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From Vitruvius to the Science Of Drawing
Daniele Barbaro's Concept of "Scaenographia"

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Abstract Daniele Barbaro's treatise on perspective is one of the most authoritative technical-scientific sources of the sixteenth century. Although largely based on the unpublished work of Piero della Francesca, the treatise had the precise and original purpose of filling a gap in the Vitruvian text about the contents of the so-called 'scaenographia', a discipline based on optical geometry of which Vitruvius provided only meagre and sibylline words. The subdivision of the treatise, examined here into the individual parts that constitute it, follows a clearly Vitruvian structure, with the first three parts dedicated to *ichnographia* (perspective drawing of plans), *orthographaia* (perspective drawing of solid bodies) and *scaenographia* (perspective drawing of the buildings and their ornaments), and with two other parts specifically dedicated to the measurements of the human body and to the drawing of the planisphere, themes treated by Vitruvius respectively in the third and ninth books of *De architectura*. In this sense, *La pratica della perspettiva*, published in 1568, should be considered as an integral text of the most authoritative commentary on Vitruvius' *I Dieci libri dell'architettura*, published in 1556 and 1567.

Keywords Linear perspective. Vitruvius. Architectural drawing. Scenography. Drawing instruments. Anamorphosis. Planisphere. Proportions.

The Renaissance exegesis of Vitruvius' *De architectura* is characterized by the progressive focus on the so-called 'obscure words', terms of difficult interpretation that have ignited the imagination and creativity of artists, architects and humanists. The term *scaenographia* is perhaps the one that required the most attention, also because it overlapped the rules of linear perspective, a geometric discipline that had revolutionized the language of the figurative arts since the early fifteenth century.[1] Daniele Barbaro did not just discuss the term in the context of his impor-

The present article derives from a lecture presented at the conference on *Daniele Barbaro*, organized in Venice by the Fondazione Giorgio Cini on November 4, 2015. The topic has been explored here to illustrate the contents of the important perspective treatise by Daniele Barbaro, interpreted in the context of his crucial Vitruvian studies. I am grateful to the editorial committee of *Venezia Arti* for their interest in this contribution.

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tant commentary on Vitruvius' treatise on architecture, but also composed an entire book on the subject, *La pratica della perspettiva*, which transformed the invention of the Moderns into the rediscovery of an ancient discipline.[2]

The idea of writing a treatise on perspective occurred to Daniele Barbaro while working on the first edition of Vitruvius' *I Dieci libri dell'architettura* (Ten Books on Architecture), published in Venice in 1556. To stimulate his interest in this field of artistic culture was the desire to fill a gap in the Vitruvian text regarding the drawing methods necessary for the construction of the theatrical scenes mentioned in chapter VIII of the fifth book. Vitruvius limited himself to describing the typology of the scenes according to the characters of the tragedy, comedy and satirical drama, but modern commentators turned to that chapter to indicate the field of application of the third species of *dispositio*, a drawing method called "scaenographia", described in the first book and usually interpreted as "perspective":

> Those who interpret that word, which is placed in the first Book, called Sciographia – writes Barbaro – and who intend Perspective in that place, where the species of the Disposition are concerned, confirm their opinion with this part of the eighth chapter of the present Book […] Many also have read Scenographia, and have understood the same, that is, the art of making Scenes; which art admirably seeks the use of Perspective.[3]

According to Vitruvius, the rules of this method of representation were established in the fifth century BC. by two of the most committed philosophers in the debate on the nature of vision, Democritus and Anaxagoras, who would have drawn inspiration from a memory written by the painter Agatharchus on a scene painted for a tragedy by Aeschylus:

> because Agatharchus, while Aeschylus in Athens taught the art of Tragedy, was the first who made a painted scene, of which he left a Commentary. From this admonished, Democritus and Anaxagoras wrote on the same thing, that is, how to operate with natural reason from the center placed in a certain place in order to correspond with lines to the eye and to the straightness of the rays, so that from an uncertain thing the certain images of buildings made their appearance in the paintings of the Scenes, and those buildings which were figured in the straight planes and façades, escaped through the foreshortening, and seemed to have relief.[4]

Those ancient sources, however, had been lost and Vitruvius had just touched on the subject. The treatise was born, therefore, as a deepening of a Vitruvian theme, and it is precisely in the comment to the quoted chapter of the fifth book, *Of Three Sorts of Scenes*, that in 1556 Barbaro was already able to present the reader with a well-articulated plan of his work.[5] At that time, the drafting of the treatise included a composition in five books: the first one dedicated to the optical-geometric principles, the second one to the perspective drawing of plane figures (*ichnographia*), the third one to the drawing of bodies (*orthographia*), the fourth one to the representation of buildings with their ornaments (*scaenographia*), and the last one to some specific themes of perspective, such as shadow casting, perspective machines and anamorphosis.[6] Twelve years later, when the work was published in 1568, this di-

1 The term "scaenographia" is constantly discussed in the comments to the Vitruvian text (see for example Cesariano 1521, c. 14*v*). A specific work on Vitruvian terminology is due to Baldi 1612, 153-4.

2 The modernity of the invention was underlined by Leon Battista Alberti in the famous prologue to his *De Pictura* (1435) dedicated to Filippo Brunelleschi: "ma quinci tanto più el nostro nome più debba essere maggiore, se noi sanza precettori, senza esemplo alcuno, troviamo arti e scienze non udite e mai vedute" (Alberti 2011, 204). For an English translation, see Alberti 1970, *Prologue*: "Our fame ought to be much greater, then, if we discover unheard-of and never-before-seen arts and sciences without teachers or without any model whatsoever".

3 Barbaro 1556, V, VIII, 157: "Quelli, che interpretano quella parola, che è posta nel primo Libro detta Sciographia et che intendono in quel luogo, dove si tratta delle specie della Dispositione, la Prospettiva, confermano la loro opinione con questa parte dell'ottavo capitolo del presente Libro […] Molti ancho letto hanno Scenographia, et hanno inteso lo istesso, cioè l'arte di far le Scene; la qual arte ricerca mirabilmente l'uso della Prospettiva".

4 Barbaro 1556, VII, *Proemio*, 182: "perché prima Agatharco, mentre Eschilo in Athene insegnava la Tragedia, fece la Scena dipinta, et di quella ne lasciò il Commentario. Da questo ammonito Democrito, et Anaxagora scrissero della istessa cosa, in che maniera bisogna con ragione naturale dal centro posto in luogo certo corrisponder all'occhio, et alla drittura de i raggi con le linee, accioche d'una cosa incerta le certe immagini delle fabriche nelle pitture delle Scene rendessero l'aspetto loro, et quelle, che nelle fronti dritte, et ne i piani fussero figurate, scorzassero fuggendo, et paressero aver rilievo". On the perspective painting of the ancient world see Rouveret 1989.

5 Moretti 2015, 2017.

6 Barbaro 1556, V, VIII, 157: "però io ho partito quell'opera in cinque volumi. Nel primo de i quali io ho gettati i fondamenti della Prospettiva, & dato le regole generali della pratica di essa, con diffinire, dividere, e dimostrare quanto alla detta ragione è

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vision into five books had given way to a division into nine parts which addressed two other Vitruvian themes not previously considered: the measurements of the human body, which is discussed in the third book of *De architectura*, and the planisphere, specific theme of the ninth book dedicated to gnomonics.[7]

When Barbaro decided to write the treatise, his optical-geometric knowledge was such as to require the help of a tutor who "in this thing could give [him] light".[8] He therefore chose to take advantage of the teachings of an authoritative mathematician of the University of Padua, Giovanni Zamberti, well known in Venetian humanistic and scientific circles since the beginning of the century, when his brother Bartolomeo had included him among the dedicatees of his edition of Euclid's works, published in Venice in 1505. The work dedicated to Giovanni was the treatise on *Optics*, and this made him appear in the scientific world as a prominent scholar in that specific field.

Zamberti's edition, which translated Euclid from Greek, was immediately noticed for the harsh criticisms that the author addressed to the Latin edition followed up to then – the one written by Giovanni Campano da Novara in 1255 and published in Venice in 1482 – and it remained for the whole century the main reference text for Euclidean studies.[9] Among the many scholars who trained on Zamberti's text before Barbaro there was also Albrecht Dürer, who purchased a copy of the book in Venice in 1507, immediately after returning from Bologna, where an unknown master had introduced him to the "secrets" of perspective.[10] Following that translation, Dürer had developed his own treatise on geometry, which Barbaro used conspicuously, certainly using the Latin edition published by Joachim Camerarius in Paris in 1532 and reprinted several times.

