.[44] Vera Keller dubs the renowned perpetuum mobile 'cosmoscope': an instrument providing a look into the cosmos.[45] Huygens described it as a glass spiral that contained a fluid that imitated the tides in an ongoing periodical movement.[46] He compared it to the rarefaction and condensation through the change of temperature, not unlike the way we would nowadays say that Drebbel's living instruments utilized changes of atmospheric pressure.[47] In his oeuvre the cosmoscope and the microscope are close: heat and light being manifestations of a similar fiery quality inherent to matter and the instruments means to bring forth this latent fire.

In 1607 Gerrit Pietersz. Schagen (1573–1616) introduced his fellow townsman with these words: 'But this philosopher from Alkmaar can demonstrate [the principles of natural phenomena] not just with reason but also with living instruments.'[48] Drebbel's instruments channeled the powers of nature. Or rather: they emulated the powers of nature, for they were simulacra of natural phenomena, a microcosm displaying the workings of the world. In an early statement he wrote:

> thus also makes all kinds of instruments that play in its time and in all what can be made for a time by descending weight or by springs, by running waters, by wind, or by fire; that can be made by this knowledge for eternity.[49]

Drebbel's living instruments inhabit the world of *Magia Naturalis*. Like the designs of Della Porta the instruments of Drebbel were means to bring about effects. These effects were in fact phenomena replicated by human means and in a controlled manner. The creation of effects implied the understanding of phenomena thus recreated. In this phenomenological conception of understanding, instruments that imitated natural processes were the key to the workings of nature. Drebbel claimed to be able to explain the meteorological dynamics of the atmosphere by means of the thunder and lightning he artificially produced.[50]

---

[43] Drebbel 1621 (in particular the first three chapters; see also Keller's translation, Keller 2008, 508–524); Keller 2008, 44–46; 377–388.

[44] Drebbel described these as early as 1613: Jaeger 1922, 100–101; 110; 125–126.

[45] Keller 2010, 41–43.

[46] Worp 1897, 116–117.

[47] Borrelli 2008; Keller 2013.

[48] Drebbel 1607, n.p. laudatory epistle: 'Maer desen Alckmaersche Philosooph can 't selfde niet alleen met reden / maer oock met levendige Instrumenten bewijsen.' Compare the translation in Keller 2008, 499.

[49] Drebbel 1607, n.p.: 'also oock maeck allerley Instrumenten / die eeuwelijck spelen op haer tijdt/ en in summa wat voor een tijdt ghemaeckt kan werden / door dalent gewicht / of door springhveeren / door loopende wateren / door wint / oft door vier / dat kan ghemaeckt worden door dese kennis voor eeuwelijck'. Compare the translation in Keller 2008, 502.

[50] Keller 2008, 166

Arianna Borrelli has given a penetrating account of Della Porta's methods of inquiry. Employing a concept proposed by Bertoloni Meli she characterizes it as 'thinking with objects'.[51] Della Porta built upon the understanding of the effects of an artifact to acquire an understanding of a related, more complex one. In this way he worked in optics from plane to spherical mirrors, and from reflection to refraction, and eventually to lenses and their configurations. The crux here is that understanding is based on the properties and manipulation of images as a whole, rather than the analysis of their make-up by tracing the paths of rays. (And we need to bear in mind that these are images as perceived by the observer, and not the Keplerian pictures painted by rays.) This holistic and perceptual understanding of images can also be recognized in the accounts and reflections of Drebbel. The lineage of his optical instruments suggests that he extended his command over imagery from instrument to instrument: transforming the casting of camera images into streaming a bundle of light; reconfiguring a weatherglass into a light organ; and so on. The assumption that Drebbel was 'thinking with objects' in similar fashion as Della Porta is confirmed by his artefactual epistemology in which the understanding of natural dynamics consists of its instrumental emulation.

