Renaissance Florence: the Optical Capital of the World

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At the end of the thirteenth century eyeglasses with convex lenses appeared for the first time at Pisa. Three centuries later Florence developed the first sample of truly optical glass for scientific instruments, including telescopes, through the efforts of Galileo and his collaborators. In the middle of this period Florentine artists worked out the principles of exact geometrical perspective, unknown to artists in the ancient world and not found in the art of any non-Western civilization. These well-known and generally accepted facts, combined with recently discovered data discussed below, suggested the intentionally provocative title of this paper in hopes of generating more interest and research on a set of extraordinary and interrelated developments affecting both Renaissance art and science.

Not known up to my publication of some new documents nearly two decades ago was the fact that by the middle of the fifteenth century Florence had almost certainly developed concave lenses, and had become the leading centre in Europe for the manufacture of the finest spectacles.[1] This means that Tuscany, and Florence in particular, achieved a leading position in optical technology ahead of Venice, which had by far the most extensive and advanced glass industry in Europe during this period. How is one to explain such

[1] These documents were first published in my article, "Eyeglasses and Concave Lenses in Fifteenth-Century Florence and Milan: New Documents," *Renaissance Quarterly*, XXIX (1976/3), 341-66. They were republished in a much enlarged and revised version of my article in my book, *Occhiali alla Corte di Francesco e Galeazzo Maria Sforza con documenti inediti del 1462-1466*, trans. G. Lopez, Milan 1978. Both contain relevant bibliography to which readers are referred. In the following pages I will list for the most part only publications that escaped me earlier or appeared later.

a leadership in view of the fact that Venetian glass workers were active in Tuscany and elsewhere in Italy and knew all the secrets of the trade? Had Venetian glass makers decided not to develop and manufacture optical quality glass suitable for telescopes and other scientific instruments? I will make an attempt to answer these questions in the following pages chiefly through the analysis of the above mentioned documents because they supply the missing link between the first pair of eyeglasses and the development of the telescope.

Although there is no need for our purposes to enter the debate on the priority of the invention of eyeglasses, which has long been disputed by Florence and Venice, it is important to restate briefly some of the known facts surrounding the invention to serve as a necessary background for the discussion that follows. It has been established that the first pair of spectacles — two glass disks enclosed by metal rims centrally connected so as to be held before the eyes — was constructed in Pisa around 1286. The inventor is still unknown and he could have been a local glass maker, who had the bright idea of adapting an old instrument to a new use. That instrument was a convex piece of clear glass or, better, rock crystal, which since antiquity had been used as a magnifier along with similarly shaped precious stones, concave mirrors, and even glass spheres filled with water. These devices were designed to correct hyperopia (farsightedness), but more commonly — presbyopia — the progressive reduction of accommodation to near vision, which almost universally occurs after age forty. Unwittingly the inventor had transformed an external optical instrument — the magnifying glass — into a device that became an integral part of the eye's own optical system because the glass disks (later to be called lenses), obviously less convex than magnifiers, compensated for the shortness of the eyeball of hyperopes and the diminishing flexibilty of the ocular lenses of presbyopes by bending the rays of light from near objects to focus properly on the retina. Naturally the invention was a boon especially for the elderly, who now could extend their reading and writing life or their capacity for close work more comfortably and more efficiently,

once methods were found to secure the lenses on the nose and free their hands for the tasks at hand.

There is no doubt that the inventor immediately realized the significance of his discovery, whose process he tried to keep secret in order to magnify his profits. Before the age of patent registration, this was the common practice of protecting the fruits of one's originality. This time, however, a Pisan Dominican friar at the local Monastery of Santa Caterina, Alessandro della Spina, who had probably purchased the new device from the inventor, learned to make it and divulged the process for the benefit of all. And it was another Pisan and colleague of Spina at the same monastery, Giordano da Rivalto, who disseminated knowledge of the invention by announcing it in one of his sermons delivered in 1306 at the Church of Santa Maria Novella in Florence. In this sermon the friar coined the word "occhiali" for the device and this word gradually came into use throughout Italy. Certainly the scholarly friars were keenly interested in the new invention and, in fact, monasteries are known to have continued to make spectacles centuries after. [2]

The present available evidence then shows that Tuscany, and Pisa in particular, originated the invention, although the possibility remains that the inventor may have emigrated there from Altare in Liguria, another glass-making centre, which is credited with having exported glass-making technology into Tuscany sometime in the second half of the thirteenth century. Although the priority of birth claimed by this centre in the Appennines above Savona over that of Venice has not been documented, its influence for the development of the Tuscan glass industry has been generally accepted. [3]

It has only been in last thirty years that Luigi Zecchin, a leading Venetian historian of the glass industry in Venice and elsewhere in Italy, has finally accepted the Pisan origin of spectacles while insisting

[2] The Pisan origin of spectacles is well documented by *E. Rosen*, "The Invention of Eyeglasses," *Journal of the History of Medicine and Allied Sciences*, 11 (1956), 13-46, 183-218. His conclusions have been generally accepted.

[3] L. ZECCHIN, "Sull'origine dell'arte vetraria in Altare," *Vetro e Silicati*, IX (1965), 19-22; and G. TADDEI, *L'arte del vetro in Firenze e nel suo dominio*, Florence, 1954, 9-10.

on some Venetian precedents for it. He believes that Venetian "cristallai" by chance discovered that the slightly convex and round crystal covers they manufactured for small vials containing medicines and precious ointments could correct presbyopia when held before the eyes. They called them "roidi da ogli," (vetri da occhi), which were mentioned for the first time in the articles of the *Capitolare dell'arte dei cristallai in 1300* as a distinct device from the old "lapides ad legendum," (stones for reading, or the early magnifiers). One of these articles merely prohibited the use of glass rather than crystal for their manufacture, which suggests that these "roidi da ogli" had been on the market for some time. The knowledge of this discovery may have travelled to Tuscany or indeed a Venetian glass worker may have gone to Pisa where he or a colleague first thought of putting two "roidi" together and creating the first pair of spectacles. The credit for the invention is then shared by Venice and Pisa, according to Zecchin, who, however, does not supply the necessary documentation to support his view. [4] Nevertheless this hypothesis is more generous to Pisa than that advanced many years ago by a Venetian historian of optics, Giuseppe Albertotti, who credited only Venice with the discovery. [5]

Zecchin himself, however, mentions some embarrasing facts that tend to connect the early development of eyeglasses more with Tuscany than the Veneto. In 1317 the *cristallai* allowed

[4] Three articles by Zecchin deal specifically with spectacles: "I 'cristalleri' e l'invenzione degli occhiali," *Giornale economico della Camera di Commercio di Venezia*, X (1956), 832-37; "I 'roidi da ogli'," ibid., XVI (1962), 438-45; and "I 'rodoli de vero'," ibid., XVI (1962), 688-94. These articles have been recently republished in his *Vetro e vetrai di Murano. Studi sulla storia del vetro*, II, Venice 1989, 236-39, 244-49, 250-55 respectively. It should be noted that up to this very recent republication of his writings in three volumes, Zecchin's articles were published in very specialized journals with limited circulation abroad. They escaped my attention when I began my research on the history of spectacles, although his contributions do not in any way affect my documentation or conclusions regarding the development of eyeglasses in the fifteenth century .

[5] Of Albertotti's numerous articles on the subject, the following offers the fullest expression of his views: "Note critiche e bibliografiche riguardanti la storia degli occhiali," *Annali di oftalmologia e clinica oculistica*, 43 (1914), 328-50.

a non-member of their guild, a certain Francesco, to make and sell in Venice "oglarios de vitro," (occhiali di vetro), clearly borrowing for the first time the word already coined by Giordano da Rivalto. This concession confirms the fact that spectacles could be made with less expensive glass and by others than glass workers as Alessandro Spina had already demonstrated. It was only in 1321 that the Venetian Senate definitely borrowed the Tuscan term, "veri da occhiali," which gradually displaced the "roidi da ogli." This in itself is significant because at this time it was the practice to use the nomenclature of the place of origin to designate glass objects and manufacturing techniques. Moreover, Zecchin concedes that specific mention of Venetian spectacle-makers or Venetian spectacles themselves are very few from the fourteenth century through the sixteenth: two in the fourteenth as mentioned above; one in the fifteenth; and five in the sixteenth. Another early piece of evidence from the Veneto is pictorial — the first known portrait of a person wearing eyeglasses (anachronistically) — that of the Dominican Cardinal Hugh of St. Cher (ca. 1200-63) in the Dominican monastery of San Nicolò in Treviso, painted by Tommaso da Modena in 1352.

In reviewing this evidence, Zecchin makes the final point that mentions of spectacles and spectacle-makers in the same period elsewhere in Italy are also scanty. [6] This view has also been confirmed by the leading historian of optics, and eyeglasses in particular, the late Vasco Ronchi of Florence. Ronchi attributes the paucity of sources until the late sixteenth century to the Platonic prejudice of medieval and Renaissance writers on optics, which led to a distrust of the sense

[6] ZECCHIN, "I 'rodoli de vero,'" 252-55. See also his following articles for summary descriptions of the products made by the Venetian glass industry from the end of the thirteenth century to the end of the fifteenth in which eyeglasses are mentioned only once: "Prodotti vetrari nei documenti veneziani (1268-1331)," *Rivista della stazione sperimentale del vetro (Murano)*, VIII (1978 /4), 159-64; "Prodotti vetrari nei documenti veneziani (1333-1400)," ibid., IX (1979/1), 17-22 (mention of eyeglasses, 22, n.1); "Prodotti vetrari nei documenti veneziani (1405-1456)," ibid., IX (1979/6), 221-26; "Prodotti vetrari nei documenti veneziani (1457-1468)," ibid., X (1980/1), 17-22; "Prodotti vetrari nei documenti veneziani (1469-1482)," ibid., X (1980/2), 59-65.

of vision and of lenses as deceitful devices and distorters of reality, unworthy of serious study.[7]

It should be emphasized, however, that although references to lenses and spectacles are rare in scientific texts before the middle of the sixteenth century, they can be found earlier and fairly frequently in state and private correspondence, wills, household inventories and, occasionally, in literary works — the very sources normally not read by historians of science and of glass technology. The latter, in fact, tend to ignore spectacles altogether or mention them peripherally as they pursue their main interests — chemical composition of glass, innovative techniques, glass products in general and their artistic merit. The *campanilismo* of Venetian and Florentine historians, I fear, has also hindered progress by concentrating attention more on the origin of eyeglasses than on their development in later centuries. I should state at the outset that being American by birth, Sicilian by upbringing, and Milanese by self-adoption, I hope to offer a more impartial perspective.