In general, Barbaro believed that no author before him had adequately dealt with the theme of perspective: "few things Alberto Durero left us – he writes – although ingenious, and subtle ones. Serlio expressed himself more roughly; but both of them (I will say so) stopped above the edge of the door".[11] Barbaro's aim was to overcome that threshold in order to fully enter the multidisciplinary rooms of perspective science; he used various sources with this purpose, among which also stands out Piero della Francesca's *De prospectiva pingendi*, which presumably Giovanni Zamberti used as a textbook for his perspective lessons. In fact, Piero's was the only text conceived as a drawing manual: he guided the apprentice's hand in every movement, replicating the same gestures many times, and perhaps for this reason Barbaro gave the unedifying judgment that we read in the *proemio*, where he defines Piero as the author of "some simple practical applications laid out without order, and foundation, and crudely explained […] that could be useful for idiots".[12] Those practical applications, however, served him a great deal to judge from the quantity of "precepts and rules", drawings and quotations extracted from the work of the painter from Sansepolcro **[fig. 1]**. In his considerations on the ideal amplitude of the viewing angle, for example, Piero is quoted literally for an entire proposition: "Pietro from Borgo S. Stefano [*sic*, read S. Sepolcro], who left some things of Perspective, from which I took some of the above descriptions says these formal words".[13]

necessario, accioche senza dubitatione l'huomo possa porre la veduta in propio, & accommodato luogo, accioche non venghino di quelli errori, che di sopra ho detto. Et cosi nella prima parte i precetti, la vista, & i quadrati si pongono. Nel secondo se insegna la Dispositione de i piani regolari, & irregolari, in squadra, & fuor di squadra, & i perfetti di qualunque corpo si sia. Nel terzo sono le misure de i corpi, accioche volendo noi da i piani perfetti tirare i piani di Prospettiva, & da questi levar i detti corpi, sappiamo le misure loro. Nel quarto si dimostra il modo di levar i corpi secondo le altezze loro, & qui si trattera delle tre sorti delle Scene predette, come si hanno a levare, & de i corpi mathematici, de i loro tagli, rilievi, e piegature, dal che ne nascera una pratica meravigliosa, & una grande utilità per molte cose, che & per adornamento, & per commodo ci vengono tutto dì per le mani. Nella quinta & ultima parte si tratta dell'ombreggiare, de i lumi, d'alcuni strumenti della Prospettiva, & d'alcune altre maniere di questa pratica, come molte cose si dipingono, che non si possono vedere, se non in un certo, & determinato punto, ò con ispecchi, ò con traguardi, ò con altre sorti di vedere".

7 On the composition of the treatise, in addition to Moretti 2015 and 2017, see also Monteleone 2020.

8 Barbaro 1556, V, VIII, 157: "…et pero con diligenza ho cercato, chi in questa cosa mi potesse dar lume, finalmente ho ritrouato un buon precettore, il nome del quale honoreuolmente serà da me posto, nel trattato della Prospettiua, che io intendo di dar in luce". See Barbaro 1569, proemio, 3 [*sic*, read 5].

9 Gavagna 2010.

10 Fara 1997, 2008.

11 Barbaro 1569, *Proemio*, 3 [*sic*, read 5]: "poche cose ci ha lasciato Alberto Durero benche ingegnose, et sottili. Più grossamente si è portato il Serlio; ma l'uno et l'altro (dirò così) si sono fermati sopra il limitare della porta".

12 Barbaro 1569, *Proemio*, 3 [*sic*, read 5]: "alcune pratiche leggieri poste senza ordine, et fondamento, et esplicate rozzamente […] che per gli idioti ci potriano servire".

13 Barbaro 1569, II, VIII, 36: "Pietro dal borgo S. Stefano [*sic*, read S. Sepolcro], il quale ha lasciato alcune cose di Perspettiva, dal quale ho preso alcune delle soprapposte descrittioni, dice queste formali parole".

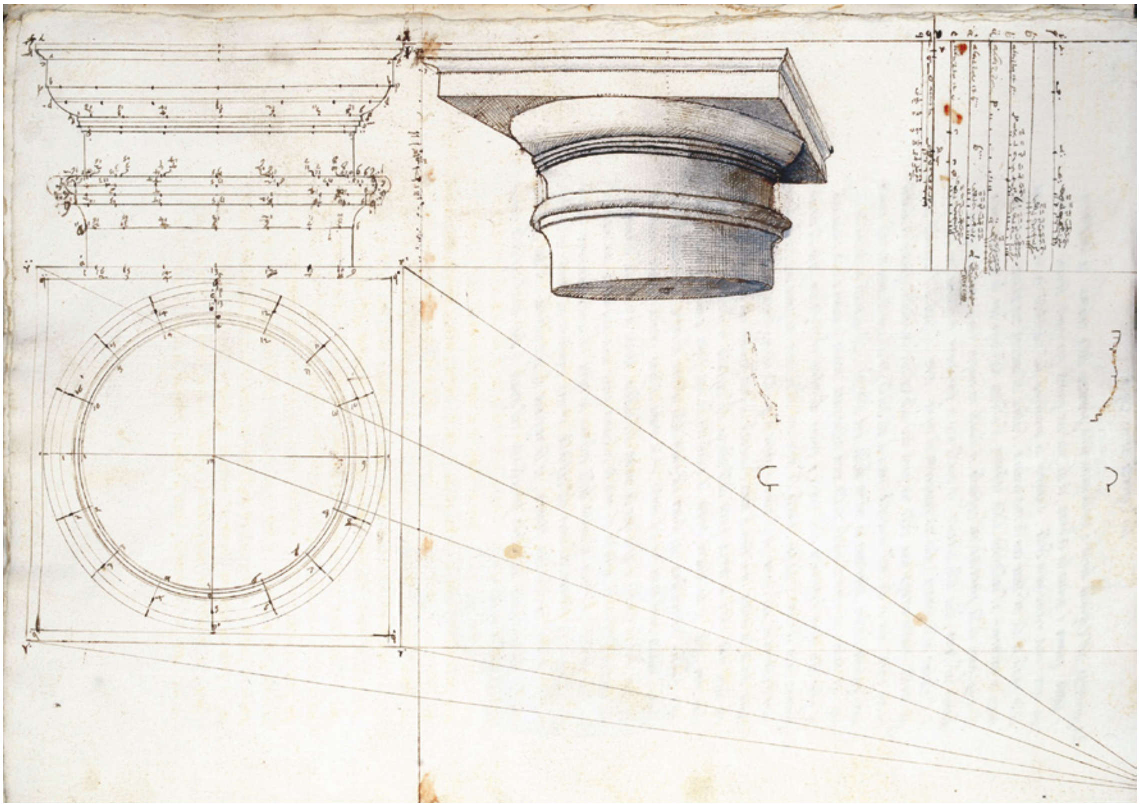

Figure 1 Daniele Barbaro, perspective drawing of a Tuscan capital with the procedure of Piero della Francesca. Venezia, Biblioteca Marciana, It. IV, 39=5446, 305*v*

The only positive judgment is reserved to one of the most eminent mathematicians of the time, Federico Commandino, who "in the planisphere of Ptolemy has placed some learned demonstrations, as he always used to do, pertinent to Perspective, as the principle of that [planisphere], not useless for to excite the minds of scholars".[14] In 1558, Commandino published in Venice a commentary on Claudius Ptolemy's planisphere in which he illustrated the projective problem of the celestial sphere transformed in a plane figure, using the painters' perspective and describing two rules (later codified by Vignola) in a much more precise way than Serlio had done.[15] The "scenographic" demonstration of the flat projection of the celestial sphere had been illuminating for Barbaro: from that text, he got the idea of including in his treatise a chapter dedicated to the planisphere. The theme fit perfectly into the program of the work because it examined the problem of the construction of the analemma discussed by Vitruvius in the ninth book of *De architectura*.[16] Barbaro went even further, composing a treatise on sundials that he never published, perhaps discouraged by the *Liber de horologiorum descriptione* that Commandino had in the meantime published, together with the edition of Ptolemy's *De analemmate* in 1562.

La pratica della perspettiva came out a year after the second edition of the *I Dieci libri dell'architettura* (1567), where Barbaro again anticipated the publication of his treatise, omitting however the description of the content given in 1556 and become outdated in the meanwhile. As in the first edition, he talks about his treatise in the comment to chapter VIII of the fifth book, where he reiterates that the construction of the scenes is based on the

> knowledge and experience in perspective, because all those things require regulating the

14 Barbaro 1569, *Proemio*, 3 [*sic*, read 5]: "nella sfera piana di Tolomeo ha posto alcune dotte dimostrationi, come egli è solito sempre di fare, pertinenti alla Perspettiva, come principij di quella, non inutili per eccitare gli animi de gli studiosi".

15 Commandino 1558; Serlio 1545; Vignola 1583.

16 On the Vitruvian analemma see Ronca 1976, and Losito 1997.

> point of view in how those faces are seen [...]. This necessity has moved me to want to facilitate those who study in this area as well, as far as I am able, and so I have written about perspective with the reasonable ways and means aimed at the practice of what is called *scenographia*. I have laid the foundations of this knowledge and the rules of this practice.[17]

The link between his perspective treatise and Vitruvian 'scenography' is enshrined from the very first words of the *Proemio*: "Among many beautiful and illustrious parts of Perspective [i.e. Optics], there is one which is called Scenography by the Greeks. Of this I remember promising to write in my commentaries to Vitruvius".[18] The Greek term *skenographia*, from which the one used by Vitruvius derives, has its origins in the classification of the mathematical sciences of Geminos, who described this discipline as a section of optics intended for the control of proportions in architecture and the figurative arts in the first century BC. From this tradition comes the term *temperatura*, used by Vitruvius to indicate those optical corrections of the proportional system in architecture which had to guarantee the preservation of perfect symmetries in the buildings, even in those cases where visibility conditions would have prevented it. And from that discipline it is presumed that the perspective rules for the construction of the theatrical scenes are also derived, those illustrated in the lost writings of Democritus and Anaxagoras mentioned again by Barbaro in the *Proemio*.[19]

