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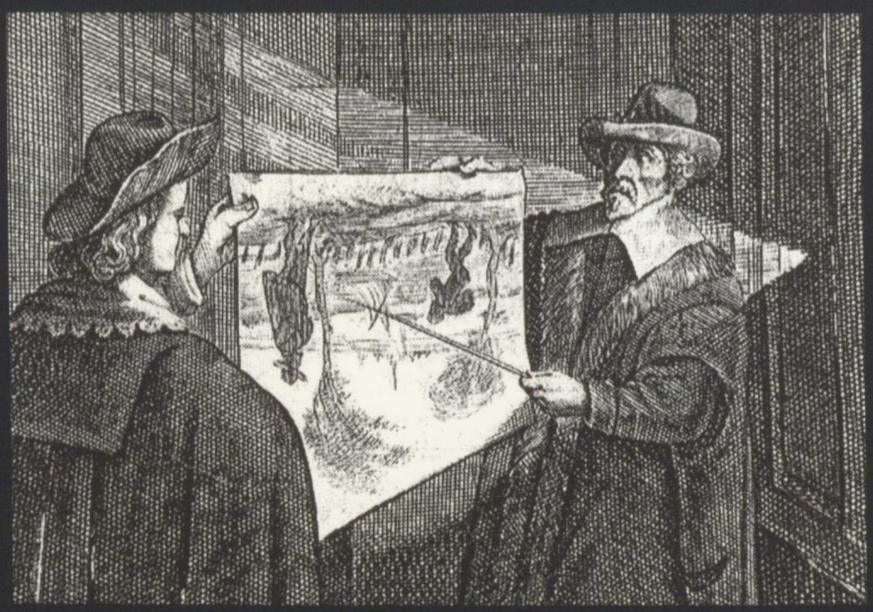


Appendix A

Vermeer and the Camera Obscura

fig. A1 Anonymous engraver Johan van Beverwijck demonstrating a room-type camera obscura in the tower of his Dordrecht house. From J. van Beverwijck, *De schat der ongesontheyt . . .*, Dordrecht 1642

Vermeer's possible use of the camera obscura has been a leitmotif of literature on the artist since the 1960s. The optical device was used as a drawing aid in the eighteenth century, mainly for topographical subjects, but its use by seventeenth-century artists is not documented and remains uncertain. One might gain a different impression from fictionalized accounts of Vermeer's life, from books intended for a wide audience (such as David Hockney's *Secret Knowledge*, of 2001), or from writers who are not primarily concerned with the matter at hand. For example, in *The Dictionary of Art* (1996) the brief entry on the camera obscura states that 'both Johannes Torrentius and Johannes Vermeer are known to have used it',[1] and a short section on painting in Delft ends with the astonishing remark that 'a typical feature of the Delft school is the use of a camera obscura in order to create the most realistic scene possible'.[2] (To the present writer's knowledge, no Delft artist other than Vermeer has ever been connected with the instrument.) By contrast, Delsaute (1998) concludes that 'no model of the darkened chamber [he translates the Latin term] could have been used regularly to draw from nature' during Vermeer's lifetime.[3] He allows that the artist must have known some form of camera obscura and would have been intrigued by it. 'We can even go so far as to say that Vermeer, in his painting, could have reacted to certain visual stimuli observable in such an optical device, but it seems rash to continue to believe that the camera obscura was one of the tools with which he worked.'[4]

The last words refer mainly to the excited articles of some forty years ago, by Seymour (1964), Schwarz (1966), and Fink (1971). Seymour compared an out-of-focus photograph of actual fabric and the lion's-head finial on a chair to a detail of the *Girl with a Red Hat* (cat. 24; fig. A3) and decided that the blurred highlights or 'discs of confusion' in the painting 'would result from poor depth of field in a seventeenth century apparatus'.[5] He also suggested that the 'remarkably casual effect of exactness in the middle distance of the *View of Delft*' (cat. 12) might have been achieved by using a room-type camera obscura in a house across the harbour (see fig. 12c), and that Vermeer's interior scenes could have been 'traced or otherwise imitated without much recourse to a complex mathematical perspective construction'.[6] That Vermeer's perspective constructions were considered 'complex' by Seymour will surprise (or amuse) anyone familiar with seventeenth-century perspective treatises and Dutch paintings of church interiors, in particular those by Gerard Houckgeest (see fig. 8a) and Pieter Saenredam. Conservator Jørgen Wadum has shown that in at least thirteen paintings (the number of canvases on which 'physical evidence of Vermeer's system' remains) the painter used the 'simple method' of a pin and strings to construct the main lines of his perspective cartoon.[7] Anything more complex than that – an angled chair or viol, for example – could have been handled after a half-hour's instruction from someone like Hendrick van Vliet (see fig. A2) or from one of the many Dutch perspective manuals that were available.