In fact, it is Milan, and specifically the huge diplomatic correspondence of the Sforza dukes, which is frequently ignored by historians of Renaissance society, that offers us the necessary documents for a conclusive answer to most of the above questions. Five of these documents are crucial because they reveal for the first time the following revolutionary data regarding the history of optics, glass technology, and costume in the middle of the fifteenth century: 1. that Florence was producing in significant quantities not only convex lenses, but also concave lenses for myopes (i.e., about a century before the latter were thought to have been developed); 2. that Florence had become the leading centre for the production of

[7] Ronchi, "A Fascinating Outline of the History of Science. Two Thousand Years of Conflict between 'Reason' and 'Sense'," *Atti della Fondazione Giorgio Ronchi*, 30 (1975), 527-32, 552-54. The existence of this philosophical prejudice, already noted by Ronchi in earlier publications, was denied by D. C. LINDBERG and N. H. STENECK, "The Sense of Vision and the Origins of Modern Science," in *Science. Medicine and Society in the Renaissance. Essays to Honor Walter Pagel*, I, ed. A. G. Debus, New York 1972, 29-45. They, however, do not explain the paucity of sources. For a later restatement and amplification of Ronchi's views, see "Altro é l'invenzione delle lenti, altro é l'invenzione degli occhiali," *Atti della Fondazione Giorgio Ronchi*, XXXV (1980/3), 314-22.

first-quality spectacles; 3. that the Florentines were well aware of the fact that visual acuity gradually declines after the age of thirty and were constructing lenses progressively graded in five-year strengths for presbyopes and in two strengths for myopes (practically prescription lenses, which came into common use only at the end of the nineteenth century); 4. that the dukes of Milan were ordering prestigious Florentine eyeglasses by the hundreds to give them away as gifts to their courtiers. Although I have already published these documents elsewhere as noted above, I must summarize their contents briefly because they are the only sources discovered to date to offer so much new information for the assessment of the Florentine spectacle industry, the focus of this essay.

The first document is a letter of 21 October 1462, sent by Duke Francesco Sforza of Milan to his resident ambassador in Florence, Nicodemo Tranchedini da Pontremoli. Having learned that Florence made the best eyeglasses, the Duke ordered three dozens of them: one dozen for "la vista longa, zoé da zovene"; another dozen for "la vista curta, zoé de vechy; et la terza da vista comune." He made it clear that he did not need the glasses for himself, but he wanted to satisfy a craving for them on the part of "many" of his courtiers. [8]

Tranchedini replied promptly on 4 November, addressing his dispatch to the ducal secretary, Giovanni Simonetta. He announced that he was enclosing the three dozen pairs of spectacles, "quali costano tre ducati perché gli ho voluti in totale perfectione." He wanted the cost to be kept secret from the Duke, "perché el facto mio non sta cum Soa Excellentia in questi minuzoli." But he urged the secretary to remind their lord that he was heavily in debt because his salary had not been paid for two years, and that he had already spent in the course of the year some of his funds to supply the Milanese court with various Florentine products, including another eighteen pairs of spectacles. This earlier request for Florentine eyeglasses, so casually revealed here, shows that the Duke had received at least fifty-four pairs from Florence in less than a year. Finally on the verso

[8] Paris, Bibliothèque Nationale, *Fonds Italien*, Cod. 1595, fol. 291.

of his dispatch, Nicodemo added the following significant note: "Questi ochiali sono de quatro maniere. Veda el Signore de quali vole et avisatemene, che gli manderò quanti piacerà ad Soa Celsitudine." [9]

These two brief letters are full of new data about the history of eyeglasses and the hitherto unsuspected role of Florence in their development. Remarkable is the speed with which the order of three dozens pairs of eyeglasses was filled — eleven days or less if we conservatively allow only two days for the courier to carry the request to Florence. Even if the order was filled by more than one shop, this speed may be evidence of a fairly efficient production on the part of Florentine spectacle-makers, who perhaps maintained a stock of lenses ready to be ground to specifications. Equally surprising is the fact that best quality spectacles cost only one ducat per dozen. Although it is difficult to correlate accurately prices and salaries in this period, it is somewhat useful to state that Nicodemo at this time received a gross monthly salary of 30 florins (12 ducats; L.43 net), plus gifts and various concessions normally granted to faithful ducal functionaries. [10] And the ambassador himself, though heavily in debt, called the total sum "minuzoli." It may be safe to assume, then, that excellent eyeglasses were commonly available at reasonably low prices at least in Florence where even a skilled artisan earning an average daily wage of 21 soldi could afford a pair. [11]

[9] Tranchedini to G. Simonetta, Florence, 4 Nov. 1462, Milan, Archivio di Stato, Archivio Ducale Sforzesco, *Potenze Estere-Firenze*, cart. 270. Hereafter all documents cited without archival identification can be found in this Archive.

[10] For Nicodemo's monthly salary in 1463, see M. FORMENTINI, *Memoria sul rendiconto di Milano per l'anno 1463*, Milan 1870, p. 66. Normally Milanese ambassadors received their home salary based on their court rank, if any, and a daily allowance for each person/horse composing the embassy if the mission lasted less than six months. Nicodemo's allowance was first reduced and later entirely eliminated because he resided permanently in his own house in Florence. Four years earlier he had bitterly complained about this elimination, taking some comfort in the hope that perhaps the Duke would accept his request for aid in paying the dowry for his daughter [Nicodemo to Cicco Simonetta, Ducal First Secretary, Florence, 19 Feb. 1459, Paris, Bibl. Nat., *Fonds Italien*, Cod. 1588, fol. 223].

[11] For the average daily wages in soldi di piccioli of Florentine skilled workers in the Florentine construction industry in 1463 and other years from the fourteenth through the sixteenth century, see R. A. GOLDTHWAITE, *The Building of Renaissance Florence: An*

This ready availability of fine eyeglasses at low cost, combined with the Duke's unequivocal statement that Florence had the reputation of making the best spectacles in Italy, constitute the first evidence discovered so far of such Florentine leadership, which hitherto has been assigned to Venice. Could the Duke have been ill informed? This time we are on firm ground in stating categorically that if there was a ruler in the fifteenth-century who was informed on a host of matters anywhere in Europe, it was Francesco Sforza. He maintained a resident ambassador in all principal Italian states and at the court of the King of France in addition to a network of special envoys in and outside Italy, all of whom kept him informed minutely on events and activities everywhere. These ambassadors also acted as purchasing agents for special products for the Duke and his family, and a perusal of the Milanese diplomatic correspondence with Venice and other powers for this period has not uncovered similar requests. [12] Moreover, the Duke commanded some of the leading trade routes criss-crossing his strategically placed domain, which were constantly travelled by merchants who could have supplied his court with every imaginable product available elsewhere. Finally the Florentine leadership is corroborated by other documents, some newly discovered, to be cited below.

The first letter also makes a fundamental contribution to the history of optics because it is the earliest definitive proof of the existence of spectacles with concave lenses to correct myopia, at least

Economic and Social History, Baltimore and London 1980, pp. 437-38. A Milanese skilled worker who earned an average daily wage of 10 soldi imperiali could certainly afford a pair of locally made glasses and perhaps even a superior Florentine one. For a succinct correlation of salaries and prices for commonly used commodities in Milan at this time, see G. Lopez, *La roba e la libertà: Leonardo nella Milano di Ludovico il Moro*, Milan 1982, pp. 100-04.

[12] For Milanese leadership in the development of Renaissance diplomatic institutions and the massive correspondence surviving for the second half of the fifteenth century, see V. Ilardi, "Fifteenth-Century Diplomatic Documents in Western European Archives and Libraries (1450-1994)", *Studies in the Renaissance*, IX (1962), 67-73 (Ital. trans. in *Rassegna degli Archivi di Stato*, 28 (1968), 349-403), and L. Cerioni, *La diplomazia sforzesca nella seconda metà del Quattrocento e i suoi cifrari segreti*, I-II, Rome 1970.

a couple of generations before they have hitherto been thought to be in use.[13] There is no question that the dozen glasses ordered "for distant vision for the young," were fitted with concave lenses. The casual way with which they were ordered suggests that these lenses were available even earlier. They were probably developed by trial and error by another unknown spectacle-maker, in Florence or elsewhere, who reasoned that if convex lenses could correct farsightedness, concave ones could correct nearsightedness. But the third dozen ordered for "vista comune" remains a puzzle unless this expression already was applied to the more common lower degrees of presbyopia as it was in the seventeenth century.[14]

Had Simonetta's reply acknowledging the arrival of the October order survived, it might have provided the answer to the puzzle. Some of its contents, however, can be surmized from Tranchedini's own reply to him on 20 November, which reveals additional data about the real optical needs of the Sforza. The ambassador wrote in part: "Ad me é stato gratissimo el piacere scrivete hano havuto quelli nostri Illustrissimi Signori et Madona [per gli] ochiali gli manday, ma molto maiore consolatione ho havuta che non vedano [cum] quelli da vechii et cum quelli da zoveni sì, perhoché questo é il bixogno nostro."[15]

[13] RONCHI, 1975, 530, and *Scritti di ottica*, Milan 1968, has maintained that there was no definitive proof of the existence of concave lenses before the middle of the sixteenth century, denying that Leonardo da Vinci had knowledge of them. See ILARDI (1978), 24 for my documented view that Leonardo did. On the other hand, a recent claim that Leonardo was the inventor of contact lenses has been demolished by R. HEITZ, "Leonardo da Vinci Did Not Invent Contact Lenses," *CLAO Journal*, 9, N. 4 (1983), 313-16. This invention has been attributed to Adolf Eugen Fick, who made his first fittings around 1887 (N. EFRON and R. M. PEARSON, "Centenary Celebration of Fick's *Eine Contactbrille*," *Archives of Ophthalmology*, 106 (Oct . 1988), 1370-77).

