RENAISSANCE VISION FROM SPECTACLES TO TELESCOPES

VINCENT ILARDI

Renaissance Vision from Spectacles to Telescopes deals with the history of eyeglasses from their invention in Italy ca. 1286 to the appearance of the telescope three centuries later. According to Dr. Ilardi, "By the end of the sixteenth century eyeglasses were as common in western and central Europe as desktop computers are in western developed countries today." This is perhaps somewhat exaggerated, but not inapt. Like the modern desktop computer, eyeglasses served an important technological function at both the intellectual and practical level, not only easing the textual studies of scholars but also easing the work of craftsmen/small businessmen.

An important subthesis of this book is that, contrary to expectation, Florence, rather than Venice, seems to have dominated the commercial market for eyeglasses during the fifteenth century, when two crucial developments occurred: the ability to grind convex lenses for various levels of presbyopia and the ability to grind concave lenses for the correction of myopia. As a result, the author concludes, eyeglasses could be made almost to prescription by the early seventeenth century.

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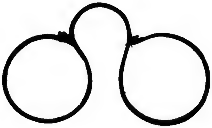

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In memory of Vasco Ronchi (1897–1988)

and with gratitude to

Lorenz Böninger
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Nina Ficarra Ilardi
Charles E. Letocha
Guido Lopez
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Sergio Tognetti

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PREFACE

THIS MONOGRAPH is based on a great number of new archival documents discovered only in the last half dozen years. It also incorporates relatively new archeological findings unearthed in digs in various regions of Europe. Although the focus is necessarily on Italy, the home of the invention of eyeglasses and where the bulk of the documents are located, it strives to include developments on a European-wide scale as much as the relatively few surviving sources can allow.

The remote origin of the book goes back to the beginning of the 1960s with a chance discovery of two orders for eyeglasses totaling at least 300 pairs which was placed by the dukes of Milan, Francesco Sforza and his son, Galeazzo Maria, to Florentine spectacle makers through their ambassador in Florence between 1462 and 1466. These orders were packed with new optical information that has not been surpassed in quantity and specificity until the late sixteenth century. In particular, they established the pre-eminence of Florence in the production of eyeglasses both for presbyopes and myopes with lenses graded in progressive powers in five year intervals for ages 30 to 70 for the former, and in two grades for the latter—practically prescription glasses. I published these documents at the end of 1976 after consultation with the late Professor Edward Rosen of New York, who had published the fundamental article on the invention of spectacles, and later with the late Professor Vasco Ronchi of Florence, another pioneer in the early history of eyeglasses. Both encouraged me to continue exploiting archival resources for additional documentation, especially because such detailed optical information was not available in scientific texts until late in the following century. Additional encouragement came from the many requests for offprints of the article by ophthalmologists, opticians, and medical schools, two of the latter located behind the then active Iron Curtain!

The kind reception of this first effort soon provoked a flood of correspondence, especially with historically minded opticians and collectors of antique spectacles, all craving additional new data about the early history of spectacles. It also spurred colleagues and students to send me additional references to eyeglasses so that soon I became the depository of this information, which I published in a number of articles. Gradually the history of this vision aid became another research interest for me alongside the history of Renaissance diplomacy, which was and remains my major interest. Most of the new sources discovered, however, confirmed Florence's leading position in this field at least up to the sixteenth century, and only a few of them mentioned Venice. Yet, to this day Venice comes to mind first whenever eyeglasses are mentioned because of its leading glass industry. However, my best efforts and those of my friends in Venice to find relevant sources in the Venetian archives and libraries have failed repeatedly. Venice, no doubt, had an imposing spectacle making industry, but this is a supposition that must be accepted on faith. Unlike Florence, Venice does not have the necessary documentation mostly because the itinerant spectacles vendors apparently kept no account books and the customs records, a good source of information in other places, were destroyed in the nineteenth century to make room for more "important" papers.

Except for the above-mentioned Milanese correspondence, which revealed that eyeglasses could be ordered in fairly large quantities, the other sources discovered consisted of individual orders with no hint of large-scale production in Florence. Nor could one get this information from articles and monographs on the artisan industry of this city because Florentine economic historians were not even aware that such a spectacle making industry existed. There can hardly be a more eloquent demonstration of this neglect than the fact that in 1999 the second volume of a multivolume history of Florence's artisan industry devoted to the fifteenth century was to appear without mention of the spectacle making industry until I was invited at the last moment by one of the editors to quickly submit a chapter based on my previous publications.

Clearly the question of establishing production figures in Florence became of great concern to me, especially after I received a request by Professor Laura Abbozzo Ronchi to write an article on the history of spectacles in memory of her father, Vasco Ronchi. Unless I could discover these figures and have even an approximate idea of the extent of the Florentine spectacle making industry, I would be repeating much of what had been written before. Fortunately, Florence has the most extensive commercial documentation of any city in Europe for this period and the answer had to be in those records. But how could a man in his middle seventies, in retirement, hope to wade through those records consisting of thousands of account books and hundreds of thousands of commercial letters? It was a case of mission impossible but one that became possible once I was able to gain the interest of leading Florentine economic historians, who worked daily on account books and commercial correspondence.

I discussed my predicament with Richard A. Goldthwaite, Florence's leading economic historian with a special interest in its artisan industry, and he gladly agreed to cooperate. Soon after, other economic historians—Marco Spallanzani, Lorenz Böninger, and Sergio Tognetti—gave their enthusiastic assent. Within weeks they began to send me a flood of new documents about sales and exports of Florentine spectacles throughout Europe and the Levant as well as the names of at least fifty-two spectacle makers, an astounding number for this period (early fifteenth century to the middle of the sixteenth). To everyone's surprise they had discovered an extensive industry whose existence was totally unknown. That such neglect could take place even among experienced researchers requires explanation. No one in his right mind would spend time searching for eyeglasses in Florentine records knowing that Venice was the place to look for them. Moreover, spectacle prices were so low that even when exported in large quantities they would not be noticeable among the huge sums involving textiles, spices, and other major commodities.

This is a common phenomenon in archival research—one concentrates his attention on a particular line of inquiry disregarding the rest since he cannot be interested in everything. How many diplomatic historians would interrupt their research in high affairs of state to take note of two orders for eyeglasses found in diplomatic files? This correspondence had lain unnoticed for more than five hundred years in the Milanese archives, and chances are that it would have remained so probably for at least a generation or more except that curiosity got the best of me that day. To be sure, the world would have gone on spinning if this discovery had not been made, but I am confident that Florentine economic historians, historians of optics and optical instruments, including the telescope, and a significant number of interested ophthalmologists and opticians worldwide are happy that it came to light, judging from my bulging correspondence and comments in the scholarly literature.

Regrettably, some scholars in Venice are not happy about these developments and this has become a serious matter for a few of them. It may surprise readers, especially those on this side of the Atlantic, that the priority of the invention of eyeglasses and the history of their early development are still hotly contested by Venice and Florence. Evidence for this late exhibition of anachronistic *campanalismo* (parochialism) has been treated in the text and need not be repeated here except to add some disconcerting personal experiences. As my publications of additional evidence relating to Florence's pre-eminence in spectacle manufacturing, especially in the fifteenth century, have progressed, some of my Venetian friends declared in a friendly manner that eventually they were going to prove me wrong. Not so friendly, however, was the remark made by the president of a leading optical firm in the Cadore region north of Venice, that what I had written about Florence's leadership position was not true, even though he didn't bother to produce any contrary evidence. Even more amazing is the fact that some American scholars specializing in Venetian or Florentine history take partisan positions on this issue.

On the other hand, it should be noted that the Florentine public in general are blissfully ignorant of this question altogether. Were they more informed they could rejoice in the mass of new documents just discovered and proceed to dismantle the hideous false funeral monument erected in the nineteenth century to the mythical inventor of spectacles, the Florentine Salvino degli Armati. Pisa itself, the most likely place for the first appearance of eyeglasses, is no less well informed. To this day there is not even a plaque commemorating the two friars who lived in the Dominican Monastery of Saint

Catherine of Alexandria—Alessandro della Spina, the "second optician" in history, and Giordano da Rivalto—who announced the discovery from the pulpit of the Dominican Church of Santa Maria Novella in Florence in 1306.

Faced with this contentious issue and the attendant questions about my published conclusions, as early as 1993 I felt the need to declare my neutrality based primarily on my family background and multi-archive research supporting these conclusions. Being American by birth, Sicilian by upbringing for my first fourteen years, and Milanese by self-adoption, all should provide sufficient diversity of influences and carry some assurance that I am able to offer a more impartial perspective. The reference to Milan simply reflects the fact that I began my career as a researcher in the State Archives of that city, and it was the diplomatic correspondence of the Sforza dukes that led to this re-examination of the early history of eyeglasses. Surely Milan deserves some credit!

It should also be added that the very composition of the group of the four economic historians named above, whom I call affectionately "the gang of four," offers a comforting diversity—one is American, another is German, two are Florentines. I have read almost all the originals of the transcriptions they sent me simply as an exercise in self-education in handling sources relatively unfamiliar to me. I found no distortion of evidence and no hint of any Florentine conspiracy against Venice. The fifth member of the "gang" is another American—Charles E. Letocha, practicing ophthalmologist, historian of spectacles, and collector of antique vision aids. He has assisted me in answering numerous questions from his worldwide contacts with the medical and optical community, and has supplied a great number of illustrations from his vast archive of photographic images, one of the most extensive in the world. He, along with Goldthwaite and A. Mark Smith, a leading historian of medieval optics, has read the manuscript. Jay M. Enoch, retired dean of the School of Optometry at the University of California, Berkeley, read and commented on the first four chapters. I am grateful to all the readers for their constructive comments. It is customary to say at this point that I am solely responsible for whatever errors remain in the narrative.

As knowledgeable as the above-mentioned readers are, they could not be expected to have firsthand knowledge of related developments throughout Europe. For this I had to rely on the advice and cooperation of a great number of scholars in various countries, especially in England and The Netherlands. A significant number of them had already graciously volunteered their services as soon as they heard that a new history of spectacles was being prepared. Documentary evidence, news of archeological finds, pictures of bespectacled persons in museums, etc., reached me in a steady stream. There may be other instances of such scholarly cooperation and generosity but this experience feels unique to me. And so it is with great pleasure and gratitude that I acknowledge hereby these additional individual contributions, hoping not to omit anyone. The details of their contributions have been noted in the footnotes.

Beginning at home, I would like to thank the following graduate students (some now colleagues), who put up with this obsession of mine in my seminars at Yale and discovered new sources: Stefano U. Baldassarri, Allegra di Bonaventura Hogan, Claudia Chierichini, Paul M. Dover, Bernardo Piciché, and Marcello Simonetta. At the University of Massachusetts (Amherst) the staff of the Interlibrary Loan Department, headed by Kathryn A. Ridenour, performed miracles in locating rare publications and promptly securing copies of journal articles. At the Office of Information Technologies, Kevin M. Skelly, Software Support Manager, more than once rescued my data with exemplary skill and patience. Particularly helpful and supportive has been the editor of the American Philosophical Society, Mary McDonald, whose patience and kind understanding helped me to overcome personal crises during the long gestation of this book. Closer to me at home, my wife, Nina, managed the logistics for our many research trips abroad, occasionally lent a hand in libraries and museums, and performed many other tasks that would have taken precious hours away from the depositories.

In Milan several friends lent support and advice in various ways. The late Sergio Lucioli offered his vast experience in the Italian publishing world. Giorgio Tassara, president of the optical firm Metallux, published my first book on this subject. This book was translated into graceful Italian by the playwright, novelist, journalist, and historian Guido Lopez, who also translated my articles on this and other topics for a couple of Italian journals. The leading historian of medieval and Renaissance Milan, Franca Leverotti, used her intimate knowledge of Italian publishing to offer advice and lay the groundwork for an Italian edition in the near future, while spurring me on to complete the book so that we could pursue our overriding common research interest—the history of Renaissance diplomacy.

Additional assistance came from other friends in Rome, Florence, Venice, and Croatia. In Rome: Arnold Esch (retired Director of the Istituto Storico Germanico), Gerardo Piciché, Maurizio Pallone, Paola Potestà, and the staff of the Fototeca dello Stato (Paolo Ferroni). In Florence, in addition to those named above, I am indebted to Anna Affortunati, Marco Beretta, Marialuisa Bianchi, Niccoló Capponi, William J. Connell, P. R. Del Francia (Centro di Restauro della Soprintendenza Archeologica per la Toscana), Pasqualino Di Nardo, Gloria Fossi, Maria Fubini, Paolo Galluzzi, Edward Goldberg, Orsola Gori, Maria Letizia Grossi, Alessandro Guidotti, Bill Kent, Aldo Landi, Laura Abbozzo Ronchi, Sharon T. Strocchia, Guido Vannini, and Nicholas Wilding. In Venice, I am grateful to the following friends for helping me search for those ever-elusive Venetian documents: Reinhold C. Mueller, Maria Francesca Tiepolo, and Francesca Trivellato. The late Astone Gasparetto helped me to confirm my hypothesis on the seeming neglect of spectacle production in Venice before the sixteenth century. In considering sources in nearby Croatia, I was fortunate to have the advice of Vjekoslav Dorn, professor of ophthalmology at the University of Zagreb, whose publications on the history of eyeglasses in this area are based on extensive archival and pictorial evidence.

After Italy, England supplied the bulk of the evidence in documentary sources and surpassed all others in archeological finds and superb analysis of the artifacts. I am grateful to the following scholars for their assistance and gracious welcome: Harry S. Cobb, John Clark (Museum of London), Sabine Eiche, Francis Grew (Museum of London), Neil Handley, Vanessa Harding, Elizabeth Leedham-Green, Stuart Jenks (who teaches at the University of Erlangen, Germany), Ronald J. S. MacGregor, Valerie Mellor, Michael Rhodes, Adele and Bernard Schaverien, Dennis Simms, Judith Stevenson, and Richard J. Walsh. The Ophthalmic Antiques International Collectors' Club served as a mine of information on the latest findings about the history of spectacles, though some of the articles in its newsletter are published without references and a couple of the authors refused to divulge their sources even when privately contacted.

In the Netherlands, Paul and Carla Aangenendt, brother and sister optometrists/opticians, have been invaluable in supplying references and pictures, with the cooperation of Marco Vermunt (archeologist) and P. J. K. Louwman, photographer. In Belgium, Sven Dupré, of the University of Ghent, generously allowed me to use his unpublished doctoral dissertation and unpublished articles, all of which formed the major texts for optical developments in the sixteenth century.

Finally, there are other scholars scattered worldwide who provided valuable assistance, especially Roland F. Cadle, Conor Fahy, Charles M. Falco, Robert Gibbs, Reva Hurtes, Walter Liedtke, David C. Lindberg, Andrea Mozzato, Salvatore Nigro, Gigliola Pagano de Divitiis, Elizabeth Ward Swain, Richard C. Trexler, Gherardo Villani, and Donald Weinstein.

Institutional support has also been generous. A monetary subsidy by the Essilor of America Corporation has been earmarked expressly for the publication of this book. Earlier grants from various foundations financed the creation of a giant microfilm collection, which includes many of the documents cited in this study and has been frequently consulted for additional sources. The collection consists of some two thousand reels and around two million documents, which I donated to the Sterling Memorial Library at Yale in 1990. It is catalogued with the title, *The Ilardi Microfilm Collection: Renaissance Diplomatic Documents ca. 1450–ca. 1500.* It is available through interlibrary loan by consulting the online reel index, which was last revised in 2003—http://www.library.yale.edu/Ilardi/il-home.htm. I am grateful to the following foundations for providing funds for microfilming and related research expenses: Fulbright Program for Italy (1959–60); American Philosophical Society, 1960–63; Rockefeller Foundation Research Grant, 1961–63; Rockefeller Foundation International Relations Research Grant, 1963–64; John Simon Guggenheim Memorial Foundation, 1970–71; National Endowment for the Humanities, Research Resources Division, three grants, 1976–85; and the National Italian American Foundation, 1985.

In closing, I should like to conclude with the plea that this work be continued. After all, the following pages offer only the first results of a long research project carried out with sources of gigantic proportions. These records have much more to reveal. But this work can be most successfully accomplished by various researchers who work daily on these sources and are willing to note and share the references to spectacles as they pursue their major interests. One or two members of the "gang of four" are ideally suited to act as coordinators and propagators of this new knowledge so that the present monograph can be constantly updated. Or a new "gang" can be constituted, hopefully with research funds supplied by an optical firm, which is relatively free of parochialism. It will be a dream worth pursuing!

RENAISSANCE VISION FROM SPECTACLES TO TELESCOPES

I

The Invention of Spectacles Revisited

ARE EYEGLASSES one of the most important inventions in the last two thousand years? They have been nominated for this distinction in a poll of some 80 scholars carried out on the Internet as a prelude and challenge for our new millennium. Spectacles "have effectively doubled the active life of everyone who reads or does fine work—and prevented the world being ruled by people under 40," commented the nominator.[1]

And yet the inventor is still unknown despite diligent research and continuous scholarly debate over the past centuries. With equal aplomb, the late Professor Vasco Ronchi described the problem associated with the invention of spectacles as follows: "Much has been written, ranging from the valuable to the worthless, about the invention of eyeglasses; but when it is all summed up, the fact remains that the world has found lenses on its nose without knowing whom to thank."[2]

Fifty years after the publication of Ronchi's witticism, one can still add another; namely, that if victory has a thousand fathers, as it is commonly said, then the invention of spectacles and of its derivative, the telescope (another nominee listed among the top inventions of the last two millennia), must have just as many. The inventors for both are still unknown and almost certainly will never be known, given the many conflicting claims and the surviving documentation, which is scarce and lacking in specificity, especially for eyeglasses. In the ancient and medieval world technological innovations were frequently the product of craftsmen, who wished to protect the secrets of their trade by restrictive oral transmission rather than by a written record, even assuming that they were all literate. In 1471 the Republic of Venice is believed to have granted

1. The results of the poll initiated by the writer John Brockman (www.edge.org) were summarized by S. Begley, "The Power of Big Ideas," *Newsweek* (11 Jan. 1999), pp. 58–59. The witty quotation was attributed to the nominator, psychologist Nicholas Humphrey of the New School for Social Research, New York.

2. Quoted by E. Rosen, "The Invention of Eyeglasses," *Journal of the History of Medicine and Allied Sciences* 11 (1956), p.13.

the first patent in western history, and a regular body of patent law began to evolve in the republic from 1474 onward in an effort to encourage technological innovation, especially related to the mechanical control of water in the lagoons.[3]

In the following exposition the most important evidence about the invention and early development of eyeglasses will be reviewed and reassessed in the light of new documents that have been published in the last two decades, with the addition of an abundance of unpublished evidence presented here for the first time. Together these fresh sources have radically changed the early history of spectacles, particularly with respect to their diffusion, manufacture, commerce, lens and frame technology, and costs, thus providing new perspectives for viewing the invention of the telescope at the beginning of the seventeenth century. It is my hope to interest an ever wider circle of scholars more knowledgeable than I in the more scientific and technical aspects of the history of optics as well as fellow humanists, who may be as fortunate in discovering new texts for the elucidation and understanding of problems still to be resolved.

Some of these problems were examined by Ronchi himself, who, along with the late Professor Edward Rosen, encouraged me, a mere novice, almost three decades ago to publish the first new and specific documents on the early development of spectacles since their first mention at the beginning of the fourteenth century. In an effort to reach this wider audience, especially historically minded opticians and ophthalmologists, I will provide English translations of several key sources while not neglecting to supply the original for the specialists, who may want to test their skill in amending the translations as they deem appropriate bearing in mind that some of the Latin and Italian passages quoted are difficult to understand and render accurately in a modern language. The bibliographical references will be kept to a minimum, limited largely to recent publications not already utilized in my previous works on the subject.

Pisa and Venice

Four decades ago Rosen made an exhaustive probe of the various conflicting claims, reviewed the extensive literature, corrected many errors of fact and interpretation of the available evidence, and came to the conclusion that the first pair of spectacles — two convex glass disks enclosed in metal or bone rims with handles centrally connected by a tight rivet so as to clamp the nostrils or be held before the eyes — was invented around 1286 most likely by a craftsman living at or near Pisa.[4] This date is derived from the

3. E. Ashtor, "The Factors of Technological and Industrial Progress in the Later Middle Ages," *Journal of European Economic History* 18/1 (1989), pp. 7–36. For the latest treatment of Venetian patents, see R. Berveglieri, *Inventori stranieri a Venezia (1474–1788): Importazione di tecnologia e circolazione di tecnici artigiani inventori. Repertorio* (Venice, 1995), especially pp. 17–26. This book, however, does not list patents in glass-making and does not mention mirrors or spectacles.

4. Rosen, "The Invention," pp. 13–46, 183–218.

following brief passage of a Lenten sermon delivered at the Dominican monastery of Santa Maria Novella in Florence on 23 February 1306 by the most popular preacher of his age, Friar Giordano da Pisa or da Rivalto, the latter name designating a castle near Pisa where he was probably born around 1260:

> *It is not yet twenty years since there was found the art of making eyeglasses, which make for good vision, one of the best arts and most necessary that the world has. And it is so short a time that this new art, never before extant, was discovered. And the lecturer [Giordano] said: I saw the one who first discovered and practiced it, and I talked to him.*[5]

Such a useful invention, especially for the scholarly Dominicans, renowned all over Europe for their learning, theological zeal, teaching, and public preaching, must have made an indelible impression on Giordano, who was about twenty-six years old when he saw the first pair. The date itself must have been vividly etched in his memory largely because it fell between two crucial events in his life: the beginning of his novitiate at the Dominican monastery of Saint Catherine of Alexandria at Pisa in 1280 and the initiation of his teaching career in the Sienese convent of St. Dominick in 1287, having already completed advanced studies at both the Universities of Bologna and Paris in the period 1284–86.[6] This lasting impression is apparent in the unequivocal statement in his sermon that he, indeed, had known the inventor and had talked to him as to reassure the less informed members of his audience that such a device did in fact exist after he had reminded them that throughout the world there were many other crafts of which they were ignorant and that new ones were being created all the time.[7] The dates of his attendance at the Universities of Bologna and Paris in the crucial two-year period are significant because they give us another clue of the Pisan origin of the invention, a fact that has not been noticed by scholars. Had he seen the first pair of glasses at either city or during his travels to these destinations he would certainly have mentioned it in his sermon. It is obvious that two renowned university cities had not seen spectacles at this time.

By the time the sermon was delivered, some of the elderly friars in Santa Maria Novella and nearby monasteries must have taken advantage of the new "Pisan" invention, probably introduced by Giordano himself in the course of his lectures given in Latin to local

5. "Non é ancora venti anni che si trovó l'arte di fare gli occhiali, che fanno vedere bene, ch'é una de le migliori arti e de le piú necessarie che 'l mondo abbia, e é così poco / / che ssi trovó: arte novella, che mmai non fu. E disse il lettore: io vidi colui che prima la trovó e fece, e favellaigli." Giordano da Pisa, *Quaresimale fiorentino, 1305–1306. Edizione critica*, ed. C. Delcorno (Firenze, 1974), sermon XV, p. 75. I have amended Rosen's translation, "The Invention," pp. 34–35.

6. For the most recent biography of Giordano based on the latest research, see C. Delcorno, *Giordano da Pisa e l'antica predicazione volgare* (Florence, 1975), pp. 3–28.

7. ". . . e così per lo mondo n'ha molte di quelle [arti] che non sapete, e non però sono trovate tutte. Molte ne sono che non sono trovate, e ognendì se ne potrebbe trovare una nuova, e sempre se ne trovano de le nuove." *Quaresimale fiorentino*, p. 75. The above quotation on the invention of spectacles follows immediately after this passage.

clergy, which were often attended by educated laymen. It may be, however, that at this early date some of the preacher's habitual listeners—merchants, craftsmen, women, including cloistered nuns in nearby convents—would not have been familiar with it. The public announcement in the vernacular was evidently designed to spread the word outside the monasteries among the general public, especially the aged, who could have used such a vision aid for their daily work.[8]

Giordano, obviously, was only the propagator of the invention, not the first optician. That honor belongs to the unnamed inventor referred to in the sermon, who wished to keep the process of spectacle making secret to reap the full benefit of his ingenuity. The process would probably have remained secret at least for a short time had it not been for a contemporary colleague of Giordano at his own monastery at Pisa, Friar Alessandro della Spina, who also knew the inventor and saw a pair. Being a multifaceted and manually gifted individual, he learned to make them and divulged the process for public benefit. This event was recorded shortly after Spina's death (1313) in the *Ancient Chronicle of the Dominican Monastery of St. Catherine in Pisa* by its first compiler, Friar Bartolomeo da San Concordio (d. 1347), but without giving other essential information about Spina's life and career, not even the dates of his birth and death. In barely three and a half lines, both in manuscript and in print, the *Chronicle* first recorded in most general terms for posterity this momentous invention for the history of optics:

> *Friar Alexander della Spina, a modest and good man, whatever he saw that had been made, he knew how to make it. Eyeglasses, having first been made by someone else, who was unwilling to share them, he [Spina] made them and shared them with everyone with a cheerful and willing heart. He knew how to sing, write, illuminate [manuscripts] and everything which mechanically skillful hands can do. Ingenious in corporeal things, by his ingenuity he made himself a room in the house of the Eternal King.*[9]

As it can be seen, these two brief records reveal only that spectacles had been invented. They say nothing about the identity of the inventor, his place of origin, his profession, or even the type of lenses first used, convex or concave. We infer from the fact that the earliest records associated spectacles with the elderly that the first lenses must have been convex to correct presbyopia. It remains a mystery that Giordano, only twenty

8. Giordano's style of preaching, the themes developed in his vernacular sermons, and the composition of his public in various churches and occasionally in public squares have been treated in detail by Delcorno, *Giordano da Pisa*, pp. 29–80.

9. "Frater Alexander de Spina, vir modestus et bonus, quae vidit oculis facta, scivit et facere. Ocularia ab alio primo facta, communicare nolente, ipse fecit, et omnibus communicavit corde hilari et volente. Cantare, scribere, miniare, et omnia scivit quae manus mechanicae valent. Ingeniosus in choralibus [corporalibus], in domo Regis aeterni fecit suo ingenio mansionem." *Chronica antiqua conventus Sanctae Catharinae de Pisis*, ed. F. Bonaini in *Archivio storico italiano* VI, pt. 2 (1845), pp. 476–77. Once again I have amended Rosen's translation, but I have adopted his correction of "choralibus" into "corporalibus, "The Invention," pp. 36–37.

years after the invention, did not choose to reveal in his sermon the name of the inventor nor did Friar Bartolomeo when he recorded it about seven years later.

What reasons could there be for all this secrecy? Surely the inventor was interested in keeping only the process secret, not his name and shop if he hoped to increase his profits with a temporary near monopoly, which was in the process of being challenged by the Dominican friars and possibly by others. He would have welcomed a free commercial from the pulpit! Actually the very idea of a "secret process" is a myth, constantly repeated over the centuries. Drilling and riveting the ends of the handles of two framed magnifying lenses could be accomplished by practically any artisan or by a talented friar-artisan like Della Spina. Here the slogan of modern surgical training comes to mind—"see one, do one, teach one." Of course, the more procedures surgeons perform, the more adept they become. By the same token, although adequate eyeglasses could be fashioned by artisans in general, good ones required skills acquired over the years by specialized artisans, as the following chapters will demonstrate. But the process itself could not remain a secret.

For lack of evidence we can simply surmise that by the time Giordano preached in 1306, the craft of making spectacles was already established by a small group of local artisans probably instructed by Della Spina, who was eager to spread knowledge of the invention. Pisa, in fact, had a thriving glass industry at least from the early years of the fourteenth century. Its mirror and drinking glass makers had become so numerous by 1321 as to require appropriate designation within the Order of the Merchants in the city. Surely, mirror makers were capable of grinding and polishing lenses for eyeglasses and fashioning frames for them once the "secret" was revealed.[10] Under these circumstances there was neither the need nor the desire to reveal the name of an inventor, who had been unable or unwilling to transcend ordinary human greed for the benefit of society, assuming that he was still alive twenty years later. Such a mention would then have been more in the nature of a reproach.[11] Surprisingly, no additional, specific information about any of these matters was added by the still partially published *Annals of the Dominican Monastery of St. Catherine in Pisa,* compiled by an unknown friar in the middle of the sixteenth century when eyeglasses for presbyopes had been common for about three centuries and for myopes for over a century! The *Annals* simply expanded slightly on the version given in the *Chronicle*.[12]

10. On the Pisan glass industry, see T. Antoni, "Note sull'arte vetraria a Pisa fra il Tre e il Quattrocento, *Bollettino storico pisano* LI (1982), pp. 295–309. Surprisingly Antoni does not mention the invention of spectacles at Pisa and his documents make no references to spectacle makers. Perhaps it was too early for the development of such a subspecialty.

11. Rosen, "The Invention," pp. 215–18, discusses and rejects several possible reasons for the secrecy put forth by other scholars, but he comes to no conclusion. As far as I know, the above hypothesis has not been advanced before.

12. The relationship of the *Chronicle* and the *Annals* was clarified by Rosen, "The Invention, pp. 18–20, who published an English translation of the relevant passage. The original Latin passage of the *Annals* was published by

Furthermore, there is even earlier evidence that the craft of spectacle making was also well established in Venice by the time of Giordano's sermon, as has been pointed out by the late Giuseppe Albertotti (former Professor of Ophthalmology at the University of Padua), the late Luigi Zecchin (leading historian of the Venetian glass industry), and most recently confirmed by Maria Francesca Tiepolo (former Director of the State Archives in Venice). These scholars argue in varying degrees for a Venetian priority in the invention itself, which they claim was exported to Pisa by Venetian glass workers and/or by Dominican friars from the Veneto.[13]

Venice, in fact, produced the earliest guild regulations regarding the manufacture and commerce of spectacles. The *Capitolare dell'arte dei cristalleri* (Regulations of the art of crystal-workers) (1300) repeated a provision previously recorded in 1284, which prohibited members from making objects of clear glass falsified to resemble rock or quartz crystal and extended the prohibition to non-members as well. In addition, no one was now allowed even to commission or sell such counterfeits, listing objects which were apparently easily or frequently falsified. In the list were included *roidi de botacelis et da ogli* (disks for vials and for eyes) and also *lapides ad legendum* (stones for reading or magnifying lenses).[14] The *roidi de botacelis* were the convex, round crystal covers for small vials used to store medicines and ointments, which could also function as magnifying lenses when positioned close to the object but also as lenses when held before the eyes to correct presbyopia. In essence this record provides probably the first clear written distinction discovered to date between magnifying lenses already used for centuries and a new

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Bonaini, *Chronica antiqua*, p. 477, n. 134 as follows: "Frater Alexander Spina manibus suis quidquid voluisset operabatur, ac charitate victus aliis communicabat. Unde, cum tempore illo quidam vitrea specilla, quae ocularia vulgus vocat, primus adivenisset, pulchro sane, utili ac novo invento, neminique vellet artem ipsa conficiendi comunicare, hic bonus vir artifex, illis visis, statim nullo docente didicit, et alios qui scire voluerunt docuit. Canebat modulate, scribebat eleganter, et descriptos libros picturis, quas minia appellant, ornabat. Nullam prorsus manualium artium ignoravit." On pp. 595–633 of the same volume, Bonaini published the *Estratti dagli Annali del Convento di Santa Caterina di Pisa*, omitting "tutta la narrazione che l'A[utore] trasse dalla Chronica Antiqua, stampata qui innanzi." (p. 597, note*).