Schwarz's article (1966) expanded upon Seymour's with respect to optical aids but added very little in terms of comparisons with Vermeer's work. That mission was attempted by Fink (1971), who discerned a constellation of optical qualities in twenty-seven of the artist's pictures. His more plausible speculations concern effects of colour, light, and focus, while the least persuasive involve tracing objects, live models, and architectural interiors. Like Swillens (1950), who is cited as an authority on the subject, Fink assumed that 'the precise placement and scale of objects in like spaces [that is, similar rooms in different paintings by Vermeer] indicate the representation of a given reality'.[8] Thus, the difference between the marble floors in *The Music Lesson* (cat. 15) and the Dublin canvas of about eight years later (cat. 31) 'results

from a later modification of the room' and, presumably, a second shipment of marble from Italy.

Until recently, it was not widely known that marble floors were extremely rare in Dutch houses of the seventeenth century and were usually installed, if at all, in the foyers or hallways of the most luxurious residences.[9] In Delft, Vermeer could have seen stone-tiled floors in a few rooms of the Town Hall,[10] but certainly not in the Nieuwe Kerk, as views of its choir by Houckgeest (but not by De Witte) might lead viewers unfamiliar with Gothic churches to expect (fig. 8a). To see a real marble floor Vermeer probably would have had to visit the princely palace at Rijswijk.[11] Marble floors were uncommon because of their great expense and coldness, compared with wooden floors. The 'strong overrepresentation of elaborately patterned marble floors in paintings'[12] by artists such as Houckgeest and Vermeer depended on the use of models found in perspective treatises and responded to the admiration of perspective effects among collectors and connoisseurs. Van Hoogstraten's one paragraph on the room-type camera obscura (and 'reducing glasses and little mirrors') as something young painters ('de Schilderjeugt') might consult in order to see what a 'naturalistic painting' should look like may be weighed against his many words of praise for artists such as Raphael and other Italian muralists, Vredeman de Vries, Carel Fabritius, and the author himself, all of whom demonstrated how 'perspectives and perspective views [*perspectiven en doorzichten*] have always and everywhere been held in high esteem'.[13] Seconding this opinion, Dirck van Bleyswijck, in his 'Description of Delft', observes that Hendrick van Vliet's views of the local churches, when he painted them 'at his best' (as in fig. A2, which was reproduced by an engraving in the book), were 'very well foreshortened and illusionistic, as well as coloured naturally'.[14]

Similar words of appreciation were expressed by one of Van Vliet's most important patrons,[15] the art-loving diarist Pieter Teding van Berkhout, after he visited Vermeer's studio on 21 June 1669. The painter showed him 'some examples of his art, the most extraordinary and the most curious aspect of which consists in the perspective'.[16] One of the pictures the amateur may have seen at the

Hendrick van Vliet
View of the Interior of the Nieuwe Kerk, Delft, from beneath the Organ Loft at the Western Entrance, 1662
Oil on canvas, 95 × 85 cm
Dr. Gordon J. Gilbert and Adele S. Gilbert, St Petersburg, Florida

time was *The Art of Painting* (cat. 26). To judge from the detailed inventory of Vermeer's residence and studio,[17] Teding van Berkhout would not have encountered a camera obscura. After surveying hundreds of inventories and other documents in connection with his two archival studies of Delft (Montias 1982, 1989), the late Michael Montias doubted that any artist, collector, amateur of science, or other person in the city during Vermeer's lifetime owned a camera obscura (to recall several personal communications).

Indeed, the only known document placing some form of camera obscura (other than a hole in a window shutter) in a Dutch collection of the period is Constantijn Huygens's account of an instrument made by the inventor Cornelis Drebbel (1572–1633). (Van Hoogstraten refers to room-type camera obscuras that he had seen in Vienna and London.) Huygens first saw the device in London in 1622 and brought it home to The Hague. In his diary (c. 1630) he records a demonstration he conducted in his father's house 'to the great pleasure of painters', namely (or including) Jacques de Gheyn II and his son Jacques III, and the eccentric Johannes Torrentius (1589–1644). The courtier describes an instrument that projected 'in a closed space on a white surface the shape of things that were shown outside it'. Torrentius asked if the 'little people' he saw in the image were really 'alive outside the room'. After Torrentius had departed Huygens questioned his 'pretended ignorance of something which nowadays is familiar to everyone', and suggested to the De Gheyns that it might have been by the same means that Torrentius had achieved effects in his paintings very similar to 'these shadow-images'.[18] The one known painting that is indisputably by Torrentius, the *Emblematic Still Life*, of 1614 (Rijksmuseum, Amsterdam), is remarkable for its effects of light and shadow and softened contours, compared with other still lifes dating from the first thirty years of the century. Perhaps the connoisseur's conjecture was correct.[19]