[14] This expression is clearly used in this sense by C. A. MANZINI, *L'occhiale all'occhio*, Bologna 1660, p. 98: "La Centina per gli Occhiali da Vista di huomo di 40 in 50 anni si descrive con una Portione di Circulo Convessa, il cui Semidiametro sia di Oncie dieci, e Minuti Cinquanta, e chiamasi Vista Comune."

[15] Once again Tranchedini refused reimbursement or gifts for the eyeglasses he had sent, but wanted his arrears in salary paid: "Ma non me piace Soa Celsitudine me mandi li denari che costorono et cossì il vino et l'altri, como scrivete. Desiderarey, et cossì ve ne prego gli faciate intendere, che como suo fameglio non posso stare qui col poco et quel poco anche non havere. Et pregassivo Soa Celsitudine [se] degnissi havermi compassione, ex consequenti aiutarmi, o saltem me consiglii che modo ho ad tenere a vivere, che

This is the first evidence discovered to date that the sixty-one year old duke could use spectacles to correct myopia, despite his earlier statement that he had no need of them, and so did his thirty-seven year old wife, Bianca Maria. Especially significant for our purposes is the revelation that the fifty-one year old ambassador was also myopic. He was a noted humanist and presumably avid reader, and we know that he always took care to have a good supply of spectacles at hand, undoubtedly taking advantage of his long residence in Florence. The inventories of his possessions in various houses he owned show these entries: Pontremoli (1468) — "paria duo oculariorum in perfectione"; Florence (1470) — "una scatola piena de ochiali fini"; Rome (1472) — "una scatoleta de coio cum parechie paia de ochiali"; Pontremoli (1472) — "doe fodere o veste da ochiali, una verde l'altra gialla." [16]

The full significance of Tranchedini's extensive personal experience with the use of eyeglasses will become apparent in the analysis of the next two documents. Here it should be noted that it may explain the reason that the ambassador did not send spectacles only for "distant," "near," and "common (normal?)" vision, as he had been instructed, but also he added a fourth category ("maniera"). One is tempted to surmise that the fourth category was comprised of spectacles with weaker concave lenses designed for reading on the part of myopic elderly persons. The Duke was probably mildly myopic and could dispense with the inconvenience, considerable at that time, of holding a pair of glasses by simply placing the reading matter at a proper distance. In this context, his earlier assertion that he had no need of spectacles makes sense. In brief, Tranchedini, who had already served his lord for at least twenty years, knew his real optical needs, but like a good courtier chose to emphasize his allegedly youthful visual acuity. Since the invention of

non m'aiuti Nostro Signore Dio, se per mille ducati ussissi de li debiti me retrovo adosso, il che me fa stare in extrema desperatione..." (Tranchedini to G. Simonetta, Florence, 20 Nov. 1462, PE-Firenze, cart. 270). The top portion of this dispatch is torn off and the supposed missing words have been placed within brackets.

[16] See P. Ferrari, "Inventari di oggetti appartenenti a Nicodemo Tranchedini," *Giornale storico della Lunigiana*, VI (1915), 105-06, 109, 112.

bifocals by Benjamin Franklin around the middle of the eighteenth century, such persons are fitted with stronger concave lenses in the upper part for distant vision and weaker concave lenses below it for closer vision.[17] There may be other explanations of the fourth category, of course.

About fifteen months later, Francesco Sforza made a third request for Florentine spectacles while Tranchedini was temporarily in Milan during the month of January 1464. Having returned to Florence on 4 February, the ambassador wrote two weeks later excusing himself for the delay in sending the eyeglasses: "Non prhenda admiratione V. Celsitudine se non ho mandati li ochiali me comandò, perhò che *volendoli per donare,* ne ho facti fare da *omne vista*, et serano forniti fra sey dì in modo che credo havervi ben satisfacto. Et al mancho saperà V. Sublimità de quelli domandare quando ne vorà per l'avenire."[18]

This time the fact that the order was given orally does not allow us to know the exact number requested. Nevertheless, the size of previous orders and the intention of giving the spectacles away as gifts to persons of *omne vista* (such intention being here explicitly stated for the first time), all suggest that perhaps a couple of dozens at least may have been ordered so as to satisfy the various optical needs of a large court. In brief, in just two years (winter 1462 winter 1464), the duke had requested a total of about one hundred pairs of Florentine eyeglasses, not counting other possible requests during the same period or at other times for which documentation is lacking.

The expression *omne vista* assumes added significance in

[17] Franklin's priority in this invention, sometimes assigned to others, has been reaffirmed in an article just published. The author, a practising ophthalmologist and a collector and historian of spectacles, also believes that Franklin was never near-sighted, but probably was a hyperope and later in life a presbyope, which led to his invention of bifocals. (C. E. Letocha, "The Invention and Early Manifacture of Bifocals," *Survey of Ophthalmology*, 35 (1990/3), 226-35. I wish to express my gratitude to Dr Letocha for reading a draft of this article and for his helpful suggestions.

[18] Tranchedini to Sforza, 21 Feb. 1464, Paris, Bibl. Nationale, *Fonds Italien*, Cod. 1590, fol. 51. The passage quoted above (emphasis added) is a postscript to this dispatch and was found by me only nine years ago. For Tranchedini's presence in Milan in January, see Tranchedini to Sforza, 27 Dec. 1463, and Sforza to Cosimo de' Medici, 17 Jan. 1464, both in *PE-Firenze*, cart. 271.

connection with a fourth request made only three months after the death of Francesco Sforza by his son and successor, Galeazzo Maria. In June 1466 the new duke wrote to Tranchedini requesting two hundred pairs of Florentine eyeglasses in such specific terms as to eliminate any doubt about the precise meaning of the earlier expression, *omne vista*. The specificity of this massive order can only be appreciated by republishing the full text of the list, which accompanied the ducal letter: "Para XV de ochiali de anni 30, 35, 40, 45, 50, [55 crossed out], fini. / Item, para XV de ochiali de anni 40, 45, 50, 55, 60, 65, 70. / Item, para X de ochiali di zovene de meza vista. / Item, para X de longa de zovene." [19]

This remarkably specific letter is the earliest and clearest evidence discovered to this day that in the middle of the fifteenth century spectacle-makers and their customers, not scientists necessarily, were aware of the principle of diminishing visual acuity in five-year intervals from the age of thirty onwards, and had at least an elementary knowledge of progressive myopic stages, expressed simply as "medium" and "distant" vision for the young. Up to the discovery of this letter it was thought that the first mention of ordering reading glasses by age category appeared about the middle of the sixteenth century, a practice that was finally systematized in a book published in 1623 by the Spanish notary, Benito Daça de Valdés. [20] This practice, which has survived to the present, is actually but a small step removed from prescription spectacles, a development that dates only from the end of last century. [21]

On the Milanese side this large order need not surprise us given Galeazzo's well-known ambition to outdo his father in everything.

[19] Galeazzo Maria to Tranchedini, Milan, *Registri delle Missive*, Reg. 77, fol. 89v. The original letter has not been found. In this copy, the list appears at the bottom of the letter, next to the signature of Giovanni Simonetta.

[20] *Uso de los antojos*, Seville 1623. The contributions to optical knowledge made by this book have been expertly analyzed by G. ALBERTOTTI, "Lenti ed occhiali," *Atti e memorie della R. Accademia di Scienze, Lettere ed Arti in Padova*, n. s., 39 (1923), 225-38. For earlier mentions without specific dates or documentation, see RONCHI, 1975, 529.

[21] See B. L. GORDON, "A Short History of Spectacles," *Journal of the Medical Society of New Jersey*, 48 (1951/1), 7.

The young duke apparently could not resist the temptation of presenting his courtiers with fine Florentine spectacles at the beginning of his reign. And his regard for this optical aid lasted well into his reign as is shown by the fact that in a series of frescoes (c. 1471), ordered by him to decorate reception rooms in the Castello di Porta Giovia in Milan with hunting and dynastic scenes, his Seneschal General (Giacomo del Piccio or Pizo, normally called "Pizeto") was to be depicted wearing eyeglasses. [22] There is little doubt that by this time the possession of Florentine glasses seems to have become not just a matter of utility, but also one of prestige, a sort of a status symbol. [23] It is hardly likely that in just four years the Sforza courtiers were suddenly afflicted all at the same time with visual problems requiring the importation of some three hundred pairs of spectacles. It is also to be excluded that they were simply intrigued by a "new device" since eyeglasses had been in use already for about two centuries. But could Florentine spectacle-makers handle a single order of two hundred pairs with such precise grinding of lenses for the various age categories? And how long did it take them to fill it, bearing in mind that the grinding and polishing of lenses involved a long and laborious process (more so for concave lenses) until the development of manually operated machines around the middle of the seventeenth century? [24]

These questions must remain unanswered for now because subsequent correspondence regarding this order has not been found. But the fact that the request was made in such a casual but precise

[22] "Item Piceto a cavalo che guardi con li ochiali dove se deve appareggiare per lo Signore..." as published by E. SAMUELS WELCH, "The Image of a Fifteenth-Century Court: Secular Frescoes for the Castello di Porta Giovia, Milan," *Journal of the Warburg and Courtauld Institutes, 53 (1990), 182*, The frescoes, if executed, have not survived, but the instructions have.