13. G. Albertotti, "Note critiche e bibliografiche riguardanti la storia degli occhiali," *Annali di oftalmologia e clinica oculistica* XLIII (1914), pp. 328–50; three articles by L. Zecchin, "I 'cristalleri' e l'invenzione degli occhiali," *Giornale economico della Camera di Commercio di Venezia* X (1956), pp. 832–37; "I 'roidi da ogli'," ibid., XVI (1962), pp. 438–45; and "I 'rodoli de vero'," ibid., XVI (1962), pp. 688–94. These articles have been republished in his book, *Vetro e vetrai di Murano. Studi sulla storia del vetro*, vol. II (Venice, 1989), pp. 236–39, 244–49, 250–55 respectively; M. F. Tiepolo, "Gli occhiali: un'avventura veneziana," in *Il Museo dell'Occhiale Pieve di Cadore* (Milan, 1990), pp. 12–14.

14. *Capitolare dell'arte dei cristallai*, November 1284, Art. III: "Item, quod nullus de arte nostra audeat laborare vitrum blanchum contrafactum ad cristallum. . . ."; Art. XIII: "Item, ordinamus quod omnes homines laborantes de arte vitri qui utuntur in nostram artem, similiter quod ipsi debeant vendere laborerii de cristallo pro cristallo et laborerium de vitro pro vitro"; Addition (2 April 1300), Art. XXXXI: Item, ordinamus quod aliquis, tam venetus quam forinsecus, non audeat emere nec emi facere aliquod laborerium de vitro blancho quod contrafaciat ad cristallum, pro revendere in Veneciis vel mittere extra terram, scilicet botoni, manici, roidi de botacelis et da ogli, tabule de anconis et de crucibus, et lapides ad legendum, . . ." (*I Capitolari delle arti veneziane sottoposte alla giustizia e poi alla giustizia vecchia dalle origini al MCCCXXX*, Vol. III, ed. G. Monticolo and E. Besta (Rome, 1914), pp. 124, 127, 133 respectively.

use for them, which made them part of the eye's visual system when connected centrally and held close to the eyes. Had this record been dated before 1286, the Venetians would have an uncontested priority claim for the invention of spectacles.

An additional provision adopted the following year allowed the manufacture and sale of *vitreos ab oculis ad legendum* (glasses for eyes for reading) by anyone (member or nonmember) subject to an oath binding the seller to label them as spectacles with glass lenses. Zecchin has speculated that by this time glass lenses were commonly used for spectacles while the more expensive crystal lenses were purchased by the more affluent.[15] In view of the fact that the above article granted freedom to anyone to make and sell spectacles with glass lenses, it is difficult to explain the necessity of promulgating a subsequent special article in 1317 which granted permission to a certain Francesco, son of the late surgeon Nicholas, to make and sell *oglarios de vitro (eyeglasses or spectacles with glass lenses)* in Venice.[16]

In granting this permission to a non-member, however, the guild used for the first time the term *oglarios de vitro,* which approximated the Tuscan word *occhiali,* first used by Giordano in his 1306 sermon. Yet the term *rodoli da ogli* continued to be used in the translation of the *Capitolari* from the Latin to the Venetian idiom (1319–30), although the Venetian Senate finally (1321) adopted the Tuscan term, *veri da occhiali,* when it imposed an export duty of 5 percent on them.[17] It is significant to point out that the imposition of such a duty indicates that Venice was already exporting spectacles in relevant quantities at this early date—the first such evidence for any state in Italy—and certainly continued exporting them in later centuries although we lack sufficient supporting documents. It is, indeed, frustrating that surviving Venetian documents for the first two centuries of the history of eyeglasses are so few in comparison to those found in Florentine and other archives, as we shall see in subsequent chapters.

While the above regulations constitute the first detailed evidence concerning the manufacture and sale of spectacles, they reveal nothing about the shape of the lenses, convex or concave. We assume that the lenses must have been convex because we have absolutely no evidence of young people wearing spectacles with concave lenses for myopia prior to the fifteenth century. The Venetian guild regulations, on the other hand, reveal a number of crucial facts about early spectacle manufacture and commerce that complement the additional evidence recently discovered for the following century.

15. 15 June 1301, Art. XXXXIII: "Ordinamus and damus licenciam quod quelibet persona que voluerit facere vitreos ab oculis ad legendum, possit ipsos facere veniendo primo ad iurandum ad cameram dominorum iusticiariorum de vendendo illud vitreum pro vitreo; . . ." (Ibid., III, p. 134). Zecchin, "I 'rodoli de vero'," *Vetro e vetrai,* II, p. 252.

16. March 1317, Art. LIII: "Iusticiarii veteres dederunt gratiam Francisco condam magistri Nicolai cirurgici de faciendo oglarios de vitro et vendendo in Veneciis, presenti capitulari non obstante. . . ." (*I Capitolari,* p. 138).

17. For the translation, Ibid., pp. 138–152; for the Senate's decree, Zecchin, "I 'rodoli de vero," *Vetro e vetrai,* II, p. 252.

The regulations make clear that spectacle makers had no guild of their own, despite sporadic efforts to organize one, probably because of the open nature of the craft itself, which did not lend itself to a specialized and well defined trade. Initially they were members of the *cristalleri* guild, which was intimately connected with the goldsmith craft as the latter also worked on crystal objects. They were finally associated as makers and vendors of spectacles with the guild of the *marzeri* (mercers), the largest, most diverse, and most influential guild in Venice until well into the eighteenth century.[18] The mercers claimed jurisdiction over the sale of a bewildering diversity of goods made in or outside Venice. In 1594 the guild controlled about three hundred shops concentrated in the *merceria*, the long street still extant that connected San Marco to the Rialto. By the end of next century its membership had risen to 1,747, outnumbering the boatmen![19] Its regulations of 1446 specifically mentioned spectacles in connection to other goods imported into the *Fondaco dei Tedeschi* (German exchange house) over which it claimed jurisdiction. The passage is worth quoting.

> *Be it understood that all mercers' wares which come into the German exchange house shall be subject to our trade, and that our mercers may freely stock and sell these goods, such as basins and other brassware, iron and tin, locks, mirrors, mirror glass, caps, gloves of wool or hide, cups, bales of cloth, shears, scissors, jugs, Paternoster beads, hats, spectacles . . . and every other kind of mercery, even though it be not named: everything shall be regarded as subject to our trade.*[20]

We can assume, therefore, that eyeglasses continued to be made by both crystal and glass workers as well as by other artisans, subject to proper lens labeling as crystal or glass, and sold in shops and by ambulatory vendors always under the jurisdiction of the mercers' guild. The primary concern of the *cristalleri* guild was the counterfeiting of glass for rock crystal not only in the production of spectacles, but more commonly in decorative vials, reliquaries, crosses, and false gems made of clear or painted glass, all of which could be mounted by goldsmiths in precious metals. It should be noted here parenthetically that from the beginning of the history of spectacles there was a close association between goldsmiths and spectacle makers, especially as gold or silver began to be used for the frames of luxury spectacles. Indeed, the association of glassmakers in general with goldsmiths dates back at least to the reign of Emperor Constantine the

18. Tiepolo, "Gli occhiali," pp. 13–14. This view has been confirmed again in the latest history of the glass industry in Venice by F. Trivellato, *Fondamenta dei vetrai: Lavoro, tecnologia e mercato a Venezia tra Sei e Settecento* (Rome, 2000), pp. 138–39.

19. R. Mackenney, *Tradesmen and Traders: The World of the Guilds in Venice and Europe, c. 1250–c.1650* (Totowa, N. J., 1987), pp. 90–113, and his article, "The Guilds of Venice: State and Society in the Longue Duree," *Studi veneziani*, n. s. XXXIV (1997), pp. 15–43.

20. The regulations of 1446 have been translated by R. Mackenney in *Venice: A Documentary History, 1450–1630*, ed. D. Chambers and B. Pullan, with J. Fletcher (Oxford, 1992), pp. 281–85, quotation pp. 283–84.

Great (306–337) when "glassmakers were associated with the corporation that included goldsmiths, artists and craftsmen who worked with precious materials."[21] Also of great significance is also the fact that by the beginning of the fourteenth century Venetian glassmakers had developed a sufficiently clear glass that could pass for crystal, at least to the layman, more than a century before their introduction of manufactured crystal. This breakthrough in glass technology may have been the result of the use of superior Levantine (mostly Syrian but also Egyptian) alkali ashes being imported into Venice from about 1375 or earlier for the making of glass and soap.[22] Presumably these ashes were also available to the Pisans and the Genoese for their respective glass industries but no documentation is available. On the other hand, recent research has revealed that already such colorless glass resembling rock crystal had been developed and was commonly available during the first century of the Roman Empire![23]

The *cristalleri* guild was actually liberal in permitting anyone, including non-Venetians, to manufacture spectacles. Non-Venetians, in fact, were already offered membership in the guild in 1284 with the payment of a higher entrance fee. There were many *forestieri* (non-Venetians including non-Italians), especially Florentines and Genoese, working as apprentices, masters, and sometimes owners of glass furnaces in Murano despite sporadic but not fully enforced restrictions designed to safeguard trade secrets and also ensure full payment of fees to the guild by this more mobile workforce.[24]

Tuscans (particularly Florentines) were numerous in Venice and the Veneto, not only as glass workers and craftsmen in various trades but also as merchants importing and exporting a wide variety of goods through Venice and as bankers controlling international credit transactions. In the late Middle Ages "Venice was swarming with Florentine merchants," according to Reinhold Mueller, a leading economic historian.[25] In Treviso alone representatives of more than sixty Florentine families are buried in the Church of S. Margherita, including Dante's son, Pietro, whereas other Florentines are buried in the Church of St. Francis, including Petrarch's daughter, Francesca. When we add the enormous influence exerted by Dante, Petrarch, and Boccaccio with their residence

21. Zecchin, "I 'veriselli'," *Vetro e vetrai*, II, pp. 239–44. This association, often cited by Zecchin in his other works as well, will also be noted in subsequent chapters. In a list of Venetian guilds in the seventeenth century, the "ochialeri" were grouped under the guild of the goldsmiths for tax collection purposes: R. T. Rapp, *Industry and Economic Decline in Seventeenth-Century Venice* (Cambridge, MA, 1976), p. 173. For the quotation, see F. Dell'Acqua, "Glassmakers in the West between Late Antiquity and the Middle Ages," in *When Glass Matters: Studies in the History of Science and Art from Graeco-Roman Antiquity to Early Modern Era*, ed. M. Beretta (Florence, 2004), p. 136.

22. See E. Ashtor and G. Cevidalli, "Levantine Alkali Ashes and European Industries," *The Journal of European Economic History* 12/3 (1983), pp. 487–91.

23. See below, p. 38.

24. Zecchin, "Cronologia vetraria," I, pp. 20–57 and "I 'forestieri nell'arte muranese fino al 1544," ibid., III, p. 79–84.

25. "Venezia pullulava di mercanti fiorentini," in R. C. Mueller, "Mercanti e imprenditori fiorentini a Venezia nel tardo medioevo," *Società e storia* LV (1992), pp. 29–40, quotation, p. 41, and idem, *The Venetian Money Market: Banks, Panics, and the Public Debt, 1200–1500* (Baltimore and London, 1997), pp. 255–87.

or frequent visits to the region, one can well come to the conclusion that there was a considerable economic as well as cultural Florentine influence.[26] On the other hand, there was an equally important Venetian glassmaking influence throughout the Italian peninsula because Venetian glass workers could ply their trade outside Venice during the summer closing of the furnaces or at other times with the payment of fines if they eventually wished to resume their work at home.[27] This intermingling of skills and of commercial and cultural links throughout Italy explains to a large extent the virtual impossibility of determining the exact origin of a particular invention or innovation such as spectacles.

In light of the evidence supplied by the Venetian guild regulations, then, it would seem that the scarcity of Venetian sources specifically mentioning spectacle makers already noted for this period by researchers like Zecchin and the present writer is of secondary importance. Zecchin could find only one spectacle maker, the above named Francesco, for the entire fourteenth century and another for the fifteenth century, a certain Bartholomeo, who was granted Venetian citizenship in 1409.[28] Clearly these individuals were mentioned because they were special cases. As we have seen, anyone was allowed to make spectacles in Venice without even belonging to a guild, but he could only sell them as a member of the mercers' guild. Such de facto "opticians" could, therefore, ply their trade without being mentioned specifically as spectacle makers especially if they also practiced another trade making them members of other guilds. Florentine and other evidence, discussed in subsequent chapters, clearly points to this conclusion as well. We should also recall that monasteries had begun to make eyeglasses with Spina and continued to do so throughout the period, and the monks were not members of guilds nor were they listed in government records as spectacles makers. In brief, during this early period of spectacle making, there were many people of various trades making or assembling spectacles who were not registered in state fiscal records specifically as spectacle makers.

Also of secondary importance is the fact that the Venetian documents do not settle definitely the question of priority in the invention. Pisa itself had a thriving but smaller glass industry making mirrors and drinking glasses as well as other products (but apparently not spectacles) at least since the beginning of the fourteenth century and possibly even earlier.[29] Moreover, the Pisan evidence not only antedates the Venetian regulations

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26. For a detailed treatment of this influence, see L. Gargan, "Preumanesimo a Vicenza, Treviso e Venezia," in *Storia della cultura veneta*, vol. 2: *Il Trecento* (Vicenza, 1976), pp. 142–70, and F. Brugnolo, "I toscani nel Veneto e le ricerche toscaneggianti," ibid., pp. 369–439.

27. Zecchin, *Vetro e vetrai* I, pp. 40–50.

28. Zecchin, "I 'rodoli de vero,'" p. 252.

29. The "arte delli spechiari" and the "arte dei bichierai" were listed in the *Breve dei Consoli della Corte dell'Ordine de' Mercanti del Comune* of Pisa, first compiled in 1321 and revised in 1341 according to T. Antoni, "Note sull'arte vetraria a Pisa fra il Tre e il Quattrocento," *Bollettino storico pisano* LI (1982), p. 295. The fact that spectacles are not

but also coined the Italian word, *occhiali*, first used by Giordano in his sermon of 1306, and this term gradually became part of the Italian language everywhere in the peninsula including Venice by 1321 as stated above.[30] The Latin translation, *ocularia*, was first used by Bartolomeo da San Concordio in his entry on Spina (1313) in the Pisan Chronicle. Perhaps it was used even earlier as *ocularia de vitro* in the popular collection of examples and comparisons designed to be used in sermons—*Summa de exemplis et similitudinibus rerum perutilis praedicatoribus* (1298–1314)—by the noted Dominican preacher, Giovanni da San Gimignano (1260/70–ca. 1333). Giovanni and Bartolomeo knew each other at least since 1322 when Bartolomeo was appointed lector at the Dominican monastery at San Gimignano, 54 and 79 kilometers south of Florence and Pisa, respectively.[31] The adoption throughout Italy of two terms born in Tuscany to designate eyeglasses, *occhiali* and *ocularia*, is significant in itself because it was a common practice in the medieval glass industry to adopt the terminology of the place of origin for a particular product or process.[32] In this case, however, it may have been just a matter of convenience—it was certainly easier to call spectacles *occhiali* rather than *roidi da ogli* or *oglarios de vitro*.

Florence's Claim

Although the tedious question of these rival invention claims is of limited importance for the purposes of this study, it cannot be ignored largely because it has given rise to a considerable literature, a tiny portion of which has fortunately served to uncover new sources for the history of spectacles. The search for the identity of the inventor, never named by Giordano or in the Pisan Chronicle, was begun in earnest by Florentine or Tuscan scholars in the late seventeenth century. This story has been well documented by Rosen but with such exhaustive details that at times they tend to overwhelm the main lines of his exposition. It will be recapitulated here in its barest outline because some of the deliberately false claims made at that time are still being repeated today, and they need to be obliterated once and for all. Also the story itself reveals a marked contrast between the attitude displayed on this matter by the Florentines of three centuries ago and

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mentioned may be explained by the relatively small quantity produced at this early date and by the paucity of Pisan records about the manufacture of glass products until the early fifteenth century.

30. The *Vocabolario degli accademici della Crusca* (Florence, 1612), p. 565, reproduced the above quoted passage from Giordano's sermon to establish the first use of the word. S. Battaglia, *Grande dizionario della lingua italiana* XI (Turin, 1981), p. 757, and N. Tommaseo and B. Bellini, *Dizionario della lingua italiana* IV (Turin, 1929), p. 559, follow suit.

31. Rosen, "The Invention," p. 201, drew attention to this possible earlier use of the term "ocularia" in the prologue to book IX ("De artificibus et rebus artificialibus) of the *Summa* (Cologne, c. 1485), but he did not establish a personal connection between Giovanni and Bartolomeo. For a brief treatment of Giovanni's life and works, see A. Dondaine, "La vie et les oeuvres de Jean de San Gimignano," *Archivum fratrum praedicatorum* IX (1939), pp. 128–83, where the approximate dates of his birth, death, and composition of the *Summa* are given.

32. I have discussed these questions with relative bibliography in my article, "Renaissance Florence: The Optical Capital of the World," *Journal of European Economic History* 22/3 (1993), pp. 509–11.

that of their present day compatriots, who are not only blissfully unaware of the entire question regarding origins, but even ignore entirely Florence's subsequent pre-eminent role in the early development of spectacles as attested by their own documents.[33]

The Pisan origin of spectacles was first put forth by Carlo Roberto Dati (1619–76), a professor at the University of Florence, in a lecture he delivered in 1673 at the famous Accademia della Crusca. This lecture was revised subsequently and finally published posthumously, incorporating information from the Pisan Chronicle and the Annals as excerpted with deliberate inaccuracies by his good friend, Francesco Redi (1626–97), chief physician at the court of the Grand Duke of Tuscany and a renowned scholar with "a perverse pleasure in perpetrating literary frauds," according to Rosen.[34] Redi's private agenda included making it appear that Spina was in effect the virtual inventor or at least the second inventor since the first had refused to divulge the secret. He liked the striking similarity between Spina and Galileo, another Pisan, who had made his own telescope just from a report about such an instrument supposedly invented in Holland without having seen the instrument itself. Though Redi was born in nearby Arezzo, he had strong Florentine sympathies, which even led him to manufacture a document in order to give Florence some role at least as far as the first mention of the invention was concerned. He claimed to possess a manuscript, *Treatise on the Management of the Family,* written in 1299 by a certain Sandro di Pippozzo in which the author mentioned spectacles as a new invention: *I find myself so burdened by age that I would not have the capacity to read and write without glasses, called eyeglasses, discovered most recently for the relief of the needy elderly when their sight declines.*[35]

If this quotation could be verified, it would be the earliest mention of spectacles, antedating both Giordano's sermon and the Pisan Chronicle, and even the first Venetian mention of 1300, although the Venetian source does not seem to have been known to Redi. Clearly, it was a spectacular find, had it been genuine. But the manuscript was never published or shown to scholars for examination and comment and there seems to be no trace of this Sandro. It was too good to be true; had it been otherwise, Redi would

33. Perhaps the most revealing evidence of this phenomenon is the fact that the multi-volume history of the Florentine artisan industry, which will be cited frequently in this study (*Arti fiorentine: La grande storia dell'artigianato*), still in course of publication, originally did not envisage a chapter on spectacle making. I was asked to write such a chapter for the second volume (1999) while it was in the last stages of preparation.

34. "The Invention of Eyeglasses," I, p. 16.

35. Redi, *Lettera intorno all'invenzione degli occhiali all'Illustrissimo Signor Paolo Falconieri* (Florence, 1678), pp. 7–8. After commenting on the similarity between Spina and Galileo as inventors, Redi added the following: "Che ne' tempi di Frate Alessandro Spina venisse in luce la invenzione degli Occhiali, io ne ho un'altra particolare riprova, imperocchè tra' miei libri antichi scritti a penna ve ne è uno intitolato, *Trattato di governo della famiglia di Sandro di Pippozzo, di Sandro Cittadino Fiorentino fatto nel 1299, assemprato da Vanni del Busca, Cittadino Fiorentino suo genero.* Nel proemio di tal Libro si fa menzione degli Occhiali come di cosa trovata in quegli anni: "*Mi truovo cosie gravoso di anni, che non arei valenza di leggiere, e scrivere sanza vetri appellati okiali, truovati novellamente per comoditae delli poveri veki quando affiebolano del vedere.*" The italics are in the original, but I have added the quotation marks for Sandro's words and I have amended the punctuation slightly for clarity.

have exhibited the manuscript and used it at least as the occasion for one of his lectures. We must agree with Rosen that the manuscript was a pure invention.

Only six years after the publication of Redi's alleged discovery, another hoax of far greater import and lasting effect was perpetrated by another Florentine patriot, Ferdinando Leopoldo del Migliore. In his book, *Firenze città nobilissima illustrata (Florence, Most Noble City Illustrated),* (1684), he claimed to own the manuscript of a burial register of the recently renovated Church of Santa Maria Maggiore, which revealed the name of the inventor of spectacles not named in the Pisan Chronicle. He was, of course, a Florentine, Salvino degli Armati, whose reclining statue adorned with his epitaph had once existed within the church, but had been obliterated during the restoration. The burial register recorded all this, he claimed, but like Sandro's manuscript, it was not produced for anyone to see and it has never been found. The famous or rather infamous short epitaph, which has been published far too many times, but should appear here again for the completion of our story, reads as follows: *+Here lies Salvino, son of Armato degli Armati of Florence, inventor of eyeglasses. May God forgive his sins. A. D. 1317.*[36]

This hoax was given wider currency by another Florentine super patriot, Domenico Maria Manni (1690–1788), who wrote an entire book to support and expand on Del Migliore's "discovery": *Historical Treatise on Eyeglasses, Invented by Salvino Armati, Florentine Gentleman* (1738).[37] But Manni's twisting of available evidence could not effectively fit a mythical Salvino in the genealogy of this family within the dates already established by Giordano's sermon and the Pisan chronicle, as was pointed out at the end of the eighteenth century by various critics. Nor could Spina be made a member of the distinguished Florentine Spini family, despite a rough similarity in the name, as some other Florentines were claiming in order to take from a sister Tuscan city the honor of the first connection to the invention. Nevertheless, despite the already exposed elements of the fraud, the renowned historian Pasquale Villari composed a plaque in 1885 honoring Salvino's memory as inventor of spectacles, which was placed on the supposed house of the Armati family in the Chiasso degli Armati, a short blind alley located about midway between the Churches of Santa Maria Maggiore (the Armati's parish church) and Santa Maria Novella where some of them were buried. The plaque, no longer extant except for its imprint on a corner house of the Chiasso degli Armati and Via del Giglio, used to read as follows:

36. Rosen, "The Invention of Eyeglasses," II, p. 184. I have slightly amended Rosen's translation. The original reads as follows: "+Qui diace Salvino d'Armato degl' Armati di Fir., Inventor degl'occhiali. Dio gli perdoni la peccata. Anno D. MCCCXVII," quoted from the facsimile edition of *Firenze città nobilissima* (Bologna, 1968), pp. 431–32.

37. *Degli occhiali da naso inventati da Salvino Armati, gentiluomo fiorentino. Trattato istorico* (Florence, 1738). Briefer versions of his claims had appeared earlier in his other books: *Dell'invenzione degli occhiali da naso. Ragionamenti accademici* (Florence, 1729), p. 125; and *De Florentinis inventis commentarium* (Ferrara, 1731), pp. 52–55.

To honor the memory of Salvino degli Armati, inventor of eyeglasses in the thirteenth century, the brotherhood of his fellow-craftsmen on 5 July 1885 placed this plaque here, where stood the houses of the Armati; celebrating their twenty-fifth anniversary, they [the brotherhood] wanted to remember the name of a citizen who knew how to use his work for the benefit of the human race. (Pasquale Villari).[38]

A real monument, the first, had been erected in the meantime to this mythical Salvino, moved about from the cloister to the Church of Santa Maria Maggiore, and then deposited in the chapel of the Orlandini del Beccuto family in the same church. This strange monument was gradually and grotesquely put together from about the middle to the end of the nineteenth century. Briefly, it is a mismatch of a fake portrait head of the "inventor" in late ancient Roman style, fastened on a wall above a plaque containing del Migliore's invented epitaph (with minor modernizing revisions), and overlooking a prone statue of Bruno Del Beccuto of the fifteenth century, made to fit on a sarcophagus of an unidentified family by cutting off his feet on which only the date "1272" is legible. The complex and confusing character of this anachronistic combination of marble body parts as it were, outlined here in an abbreviated form, can be gathered from the following amusing passage published by Isidoro del Lungo, the Florentine scholar who penned the most devastating exposure of the hoax in 1920:

a Del Beccuto of the fifteenth century, lying on a thirteenth-century sarcophagus of some other family; sarcophagus and Del Beccuto accommodated to each other's size as well as could be; dominating this handsome hodgepodge, a Greco-Roman head on a nineteenth-century base, with an inscription (also nineteenth-century) fabricated in the seventeenth century; the whole thing to honor and glorify a Florentine artisan and commoner, who had been a member of the Seignoiry and of other magistracies of his Commune in the fourteenth century, and of whom before the seventeenth century nobody ever dreamed that he had invented eyeglasses.[39]

38. Rosen, "The Invention of Eyeglasses," II, p. 184, n. 159, translated the quotation up to the "house of the Armati." I have amended slightly his translation and translated the rest of it from the original as follows: "Ad onorare la memoria di Salvino degli Armati, inventore degli occhiali nel secolo XIII, la fratellanza artigiana, qui dove furono le case degli Armati, pose questa lapide il giorno V luglio MDCCCLXXXV, celebrando il suo XXV anniversario, essa volle ricordare il nome di un cittadino che seppe col lavoro rendersi benefico al genere umano. (Pasquale Villari)." For the text, see now, *Lapidi in Firenze: Storie e personaggi che hanno fatto grande questa città*, ed. F. Niccolai (Florence, 1995), p. 205. It is strange that at this late date Salvino should be included in this collection celebrating those who had made Florence great even though the editor added the following warning: "Salvino Degli Armati, per molto tempo fu ritenuto l'inventore degli occhiali, ma non esistono documenti certi o prove plausibili."

39. Rosen, "The Invention of Eyeglasses," II, p. 197. I have again amended Rosen's translation after comparing it to the original by Del Lungo, "Le vicende d'un'impostura erudita (Salvino degli Armati)," *Arch. stor. italiano* LXXVIII, vol. I (1920), 48–49: "un Del Beccuto del Quattrocento, giacente sopr'un sarcofago del Dugento e di altra qual si voglia essere famiglia; sarcofago e Del Beccuto acconciati a misura l'uno dell'altro, come meglio si potesse; e dominatrice di questo bell'accozzo, una testa greco-romana sopr'una mensola ottocentesca, con epigrafe (pure ottocentesca) manifatturata nel Seicento. Il tutto a onore e gloria di un popolano e artigiano fiorentino, che fu della

This example of *campanilismo* (parochialism), though extreme, is not surprising given its recurrent presence in Italian history at least since the Age of the Communes. What is really surprising is the incredibly crude and clumsy execution of the hoax in one of the most culturally sophisticated cities in Italy and Europe. Remarkable is also its three-century duration, finding repeated mention in guidebooks and specialized literature about spectacles right to the present.[40] When the celebrated medieval scholar and novelist, Umberto Eco, revealed in *The Name of the Rose* (1983) with his customary tongue in cheek that the Franciscan Friar William had received a pair of spectacles as a gift from the "great master, Salvino degli Armati," he popularized the hoax worldwide.[41]

Mercifully, the last edition of the authoritative guidebook for Florence issued by the Touring Club Italiano mentions the prone statue of Bruno del Beccuto in the chapel of Santa Maria Maggiore, but not a word about the portrait of Salvino, whose name is not even listed in the index.[42] Likewise, the *Dizionario biografico degli italiani* has no

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Signoria e di altre magistrature del suo Comune nel Trecento, e che prima del Seicento nessuno mai sognò avesse egli inventato gli occhiali." This is only a summary of a very complex hoax, the details of which can be read in the preceding pages, pp. 43–48. Del Lungo, however, believed that Spina was the inventor even though he made ample use of an earlier effective debunking of the Migliore-Manni thesis published by Albertotti, the ever-alert defender of the Venetian priority in the invention: "Note critiche e bibliografiche riguardanti la storia degli occhiali," *Annali di ottalmologia* XLIII (1914), pp. 328–56. It should be added that sometime before 1999 (the year of my first visit) the plaque was removed and placed almost hidden on the left side of the altar in the chapel.