1 The First Part. *Principles and Foundation of Perspective*

"Eye, visual rays and viewing distance" are the foundations of perspective that Barbaro describes on the basis of ancient and medieval optical sources: Euclid in the first place but also the Latin "perspectivists", among which we have to include, although not explicitly mentioned, at least Pecham and Witelo. The eye was the object of study of what the Greeks called "Optika" and the Latins "Prospectus", that is the science of vision that does not investigate "a simple seeing, but a careful, and measured seeing [...] and yet the simple aspect is an operation of nature, and the Prospectus is the office of reason".[20] This distinction made the ancient physiological question on the intromission or extramission of visual rays superfluous, since on the geometric level the rules remained valid "in whatever way it is". The rays were in any case straight lines that extended from the eye to the object in a pyramidal shape and their angular amplitude determined the viewing distance. Barbaro explains that, among the various angular openings, the correct vision is obtained only under a "narrow" angle, i.e. less than 90°. Being "the black of the eye that we said was named uvea" lower than the fourth part of the eyeball, and being the apex of the pyramid in the center of the eye, the maximum permissible angular opening was that given by the triangle which has as its basis the opening of the pupil.[21] Considering, therefore, that the opening of the optical angle determined the appearance of the objects, it was possible to obtain "the regula, and the shape of the quadrant by Alberto Durero, with which he proportioned the letters, or figures, which are in the height of some columns or walls", a rule that could be seen applied "in the golden Angel above the tower of S. Mar-

17 Vitruvius 1567, 257: "intelligenza, et la pratica della prospettiva, perché tutte quelle cose ricercano il punto della vista nostra regolatore di quanto si vede in quelle facciate [...] Questa necessità mi ha mosso a voler giovare, quanto per me si può, anche in questa parte agli studiosi, et però io ho scritto di prospettiva con vie, et modi ragionevoli drizzati alla pratica che è detta scenografia, et ho gettato i fondamenti di questa cognizione, et le regole di questa pratica"; for the English translation see Williams 2019, 421. A reference to the treatise on perspective is also found in IX, 8, 398-9: "Hora per più facile intelligenza dirò cosa [concerning the *analemma*], che bene considerata, et appresa darà un lume mirabile al presente discorso, et gioverà in molte altre cose degne; et specialmente nella prospettiva, si come nel nostro trattato della scenographia havemo chiaramente esplicato"; Williams 2019, 664: "Now, for more ready understanding I will discuss that which, when thoroughly meditated and understood, will shed admirable light on the present discourse, and be of help in many other worthy things, and especially in perspective, as we have clearly explained in our treatise on *scenographia*".

18 Barbaro 1569, *Proemio*, 3 [*sic*, read 5]: "Tra molte belle, et illustri parti della Perspettiva [cioè l'Ottica], una ven'hà, la quale da Greci è detta Scenografia. Di questa ne i miei commentari sopra Vitruvio mi ricordo d'haver promesso di trattare".

19 On this topic see: Camerota 2019.

20 Barbaro 1569, I, II, 6: "non uno semplice vedere, ma uno avvertito, et considerato vedere [...] et però il semplice aspetto è operazione di natura, et il Prospetto è officio di ragione".

21 Barbaro 1569, I, V, 8: "il nero dell'occhio che dicemmo essere uvea nominata".

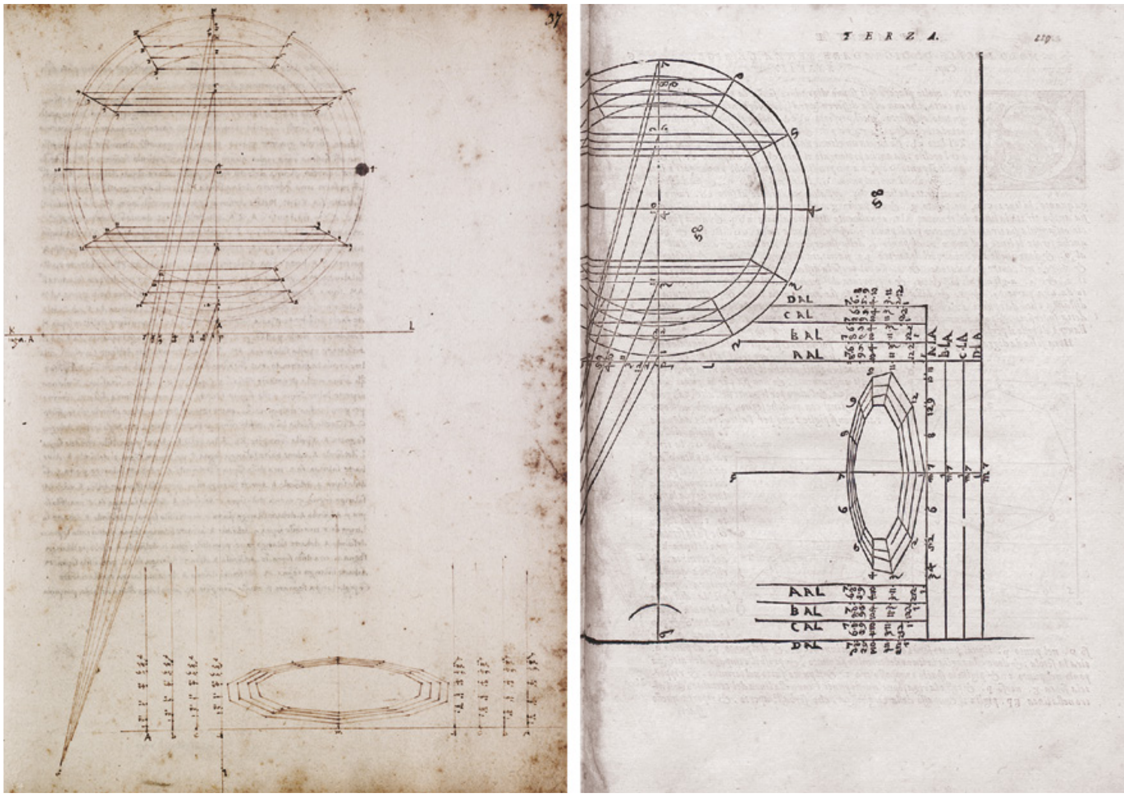

Figure 2 Daniele Barbaro, perspective drawing of a "mazzocchio" (polyhedral ring) with the procedure of Piero della Francesca, *De prospectiva pingendi*, III, IV (Barbaro 1569, III, XXXVI, 119)

co in Venice"[22] and which was practiced in similar cases by the ancients, as Vitruvius and before him the mathematician Geminos recall.[23]

In this book Barbaro exposes only the optical principles. The three fundamental elements of vision – eye, visual rays and distance – were not sufficient to define the representation of the observed things. Piero della Francesca, from whom Barbaro derives almost all the illustrations of this introductory part, had in fact indicated five basic elements, adding to the three that concerned vision as a natural phenomenon (optics or *perspectiva*) – the same mentioned by Barbaro – two others that concerned instead the representation of what is seen (perspective or *prospectiva*), that is, the object and the picture plane.

2 The Second Part. *In which it Deals with the* Ichnographia, *that is a Description of Plans*

The instructions on the perspective drawing begin with the construction of plans, "because without the *Ichnographia*, that is, the low and flat drawing of things, no figure can be described, since every elevated thing is born from the plan as the tree is born from the root".[24] Barbaro adopts the term used by Vitruvius to define the first species of the *disposition*, but his precepts and rules clearly derive from Piero's *De prospectiva pingendi*. The plans are drawn within a "perfect square figure"

22 Barbaro 1569, I, V, 9: "la regula, et la forma del quadrante di Alberto Durero, col quale egli proportiona le lettere, overo figure, che sono nell'altezza di qualche colonna o parete", as practiced "nello Angelo dorato sopra la torre di S. Marco in Vinetia [I, IX, 23]".

23 Schiene 1897; Aujac 1979.

24 Barbaro 1569, II, II, 27: "perché senza la Ichnographia, cioè disegno basso e piano delle cose, non si può descrivere alcuna figura, essendo che ogni cosa elevata nasce dalla pianta come l'albero nasce dalla radice".

to be shortened "in the given limit according to the eye and the distance". The picture plane is called limit (termine), according to the definition of Piero della Francesca, and from the XII-XV theorems of "Pietro the painter" derive the demonstrations on how to obtain the "foreshortened square" to be divided into smaller squares with the diagonal method. From Piero also derive the way of "increasing or decreasing the foreshortened plane", as well as the distance point construction, and the demonstration of the optimal distance from the picture plane which, as mentioned above, Barbaro illustrated with the same words of his source.[25] The plans are drawn inside the foreshortened floor according to the two ways described by Piero, the diagonal method and the intersection of the visual pyramid in plan and elevation. The first involved the projection of the points with reference to the diagonal of the square – both in the "perfect", the true shape, and in the "decreased", the foreshortening – while the second method consisted in the plan and elevation drawing of the object and the visual pyramid with subsequent measurement in both projections of the intersections with the picture plane.