[23] I have treated this aspect in my article, "Doni di occhiali alla Corte sforzesca," *Ca' de Sass*, N. 113 (1991), 52-56.

[24] On lens-grinding techniques of the age, see L. M. ANGUS-BUTTERWORTH, "Glass," in the *Oxford History of Technology*, ed. C. Singer et al., III, New York and London 1957, pp. 233-36. On a lathe invented in Rome for grinding and polishing lenses in the seventeenth century, see S. A. BEDINI, "Giuseppe Campani, Pioneer Optical Inventor," *Ithaca*, VIII-IX (1962), 400-04.

manner suggests that the Sforza court was well aware that the Florentines had the skill and capability to satisfy it. It would make no sense to make a request in these precise terms without prior knowledge and expectation of full compliance. We may conjecture, then, that the phrase, *omne vista*, used in connection with the third order two years earlier, was simply a less precise way of expressing the age categories specified in the fourth order. It may also signal a technological breakthrough in Florence between the date of the first order (October 1462) and that of the third, fifteen months later. The first order, in fact, was too general in its requirements, but probably the best of what was available even in Florence at that date, except that Tranchedini did include some glasses of a "fourth category." The ambassador, who had become something of an expert on the subject and who was in almost daily contact with Cosimo de' Medici, effective ruler of the Republic, was in a position to know if some spectacle-maker had developed a more precise lens-grinding technique. It is tempting to conclude that such a breakthrough did take place in those two years and that Tranchedini so informed the duke during his brief sojourn in Milan in January 1464. Pending the discovery of confirming documents, however, this must remain a tentative hypothesis.

In addition, a recently noted private order from Milan provides further evidence of Florentine leadership. In 1456 the leading humanist, Francesco Filelfo (1398-1481), who had been residing in Milan since 1439 and was patronized by the Visconti and the Sforza dukes, requested spectacles (no number specified) from his friends in Florence, Bartolomeo Scala and Andrea Alamanni.[25] In his letter to

[25] On 31 May 1456, Filelfo wrote to Donato Acciaioli to remind Scala to send the spectacles previously requested (FILELFO, *Epistolarum familiarum*, Venice 1502, fol. 94v). On 22 June 1456, he repeated his request to Alamanni as follows: "Pourquoi donc ne prierais-je pas aussi mon savant ami André de m'envoyer les objects propres à seconder la nature que nous ne trouvons pas à Milan, tandis qu'ils foisonnent à Florence? Je t'ai demandé antérieurement un carnier, aujourd'hui ce sont des yeux de verre (des lunettes) que je désire. Car un homme qui passe pour savant auprès de certain gens, doit paraître aussi très clairvoyant. Celui-là donc qui est déjà courbé sous le faix des ans, a besoin d'avoir des yeux auxiliares." (FILELFO, *Cent-dix lettres greques de François Filelfe*

Alamanni he commented that he could not find spectacles in Milan "whereas they abounded in Florence." This is an especially significant comment from an intellectual who had studied at Padua, was Professor of rhetoric at Padua and Vicenza (1416-17), served as secretary of a Venetian embassy to Constantinople (1420), lived in the Veneto region for some seven years, and maintained a constant flow of correspondence with Venetian patricians and intellectuals for the rest of his life.[26] Surely he had seen glasses in abundance in that region and he could have ordered them just as easily from Venice. And just as surely he could have purchased them in Milan because, as it will be shown below, spectacles were made in several places in Italy at this time. There can be only one explanation: he wanted good ones and the best were made in Florence, as Francesco Sforza wrote in 1462. This fact must have been so well known that he dispensed with any explanations in making his request. His friends also must have known his requirements: at the age of fifty-four he needed convex lenses to correct his presbyopia.

Although the above ducal correspondence offers the most detailed and precise optical information discovered since the late sixteenth century, and provides unequivocal evidence for the leadership of Florence in making the finest eyeglasses in Italy, this leadership is also corroborated by documents from other archives. From Ferrara in 1451 the noted, elderly woodcarver, Arduino da Baiso, requested eight or ten pairs of Florentine spectacles for near and more distant vision from Piero di Cosimo de' Medici.[27] An

... trans. and ed. E. Legrand, Paris 1892, p. 88. The mention of eyeglasses in these two letters was noted by A. BROWN, *Bartolomeo Scala. 1430-1497: Chancellor of Florence, The Humanist as Bureaucrat*, Princeton 1979, p. 19.

[26] For Filelfo's residence in Milan of about forty years and a chronology of his life, see now D. ROBIN, *Filelfo in Milan: Writings 1451-1477*, Princeton 1991), pp. 247-50. In this context, it is noteworthy that Filelfo was an intimate friend of Tranchedini, to whom he wrote over one hundred letters (ibid, 140). A check of these letters might reveal additional requests of spectacles.

[27] The optical significance of this letter of 25 Aug. 1451 was first noted by E. DE LOTTO, *Dallo smeraldo di Nerone agli occhiali del Cadore*, Belluno 1956, p. 28. De Lotto, who misdated the letter "29" Aug., cited it as the first mention of concave lenses even though the elderly Arduino (born in the second half of the fourteenth century, died in 1454),

exchange of letters from 1463 to 1465 between the exiled Florentine merchant, Filippo Strozzi, writing from Naples to request spectacles from his mother in Florence, demonstrates that a wealthy merchant with European-wide commercial contacts likewise preferred the Florentine product.[28] In 1476 the same Filippo, now permanently settled in Florence after the lifting of the ban of exile in 1466, was thanked for a dozen pairs of spectacles he had sent at the request of one of Venice's leading patricians and diplomats, Zaccaria Barbaro. Why would a Barbaro request Florentine glasses if he could have obtained excellent ones in Venice?[29]

Three years earlier there was also an order from Rome. The fifty-one year old Cardinal of Pavia, Iacopo Ammannati Piccolomini, wrote to Lorenzo de' Medici expressing satisfaction in having received glasses for his presbyopia by means of Donato Acciaioli, his former student and a noted humanist, member of Lorenzo's ruling circle.[30] Finally it is also known that by the beginning of the sixteenth century Florentine merchants were exporting eyeglasses to Constantinople by the hundreds to satisfy an ever increasing demand

was probably a presbyope. His argument that Piero de' Medici, being myopic, would assume that Arduino also suffered from the same defect, does not seem to have validity especially in a city with such an advanced optical knowledge. I accepted his view in my publications cited in n. 1, but now I think that the references in the letter to near and more distant vision refer to different degrees of presbyopia. For the relevant passage of this letter and a discussion of its earlier publication for its artistic value, see ILARDI, 1978, 22-23.

[28] See ILARDI, 1978, 26.

[29] This letter of 26 June 1476 was cited twice by D. M. MANNI, *Dell'invenzione degli occhiali da naso. Ragionamenti accademici*, Firenze 1729, p. 127, and *Degli occhiali da naso inventati da Salvino Armati. Trattato istorico*, Firenze 1738, p. 79. The letter was cited from a private Florentine collection, but I have not been able to find it in Florentine archives and libraries. Given Manni's efforts to assign the invention of glasses to Florence, one must treat this evidence as unconfirmed. It is likely, however, that Barbaro and Strozzi knew each other well because of commercial links, facilitated by the fact that the former had been the Venetian ambassador to King Ferrante of Naples (1471-73) and to the Pope (1480-81) where the latter had branches of his bank. (R. A. GOLDTHWAITE, *Private Wealth in Renaissance Florence: A Study of Four Families*, Princeton 1968, p. 57, and M L. KING, *Venetian Humanism in an Age of Patrician Dominance*, Princeton 1986, p. 326).

[30] This letter of 25 Apr. 1473 was published by A. FABRONI, *Laurentii Medicis Magnifici vita*, II, Pisa 1784, pp. 58-59. The Cardinal wrote: "Lorenzo mio. Poiché Donato vostro mi ha provveduto bene di occhiali buoni da vedere da lungi & da presso, farò pruova

for them, with each pair worth about one "aspro" on the Florentine market.[31] One need hardly add that this area was a primary commercial market for Venice, one in which Venetian spectacles should have been able to compete successfully in quantity if not in quality.

In addition to the Sforza, there was another princely court in Italy for which we have a documented case of craving for Florentine eyeglasses. The Gonzaga rulers of Mantua were on intimate terms with the Sforza, served them as their leading *condottieri,* exchanged visits frequently, and maintained resident ambassadors in Milan. They had ample opportunity to be aware of and even to witness the passion for Florentine spectacles among the Milanese courtiers. Yet no mention of spectacles has been found in their exchange of personal letters or in their ambassadorial correspondence for this period, although there are numerous references to a great variety of gifts exchanged by the two families.[32] Perhaps eyeglasses were too common by this time to merit special attention. In any case, while it cannot be definitely established whether the Gonzaga were influenced

nello scrivere mio, se così sono." This passage does not make clear whether the glasses came from Florence or elsewhere, but from the context it would seem that a Florentine or at least a Tuscan origin is implied. For the teacher-student relationship between Ammannati and Donato, see now A. FIELD, *The Origins of the Platonic Academy of Florence*, Princeton 1988, pp. 73-76.

31 Giovanni Maringhi in Pera to Ser Nicolò Michelozzi in Florence, 29 Oct. 1501: "Apparently you have not wished to get hold of the spectacles I have requested of you so many times; here there is more need of them than ever, and if they are procurable at about 100 aspri the hundred, take them, if you have way or means of doing so." (*Florentine Merchants in the Age of the Medici. Letters and Documents from the Selfridge Collection of Medici Manuscripts*, ed. G. R. B. Richards, Cambridge (Mass.) 1932, p. 136. For other mentions of spectacles, see also 186 (undated) and 223 (1520). The aspro was a Turkish coin worth about one-fiftieth of a Venetian ducat.