Still, Drebbel's writings are scarce. They do not reveal much about his instruments beyond pitches about their wonderful effects. Most of the information about the design and workings of his instruments comes from eyewitness accounts such as Peiresc and Huygens. In his own writings – basically a single exposition on the nature of elements – Drebbel focused on his natural philosophy.[52] They do not offer a very explicit account of light, images and perception. Light is largely subsumed under the category of fire, the central element in his conception of atmospheric dynamics. Drebbel and Della Porta stood in the same tradition of sixteenth-century criticism of Aristotelian theories of meteors.[53] Both set great store by a 'thermodynamic' explanation of winds substantiated in an experiment with an inverted glass vessel – showing barometric action in modern words. In this artifactual and metereological account of nature Drebbel focused on ontology in comparison to the precise epistemological steps of Della Porta.

Drebbel was connected to a circle of Low German alchemists with Hartmann as a prominent figure. The network also played a prominent role in the dissemination of his ideas and the continuation of his reputation.[54] Burggrav was an important promotor of Drebbel's philosophy, publishing German and Latin editions of his book. Even Andreas Libavius (ca. 1555–1616), who was quite critical of the group's opinions, was respectful of the artifacts and theories of Drebbel.[55] He did, however, reject Drebbel's conviction that his living machines provided a key to the cosmos.

[51] Bertoloni Meli, 2006, 1–17. Borrelli 2014, 41–46.

[52] For a detailed discussion of Drebbel's natural philosophy, as well as his ambitions and influence as natural philosopher, see Keller 2008.

[53] Borrelli 2008, 78–85.

[54] The Herborn scholar Alstedt adopted his ideas and the Kufflers became prominent members of the Hartlib circles in Northern Europe. Keller 2008, 429–461; Young, 2006.

[55] Keller 2008, 214; 406.

These northern protagonists introduced a decidedly vitalistic element in natural magic. Drebbel's cosmoscope channeled the perpetual, automotive movements of the tides. According to Burggrav it was driven by the 'magnetic spark of the Anima Mundi.[56] His own lamp of life functioned on the principle that the human blood attracts the vital celestial forces that direct individual health.[57] They also gave a spiritual twist to their inquisitive practices, fusing natural and divine knowledge in reading the Book of Nature alongside the Scripture. Drebbel strongly adhered to this religiously anchored epistemology. He acquired understanding of the workings of nature by means of devising ingenious instruments that disclosed the secrets of nature. This operational way of knowing was grounded in manual labor performed under the guidance of God. Adoration by instruments, so to say.

Characterizing Drebbel as a chymist is hazardous. He was trained as an engraver and originally he was active in hydraulic projects, building fountains and acquiring patents for pumps and chimneys around 1600.[58] He was generally referred to as an engineer and mathematician, and his instruments were called mathematical.[59] The baptism of Drebbel's fire regiment as 'thermometer' took place in the *Récréations Mathématiques*, a widespread collection of 'secrets' that went through various editions after 1624.[60] Calling metereological instruments mathematical is a fine example of shifting categories from our perspective. In general mathematics was commonly ranked among secret knowledge and natural magic, with Archimedes as the paragon of ingenuity.[61] In his reflection on the original wisdom – written around 1600 – Simon Stevin listed magic with arithmetic and chymistry among the instances of pre-classical knowledge.[62] As a hydraulic engineer Drebbel fits very well in the lineage of Dutch virtuosi like Stevin and Beeckman. Stevin may well provide a model of a vernacular philosopher for Drebbel, but historiography usually sets them apart.[63] Already in 1612 Drebbel was considered as a singular example of Dutch ingenuity.[64] Gerrit Schagen introduced him in 1607 as a nova, like the nova observed by Metius' father Anthonisz., the original Dutch engineer from Alkmaar.[65]

[56] Keller 2008, 391.

[57] Keller 2008, 111 footnote 271.

[58] Tierie 1932, 31–36; see also Jaeger 1921 and Keller 2008.

[59] Borrelli 2008, 111–113 cites a description of the experiment as a mathematical marvel and Drebbel as a smart mathematician.

[60] Keller 2013, 244–245.