40. Del Lungo, "Le vicende," pp. 42–53, cites several passages from early guidebooks or general books about Florence. In a beautifully illustrated book by P. Marly, *Spectacles & Spyglasses*, with texts by J-C Margolin and P. Biérent (Ligugé, Poitiers, 1988; orig. French ed., Paris, 1980), Marly wrote as follows about the invention of spectacles, p. 10: "Even recently, historians have been debating who first had the idea, out of the English scholar Roger Bacon, the monk Alexander Spina, doctor Bernard de Gondon [sic] in Montpellier or the Florentine gentleman Salvino d'Armati, who is most frequently credited with the invention (on his tombstone in Florence the following epitaph is to be read. . . ." Another glaring error occurs on p. 14: "Galileo invented the telescope in 1609," a fact that Galileo himself denied. On p. 89, Biérent again attributes the invention to Salvino. Rosen's article appears in the bibliography but cited only by the name of the journal and apparently was not consulted. My first article on spectacles (1976) appears in the bibliography but with "Florence" omitted from the title. Worse yet, two books I never wrote are listed under my name: *Fashions in Hair: The first five thousand years* (London, 1965), and *Fashions in make up from ancient to modern times* (London, 1972). And only Ronchi's early publications are listed. This beautifully designed book, marred by gross errors, is based largely on Marly's optical collection and museum in Paris, probably the most extensive collection in the world, which was sold in 2000 to the Essilor Corporation. The new owners continue to maintain the museum.

41. In Eco's novel, *Il nome della rosa* (Milan, 1980), eyeglasses and their use are mentioned several times on pp. 82, 94, 169, and 278. Surprisingly the lenses are described as "mandorle di vetro spesse come fondi di bicchiere," (p. 82) although the friar calls spectacles "lenti," clearly derived from "lenticchia," the commonly accepted etymology of the word. The word "occhiali" does not appear in the novel, even though Friar Giordano da Pisa is mentioned (p. 94). On the same page, Friar William of Baskerville reveals his contact with Salvino: "Io ne ebbi un paio in dono da un grande maestro, Salvino degli Armati, più di dieci anni fa, e li ho conservati gelosamente per tutto questo tempo, come fossero—quali ormai sono—parte del mio stesso corpo." The account is chronologically correct since the story begins at the end of 1327.

42. *Firenze e provincia*, 7th ed. (Milan, 1993), p. 263. It is interesting to note that in the preface by Giancarlo Lunati, President of the Touring Club Italiano, he states that in the preceding editions perhaps there was too much emphasis on the "myth of Florence," as the "New Athens," and that the present edition attempts to tone down the panegyric in favor of a more correct and balanced presentation: "Questa guida . . . al mito di Firenze cerca di sottrarsi." The omission of Salvino degli Armati seems to be part of this effort.

entry for Salvino or for the Armati family of Florence. On the other hand, the *Dizionario enciclopedico italiano,* vol. I (1955), lists Salvino but only to register the false attribution by Del Migliore.[43] Perhaps we may now see the end of this legend for in the last analysis Florence has too many legitimate accomplishments to include a false one in their company. Fortunately for Florence, the history of spectacles has never remotely approached the popularity of Shakespeare so that tourists, who in the summer already number seven out of ten pedestrians in its historical center,[44] do not flock to see Salvino's tomb the way they do in Verona to gape at the other celebrated hoax, Romeo and Juliet's tomb.

For our purposes, the Salvino story has interest above all in revealing the contrasting attitudes of the Florentines in different centuries about this most useful of inventions, even as their leadership in this field is now well documented, as will be shown in later chapters. At the same time, the scholarly debate it generated has served to uncover as many sources as could be found about early mentions of spectacles, once again to buttress Florentine claims. It is noteworthy to mention, however, that among the several exaggerated or simply false statements published by Manni, one about the preeminence of the Florentine spectacle making industry over its rival in Venice, at least in the fifteenth century, has been confirmed by my own already published research, and will be further documented in the course of the present study.[45]

The First Pictures

False, however, is Manni's assertion that Domenico Ghirlandaio was the first painter ever to depict eyeglasses with his *St. Jerome in His Study* (1480) in the Ognissanti Church of Florence.[46] This distinction belongs to an Emilian painter working in the Veneto more than a century earlier. Manni might not have been aware of the fact that the first known portrait of a person wearing (anachronistically) the earliest form of spectacles—the centrally riveted type—is that of the French Dominican Cardinal Hugh of St. Cher (ca. 1200–63), which is part of a series of frescoes adorning the Chapter House of the

43. "Armati, Salvino degli.—Uno dei pretesi inventori degli occhiali, fiorentino (m. 1317). L'attribuzione ebbe origine da un falso di F. M. Del Migliore (1684), ed è stata creduta vera per oltre due secoli," p. 637.

44. This figure was established as a result of a recent survey carried out in Florence and cited in the preface of the Touring Club guide cited in n. 42.

45. This claim was made by Manni in his *Degli occhiali da naso,* pp. 78–9: "Egli è qui però anche da ricordare, come avanti, che nella industriosissima Città di Venezia si trasportasse la eccellenza di questo lavorío [spectacle making], senza però lasciarne priva la Città nostra, che tuttora ne conserva I professori, quivi, e non altrove fioriva; imperciocchè omettendo alcuni passi di Scrittori, che dimostrano come tra noi il mestiero del *Fa gli Occhiali,* così allora chiamato, avea sempre diversi artefici in esso impiegati; . . ." I have already published much evidence supporting this claim in my article "Renaissance Florence."

46. "Domenico Grillandajo fu dei primi pittori e assolutamente il premiero che gli occhiali dipignendo ponesse in veduta," as quoted by Albertotti, "Note critiche," p. 339.

66. Barisini, Tomaso da Modena, *Cardinal Hugh of St. Cher*, 1352, Chapter House, Dominican monastery of San Nicolò, Treviso.

67. Idem, *Cardinal Nicholas de Fréauville*, 1352, Chapter House, Dominican monastery of San Nicoló, Treviso.

Dominican monastery of San Nicoló in Treviso, begun in 1351 and completed the following year by Tomaso Barisini da Modena (1325/26–1379). (Fig. 66). The frescoes represent forty luminaries of the Dominican Order in their study-cells in characteristic scholarly poses, surrounded by books and various writing implements such as inkhorns and quill pens, including an X-shaped pair of scissors, a precursor of the modern type, depicted for the first time in a work of art. Such attention to the details of everyday scholarly life, and the naturalistic drawing of the friars' faces as they seem absorbed in their various activities, have established Tomaso as a pioneer in this kind of realistic and detailed representation, anticipating the Flemish style of painting of the following century.

Beginning with the founder himself, St. Dominic, this pantheon of early leading or prominent Dominicans includes obviously the great scholars-theologians, Thomas Aquinas and Albert the Great. In addition to Hugh of St. Cher, two others are represented with vision aids—the French Cardinal of Rouen, Nicholas de Fréauville (d. 1325), who is reading with a magnifying lens (Fig. 67), but in view of his life span he could have been depicted more realistically with the recently invented spectacles; and the prominent Italian preacher, Pietro Isnardo da Chiampo of Vicenza (d. 1244), whose

68. Idem, *Pietro Isnardo da Chiampo of Vicenza*, 1352, Chapter House, Dominican monastery of San Nicolò, Treviso.

shelf above his desk contains a concave reading mirror mounted on a metal stand[47] (Fig. 68). And Tomaso also represented another reading mirror, this time enclosed in a horn-shaped leather case probably filled with sand for balance, in his column-fresco of *St. Jerome* (ca. 341–420) in the nave of the attached church of S. Nicolò, which was painted shortly after his frescoes in the Chapter House.[48] It may be added here parenthetically that thenceforth St. Jerome, the translator of the Bible and long a patron saint of scholars and especially venerated by the Dominicans, was often represented in his study with the customary instruments of scholarship, including a reading mirror and a pair of spectacles.[49] Perhaps the saint's own admission that weak sight during his extreme old age

47. For a detailed description and analysis of Tomaso's frescoes, see especially R. Gibbs, *Tomaso da Modena: Painting in Emilia and the March of Treviso, 1340–80* (Cambridge, 1989), pp. 50–87, 257–67, which has served as the basis for this discussion. See also F. Zuliani, "Tomaso da Modena," in *Tomaso da Modena. Catalogo della Mostra*, Treviso, S. Caterina-Capitolo dei Domenicani, 5 luglio–5 novembre 1979, ed. L. Menegazzi (Treviso, 1979), pp. 75–129.

48. Gibbs, *Tomaso da Modena* 85, pp. 100–04, n. 180.

49. St. Jerome was represented both as a scholarly saint as well as a penitent during the Renaissance. See B. Ridderbos, *Saint and Symbol. Images of Saint Jerome in Early Italian Art*, trans. P. de Waard-Dekking (Groningern, 1984), especially p. 45 where there is a reproduction of *St. Jerome in His Study* (1440–50), by Colantonio, now in the

prevented him from reading the closely written Hebrew texts under the light of an oil lamp, and with difficulty even in sunlight, led to this tradition of his association with reading aids to the point that by the seventeenth century he was considered the inventor of spectacles. Tomaso, however, represented him accurately with a vision aid available in Jerome's time.[50]

The real optical novelty conveyed by the frescoes in the Chapter House, however, was the first depiction of spectacles in a work of art discovered to date. It is also of interest that the frescoes depicted the concomitant use of convex lenses and concave mirrors as magnifiers as part of the scholar's equipment, making the obvious point that spectacles alone would not suffice for especially fine work. In brief, the three optical aids are illustrated as being used very much like we use them today after centuries of spectacle wearing. There is little doubt that both Tomaso and the Dominicans at San Nicoló were familiar with the use of these magnifiers and did not wish to convey the impression of novelty in the iconography. In fact, the magnifying properties of both plano-convex lenses and concave mirrors were known for several thousand years before the birth of Christ, although the actual optical use of the former in the ancient world has been debated and only in recent years has been gaining wider acceptance.[51]

It is not surprising that Tomaso da Modena's interest in the details of daily activities, especially his pioneering depiction of optically aided work, can provoke scholarly investigations in various directions. His seemingly capricious depiction of spectacles on the nose of a person who had died some twenty years before their invention, while withholding them from others contemporary with their first use, started a trend to anachronistically depict scholarly and saintly figures with glasses. It also has raised some questions about the criteria used by him or his Dominican advisers in choosing the persons to be depicted with optical reading aids among so many scholarly and/or saintly Dominicans. This is an interesting and complex question but of peripheral interest to our present task, and one that can be better pursued at another occasion. For our present purposes, it is more appropriate to treat the diffusion of the use of spectacles, especially at Treviso and the Veneto region prior to the initiation of the above-mentioned frescoes.

It is most likely that by the middle of the fourteenth century the Dominicans at Treviso, and probably the painter himself, had read or heard of Giordano's 1306 sermon given that his approximately seven hundred vernacular sermons were avidly recorded,

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Museo Nazionale in Naples, which shows a reading mirror on his desk and a spectacle case dangling from a book shelf above the desk. See also two articles by M. Meiss, "French and Italian Variations on an Early Fifteenth-Century Theme: St. Jerome and His Study," *Gazette des Beaux Arts* LXII (1963), pp. 147–70, and "Scholarship and Penitence in the Early Renaissance: The Image of St. Jerome," *Pantheon,* (1974), pp. 134–40. Neither Ridderbos nor Meiss, however, comments on the display of the two vision aids.

50. G. Albertotti, "Dagli occhiali di Fra Ugone allo specchio di San Gerolamo," *Atti del Reale Istituto Veneto di Scienze, Lettere ed arti* LXXXVII/2 (1928), pp. 553–56.

51. See below, pp. 33–45, for a discussion of this question.

collected, and widely disseminated as it is attested by the great number of surviving manuscripts, rivaling the corpus left by San Bernardino of Siena a century later.[52] On the other hand, it is doubtful that they would have had knowledge of the Pisan chronicle, which was intended as a sort of necrology for local use.

The Florentine sermon alone, however, gave a clue that spectacles had a Pisan or at least a Tuscan origin and this message must have been repeated by Friar Giordano during his travels. Like many other Dominicans, he was a much traveled man, studying, teaching, and preaching in various Dominican monasteries and churches before and since the date of the invention: Bologna and Paris (1284–86); Siena (1287); Perugia (1288, 1294); Viterbo (1295); Florence (1302–05, 1306–07, 1309); and he died in 1311 at Piacenza while on the way to Paris to study and teach. He may have traveled to other places as well, perhaps as far as Cologne, but this cannot be firmly established.[53] It is also likely that he carried one or more pairs of spectacles for his own use during his travels and showed them to colleagues, some of whom may have learned to make them. Monks did, in fact, continue to make spectacles, as it is further documented below.[54] Then other Dominicans undoubtedly visited the monastery of Saint Catherine at Pisa itself during this period and saw spectacles being made by Spina, who outlived Giordano by two years, and perhaps by other friars with similar skills. And we may just as easily suppose that the original unknown optician continued to make glasses for the lay trade, so to speak, because scribes, book illuminators, goldsmiths, tailors—indeed all artisans working on fine and detailed designs—could use spectacles, depending on their age, in addition to magnifying lenses and concave mirrors.

Once the process of making glasses had been revealed, it would not have taken long for artisans and monks everywhere to learn the craft and satisfy the enormous demand for an article that extended the comfortable working life of people in virtually all professions. Despite the scarcity of early documents, one can be bold in assuming, therefore, that the diffusion of the invention must have radiated rapidly and widely within the much-traveled community of monks, scholars, and merchants. And as I have noted above, there was an established spectacle making industry in Venice even before Giordano made his announcement. In brief, by the time Tomaso da Modena painted his frescoes, almost three generations of persons in Italy and probably outside the peninsula

52. For the popularity of Giordano's sermons, see now D. R. Lesnick, *Preaching in Medieval Florence: The Social World of Franciscan and Dominican Spirituality* (Athens, Georgia, and London, 1989), p. 111: "The fact that members of Giordano's audience so conscientiously recorded his words, which then enjoyed great diffusion (if we can judge by the unusually large number of extant manuscripts), is indicative of remarkable contemporary interest. . . ." Thus the monumental collection of this material represents a truly significant lay initiative. Indeed, no similar situation obtains for any other preacher, time, or place in western Europe until more than a century later, again in Tuscany, in the case of San Bernardino da Siena, many of whose sermons were likewise recorded verbatim and at the scene of delivery by an eager listener.

53. For Giordano's travels, see Delcorno, *Giordano da Pisa,* pp. 9–24.

54. See ch. V, pp. 176–78.

had used spectacles, and knowledge of them and perhaps of their place of origin, must have been widespread given the announced intention of the Dominicans to spread the word for the benefit of mankind.

While the Dominicans led the way in the manufacture, propagation, and depiction of spectacles, as we have seen, their Franciscan rivals were also prominent in optical theory[55] and second in artistic representation of spectacles. The second pictorial representation of a bespectacled person occurred in the Lower Church of St. Francis at Assisi, in the Chapel of St. Catherine of Alexandria (Egypt), which became the burial chapel of Cardinal Albornoz (d. 1367). Here the painter Andrea de' Bartoli da Bologna, a contemporary of Tomaso, was commissioned by the Cardinal's heirs to execute a series of frescoes celebrating the legend-shrouded life of St. Catherine, a scholarly young woman who was tortured on the wheel and executed (305) by the Roman Emperor Maximinus as punishment for having converted various pagan philosophers and the Empress herself with the power of her learning. As a virgin and martyr she became the patron of cloistered nuns and young women, while the spiked wheel of her torture along with a book became part of her iconography as a saint, prompting wheelwrights and other artisans as well as scholars to adopt her as a patron. This saint for all seasons, as it were, became one of the most popular of the later Middle Ages and was particularly venerated at Bologna as a patron of scholars.[56]

In Bartoli's little-known fresco in the above mentioned chapel, *Philosophers Confronting St. Catherine*, one of the philosophers holds a pair of rivet spectacles clamped on his nose with his left hand, and another holds a magnifying lens with his right hand while reading an open book resting on his knees while another figure pointed to a specific passage (Figs. 12, 13).[57] Gibbs points out that "it is hardly a coincidence that the second representation of spectacles is by a Bolognese artist contemporary with Tomaso, Andrea de' Bartoli, who shows the *Philosophers Confronting St. Catherine* in Cardinal Alborñoz' burial chapel at Assisi (1367–9) using both these instruments [spectacles and magnifying lens] in just the same way. There was clearly a Bolognese tradition established by 1360, probably by Tomaso himself, since of all the Emilian painters he shows the greatest curiosity about the appearance of things."[58] One can also add that in both cases the figures using

55. See below, pp. 27.

56. For a brief biography of St. Catherine, see L. Clugnet, "Catherine of Alexandria," *The Catholic Encyclopedia*, III (New York, 1908), pp. 445–46. The article by M. J. Costelloe in the *New Catholic Encyclopedia* III (New York, 1967), p. 253, is too brief and adds nothing new.

57. For a description and photographs of these frescoes, see L. Coletti, *Gli affreschi della basilica di Assisi* (Bergamo, 1949), pp. 67–69 and plates 186–200. Additional information was published by S. Nessi, *La basilica di S. Francesco in Assisi*, 2nd ed. (Assisi, 1994), pp. 326–29 with an enlarged photograph of the person holding the magnifying glass, plate n. 114. See also E. Castelnuovo, "Andrea da Bologna," *Dizionario biografico degli italiani* III (Rome, 1961), pp. 81–83, and F. Arcangeli, *Pittura bolognese del '300* (Bologna, 1978), 164–65, pp. 174–77.

58. Gibbs, *Tomaso da Modena*, p. 84, for the quotation; see also, p. 202 for this additional comment on this question: "Andrea himself appears to have adopted Tomaso's fascination with not only optical instruments but

 

12–13. Bartoli, Andrea dei, *Philosophers Confronting St. Catherine*, ca. 1367, Chapel of St. Catherine of Alexandria, Lower Church of St. Francis, Assisi. (Archivio fotografico Sacro Convento, Assisi).

the magnifying lens hold it close to the eye and far from the book, which would result in an out-of-focus image, whereas such a lens is normally held closer to the reading matter for clarity. Yet both artists and/or their patrons had almost certainly used this vision aid and should have known the proper focal point unless they chose to ignore this detail for artistic reasons. It is noteworthy that the sacristy of this church was provided with at least one "crystal magnifying lens" as listed in an inventory of 1338, and eight pairs of "silver spectacles" were noted in a later inventory of 1473.[59]

It would appear, then, that Tomaso influenced Bartoli in his rendering of optical devices and other naturalistic details of everyday life although there seems to be no evidence that he actually saw Tomaso's frescoes at San Nicoló. It is known, however, that there were several artists from the Romagna and Emilia regions among a colony of some seventy painters working at Treviso at that time, and it would be surprising if some mention, or less likely, a description, of Tomaso's frescoes at San Nicoló and other

also writing implements. . . . Andrea's artistic character is similar to Tomaso's though less assured: he was Cardinal Alborñoz' 'court artist', and there seems to be a symbiosis between his work and Tomaso's in the 1360s and '70s."

59. See L. Alessandri and F. Pennacchi, "I più antichi inventari della sacristia del Sacro Convento di Assisi (1338–1473), *Ärchivum franciscanum historicum* VII (1914), p. 80, no. 72: "Item una [sic] cristallus oculare, ad legendum;" p. 105, no. 248: "Item paria oculorum de argento, 8."

churches at Treviso did not reach Andrea in the interval of about fifteen years.[60] Even though the frescoes in the Chapter House were not meant to be generally accessible to the public, visiting Dominicans and distinguished guests, and possibly other artists, would surely be shown such splendid representations of prominent members of the Order, and they would surely have spread the word.[61] It still remains possible, of course, that Bartoli may have acted independently altogether. At Bologna with its famous university and at Assisi among the Franciscan friars he surely saw many spectacles and magnifying lenses crying to be used in scenes depicting the life of a scholarly saint so closely associated with his native city. On the other hand, it seems to be a pure coincidence that a monastery dedicated to St. Catherine at Pisa should be the home of the second optician in history whereas a chapel dedicated to the same saint at Assisi should hold the second representation of a bespectacled person in art history, albeit anachronistically.

The earliest pictorial representations of spectacles discussed above, however, do not give a clue to their place of origin. It is significant that it should have taken two painters from Emilia and Romagna interested in the implements of daily scholarly life rather than either Tuscan or Venetian artists to record for posterity the most advanced reading aid of that age. In Appendix III we shall present abundant pictorial evidence produced in Italy outside of these two regions and discuss the possible reasons for this phenomenon. In any case, the Pisan origin of spectacles has not been seriously challenged, though it is not absolutely certain, as Rosen himself admitted by concluding that the inventor "was definitely not a Florentine, and Pisa has a better claim on him than any other locality."[62] It has been speculated by Ronchi that the inventor was probably an elderly glass worker who, in the process of handling convex shaped glass disks for making leaded windows, discovered by chance that by placing them close to the eyes, he could see objects more clearly on the other side. Perhaps so, but one may add that anyone possessing two convex pieces of glass, already used with frames and handles as magnifiers for reading and other purposes as shown in the frescoes at Treviso and Assisi, could have had the bright idea of connecting the two frames centrally to create the first pair of spectacles. Whether this stroke of inventiveness occurred to the same perceptive glass worker or to another person of any profession and much earlier in time remains a mystery. Indeed, it is entirely possible that others in Italy or elsewhere may have had the same bright idea

60. L. Gargan, *Cultura e arte nel Veneto al tempo del Petrarca* (Padua, 1978), p. 261–307, gives biographical sketches of these artists. Treviso was, indeed, a prosperous trading center at this time, attracting various monastic orders as well as artists to work on their churches. For a brief discussion of this interaction, see also C. Volpe, "La pittura emiliana del Trecento," in *Tommaso da Modena e il suo tempo. Atti del Convegno di studi per il 6° centenario della morte, Treviso 31 agosto–3 settembre 1979* (Treviso, 1980), p. 237–48.

61. Although stressing the restricted access to the Chapter House, Gibbs, *Tomaso da Modena*, p. 67, believes that its decoration achieved a certain prominence already in the fourteenth century: "Yet even then it would appear to have made an impression on those distinguished visitors in it, and perhaps on itinerant artists."

62. Rosen, "The Invention," II, p. 217.

even earlier and had constructed spectacles for their own use without coining a name for them or showing them to others. After all it is well known that several people in Europe claimed to have constructed optical tubes with lenses (later to be called telescopes) in the late sixteenth century and didn't think much of the instruments until Galileo improved them and showed their full potential. Even today one occasionally sees a device produced in a mechanic's shop to facilitate a certain task, which is not propagated in any way and certainly never patented.

Ronchi adds the further point that in time the biconvex glass disks came to be called "*lenti*," an abbreviated form of the Italian word for lentils, *lenticchia*, or *lentes* in Latin from their bulging shape, which once again points to the artisan origin of the new device.[63] That the word *lente* or *lenti* was a common abbreviation for *lenticchia* is further documented by Battaglia's *Grande dizionario della lingua italiana*, which lists many such instances in Renaissance literature beginning with Boccaccio.[64] And this etymology of the word has been accepted by the *Oxford English Dictionary* and by historians of science such as the late Crombie in his monumental work on the history of science from antiquity through the seventeenth century.[65]

Optical Theory

Whatever the circumstances and profession of the unknown inventor, it seems certain that optical theory had nothing to do with the invention even if the inventor were conversant with it, a very unlikely event if he was an artisan. Actually, knowledge of contemporary optical theory would have been an impediment, Ronchi argues.[66] While Rosen agrees that medieval optical theory could not have led directly to the invention of spectacles, he is struck by the fact that the discovery took place not long after the fundamental treatise on perspectivist optics, *Book of Optics* (ca. 1000), by the great Arab

63. "E siccome nessun ragionamento teoretico poteva indurre uno studioso del 1200 a foggiare un pezzo di vetro a forma di lenticchia, si deve concludere che le 'lenticchie di vetro' furono fatte per caso da qualche maestro vetraio, che fondeva il vetro per tutt'altri scopi che per quello di far lenti. Forse per fare conterie o simili gingilli di vetro, o piuttosto per preparare quei dischi di vetro con cui si componevano, legandoli in piombo, le vetrate dell'epoca. Infatti le prime lenti furono adoperate per far leggere da vicino I presbiti, e per questo scopo sono necessarie lenti di potenza non superiore alle 4 diottrie, potenza che può capitare nei suddetti dischi di vetro, mentre I blocchetti di vetro per scopo ornamentale in generale hanno curvature molto più forti. Qualche maestro vetraio assai anziano, deve dunque aver notato che guardando attraverso a delle lentiechie [sic] di vetro poteva vedere ancora distintamente tante cose vicine all'occhio, come quando era giovane e che ora senza tali lenticchie vedeva confusamente. L'osservazione fu ripetuta, confermata, estesa, divulgata, e così nacquero gli occhiali per presbiti." Ronchi, "Storia delle lenti," *Atti della Fondazione "Giorgio Ronchi"* II (1947), p. 4.

64. Vol. VIII (Turin, 1973), p. 947.

65. *Oxford English Dictionary*, 2nd ed.; A. C. Crombie, *Styles of Scientific Thinking in the European Tradition: The History of Argument and Explanation Especially in the Mathematical and Biomedical Sciences and Arts*, vol. I (1994), p. 118.

66. See "Storia delle lenti," pp. 1–4 for Ronchi's discussion of medieval optical theory, based also on his research for the invention of the telescope published five years earlier: *Galileo e il cannocchiale* (Udine, 1942).

scholar, Alhacen, was translated into Latin (*De Aspectibus/Perspectiva*, ca. 1200). This treatise, which focused on sight and visual perception, became the standard textbook on the subject until the beginning of the seventeenth century. It heavily influenced other treatises published in quick succession; namely, *Perspectiva* (ca. 1275) by Witelo, which closely follows Alhacen's exposition; *De multiplicatione specierum* (ca. 1260) and *Perspectiva* (ca. 1265) by Roger Bacon, which were inspired in part by Robert Grosseteste's (d. 1253) treatise on the geometrically based refraction of light (*De iride*); and *Perspectiva communis* (ca. 1280) by John Pecham, a widely disseminated and briefer compendium of perspectivist optics.[67] Since the last three were English Franciscan friars at Oxford University, their writings on the subject are sometimes labeled "Franciscan optics," though they also were influenced by similar writings of Dominican friars such as Albertus Magnus. These treatises were shortly followed by those written by another Dominican, Theodoric of Freiberg (ca. 1255–1315), which will be treated in the next chapter. All of them, of course, based their theories on classical authorities especially Aristotle, Euclid, and Ptolemy, with additional comments and development supplied by the Islamic optical tradition exemplified especially by Alhacen and Avicenna (980–1037).[68] It may also be significant that Bacon, Witelo, and Pecham composed and/or circulated their treatises between 1260 and 1280 while visiting the papal court then residing most frequently at Viterbo.[69]

During this period, in fact, Viterbo became "the European capital for optics," according to Paravicini-Bagliani.[70] Throughout the thirteenth century the papal court also became the center for the study of the human body and its functions in an attempt to preserve health and prolong the lives of popes and cardinals for the good of the Church. More than seventy physicians have been identified at the papal court in Rome and in its temporary quarters in nearby cities, especially during the summer months to escape the malaria-infested areas of Rome and its environs. The study of human biology, alchemy, astronomy, and optics were combined with efforts to discover the proper diet in order to prevent or delay the infirmities of old age and prolong life. Macrobiotics was in vogue even then!

Vision, of course, was a primary concern in this quest. It was perhaps not pure chance that one of these physicians/theologians/philosophers, Master Peter of Spain, became Pope John XXI in 1276 but died eight months later in 1277 apparently as a result of a

67. A collection of key passages on optics by the above writers was conveniently assembled by D. Lindberg in *A Source Book in Medieval Science*, ed. E. Grant (Cambridge, Mass., 1974), pp. 376–441.

68. The interaction of the mendicant orders' contributions with respect to optics has been recently summarized by S. Devons, "Optics Through the Eyes of the Medieval Churchmen," in Pamela O. Long, ed., *Science and Technology in Medieval Society* (New York, 1985), pp. 205–24.

69. This connection has been emphasized most recently by P. Hills, *The Light of Early Italian Painting* (New Haven and London, 1987), pp. 64–71, who also points to a possible influence of the above optical treatises on the representation of light in fourteenth-century painting, especially in Giotto's paintings.

70. A. Paravicini-Bagliani, *The Pope's Body*, trans. D. S. Peterson (Chicago and London, 2000), p. 209; see especially the Introduction and chaps. 7–9 for details on the Viterbo papal court.

fallen ceiling in the papal palace at Viterbo. His learning prompted Dante to place him in Heaven, the only contemporary pope to earn this distinction (*Paradiso*, XII, 134–35), and the only "ophthalmologist" pope ever. Among his other works, Peter had written a most popular clinical textbook on ophthalmology, *Liber de oculo* (Eye Book), which was based on standard Greek and Arabic practices, popular especially at the medical school in Salerno, with additional remedies developed during his own practice. Written as a guide for the practicing general physician, it has diagnostic advice for various diseases of the eye and therapeutic remedies involving proper diet and collyria to apply to the eyes. The latter are standard for the age—concoctions of herbs, biles, urine (especially that of a "virgin boy"), dung, etc. There is not a word about vision aids such as magnifying lenses or concave mirrors, which Peter must have seen and probably used himself. It seems that the objective was to preserve youthful vision and prevent its deterioration by proper diet and allegedly wholesome practices rather than offering remedies for older vision or other refractive errors.[71]

At any rate, with all these writings on visual perception and preservation of sight circulating in learned circles at the papal court and in various monasteries and universities within and outside Italy just a few years before the invention of spectacles, one is tempted to think of some connection. Rosen asks: *May we not envisage an experienced glass-worker whose imagination was stirred by theoretical writings which, although not successful in solving the problem, at least pointed out the direction where the solution lay?*[72]

This question must be answered in the negative on the basis of present available evidence. Even if the experienced glass-worker could have understood the formidable intricacies of geometrically based optical theory written or lectured about in Latin, or even explained to him in the vernacular by others, his imagination would have been led in the wrong direction because medieval theory of vision was based on invalid premises. That theory understood the laws of refraction as applying only to a single lens or refracting surface, and saw the seat of vision lying at the front side of the lenticular crystalline lens of the eye. The visual rays entering the pupil were refracted on its posterior side. Placing a lens before the eye, therefore, would have caused a double refraction and

71. Two ophthalmologists have collated many of the surviving manuscripts and have provided the first English translation of the book with a brief account of the little that is known about Peter and comments on his knowledge of eye diseases. See W. J. Daly and R. D. Yee, "The Eye Book of Master Peter of Spain—A Glimpse of Diagnosis and Treatment of Eye Disease in the Middle Ages," *Documenta Ophthalmologica* 103/2 (2001), pp. 119–53.