Huygens concludes the first of his two passages on the camera obscura by asking how 'our painters' (meaning Dutch artists in general) could neglect or not know about 'an aid so pleasant and useful to them'.[20] This is an interesting question which Huygens himself and modern critics have not answered directly. One reason that the average painter would have been unfamiliar with the optical device is that reading about scientific instruments and especially owning them tended to be the province of professional scholars, court figures, and wealthy amateurs. (Such devices – indeed, the lenses alone – were expensive.) When Huygens refers to 'something which nowadays is familiar to everyone' the young secretary to the Prince of Orange means people in his privileged circle. As for artists neglecting such a 'useful' aid, here too we are reading the words of a dilettante who is not concerned with the everyday realities of studio work and the art market (nor were the De Gheyns). Huygens praises the naturalistic landscapes of Esaias van de Velde (whose *View of Zierikzee* is often cited as a compositional prototype for Vermeer's *View of Delft*)[21] and of his pupil Jan van Goyen, which 'lack nothing except the warmth of the sun and the movement [of the air] caused by coolness'.[22] Had Van Goyen actually used Huygens's drawing aid on a regular basis, he would have lost the advantages of his fast and low-cost means of production, and the esteem of collectors who admired his inventiveness and painterly virtuosity.[23]

In his well-known account of a contest between three landscape painters, Van Hoogstraten applauds the conceptual approach of Jan Porcellis, Van Goyen's headlong display of imagination (conjuring motifs out of a 'chaos' of light and shadow), and François Knibbergen's industrious niggling.[24] At the end of a single day all three landscape paintings were finished and the one by Porcellis was 'judged by the connoisseurs to be finer than the other two' because of its *keurlijker natuerlijkheyt* (more selective naturalness). As usual each artist began with a 'blank slate' in the studio, with no actual (or projected) landscape motif in sight.

Later in his diary Huygens returns to the subject of the same camera obscura and clarifies that this 'means of amusing princes' was only improved by Drebbel, not invented by him.[25] Drebbel's model was a lightly constructed device with a round lens and a 'white screen parallel to the wall'. The screen could be moved back and forth and the instrument could be turned in different directions. Huygens states that the invention might be perfected by Drebbel if he would solve the problem of the inverted image. According to Delsaute, Huygens's use of the word *triclinum* makes it clear (unlike the Dutch *kamer*) that the 'carefully closed chamber' employed with

fig. A3 Johannes Vermeer
Girl with a Red Hat (cat. 24, detail of chair finial)

fig. A4 Frans Hals
Portrait of Cornelia Vooght Claesdr, 1631 (detail of chair finial)
Oil on wood, 126.5 × 101 cm
Frans Hals Museum, Haarlem

Drebbel's apparatus was the room of a house not a box-type *camera*.[26] This conclusion is supported by the references to a movable screen and the ability to point the instrument in different directions (an unnecessary observation in the case of a portable device). Perhaps Drebbel placed a lens inside a ball-and-socket joint (which itself would fit into a window shutter), as did the painter Hans Hauer (1586–1660) of Nuremberg, according to Johannes Zahn's *Oculus Artificialis*, of 1699.[27]

Zahn's 'veritable encyclopedia of optical instruments available at the end of the seventeenth century' suggests that no camera obscura with an external observer had previously been designed for the purpose of drawing from life, nor had any treatise proposed an artistic application.[28] Delsaute concludes that Vermeer and other artists (like Van Hoogstraten's 'young painters') may have gained some appreciation of naturalistic effects from the occasional experience of a camera obscura but 'the presence of these "effects" in a painting in no way implies that the artist who produced them must have used a camera obscura in the creative process. It simply attests to the fact that this painter [Frans Hals, for example; fig. A4] was very attentive to phenomena involving light and applied himself to transcribing them in his works as faithfully as possible'.[29]

Among publications touching upon the topic of Vermeer and the camera obscura Delsaute's article is exceptional in that the author is at once conversant with the history of optical instruments and familiar with the ways in which seventeenth-century painters worked and thought about depicting reality. In general the debate divides between optical and artistic camps and on both sides proponents will argue in favour of one hypothesis or another but are ill-prepared to comprehend the reservations expressed by their critics.[30] The criticism may be inadmissible from a diplomatic point of view but it seems significant that the most self-convinced proponents of the idea that Vermeer owed a great deal to the camera obscura appear wilfully unaware of what he adopted from other Dutch artists, of how he achieved his effects in terms of painting technique, and also of basic facts about his personal circumstances. For example, Quentin Williams, for whom Vermeer is the master *sans pareil* of 'copying from *projected visible actuality*', applauds scholars such as Steadman and Wheelock because they 'have demonstrated how, alongside his friendship with Van Leeuwenhoek [who Vermeer may never have met],[31] Torrentius [who died when Vermeer was eleven years old] and others, Vermeer became adept, for practical painting purposes, in the use of the camera-obscura'. As a result, on the small canvas of *The Lacemaker* (cat. 29), 'no paint is used anywhere here to do anything more than furnish the reality of the projected image'.[32]

In a more impartial analysis one would acknowledge two types of evidence that support Vermeer's association with an optical device: the interest in optical phenomena among contemporaries such as Huygens and Van Hoogstraten; and the qualities of light, colour, contrast, and soft focus in Vermeer's paintings that resemble effects seen in camera obscura simulations. Assessing the value of these circumstantial considerations is difficult. For example, Balthasar de Monconys's brief visit to Vermeer in 1663 has been connected with the French diplomat's interest in optics.[33] However, De Monconys probably went to Delft at the invitation of other parties who were mainly interested in visiting the local Jesuit church.[34] There are other such historical 'connections' – Vermeer and the Delft microscopist, Anthony van Leeuwenhoek, for instance – which on closer inspection do not stand up.