3 The Third Part. *Which Deals with the Way of Raising Bodies from Plans*

The third part "deals with the *Orthographia*, that is, with the straight elevation of bodies, from their plans":[26] it is the second species of the Vitruvian *dispositio*, necessary for drawing in perspective the geometric bodies. In this case, Barbaro also partially followed Piero della Francesca, and described the whole series of regular bodies illustrated by Piero in the *Libellus de quinque corporibus regularibus* and by Luca Pacioli in the *De Divina proportione*. The 'unfolding' of the bodies, that is the drawing of the faces that compose them, derives instead from the treatise on geometry by Albrecht Dürer, a reference source also for the series of irregular bodies which, like the previous ones, are all depicted in perspective ("dritto", or 'straight') with their shadows ("adombrazione", or 'overshadowing'). When he came to the description of the most difficult bodies, such as the *mazzocchio*, he felt the need to introduce "some easy and quick ways to make plans, and bodies", once again using Piero's treatise. Two elements clearly derive from that source: the use of the "ponytail bristle" and two paper rulers to transfer on the drawing the intersection points in separate groups **[fig. 2]**. The procedure differed only in the way of transporting the intersection points, which occurred by means of two compasses, according to a solution suggested by Dürer.[27]

4 The Fourth Part. *In which it Deals with the Scenographia, that is, the Drawing of Theatrical Scenes*

The rules set out in the first three parts of the treatise were functional to the construction of theatrical scenes which constituted the main objective of the treatise: "I hope – writes Barbaro – that the difficulty of past things will make the Scenographia easy, and I said all which is contained in the previous three parts to be applied to the latter".[28] Here Barbaro felt the need to replicate his "opinion on that word, which places Vitruvius in the first book in chapter II, where he talks about the ideas of the *dispositio*", and reiterated that many "have interpreted that word *Sciographia* for Perspective, which is like an overshadowing. Many also read *Scenographia*, instead of *Sciographia*, and understood the same, that is, the drawing of the Scenes".[29] His opinion was that the species

25 Barbaro 1569, II, VIII, 36. Piero della Francesca 1942, I, XXIV.

26 Barbaro 1569, II, XI, 42: "Seguita che si venga alla Terza [parte], nella quale si tratta della Orthographia, cioè della elevazione dritta dei corpi, dalle piante loro".

27 Barbaro 1569, III, XXXVI-XXXVII, 117-20. Piero della Francesca 1942, III, I; Durer 1532, IV, fig. 56.

28 Barbaro 1569, IV, I, 129: "io spero che la difficoltà delle cose passate, ci farà parere facile la Scenographia, per l'uso della quale ho detto tutto quello, che si contiene nelle tre parti precedenti".

29 Barbaro 1569, IV, I, 130: "replicando la mia opinione sopra quella parola, che pone Vitruvio nel primo libro al cap. II, dove egli parla delle idee della disposizione [... molti] hanno interpretato quella parola Sciographia per la Perspettiva, la quale è come una adombratione. Molti anche hanno letto Scenographia, in luogo di Sciographia, et hanno inteso lo istesso, cioè la descrittione delle Scene". Among those who read "sciographia" as perspective, see, for instance, Serlio 1537, 3, where he describes the content of his *Third book of architecture*: "Nel terzo si vedrà la Ichnographia, cio è la pianta: la Orthographia, che è il diritto; la Sciographia, che viene a dir lo Scortio de la maggior parte degli edificij, che sono in Roma, in Italia, et fuori, diligentemente misurati, et postovi in scritto il loco dove sono e 'l nome loro". On the meaning of the term "skiagraphia" and its interpretations see Keuls 1997, 107-44.

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of the *dispositio* must necessarily be of the same genre, that is, all orthogonal projections "so that what is born, and what grows is the same thing". Like the first two species – *ichnographia* and *ortographia*, which depicted the building in orthogonal projection, respectively in plan and in elevation – the third, for completeness of the drawing, should have represented in orthogonal projection the profile and the wall thicknesses. The third species, therefore, should have been a cross section, not a perspective drawing, and if Vitruvius had not intended to include in the *dispositio* also "the profile [cross section], he would have missed greatly, both because he would have left a necessary species, and because he would have placed one, which does not belong to the nature of its genre";[30] perspective, in fact, is not an orthogonal projection.

Barbaro attempted to solve the exegetical problem by questioning the authenticity of the term "scaenographia", which could have come from a corruption of "sciographia", a term derived from the Greek "skiagraphia" (representation of shadows) to which the noun would better bind "adumbratio", adopted by Vitruvius in his definition: "Scaenographia [sciographia, according to Barbaro] est frontis et laterum abscedentium adumbratio ad circinique centrum omnium linearum responsus".[31] In the commentary to Vitruvius, Barbaro had explained that

> The third idea is the profile, called the *sciographia*, of which great use comes because through the description of the profile comes the understanding of the size of the walls and the projections and retractions of each member. In this the architect, like the physician, shows all the interior and exterior parts of the works […]. The usefulness of the profile moves me to interpret Vitruvius' text as *sciographia* and not *scenographia* because even though *scenographia* is the description of the *scaenae* and perspective and is necessary in the things of the theater, as will be seen in the fifth book, it does not appear that it is related to the ideas of disposition of which we are speaking here […]. As far as I am concerned, if it were necessary to understand perspective in this present discussion, I would have there be four ideas of the disposition, in order to propose the profile to you, so necessary does it seem to me to be […] because all the lines come to the eye unimpeded and the projections and retractions and the sizes are known as they are and not as they appear with proportionate lines and angles, as is done in perspective.[32]

Barbaro's interpretation seems to have had an immediate response in the scientific literature of the time, or perhaps it was based on the intellectual exchange that he had to have on the matter with Francesco Barozzi. The translation of Proclus' commentary on the first book of Euclid's *Elements* that Barozzi published in Padua in 1560 with a dedication to Daniele Barbaro – a work in which Proclus recalls Geminos' classification of the mathematical sciences – reported, in fact, "sciographice" instead of "skēnographikē".[33]

An eloquent example of how the three species of the *dispositio* could express the characteristics of the building in a single drawing – all belonging to the same genre – is illustrated in a plate published in Book IV of Vitruvius' *I Dieci libri dell'architettura* and proposed again in the treatise on perspective: a round temple depicted in "plan, elevation and profile", that is to say in *ichnographia*, *orthographia* and *sciographia* **[fig. 3]**.[34] Barbaro, however, was well aware of the ambiguity of the Vitruvian definition – "although it seems that the definition of *sciographia* adopted by Vitruvius hints at the definition of perspective" – and concludes that whatever Vitruvius' intention had been with regard

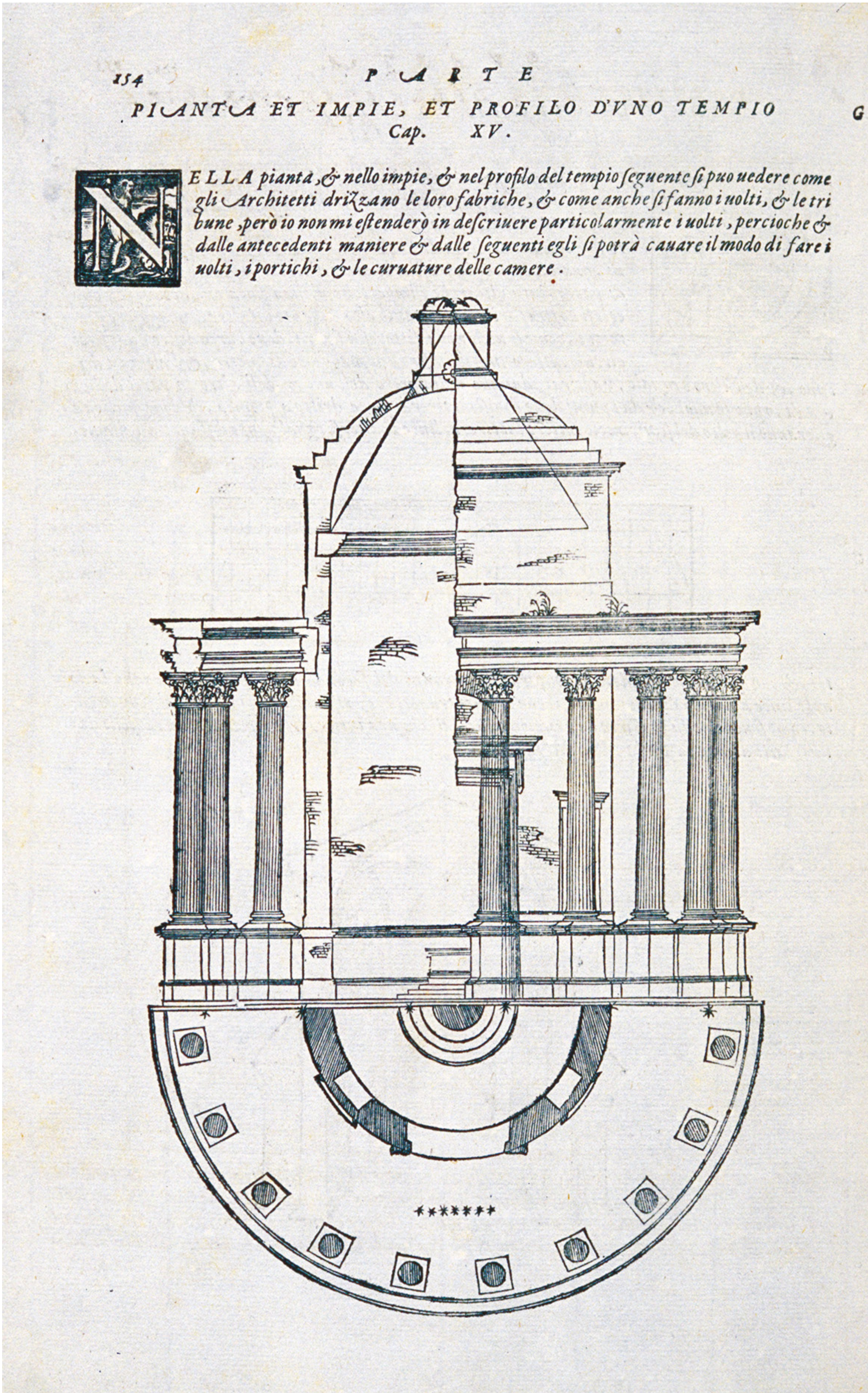
30 Barbaro 1569, IV, I, 130: "[if Vitruvius had not included] il profilo, egli haverebbe mancato grandemente, sì perché avrebbe lasciato una specie necessaria, sì perché ne avrebbe posta una, che non partecipa della natura del suo genere".