72. Rosen, "The Invention," I, p. 30, n. 75. The quotation is immediately preceded by this passage: "Ronchi was confident the inventor found eyeglasses by chance while looking for something else. . . . But if so, why were eyeglasses found about 1286, not long after Ibn al-Haitham's *Optics*, the greatest Muslim treatise on the subject, had been made available in Latin translation, evoking discussions by Grosseteste, Roger Bacon, Witelo and Pecham? Two of these writers had emphasized the possibility of improving human vision by utilizing the refractive properties of transparent media. To be sure, they did not correctly understand the process of vision in the normal eye, let alone the farsighted eye of the aged, nor did they know the true law of refraction. Therefore we can readily agree with Ronchi that the invention did not result from the application of sound theoretical principles. But this conclusion is by no means tantamount with invoking the operation of pure chance."

did not make sense in theory, but it worked in practice for some unexplainable reason. It took three centuries to arrive at a correct visual theory, which established the retina, not the crystalline lens, as the seat of vision. Modern optical theory, in fact, begins with this momentous discovery made by Johannes Kepler at the beginning of the seventeenth century. In the intervening centuries eyeglasses were commonly used empirically first to correct presbyopia and later, as we shall see in the third chapter, myopia, without bothering about optical theory. This gulf between theory and practice, of course, has always existed and it exists today in many fields, including medicine where remedies and procedures are sometimes adopted empirically because of their efficacy but without a real understanding of the operating principles involved.

Ronchi's views on the inadequacy of medieval theory of vision as an impediment to the proper understanding of lenses have been accepted by historians of medieval optics such as David C. Lindberg[73] and A. Mark Smith. The latter has succinctly and masterfully summarized the issues as follows:

> *In a naturally formed eye, . . . parallel rays from distant objects, as well as diverging rays from close objects, will come to proper focus at the retina. If, however, the eyeball is unnaturally elongated, . . . then the rays projected through the crystalline lens will be brought to focus too early, and the result will be nearsightedness. If the eyeball is unnaturally compressed, . . . the rays will be brought to focus too late, the result being farsightedness. In both cases the disorder is due to a misshapen eyeball, and the correction entails no more than refocusing the image properly on the retina. That is easily done by interposing a concave or convex lens of appropriate curvature between the visible object and the eye. . . . So the cure for farsightedness and nearsightedness is no longer a refractive* deformation *(through magnification) but, rather, a refractive* reformation *(through refocusing) of optical images.*
>
> *On its face, this conceptual breakthrough is so simple and elegant as to appear self-evident. Surely someone should have made it before Kepler. But bear in mind what that breakthrough actually entailed. Far more was at stake than a couple of methodological principles or theoretical presuppositions. Far more was demanded than a few adjustments to the prevailing account of vision. To make proper sense of lenses required an entirely fresh start, an alternative theory of sight in which the images formed by the eye have objective*

73. See Lindberg's article, "Lenses and Eyeglasses," *Dictionary of the Middle Ages*, vol. 7 (New York, 1986), p. 539: "The principles of refraction were perfectly understood, but their application was almost always restricted to a single refracting interface. . . . It might be inquired whether a more complete theory of lenses could be found in attempts to trace radiation through the crystalline lens of the eye. Medieval scholars certainly recognized the lenticular shape of this organ and applied ray geometry to it. However, according to the visual theory of the perspectivists (the only medieval scholars with a serious interest in ray geometry), the radiation efficacious in producing sight is that which falls perpendicularly on the crystalline lens; this radiation enters the crystalline lens without refraction and maintains its rectilinear course until it is refracted at the rear surface of the lens. All other radiation is ignored: once again the medieval scholar restricts his attention to a single refracting interface." For a full treatment of various theories of vision, see Lindberg's classic work, *Theories of Vision from Al-Kindi to Kepler* (Chicago, 1976).

existence alone; a theory of sight in which the eye that produces those images is literally blind; a theory of sight in which the analytic perspective is shifted completely and irrevocably to the object; a theory of sight in which perceptual intentionality has no meaningful place; a theory of sight in which all traces of the visual cone have disappeared; a theory of sight in which the physiological link between eye and brain is as incomprehensible as the perceptual one; a theory of sight, in short, that forces a wedge between objective cause and subjective effect.[74]

According to Smith, Kepler himself at first did not fully realize "the implications of his theory," having "merely replaced the crystalline lens with the retina as the primary visual interface and then revised the geometrical model of refraction through the ocular humors."[75] And Kepler in 1604 (*Ad Vitellionem paralipomena*), of course, had the advantage of three centuries of experience in the use of spectacles, the stimulus of much research in the operation of the *camera obscura* as a possible model or at least as an analogy for the eye and the visual process, and the benefit of a series of small steps in anatomical knowledge of the eye. The combination of these factors, which will be treated in the fifth and sixth chapters, contributed to his revolutionary breakthrough.

It is abundantly clear that this theoretical blank spot was the principal reason, as Smith asserts, for the astounding neglect of lenses and spectacles by medieval and early Renaissance theoreticians. They ignored what they could not explain. It is nevertheless surprising that we do not seem to have even a record of failed attempts to study and understand the working of lenses in the scientific literature of the age up to the middle of the sixteenth century with Francesco Maurolico (1554).[76] Lindberg has a plausible explanation:

First, by the time eyeglasses were invented, the creative period in medieval mathematical optics was over. After John Peckham, . . . it is very hard to find a significant writer in the mathematical tradition until the middle of the sixteenth century. In short, nobody was writing the sort of treatise in which a mathematical analysis of spectacle lenses might reasonably be expected to appear. Second, no writer in the mathematical tradition (before, during, or after its creative period) was in the business of solving practical problems. The writer of optical treatises was not an applied scientist, but a natural philosopher. His goal was factual knowledge and theoretical understanding, and as far as refraction was concerned, there was nothing to be gained from a consideration of lenses. Medieval students of optics had quite a thorough and impressive understanding of the principles of refraction at a single interface, and although these principles could easily have been extended to thin

74. Smith, "Ptolemy, Alhazen, and Kepler and the Problem of Optical Images," *Arabic Sciences and Philosophy* 8 (1998), pp. 40–42. For additional discussion of these issues, see also his article, "Getting the Big Picture in Perspectivist Optics," *Isis* 72 (1981), pp. 568–89.

75. Smith, "Ptolemy," p. 42.

76. On Maurolico's attempt, see ch. VI, pp. 237–39.

lenses, such an extension would not have taught them anything about the principles that they did not already know.[77]

To these formidable theoretical constraints, Ronchi has insisted on adding a philosophical obstacle present in the mindset of medieval natural philosophers:

The aim of vision is to know the truth; eyeglasses make figures look bigger or smaller than they would be seen with the naked eye, nearer or farther away, at times distorted, inverted, or colored; hence they do not make the truth known; they deceive and are not to be used for serious purposes.[78]

... The scepticism of mathematicians and philosophers, full of Platonism, prevented the world of high culture from taking into consideration lenses, that were considered deceitful devices and therefore unworthy of serious study; the craftsmen, immune from such prejudices, continued to make lenses and apply them for correcting presbyopia; in time they were able to correct myopia by introducing the use of diverging lenses; ...[79]

This skepticism, according to Ronchi, finally resulted in a general distrust in the sense of vision, leading to what he calls for emphasis, "a conspiracy of silence," ostracizing lenses and spectacles from learned discourse well into the sixteenth century. And this philosophical prejudice, Ronchi adds, was also reinforced by the generally poor quality of early lenses, inadequate fitting of spectacle frames lacking ear pieces, imprecise ordering of spectacles by age category, and imperfect knowledge of various types of visual disorders, all of which would have resulted in blurred or distorted vision by bespectacled persons.[80] In my view, these practical shortcomings could account for some of this prejudice, as it will be further documented in a later chapter, which treats the construction and fitting of spectacles.[81]

The philosophical impediment, on the other hand, has been disputed by other historians of science, who argue that medieval philosophers, whether Aristotelians or Platonists, were aware of the fact well established in antiquity that under various circumstances all senses deceive and are corrected by reason, but the sense of sight was the most important of the five senses for the acquisition of knowledge. "This was the conclusion reached ... by every medieval and Renaissance philosopher who considered the matter," according to Lindberg and Steneck.[82] Ronchi may have been led to exaggerate

77. "Lenses and Eyeglasses," p. 540.

78. Ronchi, *Optics: The Science of Vision*, trans. and revised by E. Rosen (New York, 1957), p. 33.

79. Ronchi, "A Fascinating Outline of the History of Science. Two Thousand Years of Conflict Between 'Reason' and 'Sense,'" *Atti della Fondazione "Giorgio Ronchi,"* XXX (1975), p. 532.

80. Ronchi, "A Fascinating Outline," pp. 529–30.

81. See chap. V.

82. Lindberg and N. H. Steneck, "The Sense of Vision and the Origins of Modern Science," in *Science and Society in the Renaissance. Essays to Honor Walter Pagel*, vol. 1, ed. A. Debus (New York, 1972), pp. 29–45, quotation p. 36. Ronchi defended his views in "A Fascinating Outline," pp. 525–55.

the fallacies of sight mostly because Plato and the Platonists in general distrusted sensation as irrational and sight most fallible of all because of its primary importance in the hierarchy of the five senses. In fact, "when catalogues of the deceptions of sense were drawn up, deceptions of sight always far outnumbered those of the other senses."[83] Reason, however, corrected these fallacies with the help of the other senses. And Aristotle's analysis of the question of primacy was full of nuances and qualifications, depending on the function of a particular sense and its "sensible" object so that at times and in certain circumstances the senses of touch and hearing would have primacy.[84] In fact, in Protestant countries beginning with Luther, there is a tendency in theological writings and in northern European art to place hearing at the head of the list for its obvious importance in hearing the word of God through the preacher's sermon.[85]

It is obvious that an extreme philosophy of skepticism toward sensorial experience in general, and the sense of sight in particular, would have totally stymied progress in any discipline. One must also recall that with Neoplatonism being the predominant philosophy of the Renaissance, and with it being itself a fusion and a reconciliation of various ancient philosophical traditions, it would be difficult to separate the several philosophical strands that influenced the minds of Renaissance intellectuals. Moreover, it would be ironic, indeed, if Florence, the leading center of Neoplatonism was at the same time a premier manufacturing and exporting center of massive quantities of allegedly deceitful eyeglasses, as my published findings as far back as 1976 clearly demonstrate.[86] And additional new evidence to be discussed in the following chapters will make the case for Florence even stronger despite my best efforts to locate more documents revealing a more prominent role for Venice in this activity. Clearly the theoretical obstacles within medieval optical theory outlined above provide the major component in the explanation

83. D. Summers, *The Judgment of Sense: Renaissance Naturalism and the Rise of Aesthetics* (Cambridge, 1987), p. 42. In two chapters, "The Primacy of Sight," followed by "The Fallacies of Sight," Summers neatly and succinctly analyzes many of these issues.

84. Aristotle's views have been analyzed with considerable clarity by A. Stigen, "On the Alleged Primacy of Sight—with Some Remarks on Theoria and Praxis—in Aristotle," in *Symbolae Osloenses*, XXXVII (1961), pp. 15–44. Stigen concludes: "The thesis of the primacy of sight in Aristotle is hardly tenable. Touch and hearing would seem to have an equally valid claim to primacy. But perhaps the most important thing that can be learnt from this inquiry is that the thesis, in the form in which it is usually presented, is too vague and that it may mean too many things to be illuminating and informative. Still, it may be suggestive and in that way fruitful." (p. 44).

85. For analysis and beautiful reproductions of works of art illustrating the five senses, see now L. Konečny, "I cinque sensi da Aristotele a Constantin Brancusi," in *I cinque sensi nell'arte: immagini del sentire*, ed. S. Ferino-Pagden (Venice, 1996), pp. 38–40. The primacy attributed to hearing by Luther, who follows Paul's Letter to the Romans, 10: 17 ("So then faith does come from hearing, and hearing through the word of Christ"), is also stressed by Margolin, "Towards a Historical Semeiology of Spectacles," p. 68, although Margolin believes that the sense of sight was thought to have primacy over the other senses by most Renaissance intellectuals, Aristotelians and Platonists alike.

86. For brevity, I cite only my most recent publication, which contains my latest views and references to my previous publications on this subject: "The Role of Florence in the Development and Commerce of Spectacles," *Atti della Fondazione "Giorgio Ronchi"* LVI/1 (2001), pp. 163–76.

of the neglect of spectacles in scientific texts for approximately three centuries after their discovery.

If medieval and Renaissance scientists and natural philosophers ignored spectacles in their theoretical treatises, they certainly clamped them on their noses and so did thousands of others in all walks of life. We find mentions of them above all in private and state correspondence and mercantile account books, but also in literary compositions, in personal inventories of domestic possessions, and sometimes in wills. A great number of these references are published here for the first time. Artists included spectacles in their works, as we have already seen above and as will be further discussed in Appendix III.

One thing is clear, however: before the age of spectacles, presbyopes were not totally at the mercy of nature, but found means to use magnifiers conveniently to continue productive work, perhaps to a degree that has been underestimated by modern scholars. The use of eyeglasses became a more convenient but not exclusive way to accomplish that goal not through magnification but by correcting the loss of accommodation in the insufficient convexity of the crystalline lens of the aged eye so that the image focused directly on the retina for clear vision. Although the difference between magnification external to the eye and corrective lenses as part of the ocular visual system was not properly understood during the late Middle Ages, spectacle makers and their patrons acted on these principles empirically as the sources make abundantly clear.

Vision Aids Before Spectacles

Documentary and archeological evidence has been accumulating in the last few decades that presbyopes had already found means of improving their vision by means of lenses and mirrors thousands of years before the birth of Christ. These discoveries have raised the old question of whether the ancients had developed spectacles and telescopes since they made use of convex and concave lenses and various shapes of mirrors. This ongoing research has resulted in some tentative conclusions and speculations, which may be confirmed through additional finds. They are succinctly summarized here to provide historical context to our narrative, and to suggest that these vision aids continued to be used in the following centuries including our period. It should be kept in mind, however, that our principal focus is the history and development of spectacles from ca. 1300 to ca. 1600 and not the history of lenses and mirrors in general.

Classical authors such as Aristophanes (c. 450–c. 385 B.C.), Theophrastus (c. 370–c. 288 B.C.), and Pliny the Elder (A.D. 23–79) mentioned the use of plano-convex lenses along with globes filled with water to ignite fires and cauterize wounds. In his comedy, *The Clouds,* Aristophanes makes clear that these burning lenses were available at local pharmacies. Their common availability is also explained by their use to ignite the "sacred" fires in temples of worship and probably in many private homes as well.[87] In fact, archeological excavations at digs in the eastern Mediterranean, dating to as early as the Bronze Age, have uncovered a good number of highly polished plano-convex lenses made of glass and rock crystal (quartz), some of which have a useful magnification as high as 7–9×, apparently shaped on primitive lathes or turning wheels. Most of them have a magnification of 1.5× or 2×, generally suitable for reading and close work. In some cases a hole in the middle or "resting points" freed both hands and allowed artisans to employ their tools under the lenses in much the same way that two convex lenses mounted on adjustable legs are used today for map reading and detail work. It has been speculated also that the same result could have been achieved by suspending globes filled with water before objects to be magnified.[88]

This supposed use has been suggested by the fact that some of these lenses have been found in shops of gem cutters and engravers along with minutely detailed artifacts such as jewels, engraved gold-glass portrait medallions, coins, cylinder seals, and micro-cuneiform tablets. Jewels themselves, such as sapphires, diamonds, emeralds, and garnets, can provide better images than glass lenses when properly shaped—a phenomenon that was most likely known to ancient artisans—and were used in microscopes as late as the early nineteenth century.[89] It can hardly be a coincidence that in the United States jewelers and opticians were "often the same person" up to the early years of the last century.[90] In effect, then, the close proximity of these lenses to finely worked objects has led some scholars to believe that convex lenses were used for magnification and not just for burning, medicinal, and decorative purposes.[91] Moreover, the discovery in Upper

87. See D. Plantzos, "Crystals and Lenses in the Graeco-Roman World," *American Journal of Archaeology* 101 (1997), pp. 451–64; H. C. Beck, "Early Magnifying Glasses," *Antiquaries Journal* VIII (1928), pp. 327–30; and R. Temple, *The Crystal Sun: Rediscovering a Lost Technology of the Ancient World* (London, 2000), pp. 55–120, with several photographs of these early lenses lying on written matter showing surprisingly clear and enlarged letters. A succinct summary is provided by C. Fryer, "Glass and Lenses in Ancient Times," *The Optician* 195 (March, 1988), pp. 22–33.

88. R. Temple, *The Crystal Sun*, pp. 84–85.

89. See A. Frank, "Jewel Lenses," *Ophthalmic Antiques*, no. 60 (July 1997), p. 11.

90. J. Bruneni, "Charles F. Prentice, Opticist," *Hindsight* 30/1 (Jan. 1999), pp. 1–7.

91. In addition to Beck, cited in preceding note, this view is held by G. Sines and Y. A. Sakellarakis, "Lenses in Antiquity," *American Journal of Archaeology* 91 (1987), pp. 191–96, and J. M. Enoch, "Early Lens Use: Lenses Found in Context with Their Original Objects," *Optometry and Vision Science* 73 (1996), pp. 707–15. Enoch (Professor Emeritus of Optometry, Univ. of California at Berkeley), has concluded that "by any definition, the lens-like elements coupled with the objects described above served as lenses and, in each case, resulted in an enlarged upright virtual image. The lens materials used are sufficiently transparent, the plano-convex surfaces are reasonably ground, objects observed through these lenses are adequately defined, and these objects maintained in their original context clearly were intended by the artist/artisan to be visible to an observer. At a minimum, the artisan had to appreciate the resultant optical features. Collectively, these factors provide necessary and sufficient conditions for lens use. . . . What is not clear is whether these lens-objects combinations were merely novelties (jewelry, or decorative/artistic items), or whether lenses were used more widely in these cultures" (pp. 714–15). Enoch amplified and confirmed these views in his most recent article, "The Cover Design: The Enigma of Early Lens Use," *Technology and Culture* 39/2

Egypt (ca. 1999) of an ivory knife handle with carved microscopic figures showing heads "only one millimeter across," (dated 3,300 B.C.) and visible only under magnification, seems to be definitive proof that some magnifying instrument was used. It is obvious that such microscopic design had to be visible to others besides the designer unless he executed it only for his own edification, which is possible but not likely. [92]

Comparatively fewer concave lenses, about forty in number, have been found largely at the Altar of Artemis in Ephesus, Turkey, while others have been unearthed in various sites in Greece and the eastern Mediterranean. Those at Ephesus are said to have good optical properties by their discoverer, who speculates that they "were used by gem cutters who were short-sighted, as working devices."[93] Only one of these has survived intact, which has allowed the determination that it has a –3× power "without the slightest distortion."[94] Actually it is not surprising that a much smaller number of concave lenses have been found given their thinness in the middle, which rendered them more fragile than the thicker convex lenses used by the presbyopic majority. Only a minority of the population, perhaps 15%, were myopes at that time, compared with a rate of about 50 percent for hypermetropia or presbyopia.[95]

On the other hand, others have hypothesized that the undeniably fine details of many of these ancient artifacts, requiring keen eyesight, could have been executed by the unaided eyes of younger myopic craftsmen under the guidance of older, less myopic, and more experienced masters just as ancient elderly scholars at times used younger scribes and secretaries for research, reading, dictation, and writing.[96] Although

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(1998), pp. 273–91. For a succinct summary of available evidence and scholarly debate on this subject, see A. A. Mills, "Single-Lens Magnifiers. Part VI: Early Lenses," *Bulletin of the Scientific Instrument Society* 59 (1998), pp. 22–25.

92. Temple, *The Crystal Sun*, pp. 120–23, with illustrations of the knife handle.

93. The discoverer, Anton Bammer, was quoted in translation by Temple, *The Crystal Sun*, p. 100, with accompanying drawings of the lenses, as follows: "Their superior surfaces are concave, their bases are slightly convex . . . Their optical properties are good . . . Looked at physically, they are reducing, diverging lenses. Perhaps they were used by gem cutters who were short-sighted, as working devices. The eyes of the artisans must often in a short time have been ruined by working with the unaided eye on the scarcely visible craftsmanship of stone, ivory, etc. The differing magnifications of the crystals could hint at this, that they were fashioned for the workers at the time. The perforated pieces found in the temple were certainly hollowed out for optical reasons."

94. Ibid., plate 45, for a photograph of the lens held over a page of writing, followed by the accompanying description, unpaginated.

95. For a fuller treatment of the incidence of myopia and presbyopia in western societies, see ch. III, pp. 78–82.

96. This alternative hypothesis was advanced by L. Gorelick and A. J. Gwinnett, Professors of Orthodontics and Oral Biology and Pathology, respectively, in their article, "Close Work Without Magnifying Lenses: A Hypothetical Explanation for the Ability of Ancient Craftsmen to Effect Minute Detail," *Expedition* 23/3 (1981), pp. 27–34, followed by the authors' discussion of readers' comments, ibid., No. 4 (1981), pp. 15–17. This hypothesis has been accepted by Plantzos, "Crystals and Lenses," who argues that "ancient craftsmen, like gem cutters, had to rely on skill and experience rather than magnification implements to do their work . . . although in the Hellenistic period physics and mathematics were sufficiently developed to include concepts like angular magnification, philosophers and physicians failed to understand the physiology of the human eye and the mechanics of vision and, therefore, could not correct defective eyesight. . . . Accordingly, most ancient 'lenses' must have been decorative" (p. 451). For the employment of younger readers and scribes by Roman scholars and church fathers, see N. Horsfall, "Rome Without Spectacles," *Greece & Rome* XLII/1 (1995), pp. 49–56.

this hypothesis may contain a measure of reality, it cannot be accepted in its entirety in my view for a number of reasons. It implies that only other young myopic individuals, many of whom could not afford to purchase the items, were fully able to appreciate their beauty and workmanship. Conversely, it would rob master-craftsmen of the ability to continue working at the peak of their career and fully judge the results, while potential buyers were deprived of the pleasure of adequately appreciating and enjoying the artifacts with their presbyopic eyes. Scholars from middle age onwards would have been at least partially dependent on others for reading and writing, and even worse, they would have had to rely on the research of assistants with less experience and knowledge. Also, this hypothesis does not adequately explain the finding of some of the lenses in close proximity to objects being worked on or the production of microscopic designs that even now cannot be read without magnification. And it strains credibility that such talented artisans, working for centuries with plano-convex crystals or other similarly shaped transparent materials, would not have observed by chance that patterns or designs placed under these lens-like devices could be seen more clearly just as written matter placed on the other side of water-filled globes was enlarged. Having chanced on their magnifying effect, the artisans would certainly have used these devices for their work.[97] This observation did not require knowledge of optical theory, had one been available during those early centuries.

Additional important evidence of the existence of both convex and concave lenses in this early period has been supplied by a most recent examination by J. M. Enoch of the eye-constructs of Egyptian statues of 4600 years ago deposited at the Museum of the Louvre and at the Egyptian Museum in Cairo. These eye structures were composed of convex and concave lenses "ground from very high quality rock crystal."[98] Such degree of perfection must have had antecedents so far unknown and it is a pity that this level of optical design declined in sophistication by varying degrees in later centuries and finally disappeared.[99] Whether this level of perfection was achieved by designers/"scientists"

97. Enoch, "Early Lens Use," pp. 708–09, expressed some of these reservations.

98. Enoch, "First Known Lenses Originating in Egypt About 4600 Years Ago: The Unique Optical Properties of These Lenses in the Context of the Known Technologies of the Time," *Documenta Ophthalmologica* 99 (1999), pp. 303–14. Enoch writes: "These lenses had a convex and highly polished front surface. On the approximately flat or 'plano' rear lens surface an 'iris' was painted. Centered in the dark-appearing pupil zone was a small, approximately hemispheric, high power, concave lens surface. Thus, these earliest known lenses were multifocal lenses with two different optical areas (iris area and pupil area) and, in part, dual optical surfaces in the pupillary zone! This dual optical zone results in the apparent observer-following action by the eyes of these statues" (p. 303).

99. Enoch concludes, ibid., pp. 310–11: "This is a complex multiple lens structure with truly unique properties! Even the quality of the rock crystal or crystalline quartz chosen for the lenses, and fine polish of the product speak against these being first lens constructs. It would be fair to assume that the apparent perceived movement of the pupillary aperture was a desired or intended effect created by the artisans fabricating the lenses. The artisan designer or designers were certainly brilliant individuals! One can only infer the significance of the design of the lens and eye structures. These constructs were incredibly advanced for their time. These are remarkable achievements taken

working in collaboration with artisans on the basis of some unknown theoretical manual on optics and lens technology or only through the latter's trial and error efforts is impossible to ascertain. We shall see in the last chapter that in the seventeenth century lens grinders and polishers achieved a high degree of perfection in producing lenses for telescopes without any knowledge of optical theory or mathematics. It was all done with their hands, often without the use of machines!

Perhaps this achievement by the Egyptians should be connected to the advanced state of their knowledge of the anatomy of the eye and the treatment of its diseases, the precise dating of which cannot be established, especially because it appears to have been based on fundamental concepts included in the second collection of ancient Indian medicine compiled by Susruta Samhita ca. 800 B.C. More complete than an earlier collection, in addition to identifying seventy-six eye conditions and prescribing various zoological, mineralogical, botanical, and nutritional treatments for conjunctivitis, cataract, trachoma, ametropia (abnormal shape of the eyes causing refractive errors), etc., this collection provided the first known description of ocular anatomy and physiology. "Undoubtedly Susruta's greatest achievement, however, was his discovery of the crystalline lens whose purpose he realised was to focus light rays on to the retina, and the invention of classical cataract surgery."[100] Could this be a hint of Kepler's retinal image theory?

It is known that the Indian/Egyptian model eventually influenced Greek medicine through the writings of Pythagoras (fl. ca. 530 B.C.) and his followers, especially Alcmaeon of Croton (fl. ca. 500 B.C.), and Hippocrates (ca. 460–ca. 357 B.C.), all of whom disseminated and further developed knowledge of these ophthalmic remedies and ocular surgery. During the first century A.D., other medical writers such as Cornelius A. Celsus (ca. 25 B.C.–A.D. 29), Rufus of Ephesus (fl. 100), and chiefly Galen (ca. 129–ca. 199) described various parts of the eye, and established the crystalline lens as the principal organ of vision, apparently ignoring the hint provided by Susruta about the actual role of the lens. This erroneous conclusion dominated optical theory until it was overthrown by Kepler's retinal image demonstration at the beginning of the seventeenth century.[101]

individually or as a group. . . . One can only express awe at this level of sophistication 4600 years ago! The writer knows of no modern lens design which utilizes this unique and ancient apparent following movement feature."

100. See C. Fryer, "Legacy from the Indus Valley," *Ophthalmic Antiques* 60 (July 1997), pp. 6–7, quotation, p. 7.

101. For details on the interconnections of these ancient contributions, the explanation of which would take us far from the central purpose of this brief exposition, see the admirable summary provided by M. Beretta, "From the Eye to the Eye-Glass," in *When Glass Matters: Studies in the History of Science and Art from Graeco-Roman Antiquity to Early Modern Era* (Florence, 2004), pp. 258–67. A convenient collection of pertinent portions of these writings with the addition of helpful illustrations has been published by N. J. Wade, *A Natural History of Vision* (Cambridge, MA, 1998), pages under various headings.

Actually, given the fragility of these lenses, it is amazing that so many have survived and now lie in various museums often unanalyzed and sometimes hardly noticed by curators with some of them simply being mistakenly labeled as decorative objects. Recent research has revealed that as glass blowing was introduced into the Western Roman Empire by middle-eastern glassmakers in the first century A.D., domestic use of glass objects dramatically increased. Both convex and concave lenses as well glass mirrors were now being made in greater quantities while the use of the traditional metal mirrors continued for centuries. These artisans also developed a type of glass so clear as to resemble rock crystal, a feat that the Venetians accomplished only ca. 1300 as I have noted above.[102] There is even a hint that they also invented an unbreakable glass, something that Leonardo da Vinci claimed to have done in the sixteenth century.[103]

Pliny the Elder (23–79) took note of this widespread use of glass and crystal for various purposes in Roman society, even referring to the crave for crystal as a "crazy addiction":

> *There is, furthermore, opaque white glass and others that reproduce the appearance of fluor-spar, blue sapphires or lapis lazuli, and, indeed, glass exists in any colour. There is no other material nowadays that is more pliable or more adaptable, even to painting. However, the most highly valued glass is colourless and transparent, as closely as possible resembling rock-crystal. But although for making drinking vessels the use of glass has indeed ousted metals such as gold and silver, it cannot bear heat unless cold fluid is first poured into it; and yet glass globes containing water become so hot when they face the sun that they can set clothes on fire. . . . I find that among doctors there is no more effective method of cauterizing parts that need such treatment than by means of a crystal ball so placed as to intercept the sun's rays. Rock-crystal provides yet another instance of a crazy addiction, for not many years ago a respectable woman, who was by no means rich, paid 150,000 sesterces for a single dipper."*[104]

It is intriguing, in fact, that the term *vitrum* (glass), apparently stemming from the verb *videre* (to see) was probably used for the first time by Lucretius (ca. 95–ca. 55 B.C.) in his *De rerum natura* as he commented on Greek sources of knowledge. From the first

102. For the results of this new research, see especially R. Temple, *The Crystal Sun*, passim, with many photographs of lenses and mirrors, and G. di Pasquale, "Scientific and Technological Use of Glass in Graeco-Roman Antiquity," in *When Glass Matters*, pp. 31–76. Many photographs of ancient glass objects, including lenses and mirrors, are published in *Vitrum: Il vetro fra arte e scienza nel mondo romano*, ed. M. Beretta and G. di Pasquale (Florence, 2004), accompanied by these articles pertinent to our study: E. M. Stern, "I vetrai dell'antica Roma," pp. 37–59; E. Schwarzenberg, "Cristallo," pp. 61–69; A. Ciarallo, "Il vetro in medicina: I casi di Oplontis e Pompei," pp. 95–107; M. Beretta, "Vetro e visione," pp. 121–33; and G. di Pasquale, "Specchi, globi e lenti ustorie," pp. 135–43. For Venice, see above p. 11.