With regard to optical effects in Vermeer's pictures, one must consider how closely they actually correspond with effects caused by lenses, whether similar effects occur in the works of other artists, and whether Vermeer's use of the effect appears arbitrary or not. Kemp (1990) notes, for example, that in *The Lacemaker* (cat. 29) the 'coalesced highlights on the relatively unfocused foreground objects [do] not replicate what can be seen in a camera obscura in a literal sense, since Vermeer scatters globules of light across relatively matt [as opposed to shiny] surfaces which would not exhibit circles of confusion in a camera. In his later works the luminous dabs are exploited as a form of painterly shorthand which is at once optical in origin and artificially contrived in application.'[35]

Westermann (2002) sets this observation in a broader context by suggesting plausibly that Vermeer would 'play up the signs' of a camera obscura because of their very modernity.[36] Similarly, Franits (2004) concludes that 'the enchanting ocular effects produced by [the camera obscura] no doubt stimulated [Vermeer's] aesthetic interest to such an extent that he often replicated them in his art but without needing direct recourse to the device. Vermeer thus modified these effects and often, surprisingly, exaggerated them to suit his artistic vision.'[37] This seems close to the mark except that Vermeer's striking display of 'optical' effects was hardly surprising at a time when artists such as Willem van Aelst, Fabritius,

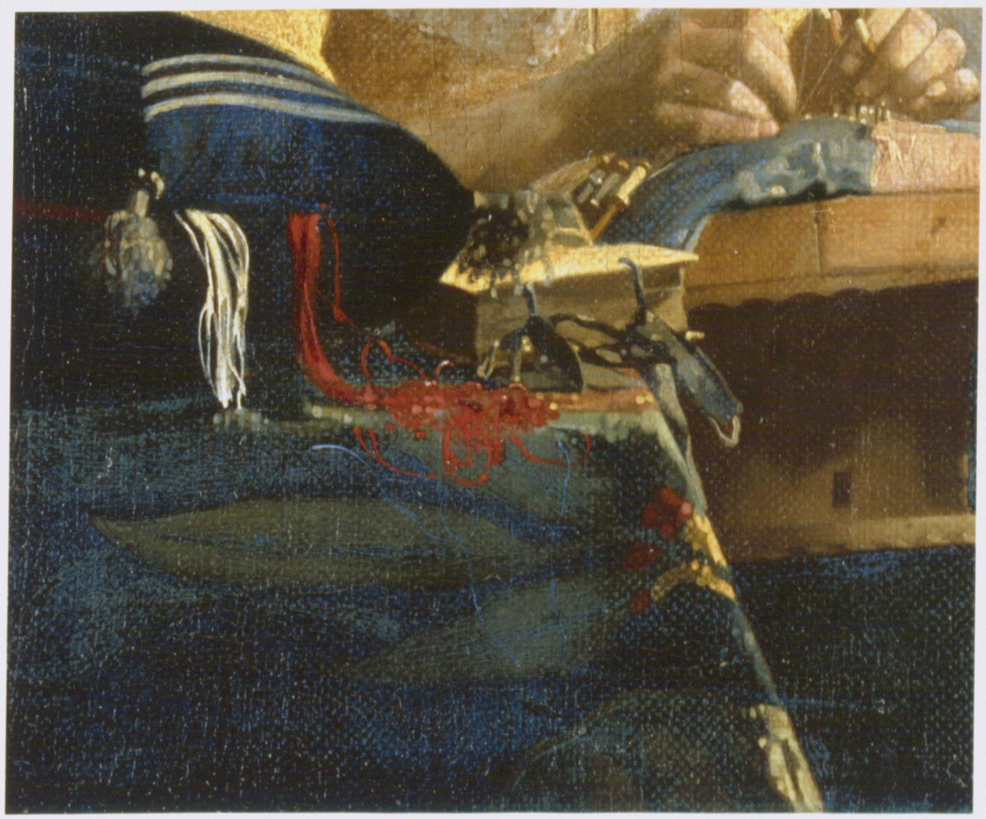


fig. A5 Johannes Vermeer
The Lacemaker (cat. 29, detail)

Pieter Janssens Elinga
Woman Playing a Guitar in an Interior, 1660s
Oil on canvas, 73.1 × 62.7 cm
Phoenix Art Museum, Phoenix, Arizona, Gift of Mr. and Mrs. Donald D. Harrington

De Hooch, Van Hoogstraten, Willem Kalf, Frans van Mieris (see fig. 33), Eglon van der Neer, and even minor talents such as Pieter Janssens Elinga (1623–1682) and the painter or painters of *The Terrace* (Art Institute of Chicago) and *The Refused Glass* (National Gallery, London) took great pains to do the same, each in their own (or in someone else's) way.[38] An article on 'optical effects from Torrentius to Janssens Elinga' might find in the latter's pictures (see fig. A6) characteristics of the camera obscura such as soft focus, intensified local colours, flaring highlights, exaggerated contrast, forced perspective, unexpected cropping, and optical phenomena not seen under normal viewing conditions (such as the chair's shadows in the corner), especially if the essay's author failed to notice in other works by the painter how often he pulled the very same rabbits out of his hat.[39]