31 Vitruvio 1997, I, 2, 2. On Renaissance translations and interpretations, see Di Teodoro 2002, 38-43. Modern criticism generally tends to follow the most widespread interpretation since the Renaissance, thus translated by E. Panofsky 1927, footnote 19: "Scenography is the illusionistic reproduction (this is probably the best translation of *adumbratio*…) of the façade and the sides, and the correspondence of all lines with respect to the center of the circle [actually the compass point]"; see Panofsky 1991, 100.

32 Williams 2019, 62-3; Vitruvius 1567, I, 2, 2, 29-31: "La terza idea è il profilo, detto sciografia, dal quale grande utilità si prende, perche per la descrittione del profilo si rende conto delle grossezze de i muri, de gli sporti, delle ritrattioni d'ogni membro, et in questo l'Architetto come Medico dimostra tutte le parti interiori, et esteriori delle opere […]. Questa utilità del profilo mi muove ad interpretare sciografia, et non scenografia, perché se bene la scenografia, che è descrittione delle scene, et prospettiva, è necessaria nelle cose de i teatri, come si vedrà nel quinto libro; non però pare, che sia secondo le idee della disposizione, delle quali si parla […]. Io per me, quando avessi ad intendere in questo luogo la prospettiva, vorrei che fussero quattro le idee della disposizione, per ponervi il profilo; tanto egli mi pare necessario […] perché tutte le linee vengono all'occhio senza impedimento et si conoscono gli sporti, et le ritrattioni, et le grossezze come sono, et non come appareno con linee, et anguli proporzionati, come si fa nella prospettiva".

33 Proclus Diadochus 1560, I, XIII: *Alia totius Mathematicae scientiae divisio ex mente Gemini*.

34 Barbaro 1569, IV, XV, 154.


154 PARTE

PIANTA ET IMPIE, ET PROFILO D'VNO TEMPIO Cap. XV. G

NELLA pianta, & nello impie, & nel profilo del tempio ſeguente ſi puo uedere come gli Architetti drizzano le loro fabriche, & come anche ſi fanno i uolti, & le tribune, però io non mi eſtenderò in deſcriuere particolarmente i uolti, percioche & dalle antecedenti maniere & dalle ſeguenti egli ſi potrà cauare il modo di fare i uolti, i portichi, & le curuature delle camere.

Figure 3 Daniele Barbaro, plan, elevation and section of a round temple (Barbaro 1569, IV, XV, 154)

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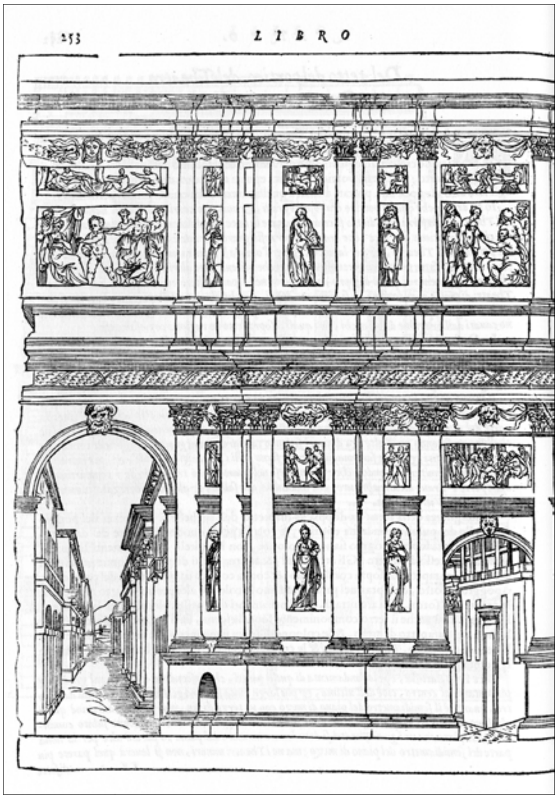

Figure 4 Daniele Barbaro, reconstruction of the ancient scene with the perspective views painted on the "periacti" (rotating triangular pillars) (Barbaro 1556, V, VII)

to the third idea of the *dispositio*, scenography remained a fundamental discipline for the construction of the scenes: "to draw the scenes", therefore, "the knowledge of Perspective it is necessary".

The scenographer's first task, having to represent buildings in perspective, was to learn the rules of architecture: the syntax of the classical orders, the proportions, and the design of the ornamental motifs. He therefore had to learn the rules of drawing in orthogonal projection according to the three species of the *dispositio*, in order to be able to "draw", "shorten" and "shade" correctly all the parts of the buildings to be painted on the various picture planes that make up the scene. The scenographer's perspective drawing was more complicated than that of the painters. It was not just a matter of painting a backdrop but of composing the image through a series of frontal and oblique canvases arranged on a sloping stage. To control the perspective correspondence between the various parts of the scene and to give the illusion of the continuity of the lines, the scenographers relied on practical devices often of their own invention. Barbaro describes a procedure invented by the Mantuan architect Pompeo Pedemonte which consisted of sighting a rope stretched between the vanishing point on the backdrop and the point of origin of the lines on the front of the stage. The sighting technique was used to make the rope "shade" or "as the mathematicians who make sundials say, the line of contingency", so as to be able to draw an objectively broken but apparently continuous line.[35]

Following Vitruvius, but drawing the iconography from Serlio, Barbaro briefly describes the characters of the three classic scenes, helping to affirm their typology in the theatrical culture of the sixteenth century. The reference to the ancient scene, however, is only literary. From a technical point of view, the scene described by Barbaro, like that of Serlio, is absolutely modern. The ancient scene was not as complex. As Barbaro himself illustrates in his commentary to Vitruvius, the ancient theater usually provided for a large front façade (*frons scenae*) closed laterally by two short orthogonal protrusions (*versurae*). The scene changes took place by means of simple revolving mechanisms, the so-called *periacti* or 'triangular machines', which were located behind the doors of the *frons scenae*: the royal door and the *hospitalia*. On those triangular prisms there were painted canvases that showed the various places where the scenic action took place. In Barbaro's interpretation drawn by Andrea Palladio, the painted images showed glimpses of buildings lined up along imaginary streets that converged on the stage **[fig. 4]**.[36] We do not know what Palladio had foreseen for the Olympic Theater of Vicenza (which of that philological reconstruction constituted, later, the material expression), but it is possible that behind the doors of the majestic *frons scenae*, he had imagined modern *periacti* rather than the three-dimensional scenes then built by Vincenzo Scamozzi.

35 Barbaro 1569, IV, XVI, 155.

36 Vitruvius 1567, V, 6, 249, 253-4.

5 The Fifth Part. *In which a Beautiful and Secret Part of Perspective is Explained*

From the fifth to the ninth part, Barbaro treated some particular perspective themes, such as the anamorphosis, the planisphere, the projection of shadows, the proportions of the human body and the perspective tools. The anamorphosis is presented as a "beautiful, and secret part of Perspective" whose rules could be derived from the same perspective principles "that I put in the first part". The images painted on the oblique planes of the theatrical scenes entailed deformations such as to suggest an adequate study of this perspective theme. The starting point, however, could also derive in this case from the reading of the *De prospectiva pingendi*, where the last three propositions precisely illustrated the playful cases of perspective; cases in which the perspective deformation of the images was artificially exaggerated to deceive the eye of the observer, making non-existent objects appear as if they were true. Beginning in the thirties of the sixteenth century, artists had begun to produce extraordinary examples of this particular application of perspective. Some refined woodcuts called 'images with secret' (*Vexierbilder*) were printed around 1530 by Erhard Schön, a painter from the circle of Dürer, and in 1533 Hans Holbein the Younger had signed the splendid double portrait of the French ambassadors Jean de Dinteville and George de Selves, then on a diplomatic mission in London, a painting in which the deformed image of a skull stood out, visible only from a lateral and grazing observation point. George de Selves had been ambassador to Venice in 1540 and may have brought news of that painting to the lagoon city. Barbaro, in turn, had been ambassador to London, at the court of Edward VI, from 1548 to 1551, and if he did not see the masterpiece of Holbein that Jean de Dinteville brought with him to France at the end of his mission, he may have seen other excellent examples of that perspective technique, such as the refined anamorphic portrait of King Edward at the age of nine painted by William Scrots in 1546.

Barbaro seems to have known many "ingenious Perspectivists": some "devising ways to write letters on panels, which cannot be read except with mirrors, through reflected rays; others drawing sundials with the reflections of light; and others who did wonderful works using the medium of water for the refraction of rays".[37] The deformation of the images was obtained by exacerbating the parameters of perspective, namely the height of the vanishing point and the distance of the viewpoint, but Barbaro did not go into the substance of the geometric construction. His approach was purely mechanical, albeit in the awareness, perhaps, that the procedure he proposed materially expressed the geometric method of Piero della Francesca. The procedure consisted in drawing the correct image on a sheet to be perforated "as if you wanted to pounce it", in placing this sheet on the edge of a panel, orthogonally or slightly inclined, and in projecting the points on the panel with the sunlight or by means of a "lamp" [fig. 5]. The images were "stretched and narrow", and appeared "without any rules and shapes, but if you stand at the point from which the sunbeams have come, the heads [the image drawn] will seem to you to be shaped as they are above the paper".[38] He also suggested that in the front view the deformed lines were masked by other representations, such as "countries, waters, mountains, stones", pretending a landscape representation of the type visible in the engravings of Erhard Schön.