103. See E. M. Stern, "The Glass Banausoi of Sidon and Rome," in *When Glass Matters*, pp. 77–120. For Leonardo's claim to have invented flexible and unbreakable crystal, see ch. V, pp. 193.

104. Pliny, *Natural History*, vol. X, trans. D. E. Eichholz (Cambridge, London, 1962); book XXXVI, 200; book XXXVII, 29.

century A.D. this term was more commonly used by Roman authors *along* with the old words for a transparent medium, *hyalus* and *crystallus* (crystal). In addition, the increasing everyday use of glass began to influence the terminology applied to the anatomy of the human eye with such terms as "glasslike humor" (the vitreous), the "crystalline tunic" or lens, also called "lenticular tunic" because its biconvex shape resembles a lentil. One of the researchers engaged in this revaluation of glassmaking in the ancient world, who is a proponent of this suggestive but not yet definitive theory about the influence of glassmaking on the terminology of the visual process, has summarized his conclusions as follows.

> *In the first place, the development of the art of glassmaking at the beginning of our era had improved the technique for producing glass of perfect transparency similar to crystal and this technical progress accompanied by the massive diffusion of glass must have inspired doctors to define the transparency of the ocular tunics and the crystalline lens on the basis of certain products of glassmaking.... In the second place, the rather widespread existence of rock crystal magnifying lenses must have inspired the definition of the crystalline lens the function of which was more than enlargement but was to form the image in the eye, or to permit the faculty of sight to create one corresponding to the object seen. The biconvex form of the magnifying lenses used by the ancients, mostly made of rock crystal, may have then favoured the analogy established with the shape of the crystalline lens and thereby have suggested its anatomical redefinition.*[105]

On the basis of this recent research, one can hazard the hypothesis that once all or most of these ancient lenses are fully examined, they will probably reveal a level of optical quality at least comparable to the lenses made just prior to the invention of the telescope and perhaps beyond. And it would be surprising if the knowledge of producing these plano-convex lenses did not survive during the barbarian invasions and throughout the early Middle Ages given their obviously immense utility as burning, medicinal, and vision aids. In fact, recent excavations at a Viking site in Gotland Island (Sweden) have dug up ten rock crystal aspherical lenses, the optimal curvature for magnification, apparently made on a turning lathe. An analysis of these lenses (now known as the "Visby Lenses") has established that they approach the optical quality of modern lenses though produced in the eleventh or twelfth century probably in the Byzantine Empire or in Eastern Europe, some five hundred years before Descartes calculated this optimum shape for a magnifying lens, but could not produce it. Some of the lenses have silver backing, suggesting their use as jewelry, but they were also designed to reflect light because both the back side of the lenses and the front side of the silver plate had a

105. M. Beretta, "From the Eye to the Eyeglass. A Pre-History of Spectacles," in *When Glass Matters*, pp. 249–82, quotation, p. 266.

polished surface to reflect images placed in front of the jewelry.[106] Although we cannot generalize from these few samples about the general availability of such high quality lenses at this time, we can surmise that there were probably other artisans in the eastern Mediterranean and even in northern Europe who could have achieved similar results by trial and error.

A significant clue to the existence of such highly trained artisans in this period is also provided by the treatise *On Divers Arts* (ca. 1110–ca. 1140), composed by the German Benedictine monk and metalworker, Roger of Helmarshausen, better known by his adopted name of Theophilus. This compilation of practical instructions for the arts of painting, glassmaking, and metalworking describes processes and techniques of the age practiced or observed by the author, some of which had originated in past centuries and transmitted orally from one generation to the next. It does not treat the making of magnifying lenses as vision aids, but offers the following description of the process for making crystal-burning globes or lenses, obviously useful devices for a metallurgy shop or for ordinary household chores. The closeness of the dates of this treatise and of the Visby Lenses is suggestive, but apparently coincidental.

> *Take a very pure piece of crystal shaped into a perfectly round form and polished, wet it with water or saliva, and expose it to the bright sun. Place underneath it a piece of the tinder called "centura," so that the sun's brilliance vibrates onto it, and it will very quickly draw fire.*[107]

On the theoretical level such a survival of empirical knowledge may also have been encouraged by Arabic translations of classical writers on optics such as Euclid (ca. 295 B.C.), Hero of Alexandria (ca. 62), Ptolemy (second century) and others, which appeared

106. See O. Schmidt, K-H Wilms, and B. Lingelbach, "The Visby Lenses," *Optometry and Vision Science* 76/9 (1999), pp. 624–30. Some of the authors' conclusions, based on a thorough optical analysis of the unmounted lenses, follow. "The shape of the lenses' surfaces show [sic] only minor departures from rotational symmetry. This leads to the conclusion that they were manufactured on some kind of turning-lathe. The surfaces are almost perfectly elliptic. . . . The lenses examined in Visby, especially the larger ones, show an obvious magnification. Furthermore, the imaging quality is very high. The aberration of the largest unmounted lens is very small up to the rim. It is hard to imagine that these properties were not observed by the manufacturer or the user of the lens. The mounted lenses, which have a silver plate on their back side, strongly suggest that the optical properties have not only been discovered but also used deliberately. The silver plate reflects the incoming light and produces distinct images of objects in front of the piece of jewelry. This means that both the back side of the lens and the 'front' side of the silver must have a polished surface. . . ." (p. 629). "The examination of the lenses exhibited in Visby shows that some of them do have much better optical properties than later produced spherical reading stones. The imaging quality is almost as good as aspherical lenses currently produced. . . . The impressive imaging quality of the lenses suggests that the craftsmen knew more about applied optics than the scientists of the time. . . . Lenses showing imaging properties of that quality were not produced out of lack of knowledge. It seems that this knowledge got lost for a least 500 years, until Descartes calculated the ideal focusing lens shape but, lacking the necessary technical equipment, could not produce it." (p. 630). The lenses are now housed in the historical museum in Visby and in the Swedish Museum in Stockholm. Additional comments on the properties of the Scandinavian lenses can be found in Temple, *Crystal Sun*, appendices 4, 7–10.

107. *On Divers Arts: The Treatise of Theophilus*, trans. from the Medieval Latin by J. G. Hawthorne and C. S. Smith (Chicago, 1963; repr. 1976), p. 190.

from the middle of the ninth century onwards in the eastern Mediterranean. Ptolemy's *Optics,* especially, provided the canonical synthesis for the visual process, which lasted for centuries. It became the model for the analysis of the three modes of vision: direct (optics), reflected through mirrors (catoptrics), and refracted through transparent bodies (dioptrics). A recently found treatise, *On the Burning Instruments,* written around 984 by the Arab mathematician Ibn Sahl of Baghdad, was based on Ptolemy's *Optics* but presents a more advanced study of refraction in convex lenses and reflection in parabolic mirrors.[108] It is not surprising, then, that by the end of the thirteenth century in another comprehensive synthesis based on classical and Latin translations of Arabic optical sources, the *Perpectiva* by Roger Bacon (ca. 1214/1220–ca. 1292), magnifying lenses were mentioned as reading aids without fanfare, implying their long-standing use.[109]

By contrast, the likely use of concave mirrors (generally made of metals, especially bronze, and since the first century A.D. more frequently of glass or crystal) as magnifiers for reading and close work does not seem to be as well attested in antiquity as that of convex lenses. There are many references, however, of their use as magnifiers for converging the rays of the sun for combustion and cauterizing wounds. The best-known, if seemingly legendary, example of their incendiary properties is still the burning of the Roman fleet off Syracuse in 212 B.C. by Archimedes. It should be added parenthetically that the above-mentioned revaluation of the quality of ancient glass seems to indicate that Archimedes' feat may have had some basis of reality, though this remains a controversial question.[110] Probably as a result of this widely propagated feat, mentions of metal or glass concave mirrors or of glass/crystal globes filled with water were more frequent as combustion and cauterizing agents in the works of such authors as Diocles (240 B.C.–ca. 180) and Pliny the Elder. As for formation of images, it is well known that for close objects in focus such mirrors produce enlarged and upright images whereas for more distant and out-of-focus viewing they reflect inverted and reversed images. For reading they provide higher magnification than convex lenses and it would seem that such use should have been noted more frequently in ancient sources.

108. See R. Rashed, "A Pioneer in Anaclastics: Ibn Sahl on Burning Mirrors and Lenses," *Isis* 81 (1990), pp. 464–91, and id., "Geometrical Optics," in the *Encyclopedia of the History of Arabic Science,* vol. 2, ed. R. Rashed (London and New York, 1996), pp. 643–71

109. This is the way Bacon described the operation of a magnifying lens to be used for reading and close work around 1265: "If somebody should look at letters and other minute objects through crystal or glass or some other transparent object placed over the letters, and if the crystal or glass is less than a hemisphere, with its convexity toward the eye, and the eye is situated in air, the letters will be seen far better and will appear larger. . . . Consequently, this instrument is useful to the elderly and those who have weak eyes, for it will endow letters, however small, with sufficient magnitude to be seen." (*Roger Bacon and the Origins of Perspectiva in the Middle Ages: A Critical Edition and English Translation of Bacon's Perspectiva,* ed. and trans. David C. Lindberg (Oxford, 1996), Pars III, dist. 2, cap. 4, pp. 317–19, and p. 389 for Lindberg's helpful comments on this passage.

110. For the latest refutation of this "impossible" feat, see D. L. Simms, "Buffon's Burning Mirrors," *Atti della Fondazione Giorgio Ronchi* LIX/5 (2004), pp. 711–42. Yet, Temple cites a successful re-enactment of Archimedes' feat made in 1973 (*The Crystal Sun,* pp. 234–37). So the controversy continues!

Mirrors and their many features, including distortions, must have produced a sense of wonder in early societies and perhaps elicited an even earlier interest in reflection than in refraction caused by transparent glasses or lenses. The fascinating properties of mirrors in general were eventually analyzed by the three Greek theorists mentioned above.[111] Lucius Annaeus Seneca (Seneca the Younger, ca. 4 B.C.–65) commented at length on these Greek sources in his *Natural Questions,* Book I. In this book he discussed various meteorological phenomena (rainbows, halos, etc.) as well as optical illusions created by refraction, magnification, and perspective. He mentioned globes of water as magnifiers for reading and he clearly alluded to the use of (concave) mirrors for the same purpose: *I have already said there are mirrors which increase every object they reflect. I will add that everything is much larger when you look at it through water. Letters, however tiny and obscure, are seen larger and clearer through a glass ball filled with water. . . .*[112] It has been speculated that Seneca emphasized the use of glass globes filled with water for reading because only the recently introduced glass blowing technique in his time was capable of producing a clearer globe resulting in a "biconvex lens" with improved magnification. It was a question of pointing out the use of an enhanced water-based reading instrument without necessarily ignoring the comparable value of convex glasses, which presumably were also improved by the new technology.[113]

Seneca, however, seems to have been even more interested in reflecting surfaces. He treated in detail the many properties of mirrors of various shapes and castigated their misuse especially in enhancing the pleasure of shameful sexual acts, of which he described details not appropriate to be mentioned in these pages. After all, he was a leading member of Nero's court and had been his tutor, but apparently he was not wholly successful in teaching him the precepts of his stoic philosophy. Mirrors, he claimed, were *invented in order that man may know himself.* A fountain or a polished stone would suffice for this purpose. But as centuries passed, these simple and necessary instruments were transformed into gadgets of vanity and luxury, personal accoutrements not only for women but also for men and even for the soldiers of his time, who spared no expense to acquire them. (Is this, perhaps, another reason for the later decline of the Roman Empire—the Roman soldiers becoming dainties?) The following remarkable passage illustrates how common metal and glass mirrors had become in Nero's age and it reveals probably for the first time the existence of full-length metal mirrors (*specula totis paria corporibus*).

111. Some interesting texts about parabolic and ellipsoidal burning mirrors, beginning with a text by Diocles, were edited and translated into French by R. Rashed, *Les catoptriciens grecs,* I, *Les miroirs ardents* (Paris, 2000).

112. Seneca, *Naturales quaestiones,* I, 6.5, trans. T. H. Corcoran (Cambridge, MA, 1971) for the quotation, but much of the book deals with reflection and mirrors, mostly based on Greek authors.

113. P. Solaini, "Storia del cannochiale," *Atti della Fondazione "Giorgio Ronchi"* LI/6 (1996), pp. 824–25.

. . . one man saw his reflection in a cup, another in bronze that was procured for some real use; and next a disc was prepared especially for this function, not yet of the brilliance of silver, but of a material fragile and cheap [glass/crystal?]. . . . Later, when luxury had already become supremely powerful, full-length mirrors were carved of gold and silver, then adorned with jewels. One of these mirrors cost a woman more than the dowry of ladies of long ago. . . . Luxury, encouraged by sheer opulence, has gradually developed for the worst, and vices have taken enormous growth. All things are so mixed up by the most various refinements that what used to be called the ornament of a woman is now a man's accoutrement; I mean all men, even soldiers. Is a mirror now used only for the sake of good grooming? There is no vice for which it has not become indispensable.[114]

The properties of various shapes of mirrors treated by classical authors were further analyzed and commented upon by their leading heir in the early Middle Ages, the polymath Ibn al-Haytham (965–ca. 1041), known as Alhacen in the West. Two of his extant treatises—*Optics* and *On Parabolic Burning Mirrors*—were translated into Latin during the twelfth century and laid the basis of medieval optical theory up to the age of Kepler. As far as I can tell, he did not treat concave mirrors as reading aids. Nevertheless, it is clear even from this bare summary that by the late thirteenth century western scholars had at their disposal practically the entire corpus of classical and Arabic treatises on optics in Latin, from which they could have fathomed the various uses of mirrors, including magnification for reading and close artisan work.[115] On the empirical level, however, new ongoing research is showing that the knowledge of making both metal and glass mirrors must have survived from antiquity. Both types of mirrors were commonly produced and traded in great quantities at least from the beginning of the thirteenth century and probably earlier, invalidating prevailing opinion that only metal mirrors were produced during the Middle Ages. They were generally small and even their frames for wall hanging varied in size from only 7.5 cm to 22 cm in length. So far these newly analyzed written sources mention only plane and convex mirrors.[116]

Only a few written and iconographic sources, however, document the use of concave mirrors as reading aids during the late Middle Ages. An explicit description of such a use was penned by the poet Jean de Meun (d. 1305). At about the same time that Bacon was writing on the use of convex magnifying lenses for reading, de Meun commented in the

114. *Naturales quaestiones*, I, 17, 4–10.

115. For an excellent and up-to-date account of Alhacen's optical theories and their influence in the West, see now A. M. Smith, *Alhacen's Theory of Visual Perception: A Critical Edition, with English Translation and Commentary, of the First Three Books of Alhacen's 'De aspectibus', the Medieval Latin Version of Ibn-al-Haytham's Kitab al-Manazir*, vol. I (Philadelphia, 2001), pp. xv–cliv.

116. See I. Krueger, "Glass Mirrors in Medieval Times," in the *Annales du 12^{e} Congrès de l'Association pour l'histoire du verre* (Amsterdam, 1993), pp. 319–332. This is an English summary of his longer article with fuller documentation: "Glasspiegel im Mittelalter: Fakten, Funde und Fragen," *Bonner Jahrbücher*, 190 (1990), pp. 233–313.

poem (*The Romance of the Rose,* ca. 1275) on (convex) lenses, but more extensively on the marvelous properties of (concave) mirrors for reading and other tasks demanding near vision, and on their capacity to light fires, all based on the authority of a book of *Observations* by Alhacen, which apparently has not survived:

> *There (in Alhacen's* Observations*) he will be able to discover the causes and the strength of the mirrors that have such marvelous powers that all things that are very small—thin letters, very narrow writing, and tiny grains of sand—are seen as so great and large and are put so close to the observers—for everyone can distinguish among them—that one can read them and count them from so far off that anyone who had seen the phenomenon and wanted to tell about it could not be believed by a man who had not seen it or did not know its causes. This would not be a case of belief, since he would have the knowledge of the phenomenon. . . . Other mirrors, if you look carefully in them, show truly the right amounts of things that one sees in them. There are others that burn things when directed at them, if one knows how to adjust them rightly in order to collect the sun's rays together when they are shining on the mirrors and reflecting from them.*[117]

Tomaso da Modena, as we have noted above, depicted a reading mirror twice in his frescoes at Treviso. Another use of the reading mirror has been connected to a contemporary of Tomaso da Modena, Petrarch, who might have seen the frescoes. The poet is represented in his study with such a device mounted on a stand on his desk in a miniature adorning his *De viris illustribus,* executed around 1400. The miniature is believed to be a copy of Petrarch's badly damaged fresco portrait (ca.1375) by Altichiero in the *Sala dei Giganti, Carrara Reggia,* in Padua, but in this case the mirror appears to be encased in a horn-shaped frame resting on his desk.[118] While the representation of the poet with a reading mirror does not prove that he actually used it, it is certain that he was aware of its magnifying properties at the very least because he was familiar with Seneca's *Natural Questions,* Book I. Petrarch, however, cited Seneca's water-filled globes, but not the concave mirror, when he revealed his visual problems as he aged, forcing him to use spectacles from age sixty onwards.[119] It is indeed mystifying that we must turn to the works

117. Guillaume de Lorris and Jean de Meun, *The Romance of the Rose,* trans. Charles Dahlberg (Princeton, 1971), p. 300, lines 18,044–18,060, and p. 302, lines 18,163–18,167. The numerous distortions caused by mirrors are further commented upon in pp. 303–04, lines 18,168–18,286. Jean does not actually describe these mirrors as being concave in shape, but this can be deduced from the context just as he does not use the word "convex" when he speaks of transparent glasses as light rays pass through them rather than being reflected by an opaque medium such as a mirror (p. 283, lines 16,855–16,880).

118. The miniature is reproduced in T. E. Mommsen, *Medieval and Renaissance Studies,* ed. E. F. Rice, Jr. (Ithaca, N. Y., 1959), ill. No. 6 from Cod. 101, fol. 1v in the State Library of Darmstadt. This is a reprint of an article, "Petrarch and the Decoration of the Sala Virorum Illustrium in Padua," published by Mommsen in the *Art Bulletin* XXXIV (1952), pp. 95–116. Mommsen also published the fresco portrait (ill. no. 4), but a clearer reproduction can be found in B. G. Kohl, *Padua Under the Carrara, 1318–1405* (Baltimore and London, 1998), p. 128. Other mentions of reading mirrors in the late thirteenth and early fourteenth centuries are cited by Rosen, "The Invention," pp. 206–08.

119. For Petrarch's mention of spectacles, see ch. II, p. 60–62.

of painters and poets to document such uses of concave mirrors and not to scientific texts, which seem to ignore this question. Was it too obvious, perhaps, to deserve comment? Considering the fact that they were more difficult to position to avoid the reversal of images, they settled on the readily available convex magnifiers.

We must wait until the sixteenth century for clear examples of the use of concave mirrors for reading/writing and as simple microscopes for the study of nature. The first documented use of a concave metal mirror as a simple microscope was recorded by a Florentine cleric and diplomat, Giovanni Rucellai (1475–1525), nephew of Lorenzo the Magnificent. Using such a device, he was able to describe the anatomy of bees, recording his observations in his long poem *Le api (The Bees),* written in 1524 but published posthumously in 1539. Long recognized as an important literary effort with special significance for the history of agriculture and zoology, this poem was apparently first noticed by Ronchi some three decades ago as the first documented microscopic observation, anticipating by almost a century similar observations with the compound microscope.[120]

In the middle of the century, we find two leading Italian calligraphers and writing masters, Giovanni Antonio Tagliente and Giovan Battista Palatino, illustrating their writing manuals with woodcut pictures of all the implements to be used by professional scribes, including mirrors. Tagliente's mirror, probably made of steel, is seen unframed and resting inclined at the bottom of the woodcut whereas Palatino's glass mirror has the same leather horn shape depicted by Tomaso da Modena in St. Jerome's portrait. In his most comprehensive writing manual of the age, Palatino, called the "calligrapher's calligrapher," stated categorically that *the mirror is used to save the sight and to assist it in continuous steady writing. It is much better of glass than of steel.*[121]

The positioning of concave mirrors requires practice and ingenuity to eliminate or compensate for the inversion and reversion of images. Users had to find means of suitably mounting and focusing these devices to free both hands as their tasks required. To date the earliest known description of such a device with a concave mirror is that published by Giambattista della Porta in his *Magia naturalis* (1589):

120. Consisting of a total of 1062 verses, a third of the poem is a translation of Virgil's *Georgics*, B. IV. The rest contains Rucellai's own verses, some of which referring to the concave mirror follow: "Dunque se vuoi saper questo tal modo,// prendi un bel specchio lucido e scavato. . . . // Così vedrai multiplicar la imago// dal concavo reflesso del metallo,// in guisa tal, che l'ape sembra un drago // od altra bestia che la Libia mena.// Indi potrai veder, come vid'io, // l'organo dentro articulato e fuori, // la sua forma, le braccia, i piè, le mani, // la schena, le pennute e gemmate ale, // il nifolo o proboscide, come hanno // gl'Indi elefanti, onde con esso finge // sul rugiadoso verde e prende i figli. // Ancor le vedi aver l'occulta spada // ne la vagina, che natura ha fatta // per la salute loro e del suo rege.//" Quoted in *Scritti di ottica*, ed. V. Ronchi (Milan, 1968), p. 34.

121. I have used the translation in *The Instruments of Writing: Translated from the Writing Book of Giovanbattista Palatino, Rome, 1540*, by the Rev. Henry K. Pierce (Newport, R. I., 1953), unpaginated. For the original, see the *Libro di M. Giovan Battista Palatino, cittadino romano, nel qual s'insegna a scriver ogni sorte lettera, antica, & moderna, . . .* (Rome, 1548): "Lo Specchio si tiene per conservar la vista & confortarla ne lo scriver continuo. Et è assai meglio di vetro, che d'acciao." (pp. H iiii), published in facsimile ed., *Three Classics of Italian Calligraphy: An Unabridged Reissue of the Writing Books of Arrighi, Tagliente and Palatino*, ed. O. Ogg (New York, 1953).

place a concave mirror on your chest so that its back touches your chest and place the writing at the point of inversion; in back of it position a plane mirror so that it is opposite your eyes; then you will be able to read without any difficulty the much enlarged images of the letters reflected from the concave to the plane mirror.[122]

As it can be seen, the quotation describes a method of magnification embodying the components of a compound microscope, but it is cumbersome to use as I learned from a quick experiment.[123] It is likely that Della Porta was describing an instrument already in common use by scribes and artisans, whose ingenuity probably produced a device positioning the two mirrors in a more practical and less cumbersome way for easy viewing. In fact, Albertotti wrote that at the end of the nineteenth century an instrument similar to the one described by Della Porta, a *liseur à miroir,* was available for sale together with the *Grand dictionnarie universel* of Pierre Larousse (1865–78), to facilitate reading of the small print.[124] Whether ancient craftsmen, who had knowledge of plane and concave mirrors, were able to construct similar or better devices is an interesting question that requires further investigation.

For our purpose it is sufficient to conclude from this brief summary that the ancients had vision aids capable of extending their working years. Moreover, the hitherto unsuspected high quality of ancient lenses and mirrors as revealed by archeological finds has led scholars like Robert Temple and others to re-examine ancient texts and in some cases amend available translations in an effort to confirm the results of archeological and technical examination of the surviving specimens. On the basis of this reevaluation they have resurrected the old question of whether the ancient world had spectacles and telescopes. On the face of it, it would be reasonable to assume that artisans working with glass and crystal would have been tempted simply out of curiosity to place a mounted magnifying lens close to one eye or a joint pair to both eyes to produce a monocle or

122. The full passage from the Italian translation (Naples, 1611), which faithfully rendered the Latin original according to Ronchi, is headed by this title: "Che col piano specchio, e col cavo le picciole lettere paiano grandissime." The text follows: "Quando i caratteri del scritto seranno così piccoli, che appena si conoscano che sieno caratteri. Perché ho visto l'Evangelio di s. Giovanni: In principio, etc., scritto in tanto picciolo luogo che appena occupava luogo di una picciola lentecchia, overo occhio di gallo, noi faremo con questo artificio che appaiano grandi: poni il specchio concavo nel tuo petto, che il dorso suo tocchi il tuo petto, e all'incontro nel ponto dell'inversione poni il tuo scritto, da dietro a quello poni lo specchio piano, che stia opposto a gli occhi tuoi; allora nel specchio piano si refletteranno l'imagini de' caratteri che sono nel concavo, che il cavo l'avea rese grandissime; onde le potrai leggere senza alcuna malagevolezza." (Ronchi, *Scritti di ottica*, pp.169–70).

123. At my suggestion, J. Enoch constructed such a device and found that it functions with some difficulty. See his article, "Concave Mirrors Used for Visual Corrections During the Renaissance and Earlier," *Atti della Fondazione "Giorgio Ronchi"* LVI/1 (2000), pp. 135–48.

124. Albertotti, *Lettera intorno alla invenzione degli occhiali* (Rome, 1922), pp. 8–11, discussed the above evidence about the use of the concave reading mirror except for Rucellai's passage. He gave a clear and detailed description of the instrument, which he himself used in the manuscript room at the Biblioteca Nazionale in Florence, made freely available there to researchers (p. 23, n. 23).

the first rivet-type pair of spectacles. Other inquisitive artisans would have been equally tempted to place combinations of two convex lenses or convex and concave lenses in alignment and move one back and forth in front of one eye for focusing to achieve modest magnification for distance viewing. In other words, the construction of spectacles and tubeless telescopes by trial and error would not have presented enormous difficulties for talented individuals. Constructing a tube-telescope with a combination of lenses and with adjustable focus is a more complicated matter and would require considerable experience, as Galileo and others learned in the seventeenth century. It is plausible, therefore, that the ancients may have had some version of rivet-type spectacles with convex lenses for near vision (called *conspicilia* in Latin), and a hand-held mounted concave lens (*smaragdus* in Latin "green shaped emerald") for myopic individuals just as the myopic Emperor Nero is reported to have used to watch the gladiatorial games. (Myopes would have found it impractical to walk longer distances with a pair of rivet spectacles precariously perched on their noses.) Whether eyeglasses were mentioned in the Old Testament (the Torah) and even earlier in Egyptian sources is unclear.[125]

Sighting, fixed tubes for celestial observations and surveying are also mentioned in ancient sources as well as portable optical tubes (both types called *dioptra* in Greek) for distance viewing as noted by Aristotle (384 B.C.–322) and Polybius (ca. 204 B.C.–ca. 122) among others. Pictorial evidence gives a hint that at least some of them were composed of collapsible sections apparently for better focusing. It is not clear whether some of them were equipped with combinations of lenses like latter day telescopes. If lenses were used, they would likely have provided modest magnification on the order of +2 to +3 at maximum as in the case of the earliest telescopes in the seventeenth century, unless ancient artisans had discovered better methods of grinding and polishing lenses. They were certainly not capable of extending vision 600 miles as has been claimed in exaggerated accounts of the optical instrument (probably a concave mirror) used at the top of the Pharos Lighthouse at Alexandria (Egypt) at the time of Pharaoh Ptolemy III (288/280 B.C.–221).

The existence of such optical devices even with modest magnification would explain the perfect alignment of the Egyptian pyramids and of the stones at the megalithic site of Avebury in England, all of which would require precise optical surveying instruments, sort of precursors of modern theodolites. It is doubtful, also, that Democritus' observation (fifth century B.C.) of the shadows of the mountains on the moon and his conclusion that the Milky Way consisted of a cluster of stars could have been accomplished without the use of optical devices. Finally, it is significant to point out that the use of sighting/optical tubes was mentioned and illustrated in medieval manuscripts

125. Temple, *The Crystal Sun*, pp. 55–91, 122–95.

and was discussed as late as the sixteenth century in artisan and scientific circles as they searched for more powerful optical devices that led to the invention of the telescope.[126]

In conclusion, then, we can say that while the use of lenses and mirrors for various purposes is well attested in the ancient world, the existence of spectacles and telescopic devices with lenses cannot be established with the same degree of certitude. If these devices existed, they do not seem to have played an influential role in society judging from the extreme paucity of citations, although it is well known that a large volume of written and archeological sources has not survived or has not been discovered to date. In contrast, from the late fourteenth century onwards there is abundant documentation that production and use of spectacles had achieved massive proportions, as the following chapters will show, and had profound influence on every segment of society. They were no longer the exclusive complement of intellectuals or of specialized levels of the artisan class as they might have been in ancient times. Certainly the first two centuries of the Roman Empire had a thriving economy, a higher standard of living than earlier periods, and a cultural elite capable of assimilating and using these inventions, but probably not a high proportion of persons over 40 in need of spectacles because relatively few lived past 40 to become presbyopic. On the other hand, in the intensely commercial and competitive society of late medieval Italy with its well developed and dispersed glass/crystal industry, where merchants and artisans wrote account books and correspondence in the highly abbreviated, cursive commercial script (known as the *mercantesca*), all combined with the vigorous intellectual life in universities and monasteries and their never-ending demand for copies of manuscripts, it is understandable that an expanding use of vision aids of all kinds was required.

Yet it is extremely difficult to isolate an overriding factor in the mix so as to divine why a certain invention, the components of which had been known for centuries, simply came into being and "caught on" at a later period. In the fifth century B.C. Leucippus and Democritus speculated that matter was composed of invisible atoms, but the atoms were not split until the twentieth century, giving rise to the atomic age. By the same token, the ancient optical tubes with their limited powers of magnification (according to present knowledge) perhaps were suggestive to later generations, but they cannot be considered powerful scientific instruments in the same class as the telescopes and microscopes of the seventeenth century, which ushered in the Scientific Revolution. Anthropologists have long wrestled with this mysterious alchemy of "things and ideas" and the following passage about the influence of glass in the development of civilization is particularly pertinent to our subject.

126. See ch. VI, pp. 207–19 for further discussion of these tubes. They have been treated extensively with illustrations by R. Eisler, "The Polar-Sighting Tube," *Archives internationales d'histoire des sciences* 2/6 (1949), pp. 312–32, who also cited Hebrew sources; and H. Michel, "Les tubes optiques avant le telescope," *Ciel et terre* 70 (1954), pp. 175–84, with additional illustrations.