[61] Schneider 1998, 1–26; Keller 2008, 214; 325.

[62] Stevin 1608, 9–16 (in 'Bepaling 6' of 'Vant Eertclootschrift' in 'Vant Weereltschrift').

[63] Keller 2008, 25 footnote 78. Stevin hardly figures in Keller's account, instead she presents Coornhert as a possible model.

[64] Keller 2008, 135.

[65] Drebbel 1607, n.p.: laudatory epistle by Gerrit van Schagen.

6.4 Porta Readings in the North

The case of Drebbel shows that there was definitely room for natural magic in the Low Countries.[66] His work was well-known and well-received, and throughout the seventeenth century his heritage is encountered. Likewise, Della Porta's works were well circulated and respected among northern readers.[67] As early as 1566 the *Magia Naturalis* was translated into Dutch and published by Plantijn in Antwerp. 'Magic, or the miraculous works of nature', contained the four books of the first edition of 1558. The second edition of 1589 was not translated, though. From the 1650s two editions of the Dutch *Magia* were published in Leiden but they were based on the 1566 translation, confined to the contents of the first four-volume edition of the *Magia*. Dutch readers had to rely on the original Latin for Della Porta's extension of his optical account to spheres and lenses of book XVII of the twenty-volume sequel. The original editions of Della Porta's publications were found in many libraries, though. Constantijn Huygens owned both the *Magia Naturalis* and *De Refractione*; Beeckman used the *Magia* as well as the *Pneumatica*. Although his work and reputation were known, Della Porta does not seem to have been a particular focus of interest. His name was mentioned among others. Someone like Huygens referred to Della Porta a few times in his correspondence but merely in the passing. The influence of the *Magia Naturalis* may have been more indirect. Through the general notion of natural magic as it appears in the *Récréations Mathematiques*; and along lines of specific topics like the weather glass.

Isaac Beeckman was very interested in natural magic. Like Drebbel he had engaged in hydraulic engineering projects, before embarking upon a scholarly career as a headmaster. From an early point on he was engaged with Drebbel's work; he read a copy the rare first edition of *Natuere*.[68] He was closely connected to the Drebbel circles and is – as we have seen – an important source of information on his instruments.[69] Beeckman also knew Della Porta's work well, having access to works like this in the library of the Dordrecht minister Colvius. On one occasion he discussed Della Porta's account of the phases of the Moon and their relationship to earthly humidity, praising the Neapolitan for his depth compared to others.[70] In

[66] In Franeker the chymistry of Burgrav and Hartmann seems to have faded somewhat in the background after the 1620s. Adriaan Metius appears to have lost part of his interest after the death of Sternsee (and the disappearance of a substantial part of his funds). This is at least the suggestion that his funeral orator Winsemius makes: alchemy had temporary fascination of Metius. Winsemius, by the way, resided in the Franeker castle but took no interest in the chymical laboratory of its previous owner. The further history of chymistry in the Low Countries need not occupy us here, but is well worth being told – including the vital uses of light.

[67] For an overview see Gemert, 2008.

[68] Beeckman 1939–1953, I, 346; II, 25; 44; 122. His father kept him up to date on developments and the book may also have been among their Middelburg circles: Berkel 2013, 30–31; 49–51. See also Keller 2008, 58. 1607.

[69] Beeckman 1939–1953, III, 302.

[70] Beeckman 1939–1953, II, 34–35.

optics too magical traits can be discerned in Beeckman's reflections, in particular in his accounts of colors. He regarded color as a clue to the nature of materials that are transformed under the influence of fiery reactions.[71] In his work on lenses and telescopes he took, however, a different direction than Drebbel and Della Porta. Beeckman is one of the few who engaged deeply in dioptrics in the Low Countries in the early seventeenth century. During the final years of his life he was intensively occupied with the grinding of lenses and the construction of telescopes. In his theoretical and experiential reflections he showed much originality and inventiveness, but he developed a rather geometrical approach along Keplerian lines.[72] As a result, in Beeckman's account of optical effects there was little room for a phenomenological approach like that of Drebbel and Della Porta.