37 Barbaro 1569, V, I, 159: "ingegnandosi di scrivere lettere nelle tavole, che non si possono leggere se non con i specchi, et quasi di riverbero, altri con riflessi di lumi hanno dissegnato horaloggi, altri usando il mezzo dell'acqua per la rifrattione de i raggi hanno fatto prove meravigliose".

38 Barbaro 1569, V, II, 159: "Piglia una carta, nella quale dipignerai una, o due teste humane […] et queste punteggierai come se ne volessi fare uno spolvero […] Da poi piglia la tavola sopra la quale tu vuoi ripportare le due teste […], drizza la tavola col taglio al Sole, secondo l'altezza sua, accioche passando i raggi per li punti della carta […] si veda nella tavola che i raggi del Sole descrivono le dette teste, le quali seranno allungate e strette […] senza regula e forma alcuna, ma se starai al punto, dal quale sono venuti i raggi del Sole, le teste ti pareranno formate, come sono sopra la carta".

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Figure 5 Virtual reconstruction of the way described by Barbaro to draw an anamorphosis. Photograph by F. Camerota and F. Corica

6 The Sixth Part. *Which is Called Planisphere*

Another "beautiful, and ingenious, and useful invention" was the plane projection of the celestial sphere, "as Ptolemy teaches in his treatise dedicated to the subject".[39] The starting point for this perspective theme, as anticipated, came from Federico Commandino's commentary on Ptolemy's *Planisphere*. The work had been published with the aim of demonstrating the projective principles underlying the stereographic representation of the celestial sphere, using "that part of optics that the ancients called scenography".[40] Geminos' text, then also spread as a work by Hero, clearly transpires from the words of Commandino which indicates that that discipline was "of great use to architects" to ensure a correct perception of the proportions in the buildings in relation to the different appearance of things: "So that when [the architect] wants to represent circles, sometimes he doesn't draw circles but ellipses".[41] In support of his demonstrations, Commandino also led the theoretical and practical experience of modern artists that was "of great help [to him] in following the thought of this little book [Ptolemy]".

The plane projection of the celestial sphere was performed on a picture plane passing through the equator, from a projection center located at the South Pole. This geometric projection was necessary to design the astrolabe and in some medieval treatises on the composition of this instrument, the polar projection point was called for greater clarity "oculus videns".[42] The image of the celestial sphere projected on the equatorial plane was compared to what an observer would have seen if he had been at the South Pole with his gaze turned towards the opposite pole. Following this tradition, but also using the Renais-

39 Barbaro 1569, VI, I, 159: "bella, et ingeniosa, et utile invenzione [...] si come insegna Tolomeo nel suo Trattato a questo dedicato".

40 Ptolemy 1558, dedicatory letter: "quella parte dell'ottica che gli antichi chiamarono scenografia".

41 *Hieronis Alexandrini Nomenclatura Vocabulorum Geometricorum*, in Dasypodius 1579, II, 18. Proclus Diadochus 1560, I, XIII: *Alia totius Mathematicae scientiae divisio ex mente Gemini*. The book, edited by Francesco Barocci, is dedicated to Daniele Barbaro.

42 See, for example, Messahalla, *De compositione et utilitate Astrolabii,* in Gunther 1929, V (*Chaucer and Messahalla on the astrolabe*).

sance perspective conquests, Federico Commandino believed he could further clarify the projective principle of the planisphere, illustrating the methods of representation elaborated by modern painters who had been useful to him to understand the text of Ptolemy. His commentary therefore presents itself as a pamphlet on perspective where the author describes two different ways of foreshortening a square plane, corresponding to the method of intersection in plan and elevation and to the distance point construction. They were the two methods then masterfully codified by Giacomo Barozzi da Vignola who Commandino remembers in the dedication to Cardinal Ranuccio Farnese, as "an excellent and very competent architect" so expert in "perspective that in this part of science no doubt gives way to anyone".

The lesson was immediately received by Daniele Barbaro, well aware – as we read in the comment to Vitruvius since the first edition of 1556 – that "the analemma is taken from the sphere laid out in the plane according to the rationale of perspective".[43] Imagining "that the eye is in one of the poles of the sphere" – specifically the Antarctic pole, given that "the contemplators of the sky" look at the North pole and the northern hemisphere – the parallel circles of the celestial sphere appear projected on the picture plane as progressively larger concentric circles from the Arctic circle to the tropic of Capricorn. In the reality of the three-dimensional model, the tropics are equal to each other and smaller than the equator, while in the projection the tropic of Capricorn is significantly larger than both the tropic of Cancer and the equator. This is because, explains Barbaro and before him Commandino, "being the tropic of Capricorn closer to the eye, it appears under greater angles than the other circles, and consequently it seems to us greater". The oblique circles were projected in the same way, that is, the ecliptic and the circles parallel to the horizon of the observer, "called Almicantarath by the Arabs". Since the obliquity of the horizon varies in relation to the latitude in which the observer is located, the projection of the almucantarat and azimuth (the meridians passing through the observer's zenith), is never the same and represents the variable part of the planisphere. The drawing of the planisphere as a perspective projection was a typically Renaissance interpretation. Ptolemy had described a geometric procedure in which the projection point was never compared to the eye of an observer, but Renaissance theorists believed they could consider that comparison implicit.

7 The Seventh Part. *Which Deals with Light, Shadows, and Colors*

The shape of shadows also responds to the laws of projection, which Barbaro briefly illustrated in the seventh part of the treatise, distinguishing the "first light", emitted directly from the light source, from the "second light", the one reflected by the shiny bodies or refracted by the transparent bodies.[44] To imitate the shadows produced by the two types of lighting, the painter had to turn more "to the observance of nature than to the laws of art". Barbaro, nevertheless, described the geometric rule deriving it entirely from Dürer, without realizing he was mistakenly reproducing the point light source [that of a lamp] in the form of the sun. The treatment of color also contributed to the perspective rendering of the pictorial representation, but in all this "it takes judgment, reason, and experience. And I know that Leonardo Aretino [*sic*! da Vinci] wrote a treatise on this".[45] We are in the years immediately following the compilation of Francesco Melzi who dedicated the fifth part of Leonardo's *Book on Painting* to the problems of shadows and color. This chapter of Barbaro, however, once again has a relationship with the Vitruvian text and is precisely linked to the term "adumbratio" that appears in the definition of "scaenographia": many "have interpreted that word Sciographia for Perspective, which is like a shadowing [*chiaroscuro*]".[46]

43 Williams 2019, 719; Vitruvius 1556, IX, 9, 245; 1567, IX, 9, 431: "l'Analemma adunque si piglia dalla sfera posta in piano con ragione di prospettiva".

44 Barbaro 1569, VII, I, 175. This theme had been particularly studied by Leonardo, whose considerations occupy the entire fifth part of Francesco Melzi's compilation; see Leonardo da Vinci 1995, II, 361-467.

45 Barbaro 1569, VII, II, 177.

46 Barbaro 1569, IV, I, 129: "[molti] hanno interpretato quella parola Sciographia per la Perspettiva, la quale è come una adombratione".

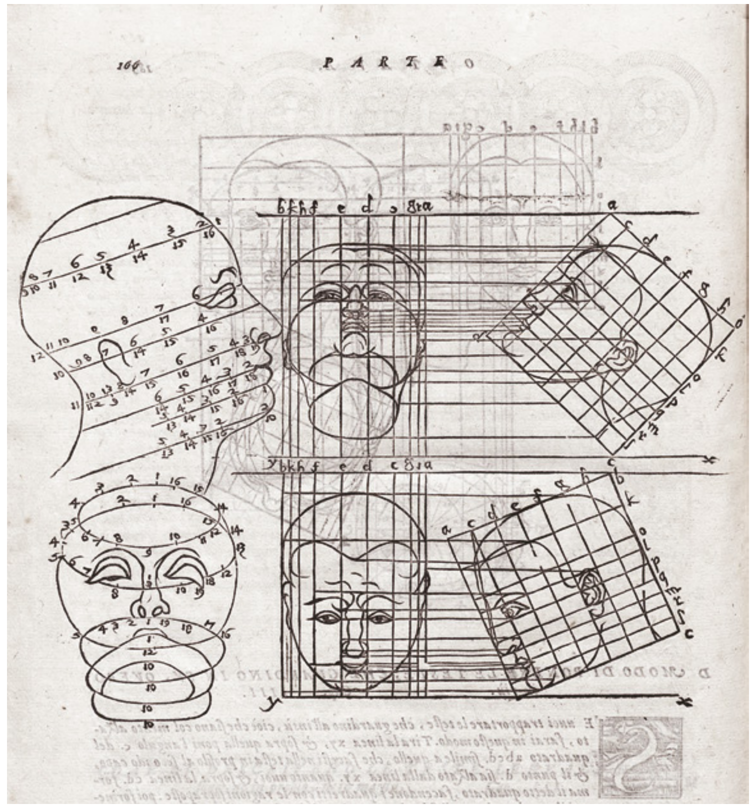

Figure 6 Daniele Barbaro, the two heads on the left derive from Piero della Francesca, *De prospectiva pingendi*, III, VIII, the others from Dürer (1528), IV, g5 (Barbaro 1569, IX, IV, 186)

8 The Eighth Part. *In which it Deals with the Measurements of the Human Body*

The brief description of the proportions of the human body still refers to Vitruvius. However, it is functional to pictorial representation and finds its most precious source in Albrecht Dürer's *Vier Bücher von Menschlicher Proportion* (1525), presumably read through the Latin edition of 1532. Using "the instrument of Dürer called transferting tool", Barbaro describes the triple orthogonal projection of the human head that he also knew through the splendid drawings of Piero della Francesca.[47] The second woodcut is in fact an awkward copy from the *De prospectiva pingendi* with the variant of the quadruple orthogonal projection in which the head seen from behind also appears. In the last chapter on the "way of placing heads, looking up, over or down", Piero and Dürer's drawings are composed on a single plate [fig. 6].