32 For the close relations between the two families and the character of their correspondence in this period, see E. W. SWAIN, "Il potere di un'amicizia. Iniziative e competenze di due nobildonne rinascimentali," *Memoria: rivista di storia delle donne*, 21 (1987/3), 7-23, which treats the cordial relations between the Marchesa Barbara Gonzaga and the Duchess Bianca Maria Sforza; and G. L. FANTONI, "Un carteggio femminile del sec. XV: Bianca Maria Visconti e Barbara di Hohenzollern-Brandenburgo Gonzaga (1450-1468)," *Libri & Documenti*, VII (1981/2), 6-29, which publishes regests of their correspondence. My own review of the correspondence of the Mantuan ambassadors in Milan for 1462 and for June-July 1466 has also given negative results.

by the Sforza in this respect, it is known that three months after Galeazzo Maria ordered his two hundred glasses, the Marchesa wrote to her son, Federico, who was taking the thermal baths at Petriolo, near Siena, as follows: "Quando venirai, vedi de portare de li ochiali assai." Federico assured her quickly: "de ochiali fornirò bene Vostra Signoria." [33]

At first glance this large (*assai*) number of spectacles, ordered without specifications by a ruling family with so many ties to the well-informed Milanese court, is as surprising as is the fact that Florence is not mentioned specifically as the place of supply. But in this case we may assume with confidence that the son was familiar with the visual needs of his parents, who at the age of fifty-four (Ludovico) and forty-three (Barbara) most likely required glasses for presbyopia. As we have noted, such glasses by age category were easily available in Florence, through which Federico was expected to pass on his return home.

We also know that earlier that year Ludovico had been complaining of declining eyesight according to the the Abbot of the Abbazia di Polirone at San Benedetto Po. Wishing to be helpful, the latter wrote to the Marchese that he was sending him two pairs of spectacles, made by one of the monks, "bon magistro de ochiali," offering to send more if he found them satisfactory. [34] Finally, a box

[33] Barbara to Federico, Goito, 18 Sept. 1466; Federico to Barbara, Petriolo, 26 Sept., 1466, Archivio Gonzaga, *Copialettere*, B. 2889, and *Lettere originali dei Gonzaga*, B. 2099, respectively.

[34] Abbot Bessarion to Ludovico, San Benedetto, 14 Mar. 1466, Archivio Gonzaga, *Mantova e Paesi*, B. 2406. The Abbot wrote in part: "Altre volte, siando qua la Ill.ma V. S. con nuy, intesimo per epsa como gli comminziava a manchare la vista et como gli bisognalia principiar a usare li ochialli; per la qual cossa, nuy sempre desiderando fare cossa grata a la prelibata Vostra Ill.ma Signoria et in quello che nuy possiamo sempre, amando de adiutarla de la vita e vista et in ogni cossa, abiando nuy uno di nostri fratelli, il quale hé bon magistro de ochiali, gli abiamo facto fare due pare per la dicta Vostra Ill.ma Signoria, li quale mandiamo per miser Jacomo da Palazio, confortando la Vostra Signoria che gli voglia usare, peroché assay li zoverano a conservare la vista. Et preghiamo che la si degna advisarne se elli son boni per essa, peroché ne faremo fare de li altri." This Benedictine monastery was at this time being restored and enlarged after a period of decadence owing to the generous patronage of the Gonzaga. I am grateful to Dr. Swain for drawing my attention to this letter and to the document cited in the next note.

containing spectacles was listed in an inventory of movable possessions found in Barbara's study in the Palazzo di San Giorgio (no longer extant) soon after her death in 1481.[35] Although the provenance of the marchesa's glasses is not given, it is clear that the Gonzaga had a readily available local supply and could also have procured them easily through Barbara's relatives in Germany, where some of the best glass in Europe was made. It is also noteworthy that the Gonzaga made frequent purchases of gilded glass vases and other luxury items in Venice, but no orders for eyeglasses have been found.[36] In these circumstances, then, the large order of Florentine spectacles offers additional confirmation of their quality, and may even indicate a possible imitation of the Sforza in giving them away as gifts.

Actually it can be argued with confidence that not only the Gonzaga, but also virtually everyone of those mentioned above who ordered Florentine spectacles, had the necessary financial means and contacts to obtain them almost anywhere in Europe. In all probability they could have purchased them locally in monasteries or urban centres from northern Italy down to Naples particularly because by the middle of the fifteenth century glass workers could be found throughout the peninsula.[37] Moreover, from the very beginning Friar Alessandro della Spina had demonstrated that one need not be a glass worker to make spectacles. In view of these facts and the failure of researchers such as Albertotti and Zecchin, who spent their entire career searching for documents to establish a Venetian pre-eminence in the development of eyeglasses, and my own active search in various archives spanning almost two decades, we can only conclude that all

[35] "Item, un'altra scatoleta simile cum ochiali dentro." Archivio storico diocesano di Mantova, *Fondo capitolo della cattedrale*, serie miscellanea, B. 2, fol. 11v.

[36] On the great variety of the luxury items purchased in Venice by the Gonzaga in this period, see especially A. BERTOLOTTI, "Le arti minori alla corte di Mantova nei secoli XV, XVI e XVII," *Arch. stor. lombardo*, XV (1888), 278-84.

[37] For succinct accounts of the spread of glass furnaces in Italy in this period, see ZECCHIN, "Vetrerie italiane nel quattro e cinquecento (a Napoli e altrove)," *Tecnica vetraria*, VII (1962/3), 14, and A. ENGLE, "A Study of the Names of Early Glassmaking Families of Europe as a Source of Glass History: I. Italian Glassmakers," *Readings in Glass History*, ed. A. Engle, N. 1 (1973), 51-58.

roads led to Florence for the supply of the finest spectacles at least during the fifteenth century.

Surprisingly, the Florentines themselves have not been aware of their early leadership in this field, which would provide a plausible prelude to their pre-eminence in the manufacture of optical glass and scientific instruments in the seventeenth century. Ronchi, who devoted much attention to medieval and Renaissance optics, was not aware of it up to the discovery of the Milanese documents, and he never uncovered new documents because he did not work in the archives. In fact, the development of the Florentine glass industry up the the beginning of the seventeenth century was almost totally ignored until the publication of Taddei's 130-page monograph four decades ago, which devoted barely two pages to the origin and early development of eyeglasses. [38] The appearance of this pioneering study, however, failed to arouse much interest in further research and publications, as one would have hoped. This is to be contrasted to the massive publications devoted to the Venetian glass industry to which Zecchin alone devoted more than two hundred brief articles. [39] Moreover, as is the case for publications on the glass industry everywhere, those devoted to Tuscany deal with many of its aspects but almost all of them totally ignore spectacles and optics in general. Only one article in the last twenty years deals specifically with Tuscan spectacle-makers. [40]

Florentine leadership in spectacle-making was not even suspected

[38] G. TADDEI, 1954 , 63-64.

[39] They are conveniently listed in his *Vetro e vetrai di Murano*, I, XVII-XXVI. See also A. GASPARETTO, "Matrici e aspetti della vetraria veneziana e veneta medievale", *Journal of Glass Studies*, 21 (1979), 76-97 for a summary account of recent contributions on the subject.

[40] See the bibliography published by G. CANTINI GUIDOTTI, *Tre inventari di bicchierai toscani fra Cinque e Seicento*, Florence 1983, pp. 13-21, who updates Taddei but explicitly excludes optics, referring the reader to outdated works on the history of spectacles (24, n. 1). The article on spectacle-makers by M. LUZZATI, "Una società per la fabbricazione di occhiali alla metà del Quattrocento, *Antichità pisane*, I (1974), 40-45, was cited by M. SPALLANZANI, "Un progetto per la lavorazione del vetro in Mugello nel secolo XV," *Arch. stor. ital.*, CXL (1982), 569-602. Optical glass in seventeenth-century Tuscany, however, is discussed by D. HEINKAMP, *Studien zur Mediceischen Glaskunst. Archivalien, Entwurfszeichnungen, Gläser und Scherben*, Florence 1986, ch. XI.

by the organizers of the most recent exhibition (1985-86) specifically devoted to spectacles — the Carl-Zeiss-Stiftung of Jena (which supplied many of the pieces from its vast collection) and the Istituto e Museo di Storia della Scienza di Firenze — because they totally ignored the existence of the Milanese documents published ten years earlier. [41] On the other hand, the catalogue of another exhibition held just two years later at the Museo Civico di Storia Naturale "G. Doria" di Genoa, based on the Rathschüler collection of that city, makes full use of these documents and has a much fuller photographic record, all of which resulted in a fresh and more reliable historical account. [42] The same can be said about a third exhibition just held in Milan (May 1991), which exhibited some of the Milanese documents from the Archivio di Stato along with other manuscripts and early printed books on optics in the Trivulziana Library, and some 350 pieces from the newly formed Museo dell'Occhiale at Pieve di Cadore. [43]

In the light of all this interest in things optical — three exhibitions in six years! — the nonchalance of the Florentines towards one of their key contributions to the evolution of optical science and technology is all the more puzzling. It continues to the present day as it was demonstrated by the absence of any discussion of optical glass at an international conference on medieval Tuscan glass furnaces and

[41] See the catalogue, *Occhiali da vedere. Arte, scienza e costume attraverso gli occhiali*, Florence 1985.

[42] The catalogue, *La lente. Storia, scienza, curiosità attraverso la collezione Fritz Rathschüler*, Genoa 1988, contains several scholarly contributions, including the historical introduction by F. ACERENZA, "Gli occhiali nella storia," 83-86, which takes account of the information revealed by the Milanese documents. In the last few months, the Rathschüler collection has been combined with another of the Luxottica Group to form a second museum in the Cadore region. Of course, this region above Venice has long been known as the centre for the manufacturing of spectacle frames.