> *In fact, it becomes difficult to distinguish the material and the theoretical. Anthropologists have long seen technology as a mix of things and ideas, of ideas embedded or congealed in objects which themselves only have their power from the practices which dictate their use. . . . It consists of ways of understanding and changing the world which include things and ideas. Nowhere is this more obvious than in the simultaneous development of ideas and techniques in the making of glass. It is both a tool of thought and a tool with thought embedded in it. What is peculiar about it, is that it is the only substance which directly influences the way in which humans see their world. It is the only substance which is a real extension of a human sense organ, and the most powerful one, the eye.*
>
> *The anthropological approach to understanding the world is what might be called 'structuralist'. Anthropologists have focused much less than historians on individual people, events or things which are important, but on their relations, on the balances and timing of the forces acting upon them. Thus it is not just the presence or absence of glass we consider, but how much there is of it, how it is used, how it enters into the relations between humans and the natural world, and how it fits with other causal factors which equally need to be considered. . . .*[127]

The structuralist approach, however, which recalls the relativity of ideas in Hegel's dialectical process, includes accidental happenings and "unintended effects" as well. Glass "was developed to make beautiful and useful things for humans. Only through a giant accident did it turn out that this magical substance could also be used to extend human vision and hence alter thought."[128] In the following chapters I present a massive amount of new evidence in the hope that it will help place the role of spectacles, and to a less extent that of other vision aids, in the mix of events and ideas that composed Renaissance society. In the process, we may discover why the unknown Pisan "optician" was so successful in making his invention stick at the end of the thirteenth century while his likely predecessors in past centuries were not as lucky.

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127. A. Macfarlane and G. Martin, *Glass: A World History* (Chicago, 2002), pp. 195–96.
128. Ibid., p. 197.

II

Early Diffusion

Early Diffusion in Italy

DURING THE first century of spectacle wearing, mentions of eyeglasses found to date in Italy are relatively few, even counting those already mentioned in the first chapter, and they occur in sources scattered from Rome northward. Nevertheless, these very early references continue to provide evidence that the invention spread rapidly throughout Italy and some of them reveal for the first time the actual cost per pair. Just ten years after Giordano's sermon in Florence, a pair of glass spectacles with case (*occulis de vitro cum capsula*) cost six Bolognese soldi (shillings), according to an expense account of the Dominican inquisitors for the provinces of Ravenna, Milan, and Genoa submitted to Bishop Arnaldo of Bologna. This is the first document to reveal the cost of spectacles with case found to date, and it comes from the Vatican Archives (*Collectoriae,* vol. 133, f. 134v). It was published by Albertotti, who expressed surprise at the low cost of the pair including the case, comparing it roughly to the value of three Italian lire of pre World War I. He and many other historians of spectacles to the present day had been under the impression that one of the reasons for the paucity of sources mentioning eyeglasses in this early period was their high cost, making them a scarce luxury item used primarily by persons of means.[1]

We now have a more approximate, but still not an exact, estimation of their value in relation to salaries and prices of the age. By coincidence in this same year (1316) we have the salary of a glass worker at Murano—s. 7½ per day whereas in 1291 a young

1. The document was discovered in 1924 by Monsignor Pietro Guidi of the Vatican Archives. He sent the transcription to Albertotti, who published it in his "Altri dati riguardanti la storia degli occhiali," *Atti della Società Medico-Chirurgica di Padova* II/4 (1924), pp. 9–10. The transcription reads as follows: "Rationes reddite mihi Arnaldo Episcopo Bononiensi ab inquisitoribus heretice pravitatis Ravennatis, Mediolanensis, et Janunensis civitatum, diocesum et provinciarum, nuncio ad hoc per Sedem Apostolicam deputato, et primo a fratre Manfredo de Parma inquisitore in civitate Bononie heretice pravitatis, ordinis Predicatorum . . . Expense mensium iulii, augusti et septembris [1316]. . . . Item in occulis [sic] de vitro cum capsula s.[solid.] VI bon[oniens]. . . ."

boy working at a glass furnace earned s.2 per day.[2] And at Pisa in 1426 a pair of man's work shoes cost s.5, a carpenter earned s.6.3, and a laborer earned from s.2.9 to s.3.6 per day.[3] Even allowing for differences in value between Venetian, Pisan, and Bolognese soldi at three fairly distant dates, it would seem that spectacles within the first century of their existence were far from being a luxury product. And we shall see that their incredibly low cost, making them affordable to artisans and probably even to laborers, will be confirmed by new documents discovered in Italy for the fifteenth century and cited in the next chapter.

By contrast, two other references found in a household inventory designate spectacles with crystal lenses and more expensive frames with a considerably higher value. A few months after the death (1364) of Orvieto's wealthy bishop, Giovanni di Magnavia, the inventory of his possessions in 1365 listed the following two pairs of spectacles: *unum occhiale de scristallo incatastatum in ramine deaurato, habet casam* ("one pair of crystal spectacles framed in gilded copper with case") and "*unum occhiale de cristallo cum casa incatastatum in osse nigro* ("one pair of crystal spectacles framed in black bone with case"), valued at one gold florin and half gold florin respectively.[4] Since the Florentine gold florin was worth s.66 d.4 in 1365,[5] this document highlights the difference in value between the spectacles with glass lenses and less expensive frames mentioned in the preceding paragraph, which were affordable to ordinary friars and to artisans, and the "luxury" spectacles worn by a rich bishop. We may say that the latter would be comparable to "designer eyeglasses" today. Another example of expensive spectacles was listed in an inventory (1322) of possessions left at his death (ca. 1321) by the Bishop of Florence, Antonio degli Orsi—"*unum par occlalium foltorum de argento deaurato*" ("one pair of spectacles framed in gilded silver"). Had their estimated value been listed, we would have had another point of comparison as this pair seems to have had glass lenses despite its expensive frame unless the crystal designation was left out.[6]

Finally, most recent findings in the account books of the Augustinian convent of Santa Maria del Fiore (commonly known as donne di Lapo) near Badia di Fiesole, just

2. For the salaries in Venice, see Zecchin, "Cronologia vetraria veneziana e muranese fino al 1490," in his *Vetro e vetrai*, I, (Venice, 1987), pp. 14 and 9 respectively.

3. See T. Antoni, "Note sull'arte vetraria a Pisa fra il Tre e il Quattrocento," *Bollettino storico pisano* LI (1982), pp. 295–309, which contains much information on salaries and various prices for goods and commodities.

4. L. Fumi, "L'inventario dei beni di Giovanni di Magnavia, vescovo di Orvieto e vicario di Roma," *Studi e documenti di storia e diritto* XV (1894), pp. 77–78, and Zecchin, "I 'roidi da ogli'," in his *Vetro e vetrai* II (Venice, 1989), p. 248.

5. For this value see R. A. Goldthwaite and G. Mandich, *Studi sulla moneta fiorentina (Secoli XIII–XVI)*, (Florence, 1994), p. 90. I am assuming that the document refers to the gold florin issued by Florence and not to other florins minted by other Italian cities, which may have had slightly different values. Readers should be aware that the relationship between prices and values of various currencies as given throughout this study is approximate and adequate only for rough comparisons.

6. The inventory is dated 8 December 1322 (R. Davidsohn, *Storia di Firenze*, vol. IV, pt. II, trans. G. Niccoli (Florence, 1965), p. 23, n. 1.

outside Florence, give additional information about prices of spectacles at the end of the fourteenth century and the beginning of the next century. These nuns supplemented their income from agricultural property by running a small school for young girls of professional and mercantile families, copying manuscripts, and conducting various types of handiwork such as embroidery and knitting.[7] Clearly these were tasks that required vision aids after age forty. In 1385 the sisters paid s.8 for "four pairs of glass [lenses] for spectacles" (*4 paia di vetri d'occhiali*).[8] In 1402 the convent paid s.16 for a pair of spectacles and for replacing the lenses in another pair, and eight years later an unspecified sum was spent to have another pair repaired.[9]

It would be unwise to draw conclusions about exact costs in these cases because we are not informed of the materials used for the lenses and the frames. These documents, however, are the first ones discovered about nunneries and women wearing spectacles in Italy, but they are a little later than the actual spectacle frames discovered at the archaeological dig under the choir stalls of the nunnery at Wienhausen in Germany.[10] Most of the documentary and artistic sources throughout the Renaissance refer to men. In any case, the above cited documents provide the only cost data for spectacles available for fourteenth-century Italy, making possible an approximate comparison with the rich data most recently discovered for the following century. They also offer sufficient evidence for the conclusion that already in the fourteenth century ordinary (not luxury) spectacles were neither scarce nor expensive, and this conclusion is also supported by evidence uncovered for other countries in the same period as discussed later in this study.

Other mentions of spectacles in this century are not as informative but they attest to their use and diffusion. At Padua in 1318 the son of a notary pleaded that because of his advanced age he needed his glass or crystal spectacles (*ocularis de vitro vel cristallo*) for a second look in order to authenticate a document in a Dominican monastery, which had been drafted by his late father.[11] In 1329 a notary from Bibbiena returning home from Florence was robbed of various goods he had acquired in the city including "a pair of spectacles" (*unum par ochialium*).[12]

7. For information about this convent, see S. T. Strocchia, "Learning the Virtues: Convent Schools and Female Culture in Renaissance Florence," in *Women's Education in Early Modern Europe, 1500–1800*, ed. B. J. Whitehead (New York and London, 1999), pp. 3–46. I am grateful to Professor Strocchia for alerting me to her findings and sending me the transcription of the following documents.

8. This document is dated 6 Sept. 1385: Florence, Archivio di Stato, Conventi Religiosi Soppressi 150, vol. 20, fol. 66r.

9. Ibid., fol. 133v, dated Sept. 1402: "diedi per un paio d'occhiali ci comperò frate Piero e per vetro rimise negli occhiali di suora Vangelista," total s.16. Sister Vangelista was a scribe. For the third document dated Sept. 1410: ibid., fol. 162r.

10. See below, p. 68.

11. "Magister Bartholomeus, ipso viso, apparuit turbatus, dicens quod ipsum cum suis ocularis de vitro vel cristallo revidere volebat, quia propter senectutem non ita bene videbat ut videre consueverat," quoted by Zecchin, "Cronologia vetraria," *Vetro e vetrai*, I, p. 15.

12. Rosen, "The Invention," 2, p. 204, and Davidsohn, *Storia di Firenze*, IV, pt. II, p. 23.

Four other references designate magnifying lenses rather than spectacles, although some of the terminology used is somewhat unclear and confusing and points to the fact that the words *occhiale* and *oculare* were used interchangeably and could designate spectacles or magnifying lenses according to the context.[13] Most often the plural form *occhiali* was used for spectacles but the use of the singular form is documented through the late seventeenth century in various dictionaries.[14] The inventory of Bishop Giovanni di Magnavia mentioned above listed *unus lapis parvus cristalli* ("a small crystal stone"), valued s.2, clearly used as a magnifier for reading and close work. Though made of crystal, such a single lens apparently not mounted into a suitable frame with handle was a low cost item.[15] A Roman inventory of 1324 described a magnifying lens as a *lapis berillus pro oculis* ("beryl [reading] stone for the eyes").[16] Finally, a fourth inventory at the Roman Curia (1367) seems to indicate a magnifying lens rather than a pair of eyeglasses, as it has sometime been interpreted: *unum oculare de cristallo cum manico et circolo de argento in una domuncula de corio* ("a crystal eye lens with silver frame and handle in a leather case").[17] A pair of spectacles would have two handles.

Although the above citations and those that follow point to a more widespread use of spectacles in fourteenth-century Italy than was formerly believed, Italian medical doctors were apparently late in realizing the usefulness of eyeglasses as reading aids, judging from their absence in their medical treatises even though it seems likely that they used them themselves. The first clear mention of spectacles occurs in a small treatise, *Ricette per gli occhi,* ("Prescriptions for the Eyes," 1361). It was written by Maestro Piero Ubertini da Brescia (died ca. 1395) as part of his medical and surgical manual, *Tesoro* (Treasury), which also contains his treatises on dreams, urine, and dog bites. He listed various remedies to ameliorate weak sight, culled from his extensive practical experience as a physician-surgeon at Lucca for twenty-two years and his reading of the writings of ancient authorities and of those of his colleagues.[18] To promote clear vision, he cited with approval pills prescribed by his colleague in Florence, Maestro Tommaso del Garbo, for the latter's octogenarian friend, a monk, teacher, and scholar,

13. See P. Sella, *Glossario latino italiano: Stato della Chiesa-Veneto, Abruzzi* (Città del Vaticano, 1944), pp. 188, 387, for these various meanings in this period.

14. See N. Tommaseo and B. Bellini, *Dizionario della lingua italiana*, vol. IV (Turin, 1929), p. 559, and S. Battaglia, *Grande dizionario della lingua Italian* XI (Turin, 1981), pp. 756–57.

15. Fumi, "L'inventario," p. 77.

16. Zecchin, "I 'roidi da ogli'," p. 248.

17. Sella, *Glossario latino italiano*, p. 387 and Zecchin, "I 'roidi da ogli'," p. 248.

18. Maestro Piero Ubertini da Brescia, *Ricette per gli occhi. Conoscimento de' sogni. Trattato sull'orina. Morsi di cani e loro conoscimento. (Manoscritto Riccardinao 2167)*, ed. Mahmoud Salem Elsheikh (Florence, 1993). This is a facsimile edition with accompanying transcription in two volumes and it is not easily available in American libraries or even in Florence itself. The introduction contains a summary of the few facts known about Ubertini's life with the claim that this is the first treatise on ophthalmology in the Middle Ages without mentioning Peter of Spain. (Reference supplied by L. Böninger).

who had complained that he "could no longer read or write without eyeglasses (*occhi di vetro*)."[19] The pills were made of an herbal mixture composed of chamomile, colocynth, quince, leeks, etc. Other herbal pills were prescribed by Maestro Tommaso for the same monk to "purge the eyes" so that spectacles for reading" (*occhiali a llegere*) would not be needed. Additional herbal salves or potions were prescribed by Maestro Piero himself to treat "painful red eyes," "cloudy eyes," and similar conditions.[20] It is interesting that the author used two expressions in mentioning eyeglasses and that the prescribed herbal remedies were intended to ward off their use. Apparently the mediocre quality of fourteenth-century spectacles made physicians cautious in prescribing them, preferring to try other remedies first. This treatise, however, is perhaps the second, not the first treatise on ophthalmology as the editor claims, having been written about a century after Peter of Spain's *De oculo*. It should be added that medical prejudice against the use of spectacles was common throughout the Renaissance and survived in attenuated form in the following centuries, as it will be noted in the last chapter.[21]

Literary References in Italy

As has been noted above, the earliest documentary references to spectacles are scattered in various regions of Italy from Rome northward. Not so when literary texts are considered. As Domenico Manni claimed in the early eighteenth century, most textual references to spectacles in Italy in the first century of their existence had a Tuscan, especially Florentine, origin.[22] This fact is confirmed by the numerous quotations illustrating the usage of the words "*lenti*" (lenses) and "*occhiali*" (eyeglasses) published in standard Italian dictionaries such as the *Vocabolario degli accademici della Crusca* (first ed. 1612), Tommaseo and Bellini, *Dizionario della lingua italiana* (1929), and Battaglia, *Grande dizionario della lingua italiana* (1973, 1981). This was the century, of course, when the foundations for the Italian language were being laid by the three crowns of Italian literature, Dante Alighieri (1265–1321), Francesco Petrarca (1304–74), and Giovanni Boccaccio (1313–75), all Florentines in origin but with many years spent outside of the city. Their enormous influence throughout the Italian peninsula and across the Alps as well as the pace setting originality of Florentine artists gradually made Florence the intellectual and artistic center of the peninsula during this period, the so-called "Athens of Italy." This leadership in the development of Renaissance culture, combined with the republic's wonderfully preserved archival commercial sources (especially account books), and the uniquely abundant memoirs of its leading citizens, largely explains the massive preponderance of

19. "Non poteva leggere né iscrivere più sança occhi di vetro." (ibid., p. 28).
20. Ibid., p. 38.
21. See chap. VI, pp. 246–52.
22. Manni, *Degli occhiali da naso inventati da Salvino Armati* (Florence, 1738), pp. 50–52, 74–75.

Florentine records about early spectacles except for artistic representations, which were far more frequent in non-Florentine art.

With regard to the first crown of Italian literature, no definitive or explicit documents have been found proving that Dante either saw or wore eyeglasses, although he died well into the second generation of their use. Yet, some passages from his works as well as evidence from his career would make him a perfect candidate for spectacle wearing. In the *New Life* (1292–93), he wrote that his eyes were strained or weakened by too many continuous tears remembering the death of his beloved Beatrice (d. 1290):

> *As a result of the rekindling of my sighs, my weeping which had abated was also refueled to such an extent that my eyes were like two objects desirous only of shedding tears; and it often happened, because I wept for so long, that my eyes were ringed with dark red, which happens as a result of some illnesses which people suffer.*[23]

In the *Convivio*, B. III, Ch. 9 (1304–08), Dante discussed the Aristotelian intromission theory of vision and the viewing of stars according to the amount of light surrounding them and the condition of the observer's eye. Here once again he mentioned eyestrain, this time caused by too much reading, and added a succinct description of presbyopia.

> *It [the star] may have this appearance also by reason of the visual organ (namely the eye), which because of illness or fatigue undergoes change, acquiring a certain coloration and a certain feebleness, as when it often happens that because the membrane of the pupil has become thoroughly bloodshot as a result of some impairment brought about by illness, things have the appearance of being completely red, and so that star seems to acquire color. And because the sight is weakened, some deterioration of the visual spirit takes place, so that things do not seem in focus but blurred, almost as our writing does on damp paper. This is why many, when they wish to read, hold the writing at a distance from their eyes, so that the image may enter the eye more easily and more sharply; in this way writing is made clearer to their vision. And so a star may likewise seem blurred. I had experience of this in the very year in which this canzone was born, for by greatly straining my vision through assiduous reading I weakened my visual spirits so much that the stars seemed to me completely overcast by a kind of white haze. But by resting at length in dark and cool places and by cooling the surface of my eyes with clear water, I regained that power which had undergone deterioration, so that I returned to my former state of healthy vision.*[24]

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23. *La Vita Nuova* XXXIX/4, trans. B. Reynolds (Baltimore, 1969), p. 95. The Italian original, ed. M. Barbi in *Enciclopedia Dantesca, Appendix*, 2nd ed. (Rome, 1984), p. 642: "Per questo raccendimento de' sospiri si raccese lo sollenato lagrimare in guisa che li miei occhi pareano due cose che disiderassero pur di piangere; e spesso avvenia che per lo lungo continuare del pianto, dintorno loro si facea uno colore purpureo, lo quale suole apparire per alcuno martirio che altri riceva."

24. *Dante's Il Convivio (The Banquet)*, trans. R. H. Lansing (New York and London, 1990), p. 116. Italian original in *Il Convivio*, ed. G. Busnelli and G. Vandelli, 2nd ed. con appendice di aggiornamento a cura di A. E. Quaglio, part I (Florence, 1964), pp. 374–76: "Peró puote anche parere così per l'organo visivo, cioè l'occhio, lo quale per infertade

Copious and continuous weeping as well as "assiduous reading" of the compressed Gothic script in Dante's time under the flickering light of a candle, torch, or oil lamp may, indeed, have caused eyestrain, but the fact that he soon recovered his former vision shows that it was a temporary condition. Some modern ophthalmologists have diagnosed the condition as a temporary spasm of accommodation of the crystalline lens of the eyes due to eyestrain, a condition that can afflict persons with normal vision as well as myopes and hyperopes. It is interesting to note that the therapy described by Dante was still recommended in Italy as late as the 1920s according to one ophthalmologist. Evidently the clear description of presbyopia (*"many, when they wish to read, hold the writing at a distance from their eyes"*) was inserted by way of comparison. Dante was about thirty years old when the above quotation was written (1294–98), not quite at the age of presbyopia.[25]

And presbyopia is also alluded to in two passages in the *Comedy: Inferno* XV, 18–21 and X, 100–04, with the former specifically applying to the weak sight of an elderly tailor.[26] Clearly the poet was well aware of this condition but neither in these passages nor elsewhere in his writings does he mention its already common remedy—spectacles with convex lenses—while he was specific in describing the perhaps more known treatment for eyestrain. Since it is hard to believe that he could not fit the word "occhiali" anywhere in his prose or poetry, despite several relevant opportunities, one can conclude that the omission was intentional for reasons that escape us. But eyeglasses might have been mentioned in his private correspondence, most of which has not survived,

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e per fatica si transmuta in alcuno coloramento e in alcuna debilitade; sì come avviene molte volte che per essere la tunica de la pupilla sanguinosa molto, per alcuna corruzione d'infertade, le cose paiono quasi tutte rubicunde, e però la stella ne pare colorata. E per essere lo viso debilitato, incontra in esso alcuna disgregazione di spirito, sì che le cose non paiono unite ma disgregate, quasi a guisa che fa la nostra lettera in su la carta umida: e questo è quello per che molti, quando vogliono leggere, si dilungano le scritture da li occhi, perchè la imagine loro vegna dentro più lievemente e più sottile; e in ciò più rimane la lettera discreta ne la vista. E però puote anche la stella parere turbata: e io fui esperto di questo l'anno medesimo che nacque questa canzone, che per affaticare lo viso molto, a studio di leggere, in tanto debilitai li spiriti visivi che le stelle mi pareano tutte d'alcuno albore ombrate. E per lunga riposanza in luoghi oscuri e freddi, e con affreddare lo corpo de l'occhio con l'acqua chiara, riuni' sì la vertù disgregata che tornai nel primo buono stato de la vista." The canzone to which Dante is referring is his second one commented in the *Convivio*, "Amor che ne la mente mi ragiona." It contains this passage that gave rise to the comment quoted above: "Tu sai che 'l ciel sempr' è lucente e chiaro,/ e quanto in sè, non si turba già mai;/ ma li nostri occhi per cagioni assai/ chiaman la stella talor tenebrosa." (ibid., I, p. 255).

25. See E. Passera, "Le cognizioni oftalmologiche di Dante," *Archivio di storia della scienza* III (1922), pp. 1–31, for a detailed discussion of Dante's ophthalmologic knowledge as can be gathered from his writings. Passera, an ophthalmologist at the eye clinic of the University of Rome, proposed this diagnosis: "spasmo dell'accomodazione, che si osserva appunto in persone giovani, in miopi, ma anche in emmetropi e ipermetropi. L'occhio allora si miopizza e le immagini degli oggetti lontani appaiono turbate, non giungendo I raggi a riunirsi esattamente sulla retina. Notevole anche, nel caso di D., il trattamento terapeutico, seguito da felice risultato; poichè oggi ancora, eccettuata l'atropina, non si saprebbe far di meglio in tali casi se non ricorrere al riposo prolungato in luoghi oscuri ed alle applicazioni fredde." (pp. 24–25). Cf. also G. Albertotti, "Un caso di spasmo dell'accomodazione descritto da Dante nel 'Convivio,'" *Annali di ottalmologia e clinica oculistica* LVIII (1930), pp. 52–53, who makes the same diagnosis without citing Passera or commenting on the treatment related by Dante.

26. Passera, "Le cognizioni," pp. 25–26, quotes the passages.

considering that in the following century private letters have revealed some of the most important evidence about their nature and early use. Myopia, on the other hand, is not mentioned or alluded to at all by Dante apparently because it was not a common condition in his time.[27]

Although the absence of the words "eyeglasses" or even "concave mirrors" and "magnifying lenses" for reading and fine work (all of them used with varying frequency at least in scholarly circles in his own time, as noted in the first chapter) from Dante's writings, deprives us of direct evidence about his knowledge of spectacles or lenses, events in his career offer abundant circumstantial evidence that he must have known about them. During the first half of the 1290s, when Dante suffered from eyestrain, he undertook an intense and wholly absorbing study of philosophy and theology for at least two and a half years partly as a solace for the loss of Beatrice. He attended lectures and disputations at the schools of monastic orders in Florence, namely the Dominicans at Santa Maria Novella and the Franciscans at Santa Croce in the opposite side of the city.[28] It is probably at this time that he began his study of optics or *perspectiva* as it was called at that time, both in its physiological aspects and in visual perception with its dependence on geometry. His works show an extensive knowledge of optics partly derived from the treatises of Alhacen, Witelo, and Bacon but also from his readings of theological tracts and sermons with their emphasis on light emanating from God. He discussed vision—direct, reflected, refracted—with numerous examples including the various effects of light on the eyes such as in pinhole images, optical illusions, distance and color of things seen, mirrors and related types of reflection, refracted light in rainbows, etc.[29]

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27. Passera, "Le cognizioni," does not cite any passages attesting to Dante's knowledge of myopia, and he is mystified by Dante's failure to mention spectacles even in certain passages of his works where it would have been natural to mention them: "La *Divina Commedia*, a quanto ne dicono gli autori, fu iniziata verso il 1302 e portata a termine nel 1321; ma può giustamente obbiettarsi come il Poeta non abbia, nelle scene di essa, trovato occasione nè motivo d'accenno, anche indiretto agli occhiali; oppure . . . non abbia creduto per essi confacente alla ragione poetica ed all'arte, un riferimento od una similitudine. Meno facile riesce invece il chiarire come e perchè Egli, se conosceva questa invenzione e la medesima, come pare, era realmente già accettata nella pratica, anche solo da presbiti dotti o cittadini fra i più cospicui ed abbienti, non ne abbia fatto neppure un cenno là ove, nel *Convito* [III, 9], come vedemmo, il passo in cui allude alla presbiopia, glie ne offriva la naturale e, direi quasi, inevitabile occasione" (p. 29).

28. G. Petrocchi, "Biografia: Attività politica e letteraria," *Enciclopedia Dantesca, Appendice*, 2nd ed. (Rome, 1984), pp. 12–13.

29. Dante's knowledge of optics and his dependence on some of the leading optical theorists of his age have been analyzed in detail by A. Parronchi, "La perspettiva Dantesca," *Studi Danteschi*, 36 (1960), pp. 5–103. See also his latest succinct statement: "Perspectiva," *Enciclopedia Dantesca*, IV (1973), pp. 438–39, and E. Crivelli, "Il vetro, gli specchi e gli occhiali ai tempi di Dante," *Giornale dantesco*, (1941), pp. 79–90. More recently, however, Dante's reliance on optical treatises written in the last half of the thirteenth century has been questioned by S. A. Gilson, "Dante's Metereological Optics: Refraction, Reflection, and the Rainbow,' *Italian Studies* 52 (1997), pp. 51–62, who maintains that for meteorological optics Dante followed mostly Aristotle and his commentators. Gilson has expanded these views in his book, *Medieval Optics and Theories of Light in the Works of Dante* (Lewiston, NY, 2000), especially chapters 6–7. Cf. also R. Kay, "Dante's Empyrean and the Eye of God," *Speculum* 78/1 (2003), pp. 37–65. Kay believes that at times Dante took some liberties with optical theory to fit his poetic imagery: "It seems that Dante used the

The *Enciclopedia Dantesca* attests that the "eye" is the most common noun in the *Divine Comedy* (1302–21), with 263 occurrences, 101 of them in *Purgatory* especially in canto XV. In fact, anyone who reads the *Comedy* in several continuous sittings as one would a novel (not recommended for sheer pleasure) would probably conclude that Dante was obsessed or fascinated by the eyes and vision in general. The noun occurs frequently in his other works as well: *Vita Nuova* (56), *Rime* (68), *Convivio* (71), *Fiore* (6). And this counting does not include the great number of eye synonyms or related words he used such as "see" and "vision."[30]

Although medieval optical theory could not explain to Dante the operating principles of spectacles, as we have noted in the first chapter, his well-known inquisitive mind must have been alerted by their obvious usefulness when he surely saw friars wearing them while he attended lectures at Santa Maria Novella and at Santa Croce. His eyestrain at this younger age (ca. 25–30) would have been eased by wearing spectacles with convex lenses.[31] Moreover, contemporaries like Francesco da Barberino (1264–1348), notary and doctor of both laws, mediocre poet, and much traveled fellow exile from Florence, could have alerted him to the use of concave mirrors as magnifiers to help "preserve" eyesight in the unlikely possibility that this fact was unknown to Dante. In Francesco's Latin comments to his love poetry, *Documenti d'Amore* (ca. 1309–10), he treats current medieval optical theory with ample comments on the properties and uses of concave mirrors including their function as reading aids despite the inconvenience of the reversal of images.[32]

It should be recalled, also, that Dante remained in Florence for sixteen years after the invention of eyeglasses, holding high positions in the government of the Commune as a member (since 1295) of the Guild of Physicians and Apothecaries, which included painters. It is believed that he joined this guild at least in part because of his admitted interest in drawing, which would have directed him to the study of geometric perspective then in its infancy under the influence of his intimate friend, Giotto.[33] It may be noted here,

extramission theory of vision as a poetic device, even though he considered the opposing intromission theory to be the correct, scientific explanation." (p. 43).

30. For these occurrences, see F. Tollemache, "Occhio," *Enciclopedia Dantesca* IV (Rome, 1973), pp. 117–21. Parronchi, "La perspettiva Dantesca," p. 46, highlights Dante's optical knowledge shown in the *Comedy* as follows: "Constatando ora come Dante, nel poema, non abbia tralasciato alcuno dei fenomeni salienti in cui la teoria ottica si riassume—tanto che i passi che verremo descrivendo costituiscono quasi nel loro insieme un breviario di *perspectiva* . . ."

31. My ophthalmologist friend, Letocha, informed me that "using convex lenses can relieve the eyestrain of younger people." (private communication, 2004).

32. *I documenti d'amore di Francesco da Barberino secondo i MSS. originali*, ed. F. Egidi, vol. III (Rome, 1924), doc. 8, pt. 7, pp. 112–19 for his comments on vision; vol. I (Rome, 1905), doc. 12, pt. 1, pp. 158–60 for his comments on mirrors: "Sed specula retinere ad studium vel scribendum vel alias ad visum conservandum. . . ." (p. 158). "Cum hoc [concave mirror] lictere manu scripte sinistra, leguntur et ubique contrario posita representantur, hic propria." (p. 160).