9 The Ninth Part. *In which Many Instruments and Ways of Drawing Things in Perspective are Described*

The treatise ends with the description of some drawing tools which testify to a twofold interest. On the one hand, once again, the Vitruvian studies relating to the discipline of the tenth book, the *mechanica*, which included machines and instruments for civil and military use, illustrating some of the most famous inventions of the ancient world. On the other, the growing interest in scientific collecting as a material expression of knowledge. Like libraries, cabinets of scientific instruments were places of knowledge that expressed the strength and power of scientific culture through material objects, often of the highest craftsmanship. We read it, for example, in a note perhaps drawn up

47 Barbaro 1569, VIII, II, 181-2. Dürer [1528] 1996, lib. I, c. F ii*r* (the instrument, which Barbaro calls "transferente", is called here "der Ubertrag").

by Gian Vincenzo Pinelli for the collection of Carlo Emanuele I of Savoy: "The instruments that can be set to decorate the Library of the most Serene and Illustrious Duke of Savoy are reduced et contained under five sections. That is, for things of Perspective [i.e., optics], for Astrology, for Music, for Geometry and for some inventions of water, air, fire, and mixed things in one or more Arts".[48] Among the liberal arts, Geometry had a leading role conferred by the fact that its tools governed a wide spectrum of practical applications, from the construction of machines and buildings, to the fortification of cities, to military techniques, to cartography, to figurative arts. According to the traditional classification of mathematical sciences, Perspective – formerly the science of vision, then the science of representation – was considered "handmaid" of Geometry, and its tools gradually became part of the scientific cabinets as material expressions of a discipline that during the course of the Cinquecento had had extraordinary developments not only in the pictorial field, but also in the cartographic and military ones.

The first instrument described by Daniele Barbaro was an invention he developed to design sundials on any surface. The instrument is called "Horario Universale" [universal time tool] and derives from a model of mechanical clock in the form of a celestial globe that began to be built in the mid-sixteenth century. A specimen of this type of clock, dating back to that period, is now preserved in the Correr Museum in Venice.[49] The part of the instrument that forms the 'universal time tool' of Barbaro is formed by the band of time lines between the Tropic of Cancer and that of Capricorn. To draw the face of a sundial, the drawing paper had to be placed correctly and the hour lines projected onto it by means of sighting, using a light source, or a silk thread tied to the center of the sphere. The instrument was connected to what Barbaro had written on sundials "in the ninth book of Vitruvius, according to the intention of Ptolemy, and the exposition of Commandino".[50]

Figure 7 Baldassarre Lanci, perspective and surveying instrument, gilded brass (1557). Firenze, Museo Galileo, inv. 152, 3165; (bottom) G. Parigi (ca 1600), *Taccuino di arte militare*, ms. Washington, Library of Congress, Rosenwald Collection, c. 239*r*: Baldassarre Lanci's instrument

The second tool was Dürer's "door", the most successful invention among painters and perspective theorists of the sixteenth and seventeenth century. Barbaro claims to have used it several times to draw "in Perspective many things of a room of the Most Reverend Cardinal de Turnon with his great pleasure".[51] This experience presumably took place in Rome, with Cardinal Franc-

48 Milano, Biblioteca Ambrosiana, ms. A 71 Inf., formerly owned by Gian Vincenzo Pinelli, sixteenth century, c. 121*r*: "L'Instrumenti che si potriano apparecchiar per ornamento della Libreria del Sereniss.mo et Ill.mo Duca di Savoia sono ridottj et contenuti sotto cinque capi. Cioè per le cose di perspettiva [*i.e.*, ottica], per l'Astrologia, per la Musica, per la Geometria et per alcuni ingegnj di Acqua, d'aere, fuogo, et di cose miste in uno et più Arti".

49 Venezia, Museo Correr, Cl. XXIX, 31; see Camerota 2008, 30-3.

50 Barbaro 1569, IX, I, 187-8. See also Barbaro 1556 e 1567, IX, 8-9.

51 Barbaro 1569, IX, III: *Lo instrumento di Alberto Durero da pigliare in Perspettiva*. "Alberto Durero ingegniosamente ritrovò uno instrumento da porre le cose in Perspettiva, il quale io ho adoperato, et riesce molto bene [...] Et io con questo instrumento pigliai in Perspettiva molte cose di una camera del Reverendissimo Cardinale Turnone con suo gran piacere".

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Figure 8 G. Parigi (ca 1600), *Taccuino di arte militare*, ms. Washington, Library of Congress, Rosenwald Collection, c. 249*r*: the camera obscura

esco de Tournon, perhaps in 1559, on the occasion of the conclave that elected Pope Pius IV.[52] The instrument had been published by Albrecht Dürer in 1525, at the end of his treatise on geometry, and was distinguished by the clarity with which it mechanically expressed the principle of intersection of the visual pyramid. Egnazio Danti later described it in the commentaries on Vignola's treatise on perspective precisely to explain "what the foundation of Perspective is".[53]

Returning from that journey to Rome, if that was the occasion of the meeting with Cardinal de Tournon, Barbaro stopped in Siena where he met Cosimo de' Medici's military engineer, Baldassarre Lanci, just in charge of providing for the fortifications of the city after the annexation to the Medici domains. In Lanci's house, Barbaro saw the third instrument illustrated in this last part of the treatise: a topographical instrument invented by the engineer which included perspective drawing among its operations.[54] The instrument was built in 1557 for the collection of the Duke of Florence and stood out for its ornamental and mechanical refinement [fig. 7].[55] It consisted of "a round brass plate" on which circumference, for a little more than a quarter of it, a semi-cylindrical panel with a drawing sheet rose. At the center of the brass disc there was a rotating element, with a sighting and a stylus, used to trace on the half-cylindrical tablet the points of an object observed from life. Lanci's intention was certainly to carry out the perspective drawing of a fortress or a territory observed from a high station point, in order to subsequently obtain the plan with a perspective restitution procedure.[56] The perspective function of the instrument was to solve the problem of taking measurements when the topographer could take advantage of only one surveying station point. "This instrument – writes Barbaro – as far as the invention is beautiful, but as for the use it needs to be better

52 Tournon returned to France soon after.

53 Vignola 1583, I, III: "in che consista il fondamento della Prospettiva, et che cosa ella sia".

54 Barbaro 1569, IX, IV: *Fabrica d'un altro instrumento di Baldessara Lanci*. "Baldessara Lanci ingenioso ingegneri essendo io in Siena, mi mostrò uno instrumento ritrovato da lui da porre in Perspettiva…".

55 The instrument is kept in the Museo Galileo – Istituto e Museo di Storia della Scienza di Firenze, inv. 152, 3165.

56 Cf. Camerota 2003.

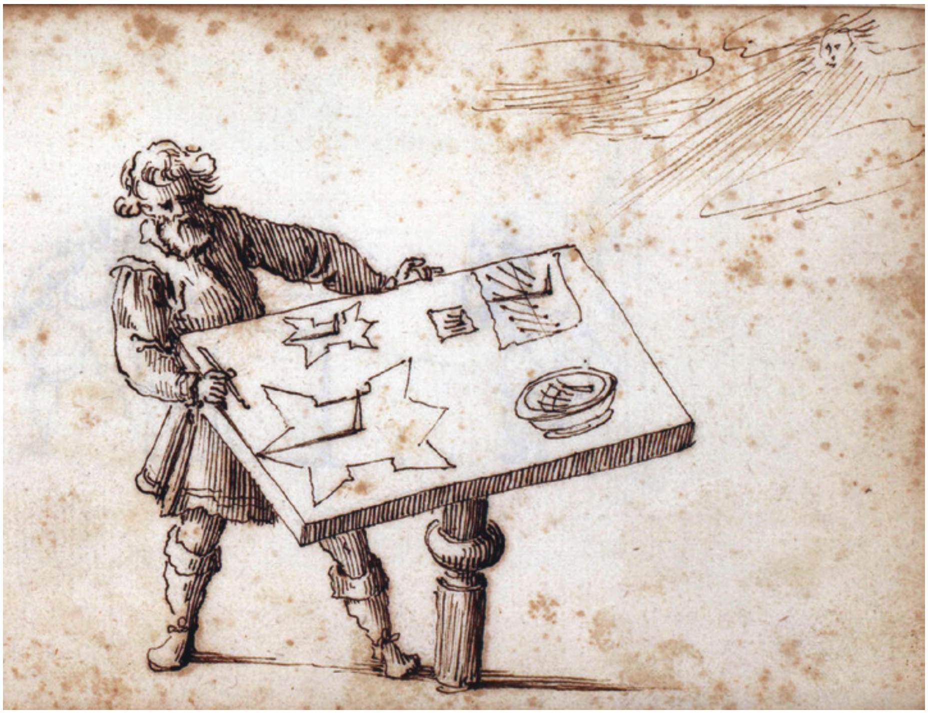

Figure 9 G. Parigi (ca 1600), *Taccuino di arte militare*, ms. Washington, Library of Congress, Rosenwald Collection, c. 247*r*: G.B. Vimercato's drawing instrument

formed, and done bigger, and with more warnings, which I leave to the inventor, who told me he wanted to reform it".[57]

The change perhaps concerned the adaptation of the instrument to the needs of painters who, according to the subsequent news of Egnazio Danti, made great use of it, at least in the Florentine workshops of the time. To adapt the instrument to pictorial purposes it was necessary to replace the curved panel with a flat one, as proposed by Egnazio Danti and as documented by a drawing by Giacomo Contarini which could betray further reflections by Barbaro on the function of the instrument.[58] The version illustrated by Contarini, heir of the humanistic culture of Daniele Barbaro, reveals a technical detail that does not exactly correspond to Lanci's instrument, but reflects instead the description of Barbaro who – trying to remember what he saw in Lanci's house ("if I remember correctly", he writes) – sinned of imprecision precisely in that detail. Contarini, in fact – as Barbaro seems to refer – erroneously shows the center of rotation of the sighting system at the base instead of half its height. In Lanci's tool, on the other hand, the rotation center is correctly positioned at the stylus level because that is the place of the perspective viewpoint.