Evidence that Vermeer did not routinely refer to a camera obscura is quite diverse. The question of the instrument's availability to Vermeer was raised above. Mills (1998) notes that lenses of sufficient size to record objects in the limited light of interiors would probably not have been accessible to the 'impecunious Vermeer'.[40] Steadman (2001) is content with the fact that 'large lenses were being made', and with the wild guess that Vermeer's father may have owned a magnifying glass because they 'were commonly used in the Dutch cloth trade'.[41] Steadman also supposes that 'the extraordinary fidelity, the minute accuracy, with which Vermeer reproduces the maps' in his interiors indicates transcription by means of a camera obscura.[42] Practising draughtsmen will reject this idea out of hand but historians of optics will dismiss it because clarity was so difficult to achieve without intense sunlight, as Huygens already emphasized.[43] In addition to 'basic imaging defects [of lenses] that show up under the conditions of use with the camera obscura, other problems not depending on the lens, such as screen diffusion, are also affecting the image quality'.[44]

Art historians may be less persuaded by technical remarks of this kind than by the sheer inconsistency of effects assigned by their colleagues to the use of a camera obscura, such as 'minute accuracy' together with blurry forms, or intensified colour values as well as 'the brown tonal aspects of the [camera obscura's] image'.[45] But anyone with access to an old studio camera will discover that images on the plate are dim and indistinct

unless sufficient light and the right lenses are employed.[46] Wirth (2007) notes that quite large lenses were needed to project a bright image of adequate size (the lens Kepler saw in Dresden was a foot in diameter) and 'so quite naturally, already in the earliest reports, larger lenses are specified explicitly as ideal for the camera obscura'.[47] In addition, Wirth, although he defers to Steadman on non-optical questions, determined 'after a variety of experiments with the camera obscura [that] multiple projections must have been used to produce a painting, by combining the desired qualities of each single one of them' (meaning each session using a lens).[48] Frequent refocusing would have been required, 'which is not possible for a camera with a fixed projection surface'.[49]

Like most scholars primarily concerned with optics, Wirth simply assumes that everything in Vermeer's paintings was actually before his eyes. Steadman, in turn, hitched his cart to the least reliable horses in the barn – Swillens and Fink – in order to arrive at his desired conclusion: that Vermeer actually lived and worked in the splendid rooms he depicted in *The Music Lesson* (cat. 15) and several other paintings, and that he set up his compositions by hanging or removing maps and pictures, shoving in the virginal or the harpsichord, and then returning to the confines of his dark closet so that he could judge the compositional consequences.[50]

In his article on 'Vermeer and the camera obscura: some practical considerations' (1998), the astronomer Allan Mills also stresses the problem of refocusing, and notes that this 'would lead to changes in magnification and therefore [the apparent] size' of objects that were recorded.[51] Experimenting with an early photographic lens and the ground glass of a plate camera, he found that in darkness 'the image of an exterior scene in bright sunlight was just about visible, but that of an interior ... was hopelessly faint'. What we see in Vermeer's pictures, of course, is often the opposite, a room filled with light right up to the ceiling (as in cat. 15), quite as Van Vliet (fig. A2) shows the interior of the Nieuwe Kerk illuminated as if by floodlights outside every window. Dimness, optical aberrations, and other shortcomings of seventeenth-century technology lead Mills to the conclusion that 'it would not have been possible for Vermeer to have painted his interior scenes directly, at full size, from images produced by a room-type camera obscura incorporating the lenses of his time'.[52] Mills also takes into account Vermeer's widely varying angles of view and deduces focal lengths from them. 'It seems unlikely that Vermeer would have access to, or have chosen to use, so many different lenses.'[53] In rebuttal, Steadman assigns Vermeer a large lens, allows it to be tilted (which 'can bring a band right across the entire image into sharp focus', rather like trifocals), and considers the remaining 'optical deficiencies' to support his argument, rather than that of the acknowledged 'expert of early optics'.[54]