[43] In the exhibition catalogue, *Sette secoli a cavallo del naso. Mostra iconografica e documentaria dalla Trivulziana e dal Museo dell'Occhiale di Pieve di Cadore*, Milan, 1991, G. BOLOGNA quotes extensive passages from the above Sforza letters in the historical introduction. In the Museum's catalogue, *Il Museo dell'Occhiale Pieve di Cadore*, Milan, 1990, BOLOGNA republishes the two main Sforza letters and quotes from the others extensively (18-19) while M. F. TIEPOLO still defends passionately the Venetian origin of spectacles (12-14), and L. MOIOLI credits unknown inventors working independently in several unspecified places (26-27).

production held in the Spring of 1990 at Colle Val d'Elsa (Siena), which has become the crystal capital of Italy. In the just published proceedings, only one paper mentions spectacles in passing, by pointing out that recently discovered archival documents have revealed the existence in the middle of the fifteenth century of a well-appointed spectacle shop at the monastery of Santa Brigida al Paradiso in Florence. The author hypothesizes that this monastery may have been the supplier of the eyeglasses ordered by the Sforza court between 1462 and 1466. Unfortunately, the Milanese documents discovered so far never mention the supplier, but the great number of spectacles ordered suggests that more than one shop was involved within or outside monastery walls. Additionally, the article cites other evidence attesting to a more extensive and more advanced Tuscan glass industry for everyday objects as well as for church windows and scientific instruments, made by monks, priests, and lay workers, already in the fifteenth century.[44] It is obvious that until much more research is undertaken on the early progress of the Florentine glass industry, some of the following statements seeking to explain Florence's leadership in optics cannot be fully confirmed.

Taddei's archival research, informative but not exhaustive, documented the existence of two spectacle-makers ("ochialari") in the Florentine Catasto of 1457, two others as members of the Medici e Speziali Guild (1499), and two vendors in 1561. These are his findings, listed by way of example, up to the beginning of the seventeenth century.[45] Additional archival research should uncover

[44] See A. Guidotti, "Appunti per una storia della produzione vetraria di Firenze e del suo territorio pre-cinquecentesca," in *Archeologia e storia della produzione del vetro preindustriale*, Atti del Convegno "L'attività vetraria medievale in Val d'Elsa ed il problema della produzione preindustriale del vetro: esperienze a confronto," Colle Val d'Elsa — Gambassi Terme, 2-3-4 aprile 1990, a cura di Marja Mendera, *Quaderni del dipartimento di archeologia e storia delle arti — sezione archeologica dell'Università di Siena*, Siena, 1991, pp. 161-73. Other papers published in the proceedings give the latest findings and bibliography about the Tuscan glass industry in our period. I wish to thank Guido Lopez of Milan and my colleague at the University of Siena, Mauro Cresti, for their assistance in obtaining information about this conference.

[45] Taddei, 1954, p. 64. His discussion of spectacle-makers in Florence is composed of only six lines and relative document citations.

several more for it is doubtful that just two spectacle-makers in the middle of the fifteenth century could have filled so rapidly the big orders from the Sforza court or the other substantial ones from other patrons listed above, not counting many others of which we have no knowledge. After all Florence was the leading centre of Italian humanism and had the most celebrated bookshop of the age, owned by Vespasiano da Bisticci. His bookshop near the Palazzo dei Signori was a popular meeting place for the local *intelligentsia* and other clients from other parts of Italy and Europe, among whom a pair or two of spectacles would have been a common equipment. In fact, Vespasiano mentions them in passing only to record his amazement that one of his clients, the nonagenarian Cardinal Branda da Castiglione (1350-1443), used eyeglasses only to read in the evening by the light of a single candle! [46]

As in Venice, the Florentine "ochialari" came originally from the ranks of the glass workers, known generally as "bicchierai" in Florence, who specialized in grinding spectacle lenses. Since the spectacle-frames were made of leather, bone, or metal, including gold and silver, other "specialists" cooperated in making the finished product. But we should not overstate the matter of specialization at this time for we have seen that the grinding of lenses could have been undertaken by laymen with some manual dexterity, who occasionally may have supplied the frames as well. Some goldsmiths, for instance, who frequently collaborated with glass workers in gilding and enameling various glass objects and made expensive gold or silver spectacle frames, could and did grind lenses for eyeglasses and made the entire product by themselves. This has been recently revealed by a partnership contract among three goldsmiths of Pisa in 1445, which

[46] In his biographical sketch of the cardinal, Vespasiano wrote that "sendo la sua Signoria [Branda] a sedere in su quello lettuccio, in quella camera non era se non uno lume, che l'aveva io, d'una candela di cera; aveva tanto potente la natura, che, sendo di più d'anni novanta, non adoperava occhiali se non la notte, e tenevagli in camera in una buca. Pigliando questo libro, mi disse che gli dessi gli occhiali, che non adoperava se non la notte; che il dì vi vedeva sanz'essi leggendo." (VESPASIANO da BISTICCI, *Vite di uomini illustri del secolo XV*, ed. P. D'Ancona and E. Aeschlimann, Milano 1951, p. 71).

is another illustration of their well-known versatility. [47] It may not be a mere coincidence that in the Catasto of 1427, of 123 goldsmiths listed, 92 are Florentines and 23 Pisans. [48] This high concentration in two cities associated with the early development of eyeglasses may be an additional indication of a close connection between goldsmithing and spectacle-making, a matter of potential interest for art historians. Finally, the close collaboration among various trades is also amply demonstrated by the amorphous membership of the Medici e Speziali Guild, which enrolled a bewildering variety of artisans (including glass workers and goldsmiths) in subordinate roles too long to list here, and who also held concurrent membership in other guilds of collateral usefulness to their principal activity. [49]

That the trade of making spectacles was not a difficult one to learn is also illustrated by a Florentine carnival song of the first half of the sixteenth century in which spectacle-makers boasted that they could make "perfect" spectacles for all ages, and announced their willingness to teach their trade to youngsters (even "putti") of both sexes and to widows and married women. [50] In another song the

[47] LUZZATI, 1974. For various examples of the colloboration between goldsmiths and glassworkers, and the remarkable versatility of the former, see BERTOLOTTI, 1888, especially 1004-29, CANTINI GUIDOTTI, 1983, pp. 28-29, 35, and F. MALAGUZZI VALERI, *La corte di Lodovico Il «Moro, III, Gli artisti lombardi,* Milan 1917, pp. 327,363-366, and IV, *Le arti industriali, la letteratura, la musica,* Milan 1923, pp. 77-103. For frames made out of pecious metals, already noted by several scholars, I simply cite the latest confirmation: G. BIAVATI, "Gli occhiali: una storia attraverso l'ottica delle ambivalenze iconografiche," in *La lente,* 1988, pp. 11-31.

[48] D. HERLIHY and C. KLAPISCH-ZUBER, *Tuscans and Their Families: A Study of the Florentine Catasto of 1427,* New Haven and London 1985, p. 129.

[49] R. CIASCA, *L'arte dei medici e speziali nella storia e nel commercio fiorentino dal secolo XII al XV,* Florence 1927, especially pp. 31-101. The multiple guild membership of various artisans, including artists, has been emphasized by M. WACKERNAGEL, *The World of the Florentine Renaissance Artist: Projects and Patrons, Workshop and Art Market,* trans. A. Luchs, Princeton 1981, pp. 301-02, 304-05, 315, 332.

[50] "Tutti sian mastri d'occhiali / de' perfetti e naturali./ Vari occhiali con noi abbiano / d'ogni vista e d'ogni etate; / volentier l'arte 'nsegnano / a pulzelle e maritate / e a vedove velate / ch'imparar vuol far gli occhiali. / Se ci fussi qualche putto / che volessi anche 'mparare, / insegnerègli l'arte in tutto: / prima i corni dirizzare, / poi segagli e trapanare, / fin che sappi far gli occhiali. / .... Dell'età trenta e quaranta / questi son de' cristallini; / e quest'altri da cinquanta / a sessanta, netti e fini; / a settanta son vicini, / donne, questi grand'occhiali. / ..." Anonymous and untitled song published in

mirror-makers, who admitted learning their trade in Germany, also proclaimed that their trade was easy to learn and were willing to teach it to women.[51] A third song revealed that "forestieri" had come to Florence to make drinking glasses and cups and some of them had also gone to Milan to practise this trade, but "forestieri" may simply denote non-Florentines coming from other parts of Italy.[52] Even allowing for some exaggeration in these claims, one wonders whether it is possible from archival sources alone to establish a fairly exact number of all artisans, not specifically classified as "ochialari," who made eyeglasses in Florence at this time.

Florence's leadership in spectacle-making, however, should not be surprising, especially to art historians. It is well known that in the first quarter of the fifteenth century Florentine artists "discovered" or "rediscovered" the principles governing linear central point perspective, which involved optics and geometry. For our purposes it is of secondary importance whether the ancients knew and applied these principles at least empirically. We know, on the other hand, that in our period ancient and medieval optical theories were known, but their shortcomings prevented their use for the solution of the problem at hand; namely, the creation of exact spatial and depth dimensions on a finite flat or curved surface through the use of geometry and a vanishing point.

The problem was first solved by Filippo Brunelleschi possibly with the assistance of his friend, Paolo dal Pozzo Toscanelli, physician, mathematician, and geographer. The same problem applied to the

its entirety by C. S. SINGLETON, *Canti carnascialeschi del Rinascimento*, Bari 1936, pp. 114-15.

[51] Giovambattista Gelli, "Canzona de' maestri di far specchi:" ..."La Magna abbiano assai tempo abitato, / ai panni, al volto, all'arte il conoscete; / ivi imparammo e qua n'abbian recato / l'arte del far gli specchi che vedete;... Se non vi basta che vi sien donati, / e pur vogliate ancora imparar l'arte, / sian, donne, volentieri apparecchati / di questo mestier nostro a farvi parte; / ... E perché il modo è facile e se ognuno / l'imparassi, apprezzato non saria, / mostrarvel qui in presenza di ciascuno, / donne, sarebbe troppo gran pazzia: / ciascuna ne chiami uno, / ché pronti siano a metter tuttavia, / pur coll'aiuto vostro, / nell'insegnarvi tutto il poter nostro. /" *Ibid.*, pp. 351-53. For another song of the "specchiai," which mentions again the German origin of this trade, see ibid., 407-09.