The fourth instrument in the series is a refined dark room **[fig. 8]**, a "natural way of drawing in perspective", as Barbaro writes, usually applied by astronomers to observe the eclipses.[59] The phenomenon had gradually emerged among the interests of the natural philosophers and, at the time of Barbaro, Giovanni Battista della Porta had made it one of the salient themes of his *De Magia naturalis* (1558), also suggesting its use in pictorial practice: "Hence it derives that anyone who does not know the art of painting, will be able to draw with

57 Barbaro 1569, IX, IV, 192: "Questo instrumento quanto alla inventione è bello, ma quanto all'uso ha bisogno di essere meglio formato, et con più avvertimenti, i quali lascio all'inventore, che mi disse di volerlo rifformare".

58 G. Contarini, *Figure d'istromenti matematici e loro uso*, Oxford, Bodleian Library, ms. Canon Ital. 145, cc. 39-40, in Camerota 2000, 256-8.

59 Barbaro 1569, IX, V: *Modi naturali di mettere in Perspettiva*.

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a stylus the image of any object".[60] As he will write more extensively in the enlarged edition of 1589 (here from the English edition of 1658):

> Hence you may, If you cannot draw a Picture of a man or any things else, draw it by this means; If you can but onely make the colours. This is an Art worth learning. Let the Sun beat upon the window, and there about the hole, let there be Pictures of men, that it may light upon them, but not upon the hole. Put a white paper against the hole, and you shell so long fit the men by the light, bringing them neer, or setting them further, until the Sun cast a perfect representation upon the Table against it: one that is skill'd in painting, must lay on colours where they are in the Table, and shall describe the manner of the countenance; so the image been remouved, the Picture will remain on the Table, and in the superficies it will be seen as an Image in a Glass.[61]

The sharpness of the image could be enhanced by placing a convex lens in the opening hole of the darkroom, an optical device previously described by Girolamo Cardano in his *De subtilitate* and promptly taken up in this chapter by Daniele Barbaro:

> If you want to see how nature shows foreshortened things [...] you will make a hole in the shutter of a window [...] as big as the glass of a pair of glasses. And takes glasses for the elderly, that is to say that it has a somewhat body in the middle, and it is not concave, like glasses for young people, who see well up close, and mount that glass in the hole.[62]

To increase the sharpness of the image and eliminate marginal aberrations, Barbaro suggested to diaphragm the lens: "and if you want to cover the glass so much, that it leaves a little circumference in the middle, which is clear and uncovered, you will see it even more alive effect".[63] The painter should have done nothing but trace the features of the things projected by the sunlight onto the drawing paper. Later in time, this "natural" way of painting would have characterized the art of one of the greatest Venetian painters of the eighteenth century, Canaletto, who developed for his paintings a portable darkroom equipped with an objective lens and a mirror for the straightening of the image: an "artificial eye", as Francesco Algarotti called it, which should have represented for painters what the telescope represented for astronomers and the microscope for physicists.[64]

"With the help of the Sun" – continues Barbaro describing the fifth instrument – it was also possible to reproduce the drawings on a larger or smaller scale.[65] The procedure was an invention published by Giovanni Battista Vimercato in the *Dialogo della descrittione teorica et pratica degli horologi solari* ['Dialogue of the theoretical and practical description of sundials'] published in Venice in 1565.[66] The instrument simply consisted of the use of two gnomonic styluses whose reciprocal height was proportional to the reduction ratio that was to be obtained **[fig. 9]**. The two styluses were placed on a tilting table, one in the center of the drawing to be reproduced, the other on the white sheet that was to house the copy of the drawing. The table was then exposed to the sun and tilted until the shadow of the first stylus touched a point on the drawing; when this happened, the shadow of the other stylus indicated its corresponding position on the second sheet. Vimercato had indicat-

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60 Della Porta 1558, IV, II, 144: "Hinc evenit, ut quisque picturae ignarus, rei alicuius effigiem stylo descrivere possit"; Italian edition, Della Porta 1560, IV, II, 142*r* ("Di qua nasce che ciascheduno il quale non sappia l'arte della pittura, potra con uno stile lineare l'immagine di qual si voglia cosa").

61 Della Porta 1589, XVII, VI, 266: "Hinc evenit ut quisq[ue] picturae ignarus rei alicuius, vel hominis effigiem delineare possit. Dummodo solùm colores assimilare discat. Hoc non parvifaciendum artificium. Feriat Sol fenestram, et ibi circa foramen imagines, vel homines adsint, quorum imagines delineare volumus, Sol imagines illustret, non verò foramen. Oppones foramini papyrum albam, ac tandiu homines ad lumen accomodabis, appropinquabis, elongabis, dum perfectam imagines Sol in obiecta tabulam referat, picturae gnarus colores superponendo ubi sunt in tabula, et ora vultus circumscribet, sic amota imagine, remanebit impressio in tabula, et in superficie, ut imago in speculo spectatibur". For the English translation quoted here, see Della Porta 1658.

62 Barbaro 1569, IX, V: "Se vuoi vedere come la natura pone le cose digradate [...] farai uno bucco nello scuro d'una finestra [...] tanto grande quanto è il vetro d'un occhiale. Et piglia un'occhiale da vecchio, cioè che habbia alquanto di corpo nel mezzo, et non sia concavo, come gli occhiali da giovani, che hanno la vista curta, et incassa quel vetro nel bucco". See also Cardano 1550, IV, 128; 2004, IV, 389.

63 Barbaro 1569, IX, V, 192-3: "[...] et se vorrai coprire il vetro tanto, che vi lasci un poco di circonferenza nel mezo, che sia chiara e scoperta, ne vederai anchora più vivo effetto".

64 Algarotti 1764, 59-63: "Quell'uso che fanno gli Astronomi del canocchiale, i Fisici del microscopio, quel medesimo dovrebbono fare della Camera Ottica i Pittori".

65 Barbaro 1569, IX, V, 193.

66 Vimercato 1565, II, II.

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ed its use to reproduce sundials but Barbaro suggested its application to any drawing: "a fortress, a human figure, and any other thing".

The last instrument of the series that derives from the practice of cartographers is also dedicated to the reproduction of drawings.[67] Wanting to "copy a Geography plate or something else in a plane", the draftsman could use two protractors, in the center of which two graduated lines of the same length, or length proportional to the reduction ratio, were pivoted. One protractor was placed on the drawing to be reproduced, the other on the white sheet, and the drawing was copied by measuring the coordinates of the points, i.e. the position angle and the distance from the center. The method of measuring and drawing by means of the coordinates of 'latitude' and 'longitude' (angles and distances) was widespread among topographers; and a complete exposition of it had been given by Leon Battista Alberti, whose mathematical writings were published precisely in those years in Venice. Alberti's mathematical works were edited by Cosimo Bartoli[68] who, from 1562, was resident in Venice as an agent of Cosimo I de' Medici, and in 1564 published an important treatise on measuring techniques, *Del modo di misurare le distantie* ['On the method of measuring distances'], which illustrated the topographical use of a protractor derived from the astrolabe. Following the instructions of the cosmographer Juan de Rojas Sarmiento, Bartoli also hinted at a perspective function of the instrument that may have inspired Barbaro's description.[69] Copying from life or copying from another drawing was basically the same thing.

With the description of this instrument, Barbaro concludes his articulated treatment of perspective, and perhaps only after having already printed the last page did he decide to attach to his small 'collection' of instruments an invention of the engineer from Urbino Giacomo Castriotto. The description of this instrument is reproduced literally, text and image, from a page of the treatise *Della fortificatione delle città* ['On the fortification of cities'], published posthumously in Venice by Girolamo Maggi, with extensive additions, in 1564.[70] The instrument was mainly used to measure the slope of a fortress wall but, as Castriotto points out, it also does "service in transforming plans from large to small", and it is this function that certainly attracted the curiosity of Barbaro, evidently insatiable in obtaining pleasure from inventions of ingenuity. So strong was the desire to know, as he writes in his dedication to his friend Matteo Macigni, that he wished one day to see what apparently may seem impossible, such as "the triangle of an infinite straight line, and the center major of the circumference".

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67 Barbaro 1569, IX, V, 193.

68 Bartoli 1568: Alberti's protractor, the "horizon", is described in *Ludi matematici* (*Piacevolezze matematiche*) and in *De statua* (*Della statua*). Bartoli's edition does not contain the *Descriptio urbis Romae*, where the use of the instrument is fundamental for cartographic drawing.

69 Bartoli 1564, I, XXV; see also Rojas Sarmiento 1550, IV, 22.

70 Maggi, Castriotto 1564, II, II, 42.

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