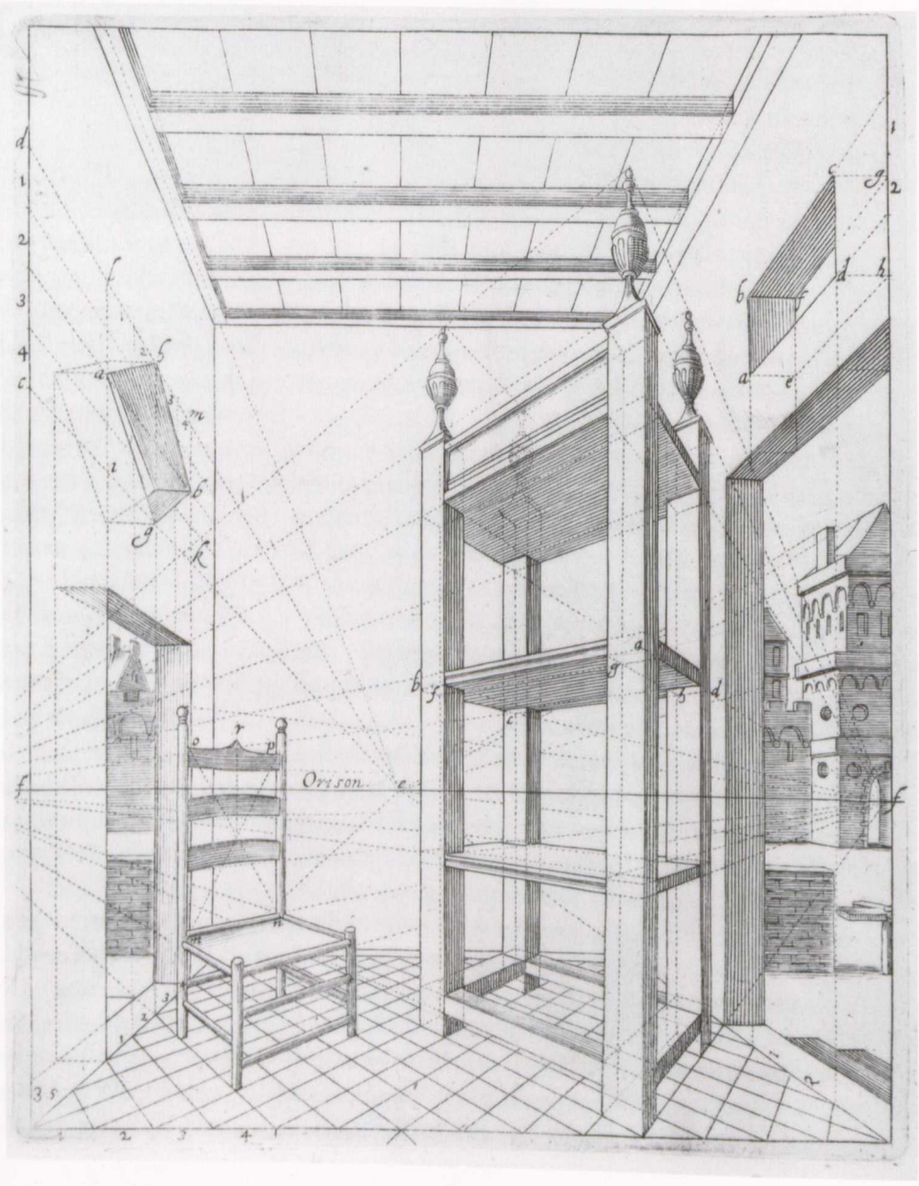
One of Steadman's most effective ploys is to assure the reader of 'the *extreme* sophistication and precision of the underlying perspective geometry of Vermeer's pictures'.[55] This will impress some critics (Seymour was cited above) but for 'anyone who has set up perspectives on the drawing board'[56] the claim amounts to transparent disinformation. Even Fabritius's projection of an actual view in Delft (fig. 16a) onto the hemicylindrical surface of a perspective box was (like Van Hoogstraten's comparable operations; see fig. 15d) a simple matter of following the rules and diagrams laid out in standard treatises like those by Hondius and Marolois (fig. A7).[57] Steadman points to the legs and stretchers of the chair in the foreground of *The Glass of Wine* (cat. 8; fig. A8) and declares the passage 'an absolutely virtuoso piece of perspective rendering, geometrically correct in every detail ... Even as accomplished a perspectivist as De Hooch would probably have improvised here.'[58] Perhaps so, since De Hooch was ham-fisted compared with Vermeer when it came to mechanical drawing, and probably incapable of drafting something like one of Houckgeest's choir views (for example, fig. 8a, which some viewers will recognize as a more complicated version of the drafting problem presented by Vermeer's chair). However, it is true that the chair in Vermeer's picture was intended as a 'virtuoso' motif, in the handling of light effects, the interplay of contours and patterns, and even (for amateurs like Teding van Berkhout) the perspective scheme.

In the right background of *The Glass of Wine* and in the lower corners of the composition Vermeer's chessboard of floor tiles is somewhat distorted. As in Houckgeest's broad view of the entire ambulatory in the Nieuwe Kerk, Delft, of 1651 (Mauritshuis, The Hague), this resulted from using a short distance construction – in other words,

selecting a wide angle of view.[59] Wadum observes that 'as Vermeer's career progressed, he solved this problem by moving the distance points [to which the sides of his floor tiles recede] farther away from the scene [beyond the sides of the composition], thereby eliminating the distortion'.[60] The same sort of adjustments made in some form of camera would require lenses with different focal lengths as well as frequent refocusing.[61] For clarity's sake (in the painting, not the argument), Steadman calls for 'the lens to be *tilted* [his emphasis] (while the screen remains fixed). This has no effect on the perspective.'[62] The actual effect of decentralizing the vanishing point in a camera obscura is dramatic, as explained and diagrammed by Kitao.[63]