The phenomenological approach to optics resonated much better with Constantijn Huygens. Upon his return to the Republic he brought a Drebbel camera and microscope with him to entertain and inspire his acquaintances and visitors. He urged painters to make use of the microscope to paint a new world and employ the camera as a way to bring painting to life.[73] He suggested scholars to study refraction and supported Descartes' efforts to build a flawless telescope.[74] During his long life Huygens became one of the most prominent cultural intermediaries of the Republic. His case illustrates the relative marginality of Della Porta in Dutch culture. He knew and esteemed the *Magia Naturalis*, but his unreserved praise went to the ingenuity of Drebbel. In general, it seems that drebbelian conceptions and circles were dominant in northern natural magic and overshadowed Della Porta.

Constantijn passed on his enthusiasm for optics this his sons Constantijn jr. (1628–1697) and Christiaan (1629–1695) (he wrote his memento on his youth in the weeks after the latter's birth). Together they would grind lenses, build telescopes, and observe the heavens.[75] Christiaan would of course acquire fame with his mathematical and philosophical writings on light and telescopes but he also continued another part of his father's optical interest: the drebbelian camera. In 1662 his father was at the Paris court involved in laborious negotiations for the Oranges. With a view to entertain his audience he asked his son to send a 'lantern with two or three pictures of which it makes the representation'.[76] This was a magic lantern and Chrstiaan had invented it somewhere in the 1650s.[77] Rather than projecting light on a sheet inside the camera, it projected light through a picture on glass upon a surface

[71] Dijksterhuis 2016.

[72] Dijksterhuis 2010.

[73] Huygens 1911, 94 (Letter 143, to his parents April 1622).

[74] Dijksterhuis 2011, 100–103; Dijksterhuis 2007, 65–67.

[75] Dijksterhuis 2004, 53–63; 214–216.

[76] Huygens 1888–1950, IV, 102 (letter 1001; to his brother Lodewijk, 5 April 1662). 'Voila encore une autre commission que mon Pere me donne, de luy ajuster une lanterne avec 2 ou 3 diverses peintures dont elle face la representation.'

[77] Huygens 1888–1950, XXII, 196–197; 521–523.

outside. The historical link between Christiaan's magic lantern and the Drebbelian camera of his father requires further investigation.[78]

Christiaan's attitude differed considerably from his father's, though. He reluctantly complied with the request and secretly instructed his brother Lodewijk to leave out a crucial lens in order to more or less sabotage it.[79] Apparently Christiaan did not want to be associated with an instrument that he considered nothing but a playful entertainment. Historiography has strictly separated the natural magic of Drebbel from the science of Christiaan Huygens. The perpetuum mobile is often invoked to illustrate the chasm. However, even in the case of Christiaan Huygens things are not as simple as they appear. He may have rejected the possibility of a perpetuum mobile qua mechanics but he did not exclude the possibility as regards heat or magnetism.[80] That is: machines could very well run on their own when employing the hidden forces of nature. Natural magic was as real for Christiaan as it was for his father.

Huygens had been reading Della Porta quite well. Although he never discussed the ideas of *Magia Naturalis* and *De Refractione* extensively, he approvingly mentioned them at several places.[81] For example, he named Della Porta as one of the pioneers in the 'measure of refraction' – that is the mathematical regularity of refraction angles – with Maurolyco and Kepler. Furthermore, in the theory of vision – that Huygens never really elaborated but did make some notes about in his manuscripts – Della Porta figures prominently with his account of images appearing in the dark. Huygens also noted that Della Porta has the image in the crystalline lens as contrasted to the retinal image of Kepler.