33. Passera, "Le cognizioni," pp. 6–7 and Parronchi, "Perspettiva," p. 438.

parenthetically, that this guild also enrolled spectacle makers in the fifteenth century and perhaps even earlier.[34]

Finally, it is entirely possible that by the time Dante was exiled from Florence in 1302, he might have met Della Spina either at Pisa or in Florence as the "optician" friar's fame surely spread. It is more probable that he met Giordano da Rivalto years before the latter made his famous public announcement in 1306.[35] By this date the poet was in his fourth year of exile, traveling, studying, and writing in various places in Italy, including the Veneto region and Venice itself, with additional ample opportunity to see bespectacled persons. By the time of his death in 1321 at the age of fifty-six he must have developed presbyopia and learned the usefulness of eyeglasses. And if weeping and excessive reading caused the eyestrain in his younger years, he did plenty of both from the age of 37 onwards as he traveled as an exile for the rest of his life after the confiscation of his property and the passing of two death sentences, not to mention the loneliness of being separated permanently from his wife after the first year of his exile.[36] His was a life full of stress, certainly not beneficial to eyesight or other bodily functions. In conclusion, there is enough circumstantial evidence to risk hanging a pair of spectacles on Dante's nose. But since the documents are not available, a more restrained hypothesis is in order; namely, Dante certainly saw spectacles and almost certainly wore or tried them at least once! To believe otherwise, we must regard him as blind as he accused his Black Gwelph enemies in Florence of being, the very people who had exiled him.

Such doubts, however, do not exist as far as Petrarch is concerned. Born two years before Giordano preached his sermon, the poet and father of Renaissance humanism lived his entire life in what can now be called the "age of spectacles." His well-known vanity would not allow him to neglect informing posterity that he, too, needed this aid for elderly scholars, just as Tomaso da Modena had already depicted Cardinal Hugh of St. Cher. Among his *Epistolae Seniles (Letters of Old Age)* (1370–74), the poet addressed an unfinished one to posterity in which he sketched a succinct and often quoted account of his physical attributes:

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34. See ch. V, p. 154–55.

35. Although the movements of Giordano are scantily documented in this period, one Dante scholar believes that direct contacts between him and Dante cannot be entirely excluded. See A. Vallone, "Dante e fra Giordano da Rivalto," in his *Ricerche Dantesche* (Lecce, 1967), p. 115. He maintains, in addition, that "par certo che l'uno e l'altro leggevano gli stessi libri, frequentavano gli stessi ambienti e luoghi, avevano dimestichezza di situazioni a loro particolarmente note. La lingua stessa nel suo insieme (salva ogni distinzione di poesia e predica) nasce quasi in un unico atto ed ha egual forza, calore e sicurezza. La mole poi dei riscontri, di pensiero e di stile, di strutture e d'immagini, addotti sul piano esemplificativo, sottolinea, anche per questa via, la contemporaneità e la consaguineità di Dante e Giordano da Rivalto" (p. 131). Vallone reaffirms these views in his article, "Giordano da Pisa," *Enciclopedia Dantesca* III (Rome, 1971), p. 174.

36. Dante's travels during his long exile are not well documented. For various bits of evidence and suppositions about his movements, and for events in his life in general, see Petrocchi, "Biografia," pp. 1–53.

> *In my prime I was blessed with a quick and active body, although not exceptionally strong; and while I do not lay claim to remarkable personal beauty, I was comely enough in my best days. I was possessed of a clear complexion, between light and dark, lively eyes, and for long years a keen vision, which however deserted me, contrary to my hopes, after I reached my sixtieth birthday, and forced me, to my great annoyance, to resort to glasses. Although I had previously enjoyed perfect health, old age brought with it the usual array of discomforts.*[37]

Clearly, Petrarch hoped to escape the necessity for a man of sixty to use spectacles not just because his vision remained keen up to that point, but also because most likely he previously had resorted to magnifying lenses and concave mirrors for close work. His association of the use of spectacles with the annoying discomforts of old age is tempered by his admiration of them as one of the clever devices invented by men to remedy the imperfections of nature as expressed in his earlier work, *Remedies for Fortune Fair and Foul* (1354–66). In a remarkable passage celebrating the dignity of man as God's noblest creation and contrasting his inventiveness to the hapless state of animals, he listed eyeglasses as one of man's notable accomplishments:

> *Man, however, though he be naked, is appareled, adorned, and, when necessary, armed with a mind. If he gets lame and weak, he rides on a horse, in a boat or a carriage, or leans on a helpful staff. In short, he uses all available means to assist and ease himself. He has learned to make wooden legs, iron hands, and wax noses, when these organs are missing, and deals with unforeseen mishaps by preparing medicines to brace his failing health. He wakes his sluggish appetite with spicy sauces, succors his bleary eyes with glasses, in which respect you have made significant progress over your ancestors, who, as Seneca mentions, used glass containers filled with water. . . .*[38]

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37. *Petrarch: A Humanist Among Princes. An Anthology of Petrarch's Letters and of Selections from His Other Works*, ed. D. Thompson (New York, 1971), p. 2. Latin: "Forma non glorior excellenti, sed que placere viridioribus annis posset: colore vivido inter candidum et subnigrum, vivacibus oculis et visu per longum tempus acerrimo, qui preter spem supra sexagesimum etatis annum me destituit, ut indignanti michi ad ocularium confugiendum esset auxilium. Tota etate sanissimum corpus senectus invasit, et solita morborum acie circumvenit." (F. Petrarca, *Prose*, ed. G. Martellotti, P. G. Ricci, E. Carrara, and E. Bianchi (Milan, Naples, 1955), p. 2).

38. *Petrarch's Remedies for Fortune Fair and Foul: A Modern English Translation of De remediis utriusque Fortune*, with a Commentary by C. H. Rawski, Book II, Chapt. 93, vol. 3 (Bloomington and Indianapolis, 1991), p. 227. In Latin: "Animalibus ergo que vel senio vel scabie depilata aut caligantia oculis aut pede clauda conspicimus remedii nihil est, nisi ab homine conferatur. Homo autem per se nudus ingenio vestitur atque ornatur et si res poscat armatur. Claudus atque debilitatus equo aut navi fertur aut vehiculo aut auxiliaribus bacillis immittitur. Denique modis sese omnibus adiuvat attolitque, quin amissis artubus pedes ligneas, manus ferreas, nasos cereos fabricari didicit, et fortuitis casibus obstare, valitudinem fatiscentem medicamentibus erigit, gustumque torpentemque saporibus excitat, visumque languidum ocularibus refovet. Qua in re maioribus vestris acutius cogitastis, qui vasculis vitreis aqua plenis, ut Seneca meminit, utebantur." (C. Trinkaus, *In Our Image and Likeness: Humanity and Divinity in Italian Humanist Thought*, vol. I (Chicago, 1970), pp. 399–400, n. 34).

At the present we may smile at his admiration of primitive orthopedic and cosmetic surgery, but this early humanist displays essentially the same enthusiasm for his age's ingenuity as we do for the almost daily breakthroughs in medicine and computer technology. This is even more significant in Petrarch's case because he frequently belittled the achievements of his age when compared to the glories of ancient Greece and Rome. Yet in the second quotation there is a hint of smugness toward the ancients' use of water-filled bottles as reading aids, although he neglected to add that in the preceding sentence Seneca had also mentioned the use of concave mirrors as magnifiers.[39] In fact, except for the above two specific mentions of spectacles found to date in Petrarch's writings, we look in vain for references to magnifying lenses and reading mirrors in his works even though two of his portraits show a concave mirror on his desk, as we have noted in the first chapter. Unlike Dante he does not seem to be interested at all in theoretical optics or related questions affecting vision except in the practical matter of acquiring spectacles for his presbyopia, which he could easily have done during his twenty-year residence in northern Italy and the Veneto.[40] And it is surprising that being the "first modern author of whom we possess a likeness that is more or less contemporary," and having been "portrayed more often than any other writer" within a generation following his death, that no artist was inspired to portray him wearing or holding glasses or illustrate any of his works with this vision aid.[41]

Even less helpful in this respect is Boccaccio, in whose writings no mention of spectacles or other vision aids has been found. Even in his biographies of Dante and Petrarch there is no mention of the former's absorbing interest in optics and of the latter's presbyopic vision. It is amazing that in the many humorous stories in the *Decameron*, Boccaccio could not find a place for mirror tricks, which could easily have been suggested to him by reading Seneca's *Natural Questions*.[42] It is practically certain that by the time of his death at age 62 he would have needed spectacles or magnifying lenses for his scholarly work just like his intimate friend and mentor, Petrarch, whom he visited several times at his various residences in the Veneto. Perhaps his familiarity with such devices might

39. See chap. I, p. 42.

40. This is confirmed by the diligent research of one of Petrarch's biographers, E. H. Wilkins, *Life of Petrarch* (Chicago and London, Phoenix ed., 1963), whose comprehensive index includes a host of topics treated by the poet with only one entry for eyeglasses and no entries for magnifying lenses or mirrors.

41. See the long survey by J. B. Trapp, "The Iconography of Petrarch in the Age of Humanism," *Quaderni petrarcheschi*, IX–X (1992–93), pp. 11–73, quotation p. 15. See also G. Mardersteig, "I ritratti del Petrarca e dei suoi amici di Padova," *Italia medioevale e umanistica* XVII (1974), pp. 251–80. A portrait of the poet in his study in an untitled manuscript [Strozzi MS 172, fol. 1^v, Biblioteca Medicea Laurenziana], at first glance appears to show glasses on his nose, but on closer inspection I realized that the artist drew with dark lines the orbit around his eyes, not spectacles. On the desk there appears to be a concave mirror mounted on horn.

42. The database on the *Decameron*, maintained by Brown University, shows no entries for spectacles (occhiali), lenses (lenti), or mirrors (specchi).

explain his silence on this topic although he mentioned a host of other common household objects.

The humorous aspects of inadequate vision and its correction by spectacles, however, were fully appreciated by a younger contemporary and admirer of both Petrarch and Boccaccio, Franco Sacchetti (ca. 1332–1400), whose career as a Florentine merchant and self-taught writer resembles somewhat Boccaccio's own. In the earthy language of the people, Sacchetti recounted many humorous stories in his *Trecentonovelle* (ca. 1392), in one of which he described the trick played on a certain Tommaso Baronci by his fellow priors sleeping in the Palazzo Vecchio in Florence. His colleagues had reversed his shoes during the night and he needed spectacles after arising to discover the joke and put them right. Baronci remarked: *These [shoes] do not seem to be mine although I don't see them well without my spectacles; and he took out his spectacles from his side and with them on he bent down as much as he could moving toward the window; . . .*[43] This may well be the first instance of spectacles being cited in a humorous or comical way in a literary work intended for the entertainment of the general public, a precursor of the type of humor and even satire associated with spectacles, which gradually became common from the end of the fifteenth century.

Sacchetti also seems to have been the first to mention glasses in poetry. In a *frottola* (song) entitled, *Sopra le nuove disposizioni del mondo mutate al male (On the New Order of the World Gone Bad),* (ca. 1391), he lamented the sorry state of virtually every aspect of his society, a world out of joint, which was a common theme in his short stories as well. In this song he wrote: *Artisans, seems to me, have become as knowledgeable and astute as brokers: they [examine] the books with spectacles to settle accounts [fanno specchi], and with pens [resting] on their ears and with disguised interest-bearing loans [cambi secchi], everyone buys and sells.*[44] Here there seems to be an image of the spectacle-wearer as an overly astute and even deceitful person, ready to settle accounts and hide interest charges through fictitious exchange contracts to avoid the penalties for usury—an image that will become common in the satire of bespectacled persons in the following centuries. Sacchetti, then, appears to be the first literary figure to originate the above two themes (satire and deceit) connected to the wearing of spectacles, not an insignificant achievement for a writer who has long been in the shadow of the three literary giants of his age. Indeed,

43. "Elle non paiono le mia, benché io non le veggo bene, se io non ho gli occhiali. E cavossi gli occhiali da lato, e misseseli, e con essi si chinava quanto potea, facendosi verso la finestra; . . ." (*Il Trecentonovelle,* ed. E. Faccioli (Turin, 1970), No. 83, p. 214).

44. *"Artefici son, parme, / divenuti / saputi / ed astuti / tra' sensali: / su' libri co gli ochiali / fanno specchi, / e con penne agli orecchi, / con cambi secchi / ciascun compera e vende."* F. Sacchetti, *Il libro delle Rime,* ed. F. Brambilla Ageno (Florence-Perth, Australia, 1990), No. 248, pp. 393–94. For an explanation of fictitious exchange contracts, *"cambi secchi"* ("dry exchanges"), to disguise interest-bearing loans, see R. De Roover, "Cambium ad Venetias: Contribution to the History of Foreign Exchange," *Studi in onore di Armando Sapori* (Milan, 1957), pp. 633–34.

this is a contribution to the history of eyeglasses that has not been noted previously, as far as I am aware.[45]

Early Diffusion Outside Italy

As in Italy, documentary evidence and artistic representations of eyeglasses in the fourteenth century are relatively few in other European countries. They occur much more frequently from the early fifteenth century onwards with the massive diffusion of spectacles. There is little doubt that the use of eyeglasses and the knowledge to construct them spread with reasonable rapidity across the Alps among clergymen, monks, merchants, and artisans who probably traveled with more frequency than has been realized. It should also be recalled that the papacy resided in Avignon for sixty-eight years (1309–77) and attracted suppliers and professional people along with clerics and many other visitors from all nations.

France, in fact, produced the second undisputed and clear mention of spectacles in a medical treatise—*Chirurgia magna*—completed in 1363 by Guy de Chauliac (ca. 1300–1368), surgeon and professor of medicine at the University of Montpellier, little more than a day's journey (96 km) from the papal court. Guy received his medical degree at Montpellier but also studied medicine at Bologna, and from about 1344 until his death he resided in Avignon at the service of three popes. Clearly he had ample opportunity to be familiar with eyeglasses. In part VI of his treatise, which became a standard medical textbook for the next two centuries at least, he advised the use of spectacles with glass or beryl lenses if various remedies, balsams, and potions (like fennel seeds or fennel water, for instance) did not alleviate enfeebled vision: *et si ista non valent, ad ocularios vitri aut berillorum est recurrendum.*[46] Although prescribing eyeglasses as a last resort was not an enthusiastic endorsement, as Maestro Ubertini had also written only two years earlier, this second reference shows at least that the medical profession was beginning to take notice of them three generations after their appearance without really understanding the principles behind their operation.

This conservatism of the medical profession is further exemplified by two other professors at Montpellier just preceding Guy, both of whom almost certainly had seen or known spectacles but did not mentioned them in their writings. Arnald of Villanova (ca. 1240–1311), a Spaniard who studied and traveled widely in places from Sicily to Paris, acquired such a reputation for his extensive knowledge of medicine, alchemy, astrology, and theology that various rulers sought his medical advice. In his treatise, *De conservatione*

45. A brief account of Sacchetti's busy commercial and political career in various regions of Italy, and a perceptive analysis of his writings, were published by N. Sapegno, *Il Trecento*, 2nd ed. (Milan, 1955), pp. 429–50.

46. Guigonis de Caulhiaco (Guy de Chauliac), *Inventarium sive chirurgia magna*, volume one: Text, ed. M. R. McVaugh (Leiden, New York, Köln, 1997), p. 346. For a brief biographical sketch of Guy, see pp. ix–xv.

juventutis et retardatione senectutis (On preserving youth and retarding old age) (ca. 1310) he simply advised that to ameliorate diminishing vision caused by aging one should ingest fennel seeds, which was a common prescribed remedy for several maladies.[47] Most assuredly he was familiar with magnifying lenses, but he did not mention them at least in this context. They were mentioned by his colleague, Bernard de Gordon (fl. 1283–1308), however, who in his popular major medical textbook, the *Lilium medicinae* (1303–05), prescribed an eye drop so powerful that the aged could read minute letters without a "beryl eye" or "eye of beryl" (*oculo berillino*). By this phrase Bernard almost surely meant to denote a magnifying lens rather than spectacles as both Albertotti and Rosen have already noted.[48] Like his colleagues, Bernard also advised the use of various salves for the eyes but cautioned in his *Tractatus de gradibus* (1303) that "if we want to test some drug on the human body, we should first experiment on birds, then on dumb animals, then in hospitals, then on Franciscans [fratribus minoribus], and so on progressively, lest it should prove to be poisonous and so fatal."[49] Sound advice except for the trial groups and certainly not to be applied to the Franciscans—the phrase is perhaps more appropriately rendered as "lesser brethren," presumably feeble-minded individuals.

Except for the clear mention of spectacles by Guy de Chauliac, other references found in French inventories with various dates from 1363 to 1399 appear to denote magnifying lenses from their context rather than spectacles as they have sometimes been interpreted.[50] The confusion arises over the fact that these sources mention the words

47. See P. Pansier, *Histoire des lunettes* (Paris, 1901), who quoted the relevant passage as follows, p. 19, n.1: "In minoratione visus quae est accidentibus senectutis, est confortare proprie virtutem cerebri et frequenter uti semine foeniculi." Cf. J. Ziegler, *Medicine and Religion c. 1300: The Case of Arnau de Vilanova* (Oxford, 1998), pp. 21–34 for biographical data.

48. According to the original Latin, the eye drop "est tante virtutis quod decrepitum faceret legere literas minutas sine oculo berillino," as quoted by L. E. Demaitre, *Doctor Bernard de Gordon: Professor and Practitioner* (Toronto, 1980), p. 53, n. 91. See also Rosen, "The Invention," II, pp. 201–02, and Albertotti in Pansier, *Histoire des lunetttes*, addendum, pp. 134a–b. Both Rosen and Albertotti point to the corruption of various passages in the works of Arnald of Villanova and Bernard for the mistaken belief that both writers mentioned spectacles.

49. Quoted and translated by M. R. McVaugh, "Quantified Medical Theory and Practice at Fourteenth-Century Montpellier," *Bulletin of the History of Medicine* 43 (1969), p. 403 and n. 10 for Latin original: ". . . quod si aliquam medicinam volumus experiri in corpore humano, quod prius experiamur in avibus et postea in brutis animalibus et postea in hospitalibus et postea in fratribus minoribus et postea in aliis per ordinem, quia si forte esset de genere venenorum interficeret."

50. See J. Rouyer, *Coup d'oeil rétrospectif sur la lunetterie*, 2nd ed. (Paris, 1901), p. 102, for the following list of items, mostly taken from L. Laborde, *Notice des émaux, bijoux et objects divers, exposés dans les galeries du Musée du Louvre*, 2nd part (Paris, 1853), glossaire, articles "Bericle" and "Beryl," pp. 163–64.

"1363. Un estein (étui) de bericle garni d'argent esmaillé [poise VJ marc] (Inventaire du duc de Normandie).
1372. Pour un vericle encerné en manière de lunette, prisé XX francs (Compte de la reine Jehanne d'Evreux).
1379. Un bericle rond plat environné de corne noire.
Deux bericles dont l'un a la manche de bois [loupe à lire] (Inventaire de Charles V).
1380. Un grand estrin (étui) de bericle garni d'argent esmaillé, pesant XVJ marc (Inventaire de Charles IV).
1399. Un bezigue rond, plat, environné de corne noire (même object que celui précédemment décrit. Inventaire de Charles VI)."

bericles, besicles, and *vericles* all deriving from the late Latin word *beryllus* (beryl), a natural mineral form of clear and colored crystal commonly ground in convex shapes and used as "reading stones" or lenses before and after the invention of spectacles. The medieval French words for spectacles, *bericles* or *besicles,* obviously, derived from "beryl," but from the fifteenth century onwards they were gradually displaced by the terms, *lunectes,* but more commonly *lunettes,* which became the modern term. This last transformation derived from the shape of the small disks or lenses for spectacles, resembling "small moons" from the Latin *luna* (moon).[51]

Clear evidence of spectacles, however, is supplied by two manuscript illuminations in French libraries. A psalter of the mid-fourteenth century, used by the Diocese of Angouleme and presently in the public library of Besançon (Ms. 140), shows an illuminated initial letter "D" at the beginning of the book of the dead in which the eldest cleric in a group of four singers wears a pair of rivet spectacles.[52] A later miniature in the initial letter "P," decorating Paul's first epistle to the Romans in the *Bible historiale* in the Bibliothèque Nationale, depicts the apostle reading a book with a pair of rivet spectacles fitted with dark colored lenses. This may well be the first representation of color spectacle lenses unless we accept a later date of 1420–30 rather than the usual assigned date of 1380.[53] Could the symbolism of color lenses for reading rather than for shading from the sun or bright light be connected perhaps to the blinding light of revelation while examining a sacred text?

Similar confusion in terminology and misinterpretations of sources, sometimes caused by corrupt manuscripts, reigns in Germany. Rosen clarified these cases with his customary thoroughness. The German poet Meissner (1260–80) did not mention eyeglasses six years before the generally accepted date for their invention, but simply wrote that small writing can be made legible for the aged by the use of a [concave] mirror (*spiegel*). Likewise a passage in the *Legatus divinae pietatis* written about St. Gertrude after her death (ca. 1303) refers to a *speculum* (concave mirror) used for magnification.[54]

Finally, the claim made by one scholar that the Dominican Theodoric (Dietrich) of Freiberg (ca. 1250–ca. 1310) was "the first [man of science] who specifically mentioned spectacles as devices to sharpen vision,"[55] cannot be proved through the Dominican's

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Rouyer classified all the above as magnifying lenses with handles and so do Madame A. Heymann, *Lunettes et lorgnettes de jadis* (Paris, 1911), p. 2, and R. Greeff, *Die Erfindung der Augengläser. Kulturgeschichtliche Darstellungen nach urkundlichen Quellen* (Berlin, 1921), p. 102. Cf. also M. A. Dollfus, "Les lunettes et la profession d'opticien d'après les comptes des XIV^e^ et XV^e^ siècles," *Archives Ophtalmologiques* 27 (1967), pp. 707–11.

51. See A. Vitols, *Dictionaire des lunettes* (Paris, 1994), articles "Béryl," and "Étymologie," pp. 68–70.

52. The contents of the manuscript are listed in the *Catalogue général des manuscrits des bibliothèques publiques de France* XXXII (Paris, 1897), pp. 95–97.

53. Reproduced in Heymann, Lunettes, p. 33.

54. See Rosen, "The Invention," II, pp. 206–08, for a detailed analysis of these expressions.

55. The claim is made by P. A. Rossi, "Cenni storici sulle origini del cannocchiale," in *La lente: Storia, scienza, curiosità attraverso la collezione Fritz Rathschüler* (Genoa, 1988), p. 70: "il domenicano Teodorico di Vriberg il primo

writings. It is true that in his various optical treatises (*De luce, De coloribus, De iride,* 1304–10), Theodoric treated refraction and reflection in transparent and opaque bodies such as magnifying lenses, plane, convex and concave mirrors, prisms and transparent crystal spheres and "stones" (beryls), and provided an advanced theory explaining the reflection/refraction phenomenon of drops of water in clouds forming rainbows, but he never mentioned eyeglasses as far as I can gather.[56]

One passage in Theodoric's *Treatise on the Intellect and the Intelligible* (ca. 1304), however, may have given rise to the above claim: "Also, in the use and operation of some of the senses even art is sometimes employed. This is apparent in the case of those who see by means of a crystal lens and the like [*qui vident per berillum et similia*]."[57] In this context the use of a convex shaped piece of beryl as a lens is clear, whereas the word *similia* would certainly include similarly shaped glasses or concave mirrors as vision aids, but less likely spectacles for which the term *ocularia* was already known, especially in Dominican circles. It is, indeed, odd that a specific mention of this vision aid is missing in his writings, given the fact that by the time of his death he could hardly have escaped noticing spectacles perched on his colleagues' noses and he probably used them himself. It may also be significant to note that he is last mentioned as a participant in the general chapter of the Order at the Dominican monastery at Piacenza (1310), held just a few months before Giordano da Rivalto's death at the same monastery in 1311 as the latter was traveling towards Paris. Perhaps Theodoric regarded eyeglasses as another form of vision aid not significantly different from reading stones, convex glass/crystal lenses, and concave mirrors especially because the rivet spectacles could form a more powerful magnifier when the two lenses were superimposed in the closed position. As such, they need not be treated as a separate category requiring distinct mention or analysis. As has been pointed out in the first chapter, medieval perspectivists did not attempt to apply optical theory to lenses for spectacles because "it was not the principles of optical instruments that were being sought, but an understanding of the laws of nature, applied to the most general cases; medieval optics was not an instance of applied science, but of natural philosophy."[58]

che parli espressamente di occhiali come di strumenti per acuire la facoltà visiva." The author does not give a reference to Theodoric's writings.

56. For an analysis of Theorodic's optical writings, see especially W. A. Wallace, *The Scientific Methodology of Theodoric of Freiberg* (Fribourg, Switzerland, 1959), pp. 170–82, 219, and A. C. Crombie, *Styles of Scientific Thinking in the European Tradition,* vol. I (London, 1994), pp. 382–88. Wallace translated portions of "On the Rainbow," in *A Source Book in Medieval Science,* ed. E. Grant (Cambridge, MA, 1974), pp. 435–41, making corrections after consulting the Leipzig manuscript.

57. See Dietrich of Freiberg, *Treatise on the Intellect and the Intelligible [Tractatus de intellectu et intelligibili],* trans. M. L. Führer (Milwaukee, 1992), p. 111. For the Latin text, Dietrich von Freiberg, *Opera Omnia* I, ed. M. Burckhard (Hamburg, 1977), III, 25, (9), p. 198: "In usu etiam et operatione aliquorum sensuum nonnumquam etiam arte utuntur, ut patet de illis, qui vident per berillum et similia." I am indebted to Professors Wallace and Führer for guidance in interpreting Theodoric's writings.

58. For the quotation: D. C. Lindberg, "The Science of Optics," in idem, ed. *Science in the Middle Ages* (Chicago, 1978), pp. 361–62.

On the other hand, archeology has established a genuine German priority in the history of spectacles. A recent (1953) archeological dig under the choir stalls in a nunnery at Wienhausen, a village near the town of Celle (Lower Saxony), has uncovered two complete eyeglass frames along with fragments of other frames and seven plano-convex lenses for rivet spectacles with refractive power ranging from +2.25 to +3.75. The survival of these lenses is, indeed, rare and may well be the only such example on record unless we include the four spectacle lenses (+2.5 to +3.5) of roughly the same date, which served as decoration on the lid of a casket or box found in 1849 in the nearby Lüneburg Town Hall. The Wienhausen frames are made of "hard, fine grained brown box wood, which was frequently utilised to make small and fine woodcarvings in the countries surrounding the Mediterranean Sea."[59] Some of the centrally riveted handles are straight, resembling the type depicted by Tomaso da Modena, while others of a later date are curved to form a rounded arch held together by the rivet. The fact that the choir "dates from about 1330," leads to the conclusion that the spectacles with the straight handles were made some time later in the fourteenth century but their place of origin has not been determined. The wood could have been imported from a Mediterranean country and the eyeglasses assembled in Germany or the whole product was imported. These spectacles may well be the first ones associated with women found to date, antedating those mentioned above in connection with the Florentine nunnery. The use of spectacles by women during the Renaissance has not been well documented owing to the scarcity of relevant documents.

A more recent (1982) discovery of two spectacle frames made of beech wood and a wooden spectacle case recovered near an Augustinian monastery in Freiburg is also dated in the fourteenth century. In this case the lenses have not survived. The frame handles are curved and centrally riveted to form a rounded arch or bridge.[60] These findings are remarkable discoveries and appear to offer the oldest specimens of early spectacles known to date with the possible exception of the fragments of five spectacle frames found in an archeological dig at the Cistercian monastery of Alvastra in Sweden. These frames have riveted straight handles like those discovered at Wienhausen and were found at a layer of the dig dated around 1300, but since stratigraphic dating is

59. Four publications by H. Appuhn supply details on this discovery: "A Memorable Find," *Zeiss Werkzeitschrift* 27 (1958), pp. 2–8; "How Old Are the Riveted Spectacles of Wienhausen?," ibid., 30 (1958), pp. 62–65; "Die Brillengläser und dem Buchkasten und die Brillen im Kloster Weinhausen," *Lüneburger Blätter*, No. 14 (1963), pp. 21–28; and his booklet, *Der Fund vom Nonnenchor* (Kloster Wienhausen, 1973), trans. H. Obstfeld, "The Oldest Spectacle Frames and Other Utensils for Daily Life," in *Ophthalmic Antiques Extracts, 1986–1996*, ed. R. J. S. Macgregor (London, 1996), pp. 7–9, quotation p. 7.

60. R. J. S. MacGregor, "The Freiburg Find," *Ophthalmic Antiques*, No. 57 (Oct. 1996), pp. 2–3, which contains additional information from the Museum of Ancient and Early History of the City of Freiburg, where the items are on display.

hardly precise, we can only say safely that they appear to be of the same date as those found in Germany.[61]

German Switzerland offers a contender for first place in representing eyeglasses with color lenses in the *Book of Chess*. The manuscript consists of a treatise written around 1290 by the French theologian, Jacques de Cessolis, to inculcate the "rules of morality and behaviour of the various groups of mediaeval society, which were symbolized by chess pieces that have to act (move on the board) in accordance with their rights and status."[62] It was translated into German verse form around 1337 by a Benedictine monk, Kunrat von Ammenhausen, and illuminated by an unknown artist near the end of the century. One of the miniatures depicts the eighth pawn holding three dice in one hand, a bag of coins in the other, intending to play the game with a bespectacled monk seated at a table with three dice in front of him. The rivet spectacles have dark color lenses—no blinding light of revelation this time, perhaps blind greed or fortune?

Another German-speaking country, Austria, offers the third oldest painting depicting eyeglasses after those at Treviso and Assisi—an altarpiece painting of the death of the Virgin Mary originally erected in eastern Austria between 1370 and 1372 and now on view in the Tyrolean Museum Ferdinandeum in Innsbruck. Mary on her death bed is surrounded by Christ receiving her soul and by apostles, one of whom is holding a pair of straight handled rivet spectacles before his eyes while reading a book held open by another apostle.[63]

Other early discoveries have been made in Zadar on the Dalmatian coast of Croatia. A notarial register of the effects of a local prelate, Philip de Sloradis of the Church of St. Peter, records *unum par oculorum de vitro* ("one pair of spectacles with glass lenses") with no listed value, dated 6 February 1388. This is the earliest reference found in Croatia, which also offers one of the first samples of a paper watermark depicting a pair of spectacles with straight wire handles bent to form a three-leaf cluster roughly resembling sugar tongs or pincers. The watermark was discovered in a manuscript dated mid-fourteenth century in St. Mary's monastery also in Zadar and is composed of paper of Italian origin. There are several other documentary references and artistic representations of spectacles of later centuries in Zadar and other parts of Croatia. This is hardly

61. The monastery at Alvastra was founded in 1143 and demolished in 1500. Although the dig began in the 1930s, the identification of the spectacle fragments by Prof. Robert von Sandor of the College of Applied Visual Sciences was made around 1989 on the occasion of an exhibition on the Alvastra monastery at the Historical Museum in Stockholm where the artifacts of the dig have been deposited. This information was supplied by Prof. Sandor in a private letter of 24 Nov. 1989 addressed to C. Letocha, who kindly made it available to me.