A few readers of Steadman's book have been impressed by one point in particular: the claim that in six cases, according to his calculations, the size of the 'actual' room's image (for instance, the interior seen in *The Music Lesson*; cat. 15) projected onto the rear wall or screen inside the artist's dark closet comes close to that of the corresponding canvas.[64] It is pointless to review the geometry since the number of unknown variables is considerable, and the hypothesis involves circular reasoning proceeding from perspective constructions that wind up resembling themselves. Steadman's diagram comparing the sizes of Vermeer's canvases could be used to illustrate Bruyn's article on standard canvas sizes used in the North-

A7 Perspective projection of furniture in a room
From Hendrick Hondius, *Institutio artis perspectivae*, The Hague 1622
Koninklijke Bibliotheek, The Hague



ern Netherlands at the time.[65] 'Ten painter's canvases' and 'six panels' were in Vermeer's studio at his death,[66] suggesting that he did not cut supports after measuring images cast onto a wall. If he did, only one measurement – diameter – was necessary because the image projected by a lens 'is circular in shape. We must imagine that Vermeer chose a rectangular area within this circle for each picture.'[67] In other words, the painter arbitrarily cropped the image's size and format, and in the process 'did not in general select a rectangle at the very centre of this circle'. Thus, the projected image of the room seen in *The Geographer* (cat. 27), where the vanishing point is behind the figure to the right, was a circle of light about twice as wide (91 cm or three feet) as the canvas. And, of course, the image was

fig. A8 Johannes Vermeer
The Glass of Wine
(cat. 8, detail)

upside down and reversed left to right. The lateral flop was forgotten by Steadman in his diagram,[68] which is all for the best since the proper image would imply that Vermeer worked in a room with windows to the right, something quite unexpected of any Dutch painter and perhaps especially of this one.

Not every problem with Steadman's geometry can be considered here, nor is any of it actually relevant to what Vermeer did in his studio. Those who are persuaded by Steadman's six cropped images probably have not considered the consequences of using more or less consistent distance measurements (angles of view) when drafting perspective schemes.[69] Similarly, the uncritical reader will have accepted Steadman's notion that the artist's longer projections (longer than the considerable depth of the interior [6.6 metres] seen in *The Music Lesson*) were recorded from yet another room, through a doorway or internal window.[70] Considering the house that the artist actually lived in, Wadum (2003) cautions that this arrangement 'would have left Vermeer hovering with his camera obscura in the air above [the] Molenpoort' next to the irregular corner property.[71] The sympathetic reader of Steadman's book will also have passed over the optional elements in his geometric calculations, such as the movement of Vermeer's lens 'backward and forward some 50 cm or so, and [displacement] laterally over a larger distance'.[72] Perhaps, then, the light-tight cubicle really consisted of curtains with a lens 'fixed in a tube poking out', a tube which (as we have learned above) could tilt up and down and accommodate a variety of lenses with large diameters. The curtains would have facilitated Vermeer's need to see (and feed?) his subjects occasionally, in particular to 'study the colours before diving back into his tent'.[73] Or perhaps Vermeer could have simplified his life by working like other Dutch genre painters did, inventing plausible realities in the bright light of knowledge and experience.

The technical questions discussed above cast considerable doubt on the hypothesis that Vermeer used a camera obscura as a 'composition aid' or as some kind of recording device. Of course, there was little need to review the practical problems of using an optical instrument for the benefit of readers who are familiar with the material culture of Dutch life and of Vermeer's own household; with the time-consuming painting techniques he employed; with the formal conventions that were shared by Dutch genre painters during the 1650s and 1660s; and with the pictures themselves. The paintings, as Vermeer scholars and admirers will know, reward the most sustained contemplation, and indeed require something like the intense concentration he devoted to each composition and effect in order to appreciate what has been achieved.

An attempt has been made in the text and catalogue entries of this book to describe Vermeer's art and his reality, two very different worlds. For Steadman, by contrast, they are nearly the same, a view of Dutch art that stretches back through Swillens to writers of the mid-nineteenth century.[74] Thus he observes that 'there is only the evidence of the paintings themselves as to what might actually have been in front of Vermeer's eyes',[75] whereas scholars from Gowing onward have seen in the same evidence responses to Ter Borch, De Hooch, Van Mieris, and a host of other painters, and artistic refinements that are at once the products of a unique personality and of artistic traditions in Delft.

Vermeer's interest in the camera obscura and its function as a source of inspiration for some of his optical effects are hypotheses supported by the present writer and by other scholars who have studied his work for decades. But the more they have considered the evidence the more they have found, like Newton, traces of the maker's hand. And of his eye and mind. Vermeer had extraordinary visual acuity, a gift that embraced his keen interest in the behaviour of light and his ability to remember images (as another person might recall dialogue). Whether he first saw something in the environment, an optical device, or another painter's work is a complicated question precisely because once seen the effect became part of the artist's repertoire, a characteristic of his style to be repeated or modified at will. That much was learning. The rest of it – genius – cannot be explained.