[52] Baccio Talani, "Canzona de' maestri di far bicchieri," *ibid.*, pp. 360-61 .

perspective projection of map-making, a lively interest in Florence since the arrival of Ptolemy's *Geographia* in 1400, which was translated into Latin by 1405. Since Brunelleschi's experiments with establishing the vanishing point involved the use of mirrors, as later did Leon Battista Alberti's *camera obscura,* it is reasonable to suppose that artists were in contact with glass workers and possibly with spectacle-makers. At any rate it is clear that visual perception, both real and illusory, was in the air in Florence during that remarkably creative generation that included also Masaccio, Donatello, Lorenzo Ghiberti, and Luca della Robbia. [53] Donatello himself has been credited with being the first Renaissance artist to apply consciously and most often the necessary optical corrections from the viewer's normal visual angle, a technique apparently developed by the ancient Greeks and seemingly first revived by Giovanni Pisano for the upper facade of the cathedral of Siena (1284-96). (Siena and Pisa — Tuscany again!). [54] It is entirely possible that such discussions among artisans/artists, and other intellectuals could have influenced mirror and spectacle-makers into making efforts to improve their product and even develop concave lenses.

[53] For the gamut of questions relating to the development of linear perspective in Florence and the artists' interest in the use of mirrors, see especially S. Y. EDGERTON, Jr., *The Renaissance Rediscovery of Linear Perspective*, New York 1975, pp. 134-42; J. V. FIELD, R. LUNARDI, and T. B. SETTLE, "The Perspective Scheme of Massaccio's Trinity Fresco," *Nuncius. Annali di storia della scienza*, IV, fasc. 2 (1989), (estratto); M. H. PIRENNE, *Optics, Painting & Photography*, Cambridge, 1970; M. KUBOVY, *The Psychology of Perspective and Renaissance Art*, Cambridge, 1986; K. H. VELTMAN (in collaboration with K. D. Keele), *Studies on Leonardo da Vinci I. Linear Perspective and the Visual Dimensions of Science and Art*, München 1986; and M. KEMP, *The Science of Art: Optical Themes in Western Art from Brunelleschi to Seurat*, New Haven 1990, pp. 9-52 , 167-220. For various optical theories in the ancient-medieval world, see also D. C. LINDBERG, *Theories of Vision from Al-Kindi to Kepler*, Chicago and London 1976, *Studies in the History of Medieval Optics*, London 1983, and "Roger Bacon and the Origins of Perspective in the West," in *Mathematics and its Applications to Science and Natural Philosophy in the Middle Ages: Essays in Honor of Marshall Clagett*, ed. E. Grant and J. E. Murdoch, Cambridge 1987, pp. 249-59; B. S. EASTWOOD, *Astronomy and Optics from Pliny to Descartes: Texts, Diagrams, and Conceptual Structures*, London 1989, especially studies nos . VIII-XI; A. C. CROMBIE, *Science, Optics, and Magic in Medieval and Early Modern Thought*, London 1990; A. M. SMITH, "Getting the Big Picture in Perspectivist Optics," *Isis*, 72 (1981), 568-89; and R. TOBIN, "Ancient Perspective and Euclid's Optics," *Journal of the Warburg and Courtauld Institutes*, 53 (1990), 14-34.

[54] R. MUNMAN, *Optical Corrections in the Sculpture of Donatello, Transactions of the*

It has not been established whether the Medici themselves encouraged or sponsored what may be termed this "optical research" for personal reasons as well as for their interest in art patronage in general. Cosimo de' Medici did sponsor, however, the translation from the Greek to the Latin of Diogenes Laertius' *Lives of the Philosophers,* which contained many allusions to classical Greek optical theory and was well known to Alberti. [55] Many in the Medici family had protruding eyes, a condition sometimes associated with myopia, but pictorial and archival evidence proves that only five of them were myopes: Lorenzo il Magnifico and his son Giovanni (later Pope Leo X), Ferdinand I (1549-1609), and the two queens of France (Caterina, 1519-89) and Maria (1575-1642). The Tornabuoni family, related to the Medici by marriage, also presented protruding eyes, including Lucrezia, wife of Piero di Cosimo. [56]

Moreover, although it is amply documented that state's measures to promote and protect the fledgling glass industry in Florentine territory, centred in villages such as Gambassi and Montaione, were already in force by the first years of the fifteenth century, they became more frequent during the Medici period. A rigid mercantilistic policy was then adopted so as to ensure a native supply of common utilitarian products such as drinking glasses, bottles, fiaschi, etc., restricting their importation from other places, especially Venice, whose crystal was excepted. No other Florentine industry was similarly protected, according to Taddei. [57]

American Philosophical Society, 75, Pt. 2, Philadelphia 1985, 1-9.

[55] The book was translated about 1435 by the humanist, Ambrogio Traversari (EDGERTON, 1975, 64, and 172 n. 2).

[56] These are the conclusions of G. PIERACCINI, *La stirpe de' Medici di Cafaggiolo. Saggio di ricerche sulla trasmissione ereditaria dei caratteri biologici,* 2 ed., III, Florence 1947, 59-66. In a recently published letter by Lorenzo to Jacopo Guicciardini, Careggi, 8 Aug. 1479, Lorenzo wrote that he used spectacles, but without specifying the nature of his visual problem: "et benché stessi molto prima con li occhi aperti et mi mettessi buoni occhiali,...". It is noteworthy that the back of this letter contains this notation by Francesco Guicciardini: "delli occhiaii." (LORENZO DE' MEDICI, *Lettere*, IV (1479-1480), ed. N. Rubinstein, Florence 1981, p. 165).

[57] TADDEI, 1954, pp. 24-26: "Una simile protezione non si riscontra per nessuna altra attività fiorentina, ciò dimostra l'importanza che si riconosceva a questa industria, che

The exquisite artistic taste of the Medici led them also to foster from the middle of the sixteenth century onwards the production of artistic vessels, "alla Veneziana," the very field in which Venice was supreme. Cosimo I and his immediate successors spared no expense in attracting some of the finest Venetian glassmakers, including Bortolo d'Alvise and the brothers, Jacomo and Alvise Della Luna, to establish glass furnaces in Florence and Pisa.[58] Although the unusually advantageous terms offered to these glassmakers from Murano largely explain their taking the risk of heavy fines, temporary or perpetual exile, and even prison terms if they returned home, it is known that they were not the only defectors. Glass workers in general braved possible risks imposed by local governments for the sake of profit elsewhere. Workers from Altare, for example, established numerous glass furnaces in and outside Italy.[59] It has also been documented that Tuscan glass workers were active in the furnaces of Murano at least from the beginning of the fourteenth century.[60]

Under these circumstances it is obvious that local inventions or processes could not remain secret for long. In any case there were few secrets left to guard after the publication of a Florentine abbot, Antonio Neri, *Arte vetraria distinta in libri sette* (Florence, 1612), the first comprehensive treatise on all phases of glass production and related processes. This book clearly demonstrates that Neri was intimately familiar with Venetian glassmaking processes and techniques, which had held unsurpassed mastery for over a century.[61]

Fortunately the Medici's interest in glassmaking did not confine

pure sembrerebbe non dovesse avere, nell'economia dello stato, grande rilievo." (26) Tuscany possessed an abundance of raw materials for glass furnaces, such as oak trees and sand from the Arno and the Pisan beaches: SPALLANZANI, (1982), pp. 569-602.

[58] TADDEI, 1954, pp. 47-55; ZECCHIN, I, 1987, 102-47 and III, 1990, pp. 96-101.

[59] M. CALEGARI and D. MORENO, "Manifattura vetraria in Liguria tra XIV e XVII secolo," *Archeologia medievale*, II (1975), pp. 22-26.

[60] CANTINI GUIDOTTI, pp. 29-31; ZECCHIN, I, 1987, pp. 40-43.

[61] R. BAROVIER MENTASTI, "Tecnica del vetro nella Venezia del Cinquecento," *Cultura, scienze e tecniche nella Venezia del Cinquecento*, Atti del Convegno Internazionale di Studio: Giovanni Battista Benedetti e il suo tempo, Venice 1987, pp. 473-82.

itself just to utility and luxury products, but it also led them to promote the development of special and purer glass for scientific instruments, such as alcohol thermometers and mercury barometers, and above all better techniques for the grinding of lenses for telescopes and microscopes. Florentine glassblowers invented new and more accurate methods of shaping glass by means of the controlled flame of the oil lamp, and, working under the direction of scientists like Galileo and Evangelista Torricelli, they constructed instruments with exact gradations and of some artistic merit as well. It was this constant collaboration between theorists and artisans, working together in the laboratory, that led to the creation of the first sample of purer optical glass (1610), one year after Galileo left Padua for Pisa, his native city. In this achievement it is important to underline the steadfast support of the project by Gran Duke Cosimo II, and the fact that mirror-makers in Murano were uninterested in supplying the high-quality glass required despite the strenuous efforts of Galileo's Venetian patrician friend, Giovanfrancesco Sagredo. Zecchin himself admits that Venetian glassmakers would rather devote their attention to the manufacture of high-profit items such as mirrors and vessels of legendary beauty and artistry than serve the occasional needs of scientists for specialized labour-intensive devices. Without doubt the Medici patronage of these efforts largely explains Florence's unrivalled leadership in this field during the seventeenth century.[62] In contrast, scholars have noted a gradual decline in the support of creativity and innovation among tradition-bound Venetian patricians, discouraged over the approaching eclipse of Venice's past political-economic leadership while princely power was on the rise everywhere. Instead there was a tendency in Cinquecento Venice to