Around 1692, at the end of his life and not that long after the death of his father in 1685, Christiaan was reading the *Dioptrica Nova* of William Molyneux, making all kinds of comments and corrections.[82] At one point he noted that Molyneux, on the basis of Borel and Sirturi promoted Sacharias Janssen and Fontana as inventors of the telescope. Huygens had refuted that claim himself: some time earlier he had done some archival work and found out that the authorship of Janssen was

[78] The phantasmagorical projecting of colors and objects on a screen by Drebbel is interesting. It suggests a continuity from Drebbel to Christiaan Huygens, Walgenstein and Kircher. The editors of the *Oeuvres Complètes de Christiaan Huygens* refer to Constantijn's interest but do not discuss it further: Huygens 1888–1950, XXII, 521–523. Wagenaar's substantive history of the camera from 1979 does not mention it; Hankins 1995 (chapter 2: 'The Magic Lantern and the Art of Demonstration') 43–48 mentions it but does not pursue the suggestion. Neither does Steadman, who apparently has not inspected the details of Constantijn's description; his suggestion that the camera depicted by Kircher is akin to Drebbel's is significant. Steadman 2001, 17–19. Keller merely mentions the camera, without considering the details of the set-up. Keller 2008, 233 footnote 540; 471 calling it magic lantern; on p. 471 explicitly. Keller 2008, 21 footnote 64 raises the question whether it was an arrangement of mirrors rather than a lantern, but does not elaborate on it.

[79] Huygens 1888–1950, IV, 109–110 (letter 1004; to his brother Lodewijk, 12 April 1662).

[80] Huygens 1888–1950, XIX, 553; 575–581; 591–603.

[81] Huygens 1888–1950, XIII, 437; 588–590; 740–750.

[82] Huygens 1888–1950, XIII, 826–844.

manufactured.[83] Huygens elaborated a brief history of the telescope in the 1680s when he was preparing a treatise on dioptrics. Besides the theory of the telescope – that he had elaborated in the 1650s but never published – it also included the microscope. He named Drebbel as the true inventor of that instrument. The true inventors of the telescope were Lipperhey and 'the brother of Metius' he concluded. But Della Porta deserved the credit for having been the first to suggest the idea of the telescope. If he had not made sufficient progress, this was because he only knew the rudiments of the art of optics as Huygens knew it.[84] This appreciation for Della Porta went back to his first plans for a treatise on dioptrics in 1672: 'Porta was the first who had begun.'[85]

References

Beeckman, Isaac. 1939–1953. *Journal tenu par Isaac Beeckman de 1604 à 1634*, ed. C. de Waard. The Hague: Martinus Nijhoff.

Berkel, Klaas van. 2013. *Isaac Beeckman on matter and motion: Mechanical philosophy in the making*. Baltimore: The Johns Hopkins University Press.

Bertoloni Meli, Domenico. 2006. *Thinking with objects: The transformation of mechanics in the seventeenth century.* Baltimore: The Johns Hopkins Press.

Borel, Pierre. 1655. *De vero telescopii inventore. cum brevi omnium conspiciliorum historia; ubi de eorum confectione, ac usu, seu de effectibus agitur, novaque quaedam circa ea proponuntur, accessit etiam centuria observationum microcospicarum*. The Hague: Adriaan Vlacq.

Borrelli, Arianna. 2008. The weatherglass and its observers in the early seventeenth century. In *Philosophies of technology: Francis Bacon and its contemporaries* (Intersections 11/1), ed. Claus Zittel, Gisela Engel, Nicole C. Karafyllis and Romano Nanni, 67–130. Leiden: Brill

———. 2014. Thinking with optical objects: glass spheres, lenses and refraction in Giovan Battista Della Porta's optical writings. *Journal of Early Modern Studies* 3: 39–61.

Burggrav, Johann Ernst. 1610. *Lampas Vitae et Mortis omniumque graviorum in Homine pathoon*. Leiden: Hendrik Haestens.

———. 1611. *Biolychnivm seu Lvcerna : Cum vita ejus, cui accensa est MysticeÌ, vivens jugiter, cum morte ejusdem expirans, omnesq[ue] affectus graviores prodens*. Franeker: Uldricus Balck.