1. J.C. Harvey in vol. 5, p. 519.
2. I.M. Veldman, in vol. 8, p. 669.
3. Delsaute 1998, p. 119.
4. Ibid., p. 120; see p. 122 nn. 13–16 on Huygens, Torrentius, and Van Hoogstraten.
5. Seymour 1964, pp. 325–26.
6. Ibid., p. 326.
7. Wadum 1995, pp. 67, 71.
8. Fink 1971, p. 503.
9. See Fock 1998 and C.W. Fock in Newark and Denver 2001–2, pp. 85–91.
10. See A. de Groot in Delft 1981, p. 47.
11. See Fock in Newark and Denver 2001–2, p. 88.
12. Ibid., p. 91.
13. Van Hoogstraten 1678, p. 263, in the chapter on 'the gradation of shadows and lights'; p. 275 on perspective's esteem.
14. Bleyswijck 1667–[80], vol. 2, p. 852.
15. See New York and London 2001, no. 83.
16. See ibid., pp. 15, 568 n. 56.
17. Montias 1989, doc. 364.
18. Huygens 1971, p. 86.
19. See Wallert 2007; Y. Bruijnen in Bikker et al. 2007, pp. 367–69; and Groen 2007, p. 206, fig. 9, where the camera obscura is mistakenly described as a seventeenth-century device.
20. See Huygens 1971, pp. 86–87, for a good Dutch translation of the original Latin, and Tierie 1932, pp. 50–51, for less reliable English.
21. See Wheelock 1981, pp. 15, 94, fig. 7.
22. Huygens 1971, p. 73.
23. See E. J. Sluijter's essay in Leiden 1996–97, pp. 38–59.
24. Van Hoogstraten 1678, pp. 237–38; see Sluijter in Leiden 1996–97, pp. 45–46, 57 n. 93, and Liedtke 1997, p. 125.
25. Huygens 1971, pp. 120–21. The observation is true, of course: see Wenczel 2007, p. 15, on Della Porta's description of 1589; and Dupré 2007, p. 59, on Kepler's experience in the Dresden Kunstkammer.
26. Delsaute 1998, p. 113.
27. See ibid., pp. 112, 121 n. 4, fig. 2.
28. Ibid., pp. 112–13.
29. Ibid., p. 120.
30. Similarly, in the literature of equestrian art one finds scholars of horsemanship noting that Leonardo da Vinci was 'mistaken' about some pose or proportion but they have never heard of Verrocchio, and art historians who claim that Jacob Jordaens depicted 'a cavalier executing a passade' when it is obvious to dressage experts that neither the rider nor the horse in the painting performs a *pesade* or a *passage*.
31. See Montias 1989, pp. 225–26.
32. Williams 1995, pp. 274, 276.
33. Delsaute 1992, p. 71.
34. See New York and London 2001, pp. 12–13.
35. Kemp 1990, p. 194.
36. Westermann 2002, p. 358.
37. Franits 2004, p. 169.
38. The Chicago and London pictures are attributed to Ludolf de Jongh in Fleischer 1997.
39. See Delft 1996, figs. 183–87, and Krempel 2005, pp. 151–59.
40. Mills 1998, p. 216.
41. Steadman 2001, p. 142. See Liedtke 2007, p. 699, to appreciate where this conjecture comes from.
42. Steadman 1995, p. 353.
43. Huygens 1971, p. 121; on this problem, see Dijksterhuis 2007.
44. Molesini 2007, p. 126.
45. Wheelock 1977, p. 97.
46. See the murky image projected by a Christiaan Huygens lens, in Cocquyt 2007, fig. 2.
47. Wirth 2007, pp. 158, 161.
48. Ibid., p. 168.
49. Ibid., pp. 153, 175.
50. See Steadman 2001, pp. 144–45, on Swillens and Fink as authorities; p. 143, on Vermeer as furniture mover; p. 176, on 'actual and reconstructed sizes of keyboard instruments'. See also pp. 17–20 above on the inventory of Vermeer's residence, which does not list a single musical instrument.
51. Mills 1998, p. 216.
52. Ibid., p. 218.
53. Ibid., p. 215.
54. Steadman 2001, pp. 139–41.
55. Ibid., p. 154, which is found convincing in Westermann 2004, p. 40.
56. Ibid., p. 145.
57. See Liedtke 2000, pp. 61–62.
58. Steadman 2001, p. 145.
59. See New York and London 2001, no. 39, and fig. 260 for Houckgeest's perspective scheme.
60. Wadum 1995, p. 69.
61. The focal lengths would range from 60 to 113 cm; see Mills 1998, pp. 215–16, table 1.
62. Steadman 2001, p. 141.
63. Kitao 1980, pp. 506–7, figs. 5, 6.
64. See Steadman 2001, pp. 101–6.
65. Ibid., fig. 65. See Bruyn 1979.
66. Montias 1989, p. 341.
67. Steadman 2001, p. 106.
68. As noted in Wadum 2003, p. 126.
69. See Wadum 1995, pp. 69–71.
70. Steadman 2001, pp. 98, 112–13.
71. Wadum 2003, p. 126.
72. Steadman 2001, p. 103, figs. 49, 50.
73. Wadum 2003, p. 126.
74. See Liedtke 1997, pp. 116–17.
75. Steadman 2001, p. 144.