[62] For concise treatements of these matters, see TADDEI, 1954, pp. 56-72, and ZECCHIN, "I cannochiali di Galilei e gli 'occhialeri' veneziani," II, 1989, pp. 255-65. Galileo continued to press Sagredo for results, but he apparently ended his attempts to obtain optical glass made to his specifications in Venice after Sagredo died in 1620. Zecchin rightly concludes that "la ricerca di un buon vetro per lenti da cannocchiale non era un problema che potesse destare un serio interesse nei muranesi del Seicento, orientati verso produzioni senza confronto più redditizie, come i 'quari' da specchio e i 'supiadi' cristallini, famosi gli uni e gli altri in tutto il mondo." (p. 264).

relive past glories by emphasizing the "myths" of the republic in elaborate rituals, music, paintings, and books. It is significant that Duke Emanuele Filiberto of Savoy lured Venice's leading mathematician, Giovanni Battista Benedetti, to his court and that Andrea Palladio was willing to follow him, and that the Medici grand dukes surrounded themselves with intellectuals in all fields, including the former Paduan professor, Galileo. [63]

This disinclination of the Murano glassmakers to supply a purer product for scientific instruments as required by Galileo and his colleagues may be indicative of a similar reluctance on their part in making Venice the centre for the best spectacles two centuries earlier. It is clear that by the middle of the fifteenth century eyeglasses were manufactured almost everywhere by glass workers as well as monks, goldsmiths, and others including women and "putti." They could be purchased anywhere at a reasonably low cost. Under these circumstances it is understandable that the glassmaking capital of Europe, famous for the artistry of its products and the sheer volume of its overall output with consequent high profits, would not have the same incentive in making a product with a far lower profit margin. The road was clear for another and lesser glassmaking centre to forge ahead in this field. [64]

A set of unusual circumstances contributed to making Florence that centre — the interest in optics and visual perception by its artists as they developed the geometric rules of linear perspective, and the personal interest of the Medici for art in general and their visual problems in particular. The combined influence of these two factors might have provided the necessary impetus for the gradual growth of a spectacle-making industry of high quality. As the above documents

[63] See G. Cozzi, "La politica culturale della Repubblica di Venezia nell'età di Giovan Battista Benedetti," and M. Tafuri, "Daniele Barbaro e la cultura scientifica veneziana del '500," both in *Cultura, scienze e tecniche*, 9-27, 55-81, respectively. Cozzi is particularly explicit on this point.

[64] Most recently this hypothesis was accepted by the greatest living authority on the history of the Venetian glass industry, Astone Gasparetto. I wish to express my appreciation to Mr. Gasparetto for his gracious hospitality in June 1991 and for allowing me to discuss with him various questions raised in this essay.

demonstrate, that industry had acquired such a reputation that knowledgeable people of means throughout Italy automatically ordered their spectacles from Florence, preferring them to the local product. There is no doubt that fine spectacles could have been made anywhere by any monk or artisan able to obtain the clearest glass or crystal, and willing to exercise the necessary care in grinding and polishing the lenses. Moreover, whatever secret process for making fine convex or concave lenses was invented by the Florentines, it would have been disclosed in a short time by migrating workers to the Venetians and to others and mastered by them, had they been interested. The Florentines, then, were allowed to assume leadership in this field to the point that owning a pair of Florentine spectacles had become a matter of prestige or a status symbol as the Milanese documents suggest. The Venetians had apparently misjudged the future market for scientific and optical glass.

The following conclusion, then, seems to be inescapable. From the invention of spectacles at the end of the thirteenth century, through their development and refinement in the fifteenth century, and finally to the construction and improvement of scientific instruments by Galileo and other Tuscans in the seventeenth century, Tuscany in general and Florence in particular led the way in things optical. Tuscan artists from Giotto to Michelangelo applied modified Euclidian optical principles to art, while Ficino at the end of the fifteenth century was doing his best to reconcile Plato, Aristotle and other ancient philosophies and cosmological theories with Christian revelation. Florentine humanists from Petrarch to Leonardo Bruni developed a new way at looking at themselves and their world, distant in time from the classical world but closer in values — a historical distance or perspective — also reflected in contemporary art. It is hardly possible that all this creativity in one small region was due to mere coincidence rather than to the constant interplay of art, science, philosophy, literature and theology as interpreted by successive generations of first-rate inquisitive minds. In recent decades, in fact, there has been a growing body of publications assessing the importance of Renaissance humanism in

the origins of modern science. Some scholars have emphasized the reciprocal influence of the literary disciplines and the "mechanical arts," in practically all of which Renaissance Florence played a leading role just as Athens had done among the Greek states two thousand years earlier. [65] In surveying these publications, Pamela Long has compressed their major findings in this concluding paragraph.

"We can conclude, then, that the humanists made a profoundly important, though often indirect, contribution to early modern science. Beginning with Petrarch, they attacked the method of arguing from the authority of the ancients, particularly Aristotle. Their alliance with artists and artisans and their propagation of artists' perspective led to an increased appreciation for mathematics and at the same time to a growing respect for handwork and empiricism. Artists' perspective was enriched by, and in turn contributed to, the disciplines of cartography and optics. The humanist discovery and dissemination of ancient scientific texts, and the humanist stimulus for the writing of contemporary treatises on scientific and technical subjects, both

[65] The pivotal role of the Tuscan artist/scientist/philosopher — the Renaissance man — exemplified by Galileo, has been brilliantly summarized by CROMBIE, "Science and the Arts in the Renaissance: The Search for Truth and Certainty, Old and New," 1990, (Orig. published in 1985), p. 173: "Galileo with his learned love of literature, music, and the visual and plastic arts, his eloquent baroque Italian and his matching skills as lutanist and as draftsman, his sense of scientific elegance and of cosmological design, his insistence on being both a philosopher and a mathematician, his desire to win an argument as well as to win the truth — Galileo belongs as recognizably as any of his literary or artistic or philosophical contemporaries to the Tuscan intellectual culture into which he was born.... He was an exemplary man of *virtù*, the rational experimenter, in all these sciences and arts of the Renaissance." Cf. also T. B. SETTLE. "Ostilio Ricci, a Bridge between Alberti and Galileo," in *XIIe congrès international d'histoire des sciences: actes 3-B*, Paris 1968, 121-26, and "The Tartaglia Ricci Problem: Towards a Study of the Technical Professional of the 16th Century," in *Cultura, scienze e tecniche*, 217-26. All the essays in a book edited by J. W. SHIRLEY and F. D. HOENIGER, *Science and the Arts in the Renaissance*, Washington 1985, deal with these issues. Many of the ideas expressed by the above scholars, however, can be traced to two brilliant essays by E. PANOFSKY, *Renaissance and Renascences in Western Art*, Stockholm 1960, pp. 1-41 (rev. ed. of essay of 1953), and G. DE SANTILLANA, "The Role of Art in the Scientific Renaissance," in *Critical Problems in the History of Science*, ed. M. CLAGETT, Madison, WI 1962, pp. 33-65.

contributed to growing knowledge in these areas. Humanist Neoplatonism propagated new cosmological views and new ideas in chemistry and medicine.... Galileo used humanist rather than scholastic modes of expression. Galileo's adoption of the language of humanism is an indication of his indebtedness to it — not surprising in view of the humanist influence on European culture in the previous two centuries." [66]

Indeed, a prominent art historian and leading student of linear perspective, Samuel Edgerton, believes that it was not just a coincidence. He argues persuasively with full documentation that this uniquely Tuscan or Florentine achievement in visualizing spatial relationships on a flat or curved surface and the related use of shading to create the third dimension, combined with the new Renaissance mindset, more disposed to question, measure, and experiment, and the patronage of similarly-minded Medici grand dukes - all supplied the necessary impetus for the scientific and technological leadership achieved by Western civilization from the Renaissance onwards. [67] Oddly, however, although Edgerton clearly connects spectacles and the telescope with the laws of

[66] P. O. LONG, "Humanism and Science," in *Renaissance Humanism: Foundations, Forms, and Legacy*, vol. 3: *Humanism and the Disciplines*, ed. A. Rabil, Jr., Philadelphia 1991 paperback; orig. publ. 1988, pp. 486-512, quotation (505). Cf. D. CAST, "Humanism and Art," and C. V. PALISCA, "Humanism and Music," *ibid*, pp. 412-49, 450-85, respectively. Cast's essay, in turn, is based largely on two seminal books by M. BAXANDALL, *Painting and Experience in Fifteenth Century Italy: A Primer in the Social History of Pictorial Style*, Oxford 1972, and *Giotto and the Orators: Humanist Observers of Painting in Italy and the Discovery of Pictorial Composition, 1350-1450*, Oxford 1971, new ed. 1986.

[67] S. Y. EDGERTON, *The Heritage of Giotto's Geometry: Art and Science on the Eve of the Scientific Revolution, Ithaca* 1991. Edgerton opens his book with these questions: "Why was capitalist Europe after 1500 the first of all civilizations in the world to develop what is commonly understood as modern science, moving rapidly ahead of the previously sophisticated cultures of the East? Why were some of the most spectacular achievements of both the Western artistic and scientific revolutions conceived in the very same place, the Tuscan city of Florence? Was it only coincidence that Giotto, the founder of Renaissance art, and Galileo, the founder of modern science, were native Tuscans?" (p. 1). For a contrary view, not entirely convincing in my opinion, see M. S. MAHONEY, "Diagrams and Dynamics: Mathematical Perspectives on Edgerton's Thesis," in *Science and the Arts*, 198-220.

perspective,[68] neither he nor other writers on this subject have used the above previously published evidence about Florentine leadership in spectacle-making. It is hoped that the present fuller presentation of this evidence will be considered in future treatments of these issues.

[68] "Indeed, any man or woman of any race or creed who wears spectacles must appreciate that the very laws of optometry that sharpen vision as one reads the newspaper are the same as those that were applied to perspective picture making in the Renaissance." (*Ibid,* p. 5). "In point of fact, both the microscope and the telescope, the two most important tools that Renaissance technology bequeathed to modern science, were invented according to the same optical principles that underlie Renaissance perspective painting. (*Ibid.,* p. 20).