Dijksterhuis, Fokko Jan. 2004. *Lenses and waves. Christiaan Huygens and the mathematical science of optics in the seventeenth century*. Dordrecht: Springer.

———. 2007. Constructive thinking. A case for dioptrics. In *The mindful hand: Inquiry and invention from the late Renaissance to early industrialisation*, ed. Lissa Roberts et al., 59–82. Amsterdam: Edita.

———. 2010. Labour on lenses. Isaac Beeckman's notes on lens making. In *The origins of the telescope*, ed. Albert van Helden, Sven Dupré, Rob van Gent, and Huib Zuidervaart, 257–270. Amsterdam: KNAW Press.

[83] Huygens 1888–1950, XIII, 436–437; 591–593.

[84] Huygens 1888–1950, XIII, 436–437.

[85] Huygens 1888–1950, XIII, 738–741. 'B. Porta est le premier qui a commencè'. Huygens added that reading of Della Porta may have assisted the Dutch achievement: 'Progres en Hollande peut estre par la lecture de Porta.' On the dating of these manuscript notes see Dijksterhuis 2004, 92 and 140.

———. 2011. Moving around the Ellipse. Conic sections in Leiden, 1620–1660. In *Silent messengers: The circulation of material objects of knowledge in the early modern low countries*, ed. Sven Dupré and Christoph Lüthy, 89–124. Berlin: Lit.

Dijksterhuis, Fokko Jan. 2016. Varieties of theories in the color worlds of the early seventeenth century. In *Early modern color worlds*, ed. Tawrin Baker, Sven Dupré, Sachiko Kusukawa, and Karin Leonhard, 227–247. Leiden: Brill.

Dijkstra, Arjen. 2012. *Between Academics and Idiots. A Cultural History of Mathematics In The Dutch Province Of Friesland (1600–1700).* Dissertation University of Twente

Drebbel, Cornelis. 1607. *Wonder-Vondt van de Eeuwighe Bewegingh*. Alkmaar: Jacob de Meester.

———. 1621. *Een Kort Tractaet van de Natuere Der Elementen*. Haarlem: Vincent Casteleyn.

Dupré, Sven. 2005. Ausonio's mirrors and Galileo's lenses: The telescope and sixteenth-century practical optical knowledge. *Galilaeana: Journal of Galilean Studies* 2: 145–180.

———. 2006. Visualization in Renaissance optics: The function of geometrical diagrams and pictures in the transmission of practical knowledge. In *Transmitting knowledge: Words, images and instruments in early modern europe*, ed. Sachiko Kusukawa and Ian Maclean, 11–39. Oxford: Oxford University Press.

Gemert, Guillaume van. 2008. Giovan Battista Della Porta in den Niederlanden. Ansätze zu einer Rezeptionsgeschichte. *Morgen-Glantz* 18: 29–61.

Hankins, Thomas, and Robert Silverman. 1995. *Instruments and the imagination*. Princeton: Princeton University Press.

Harting, Pieter. 1850. *Het Mikroskoop, deszelfs gebruik, geschiedenis en tegenwoordige toestand*. Utrecht: Van Paddenburg & Comp.

Humbert, Pierre. 1951. Peiresc et le Microscope. *Revue d'histoire des sciences et de leurs applications* 4–2: 154–158.

Huygens, Christiaan. 1888–1950. *Oeuvres complètes de Christiaan Huygens*. Den Haag: Martinus Nijhoff.

Huygens, Constantijn. 1911. In *Briefwisseling. Deel 1: 1608–1634*, ed. J.A. Worp. Den Haag: Martinus Nijhoff.

———. 1987. *Mijn jeugd* (trans., ed. C.L. Heesakkers). Amsterdam: Querido.

Jaeger, F.M. 1922. *Cornelis Drebbel en zijne tijdgenooten*. Groningen: Noordhoff.

Jorink, Eric. 2010. *Reading the book of nature in the Dutch golden age, 1575–1715*. Leiden: Brill.

Keller, Vera. 2008. *Cornelis Drebbel (1572–1633): Fame and the making of modernity*. Dissertation Princeton University.

———. 2010. Drebbel's living instruments, Hartmann's Microcosm, and Libavius's Thelesmos: Epistemic machines before Descartes. *History of Science* 48-1: 39–74.

———. 2013. Re-entangling the Thermometer: Cornelis Drebbel's description of his self- regulating oven, the regiment of fire, and the early history of temperature. *Nuncius* 28: 243–275.

McKeon, Robert M. 1986. Le renouvellement de l'astronomie de précision de Tycho Brahe a Jean Picard. In *Picard et les debuts de l'astronomie de précision au XVIIe siècle*, ed. Guy Picolet, 119–131. Paris: CNRS.

Reeves, Eileen. 2008. *Galileo's glassworks. The telescope and the mirror*. Cambridge: Harvard University Press.

Ronchi, Vasco. 1954. Du 'De Refractione' au 'De Telescopio' de G.B. Della Porta. *Revue d'Histoire des Sciences* 7: 34–59.

Ruestow, Edward. 1996. *The microscope and the Dutch Republic. The shaping of discovery*. Cambridge: Cambridge University Press.

Salloch, Sabine. 2006. *Das hessische Medizinalwesen unter den Landgrafen Wilhelm IV. und Moritz dem Gelehrten. Rolle und Wirken der fürstlichen Leibärzte*. Dissertation Philipps-Universität Marburg.

Schneider, Ivo. 1998. *Johannes Faulhaber 1580–1635. Rechenmeister in einer Welt des Umbruchs*. Basel: Birkhäuser.

Steadman, Philip. 2001. *Vermeer's camera: Uncovering the truth behind the masterpieces*. Oxford: Oxford University Press.

Stevin, Simon. 1608. *Wisconstige Gedachtenissen,* vol. 1. Leiden: Jan Bouwensz.

Tierie, Gerrit. 1932. *Cornelis Drebbel (1572–1633)*. Paris: Amsterdam.

Wagenaar, Willem. 1979. The true inventor of the magic lantern: Kircher, Walgenstein or Huygens? *Janus: archives internationales pour l'histoire de la médecine et pour la géographie médicale* 66: 193–207.

Winkler, Mary G., and Albert Van Helden. 1993. Johannes Hevelius and the visual language of astronomy. In *Renaissance and revolution: Humanists, scholars, craftsmen and natural philosophers in early modern Europe*, ed. J.V. Field and Frank A.J.L. James, 97–116. Cambridge: Cambridge University Press.

Worp, Jacob Adolf. 1897. Fragment eener autobiographie van Constantijn Huygens. *Bijdragen en Mededeelingen van het Historisch Genootschap* 18: 1–122.

Young, John T. 2006. *Faith, medical alchemy, and natural philosophy: Johann Moriaen, Reformed intelligencer, and the Hartlib circle*. Aldershot: Ashgate.

Zuidervaart, Huib. 2010. The 'true inventor' of the telescope. A survey of 400 years of debate. In *The origins of the telescope*, ed. Albert van Helden, Sven Dupré, Rob van Gent, and Huib Zuidervaart, 9–44. Amsterdam: KNAW Press.

Arianna Borrelli • Giora Hon • Yaakov Zik
Editors

The Optics of Giambattista Della Porta (ca. 1535–1615): A Reassessment

Springer

Editors
Arianna Borrelli
History of Science
Technische Universität Berlin
Berlin, Germany

Giora Hon
Department of Philosophy
University of Haifa
Haifa, Israel

Institute for Advanced Study on "Media Cultures of Computer Simulation (MECS)"
Leuphana University
Lüneburg, Germany

Yaakov Zik
Department of Philosophy
University of Haifa
Haifa, Israel

ISSN 1385-0180 ISSN 2215-0064 (electronic)
Archimedes
ISBN 978-3-319-50214-4 ISBN 978-3-319-50215-1 (eBook)
DOI 10.1007/978-3-319-50215-1

Library of Congress Control Number: 2017932422

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Contents