62. T. Voronova and A. Sterligov, *Western European Illuminated Manuscripts of the 8th to the 16th Centuries in the National Library of Russia, St. Petersburg* (Bournemouth and St. Petersburg, c. 1996), quotation attached to miniature No. 307.

63. F. Daxecker, "Representations of Eyeglasses on Gothic Winged Altars in Austria," *Documenta Ophthalmologica* 93 (1997), pp. 169–71, with two photographs of the painting.

surprising since Dalmatia and the entire eastern Adriatic coast were under Venetian influence and control for centuries and Zadar itself (Latin, Jadera, Italian, Zara), was long contended by Venice and Hungary and finally was purchased by Venice in 1409.[64]

English archeologists have also been active and most successful in finding fragments of early spectacle frames (without lenses), but their discoveries date from the early fifteenth century and will be treated in a later chapter.[65] England, however, offers the largest number of documentary references to fourteenth-century eyeglasses outside Italy. As in the rest of Europe, the terminology is equally confusing and must be interpreted in context. The Middle English term, *spectacle* (also *spectacule, spectakle*), could designate various things from a magnifying lens to mirrors and transparent glasses including windows. Its Latin root, *spectaculum* from *spectare* (sight, to watch, hence spectacle) is close to the Latin word for "mirror" (*speculum*) which also incorporates watching and seeing.[66] Nevertheless a pattern has been noted by Michael Rhodes, who has admirably examined this early evidence up to the middle of the sixteenth century and found that the term *speculum* was usually applied to mirrors and the term *spectaculum* to spectacles.[67] A magnifying lens was called *oculo vitreo* ("eyeglass") by Thomas Waleys (d. ca. 1349), an English Dominican friar who had been a lector at the Dominican *studium* at Bologna and a chaplain at the papal court in Avignon, and was certainly familiar with the current Latin term for spectacles, *ocularia*.[68] It is not clear why the classical term *conspicilia*, denoting convex lenses for magnification and near vision, was not readily and frequently used in England and elsewhere until the fifteenth century.[69]

The earliest English document mentioning spectacles lists *unum spectaculum cum duplici oculo, precii ijs* (a pair of spectacles with two lenses, priced two shillings), found in the inventory of the effects of Bishop Walter de Stapeldon who died in 1326, only twenty years after Giordano's sermon in Florence. There is no doubt that the word *spectaculum* designates eyeglasses because a few lines down in the same inventory a mirror

64. For a detailed, illustrated account of these findings, see V. Dorn, "A Contribution to the History of Spectacles in Croatia," *Documenta Ophthalmologica* 86 (1994), pp. 173–89. The later evidence will be treated in subsequent chapters.

65. See ch. IV, pp. 139–40.

66. The various meanings of the word "spectacle" are amply illustrated in the *Middle English Dictionary*, ed. R. E. Lewis, vol. 11 (Ann Arbor, 1988), pp. 392–93. By the fifteenth century it seems that the word "spectacle" was reserved for eyeglasses as can be seen in the *Catholicon Anglicum: An English-Latin Wordbook, dated 1483*, ed. S. J. H. Herrtage (London, 1881), p. 352.

67. M. Rhodes, "A Pair of Fifteenth-Century Spectacle Frames from the City of London," *Antiquaries Journal* 62/1 (1982), p. 64.

68. See B. Smalley, *English Friars and Antiquity in the Early Fourteenth Century* (Oxford, 1960), p. 82, n. 2, for the following quotation from one of Whaleys' commentaries on the Bible: "Non potuerunt (senes) scripturam legere, unde indigerent ad legendum oculo vitreo, quia enim vitrum litteram facit grossiorem saltem aspectui legentiis; ideo mediante vitro legit quod aliter non posit." This might be a clear indication that the elderly might have found the magnifying lens more useful than the spectacles then available.

69. See ch. I, p. 47 for the use of the classical term.

worth one penny is listed (*unum speculum, precii jd*). Three beryls, one big and two smaller ones valued at one shilling each, were also inventoried—"*unum berillum grossum, precci xijd* and *ij berelli (sic) minores, precii ijs.*"[70] If the beryls functioned as magnifying lenses, as I believe they did, then this document offers another opportunity to gauge the relative monetary value of spectacles and magnifying lenses without considering the mirror, which was a plane one in all probability and not magnifier. If this interpretation is correct, then it is evident that in England the price of spectacles was double that of magnifying lenses, and rather high considering that a carpenter earned a daily wage of 3.12d without food or drink, according to manorial records of this decade, with London wages being about 50% higher.[71] But the high value placed on the bishop's eyeglasses suggests that the lenses were made of crystal and the frame of precious or gilt metal, which would be common for persons of this rank, and is consistent with prices of similar constructed glasses in the fifteenth century to be discussed in next chapter.

It is presumed that the bishop's spectacles were of the early riveted type and were purchased several years earlier somewhere on the continent being that no records of spectacle makers have been found in England for the fourteenth century. The bishop, in addition to being Lord High Treasurer of England (and cofounder, with his brother, of Exeter College, Oxford) undertook several diplomatic missions on the continent, and just before assuming his bishopric, he served as chaplain to Pope Clement V then residing in France. He had ample opportunities to purchase or import them from several places.[72] On the other hand, if the Italian pattern of spectacle making can be extended to England, then other craftsmen and monks besides spectacle makers made or assembled eyeglasses and the Bishop could possibly have purchased them locally even at this early date.

Disregarding the "4 specularia" valued at 2 pennies from a later inventory of 1378 of a London haberdasher, which Rhodes properly classified as mirrors rather than spectacles on the basis of terminology and cost,[73] the last documents of great importance in this century are a few surviving customs records. In this fragmented source, only the entries for 1384 and 1390–91 show spectacle imports and in surprising quantities in this early period, as discovered by Vanessa Harding, Arthur MacGregor, and Stuart Jenks. The entries for 1384 indicate that eight gross (1,152 pairs) of eyeglasses were imported

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70. *The Register of Walter de Stapeldon, Bishop of Exeter (A.D. 1307–1326)*, ed. F. C. Hingeston-Randolph (London, 1892), p. 565.

71. D. L. Farmer, "Prices and Wages: 1350–1500," in E. Miller, ed., *The Agrarian History of England and Wales, 1348–1500* III (Cambridge UK, 1991), pp. 467–71.

72. See J. L. Reed, ". . . Valued at Two Shillings: A Fourteenth-Century Bishop and His Spectacles," *Vision* 6/2 (1952), pp. 31–32.

73. Rhodes, "A Pair," p. 64. For the document see *Memorials of London and London Life, in the XIIIth, XIVth, and XVth Centuries: Being a Series of Extracts Local, Social, and Political from the Early Archives of the City of London, A. D. 1276–1419*, selected, trans. ed. H. T. Riley (London, 1868), pp. 422–23. The editor translated *specularia* as "eyeglasses."

into London in the three-month period between July 1 and September 29 in non-English ships.[74] In May–June 1390 a total of 764 pairs were imported while in April–May 1391 the total rose to 4,104 with the May shipment alone amounting to 3,744 pairs—a record for fourteenth-century Europe.[75] But this may not be the end of the story. London also imported large quantities of glass and some crystal, which could be ground into lenses. A lot of mirrors appear in these records, some of which could be used as reading aids if concavely shaped. There are also general categories such as "*mercerie*" (merchandise) and haberdashery under which spectacles in England and on the continent were sometimes included. Finally, great quantities of cattle bones and horns or horn flats are listed, both of which were used for spectacle frames.[76]

Furthermore, it is reasonable to suppose that additional shipments of varying magnitudes probably landed earlier in other English ports, and that some imports in London and elsewhere were not reported in order to escape the custom duties, since long experience has demonstrated that, like death and taxes, contraband is inevitable, especially for easily hidden products of the kind. In essence, the above numbers are likely to understate to an unknown degree the actual quantities of imported spectacles into England, especially when we consider the incompleteness of these records as well as possible imports in English ships. It is indeed surprising that barely a century after their invention, spectacles should be so much in demand in a country with an underdeveloped economy compared to that of Flanders or Italy. In fact, no comparable shipments of eyeglasses have been found for the entire Italian peninsula in the fourteenth century, probably because customs or other records have not survived or have not been subjected to scholarly scrutiny. When we add the more massive English imports in the following century, we come to the surprising realization that with present knowledge, England is second only to Italy in the fifteenth century for the volume of spectacle shipments discovered to

74. Rhodes, "A Pair," p. 64. Rhodes reported these shipments from information supplied by Vanessa Harding, who has not published her dissertation or discussed details of these findings in her article, "Cross-channel Trade and Cultural Contacts: London and the Low Countries in the Later Fourteenth Century," in C. Barron and N. Saul, eds., *England and the Low Countries in the Late Middle Ages* (New York, 1995), pp. 153–68. I wish to thank Professor Harding for helpful advice especially in alerting me to Professor Jenks' research.

75. Professor Jenks, who is preparing an edition of the Customs Accounts, Tonnage and Poundage for the period 1390–1450 in the Public Records Office, has kindly extrapolated the data regarding spectacle imports into London and supplied me with the following transcriptions.

E122/71/13, m. 8, 4 May 1390: "William Canston . . . 4 dossenis spectacules 2s 2d".

"Roger Crane . . . 9 dossenis spectacles 24s 6d".

"Ricardo Bertegrane . . . 500 spectacules 21s".

m.13, 17 June 1390: "Petro van Crowemer . . . 9 dossenis spectacules 6s".

E122/71/16, m.9, 24 April 1391: "Petro Cruner . . . 30 dossenis spectacules 12s".

m. 10, 2 May 1391: "Hans Knygth . . . 26 grossis spectacules £4 6s 8d."

76. See A. MacGregor, "Bone, Antler and Horn Industries in the Urban Context," in *Diet and Crafts in Towns: The Evidence of Animal Remains from the Roman to the Post-Medieval Periods*, eds. D. Serjeantson and T. Waldron (Oxford, 1989), pp. 123–24, who cites some of the above entries from the Customs Accounts, Tonnage and Poundage, E.122/71/13, m. 8^v, and m. 9, along with other entries in the following century to be discussed in chap. IV.

date.[77] Moreover, with thousands of spectacles ensconced on English noses, one would expect some local production or at least the existence of artisans and monks ready to replace broken lenses and repair or replace misaligned or damaged frames, though we have no documents supporting this hunch. But Italy is still far ahead in the number of literary references in the fourteenth century, which for England are reduced to just one, Chaucer, around 1395: *"Pourte a spectacle is as thynketh me Thurgh which he may his verray freendes se."*[78] Apparently the imagination of English literary figures and artists was not stimulated by the spectacle of so many Englishmen precariously balancing glasses on their noses.

The above effort to list and examine briefly what is known about the history of eyeglasses during the first century of their use may serve to dispel the notion even among the few historians of spectacles that the fourteenth century offers meager pickings. As we have seen, the evidence is more plentiful than previously thought, and it illuminates a number of issues. Account books, wills, inventories, glass/crystal guild regulations, and customs records, in addition to literary references, attest to their spread in several countries, reveal the relatively low cost of spectacles with ordinary frames, and the persistent use of magnifying devices such as lenses and concave mirrors. Archeologists have uncovered spectacle frames and analyzed the materials from which they were made. At least three medical doctors mentioned glasses but continued to prescribe herbal remedies for "weak" elderly sight. Artists and literary figures took notice of them more commonly in Italy. Yet, the above evidence lacks detailed optical information—only the context makes clear that spectacle wearing was a remedy for presbyopia, correctable through the use of convex lenses, the "lentils." We must wait until the middle of the next century to get the first detailed and exact optical information about the various degrees of presbyopia and the first definite mention of myopia, the young people's affliction.

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77. See Rhodes, "A Pair," p. 66, for these later imports, which will be discussed in ch. IV along with the probable origin of the spectacles.

78. Quoted in *Middle English Dictionary*, vol. 11, p. 393.

III

Glasses for All Ages in Italy

THE FIRST HALF of the fifteenth century in Italy offers relatively few references to eyeglasses in contrast to the flood of new documents characterizing the second half. Yet, some documents of this period give crucial information about availability, cost, and manufacture of spectacles, all of which are confirmed in more detail after 1450. Moreover, there is the first association of spectacles with contemporary saints, sometimes accompanied by relative iconography, and the development of eyeglasses as sacred relics. Saintly learned figures, such as St. Jerome, had already been depicted anachronistically with spectacles in the preceding century, as we have seen. Relics and representations of bespectacled persons offer a great deal of data on spectacle shapes and frame materials, topics to be treated in a later chapter. But the most significant documents for the history of eyeglasses are dated after 1450. These new documents disclose for the first time the existence of concave lenses to correct myopia, apparently first developed in Florence, which became the leading manufacturing center for high quality spectacles, at least in the fifteenth century.

Concave Lenses Before 1450?

One recently discovered document constitutes one of the few crucial references for this period. It is an entry in an account book from 1415 of the Florentine *merciaio* (haberdasher) Lapino di Lapino, which is surprisingly detailed about costs of spectacles with various frame materials as purchased from another haberdasher in Florence, Franciesco di Bonachorso:

1415

Franciescho di Bonachorso, haberdasher, is owed [money] as of 24 May for the following things I purchased from him on that day:

6 big Venetian mirrors @ s.34 per dozen £– s.17
6 Venetian mirrors, seconds, @ s.26 per dozen £– s.13

6 pairs of spectacles with wooden frames @ s.8 per dozen £– s.4
6 pairs of spectacles with boxwood frames @ s.18 per dozen £– s.9
6 pairs of spectacles with bone frames @ s.44 per dozen £1 s.2
25 glass blanks for spectacles @ s.32 per hundred £– s.8

6 small Venetian mirrors @ s.17 per dozen £– s.8 d.6[1]

To date this is the first document discovered that neatly differentiates the costs of spectacles with frames made of various materials. Wood-framed ones at s.0.66 and s.1.33 (boxwood framed) per pair respectively were very low in price and, surprisingly, remained practically at the same level throughout our period. On the other hand, glasses with bone frames at s. 3.66 a pair cost much more than those similarly framed and exported in large quantities (hundreds and thousands) from Florence later in the century, which ranged from 2 to 3 soldi a pair.[2] The entry for glass blanks, at s.0.32 each, does not reveal whether the blanks had already been ground and polished into lenses of various powers, but it denotes that the cost of comparatively clear glass suitable for spectacles was rather low. Likewise the entries for the mirrors are not sufficiently specific to reach firm conclusions on pricing although mirrors are not a major concern for this study. Even considering that the resale unit prices were bound to be higher, one is left with the impression that, as in the fourteenth century, eyeglasses were affordable for many persons in need of them. It has been established that in 1415 in the Florentine construction industry the average daily wage for skilled laborers was s.17.9 *di piccioli* and for unskilled, s.10.7.[3] It was within their means to own a pair. The same can be said for Venice where the minimum daily wage for workers in the Arsenal was s.10.[4]

This period also offers the first documented evidence of goldsmiths as spectacle makers; i. e., assemblers of the entire product, not just makers of spectacle frames. It

1. Florence, Archivio Ospedale Innocenti, Estranei, 585, *Debitori e creditori di Lapino di Lapino, merciaio in Firenze,* f. 4^v. The document was discovered by Marco Spallanzani, who sent me the following transcription.

Mccccxv

Franciescho di Bonachorso, merciao, de' avere, a dì xxiiii di maggio, per queste chose tolsi da lui detto di: . . .
vi specchi viniziani grandi a soldi xxxiiii dozzina £– s.xvii
vi specchi viniziani sechondi a soldi xxvi dozzina £– s.xiii
. . .
vi paia d'occhiali di legno a soldi viii dozzina £– s.iiii
vi paia d'occhiali di bosso a soldi xviii dozzina £– s.viiii
vi paia d'occhiali di osso a soldi xliiii dozzina £1 s.ii
xxv vetri da ochiali a soldi 32 centinaio £– s.viii
. . .
vi specchi piccholi viniziani a s. xvii dozzina £– s.viii d.6

2. See ch. IV.

3. R.A. Goldthwaite, *The Building of Renaissance Florence: An Economic and Social History* (Baltimore and London, paperback ed., 1982), pp. 436–37.

4. See E. Zille, "Salari e stipendi a Venezia fra Quattro e Cinquecento," *Archivio Veneto* LXXIII (1992), p. 17.

was a natural development for them, for we have noted in the preceding chapters their close relationship with glass workers in gilding and enameling various glass objects and in the fashioning of gold and silver frames for luxury spectacles often mentioned in wills. This development was revealed in a contract signed in 1445 by three goldsmiths of Pisa, who entered into a partnership to manufacture eyeglasses with bone frames: *construendo, fabricando, archimiando et facendo occhialia de ossis et vitreis.* The contract is specific about the distribution of the profits after subtracting operating expenses and costs of raw materials such as glass blanks and bones, without specifying the exact nature of the latter—perhaps metacarpal bone of bulls.[5] Glass blanks were readily available from Pisa's well-developed glass industry and the cattle bones were abundant practically everywhere.[6] Most revealing is the fact that the frames were not made of metal, as one would expect of goldsmiths, and that the partners had to purchase suitably prepared bones from bone artisans and glass blanks from glass workers. It is not revealed also whether they ground their own lenses or purchased them already ground and polished to specifications. In essence, then, the three goldsmiths were functioning as assemblers of spectacles, coming close to the role of modern opticians.[7]

On the other hand, the contract was clear about prohibiting the partners from divulging the secret of making spectacles and their use of alchemy in the supposedly mysterious process of making them, which is sometimes cited in the sources of the age. This emphasis on keeping the process secret to the point that the partners so bound themselves by an oath on the Bible and a penalty of one hundred gold florins is somewhat surprising.[8] What was the secret after almost two centuries of spectacle making practically everywhere in Europe? One can surmise that the senior partner, Simone Nerucci, who possessed the secret and the tools for making glasses while the other two supplied the labor, had discovered perhaps a more efficient way of grinding and polishing convex lenses graded to age category and perhaps even concave lenses to correct myopia—apparently two new techniques that were definitely documented in Florence only seventeen years later, as we shall see. Should this surmise prove correct, then Pisa could claim a virtually unbroken chain of distinguished optical pioneers from Alessandro della Spina to Galileo.

The Pisan contract makes clear what we have already gathered from previously presented evidence; namely, spectacle making in Italy and most likely elsewhere, was not

5. For details on bone spectacle frames, see chap. V, p. 153–59.

6. For the development of the Pisan glass industry from the early years of the fourteenth century, see now T. Antoni, "Note sull'arte vetraria a Pisa fra il Tre e il Quattrocento," *Bollettino storico pisano* LI (1982), pp. 295–309.

7. The entire contract was published by M. Luzzati, "Una società per la fabbricazione di occhiali alla metà del Quattrocento,"*Antichità pisane* I (1974), pp. 40–45, with ample comment. Professor Luzzati has kindly informed me that to his knowledge this is the only contract of this type found to date.

8. "Et quod nullus ipsorum [the partners] possit aut debeat docere aliquem ad faciendum sive laborandum aliquid de predictis pertinentibus ad dicta occhialia. . . . [in contravention of this and other clauses in the contract, each bound himself] ad penam florenorum centum auri," ibid., pp. 40–41.

considered an independent trade. The Aretine humanist and librarian of Pope Nicholas V, Giovanni Tortelli (ca. 1400–1466), said as much five years later in his most popular philological dictionary of Greek terms used in Latin texts (*De orthographia dictionum e Graecis tractarum*, ca. 1450) in which he treated a great number of subjects including ancient and "new" inventions. Of eyeglasses he wrote: *Making two disks of thin glass or crystal or beryl, by which a feeble vision sees better, if it is to be believed, does not fall under any art. These they name spectacles.*[9] He was fifty years old when he wrote these lines. His skepticism about the value of glasses can hardly signify unfamiliarity with them; most likely he had tried them, found them wanting for his condition, and chose to continue using magnifying lenses and/or concave mirrors for close work unless he was one of those rare individuals having no need of vision aids at any age.

The first half of the fifteenth century, however, adds nothing new to optical knowledge as we have learned so far, although additional discoveries will likely amend this judgment. Glasses were still associated only with mature or elderly individuals whose "feeble" sight, if not relieved by balsams and herbs, could be aided by the use of spectacles with convex (positive, converging) lenses. But how did young persons before the age of thirty cope with shortsightedness or myopia, which presented distant objects out of focus and blurred because in their elongated eyeballs the light rays converged well before the retina? This condition can only be corrected by the use of concave (negative, diverging) lenses, which diverged or spread the rays sufficiently to focus the images on the retina. The ancients were already familiar with myopia, but left no record of a possible remedy. They used convex lenses and concave mirrors as magnifiers and Egyptian statues had eye assemblies composed of both convex and concave lenses, as we saw in the first chapter, but they did not have spectacles to produce corrected vision for short and longer distances as far as it can be established at the present time. In fact, we have a record of a 44-year-old Egyptian weaver being excused from serving in the Roman army in A.D. 52 because he was "suffering from cataract and shortness of sight."[10] The weaver might have been glad that his incapacity allowed him to escape military service whithout hindering him from continuing to pursue his close-focused trade. By coincidence, contemporary evidence shows that his much younger Emperor Nero (b. A.D. 37, Emperor 54–68) was also myopic and used a concave emerald stone to watch the gladiatorial games. It was once thought that this constituted the first documented use

9. A. Keller, "A Renaissance Humanist Looks at 'New' Inventions: The Article 'Horologium' in Giovanni Tortelli's De Orthographia," *Technology and Culture* 11 (1970), p. 354, and p. 351 for the original Latin: "Illud in artem nullam cadit fecisse duas orbes e tenui vitro chrystallove aut berillo: per quae infirmior visus melius: si credibile est: videat: quae ocularia nominant."

10. See J. D. Crossan, *The Historical Jesus: The Life of a Mediterranean Jewish Peasant* (San Francisco, 1991), p. 26: "Release from service was granted by Gn. Vergilius Capito, prefect of Upper and Lower Egypt, to Tryphon, son of Dionysius, weaver, suffering from cataract and shortness of sight, of the metropolis of Oxyrhynchus. Examination was made in Alexandria. . . ."

of a concave lens for distance viewing, but it is now believed that the stone was used as a means of shading his eye from the bright sun, a sort of a sunglass monocle.[11]

Yet, in these intervening centuries up to our period, there must have been a proportion of youths affected by myopia. Studies have shown that in Western societies in the 1930s, generally 15 to 20 per cent are nearsighted and about 50 percent farsighted. Since these conditions are hereditary, it would not be surprising if a lower proportion of myopia held true for the Renaissance (perhaps 10–15 percent) and a higher rate, perhaps 25 percent for the present time, as the generational process continues and youths are more frequently tested with refined methods of diagnosis.[12] In any case, it is clear that myopes were a small minority at that time and they were not totally handicapped. By shortening the distance of the object, myopic individuals are ideally suited for short distance tasks such as goldsmithing, needlework, miniature painting, reading/writing, and fine detail work in good light, and as they grow older, many tend to become less nearsighted. In fact, a significant number of mildly nearsighted persons may not need reading glasses until well past 40, if at all, because their eyes are naturally focused to near objects. But myopes would be at a great disadvantage as sailors or soldiers and in a sword fight, for instance! Whereas farsighted or presbyopic persons would find it difficult, if not impossible, to perform tasks adequately at less than an arm's length. The pressing need of this much larger proportion of the population for visual correction largely explains the fact that in the first period of spectacle development the attention of writers and artisans was focused on promoting the production of eyeglasses with convex lenses for those over forty. The lack of sidepieces to hold eyeglasses in place until well into the eighteenth century also explains the almost total absence of persons represented in paintings wearing glasses for long distance viewing. A monocle with a concave lens, however, could be used as shown in Raphael's portrait of the myopic *Pope Leo X and Two Cardinals* (1518).

Nevertheless, it seems hardly credible that from the invention of eyeglasses until the fifteenth century no writer or artisan had reasoned that if convex shaped lenses could correct farsightedness, the opposite curvature, concave, could correct nearsightedness. It is likely that someone did and probably used and sold spectacles with concave lenses for myopia, but no such record has been found. According to some scholars, the first hint that a spectacle maker had inserted such lenses in a pair of spectacles was recorded for posterity by Jan van Eyck in his painting, *Canon George van der Paele praying to the Virgin* (1436). The Canon (ca. 1370–1443) was depicted in the moment that he had interrupted his reading of an open prayer book to look in the distance in apparent meditation

11. Ancients' knowledge of lenses and Nero's use of the emerald stone have been amply discussed by D. Plantzos, "Crystals and Lenses in the Graeco-Roman World," *American Journal of Archaeology* 101 (1997), pp. 451–64.

12. For these percentages, see P. Trevor-Roper, *The World Through Blunted Sight: An Inquiry into the Influence of Defective Vision on Art and Character*, rev. ed. (London, 1988), pp. 20–21.

on what he had read while holding a pair of spectacles in his right hand. He was 66 years old when the painting was completed and suffering from painful and disabling temporal arteritis, which would have made it difficult for him to use his arms to hold the book at a comfortable reading position. A pair of spectacles with concave lenses, it is claimed, may have solved the problem, which ordinarily could have been also solved by any myope by holding the reading matter closer to the eyes. (He could also have used an adjustable lectern, widely available at that time.) But this modern medical diagnosis has been disputed by at least three American ophthalmologists and two opticians, and another two opticians in Holland. After carefully observing the written lines under the lenses from an enlarged reproduction of the painting, they came to the conclusion that the lenses were convex with a power of +2.50. Clearly, they were reading glasses for a presbyope. Typically the canon also has a spectacle case dangling from his belt.[13]

More certain in this respect, on the other hand, is the often-cited quotation from Cardinal Nicholas of Cusa's *De beryllo* (On the Beryl) as the first mention of concave lenses for the correction of myopia. In this treatise, written over a five-year period and completed in 1458, Nicholas treated the beryl metaphorically but also as a practical magnifying device:

> *The beryl is a clear, bright, and transparent stone, to which is given a concave as well as a convex form, and by looking through it, one attains what was previously invisible. If the intellectual beryl, which possesses both the maximum and the minimum in the same way, is adapted to the intellectual eyes, the indivisible principle of all things is attained.*[14]

Shorn of its convolution, for which Nicholas had a special aptitude, this passage seems to indicate that the beryl used in its concave shape aided distant vision ("the maximum") whereas the convex shaped one brought short distance images into focus ("the minimum"). And in another passage from his *Compendium*, completed in 1463, he again cited beryls as lenses to aid vision in a celebration of human creativeness and inventiveness to remedy the deficiencies of nature and master the environment at a level far superior than the capabilities of the animals. This passage is so reminiscent of Petrarch's boasting, quoted in the preceding chapter, that one is tempted to describe it as a direct borrowing of the concepts expressed. Unlike Petrarch, who used the term *ocularibus*,

13. B. G. Lane, "The Case of Canon Van der Paele," *Source: Notes in the History of Art* 9/2 (1990), pp. 1–6, summarizes the details of this medical diagnosis. The opposite view is held by Charles E. Letocha, historian of spectacles and practicing ophthalmologist. He polled two colleagues and two opticians in his office in York (PA) and contacted two opticians (Carla and Paul Aangenendt) in Eindhoven, Holland. They all independently agreed on the canon's presbyopia.

14. Quoted by P. Moffitt Watts, *Nicolaus Cusanus: A Fifteenth-Century Vision of Man* (Leiden, 1982), p. 172, with the Latin original: "Beryllus lapis est lucidus, albus et transparent, cui datur forma concava pariter et convexa; et per ipsum videns attingit prius invisibile. Intellectualibus oculis si intellectualis beryllus, qui formam habeat maximam pariter et minimam, adaptatur, per eius medium attingitur indivisibile omnium principium."

the cardinal stuck to the word *berylli*, probably thinking of its German derivative *Brillen* (eyeglasses).

> *For man alone discovers how to supplement weakness of light with a burning candle, so that he can see, how to aid deficient vision with lenses [berylli], and how to correct errors concerning vision with the perspectival art. He makes raw food pleasing to the taste by cooking it, he drives out stench with fragrant fumes and he drives out cold with clothes and fire and homes. He helps himself to travel more swiftly with carts and boats, he aids himself in his own defense with weapons, and he helps his own memory with the invention of writing and the art of memory.*[15]

The above quotations seem to indicate that Nicholas was familiar with spectacles fitted both with concave and convex lenses just a few years before we have unequivocal proof of the former's availability in quantity. In Rome at this time he could hardly have failed to see many of his colleagues using eyeglasses as the large imports of such items listed below fully attest. Nicholas was after all a well-informed and much traveled prelate with a long residence in Italy. Educated at the Universities of Heidelberg, Padua, and Cologne, friend and correspondent of many Italian humanists, including Paolo Toscanelli and Leon Battista Alberti, theoreticians of "the perspectival art" just mentioned, he was widely known and admired in Germany and Italy for his learning in theology, philosophy, mathematics, and canon law. His primary concern, however, was theological to the extent that his statements on vision and optics are often expressed in methaphorical terms and made part of his quest for understanding superior divine vision. Yet he also seems to have had a practical vein, leading him to propose experiments to test or illustrate scientific theories. This interest in earthly matters and in the "natural" wisdom of the intelligent but not formally educated layman (Idiot) is especially evident in his treatise, *Idiota de staticis experimentis (The Layman on Experiments Done with Weight-scales)* (1450). It is also present in some of his other works such as in the *Idiota de mente (The Layman on Mind)* (1450), a dialogue between a philosopher and a spoon carver, in which the craftsman attains and demonstrates practical wisdom through the manual arts, as shown in the following passage about the reflecting polished spoon. The philosopher, clearly, had never thought of looking at a polished spoon so closely, nor have most people to this day!

> LAYMAN: . . . *I wanted to make a spoon which would also be a mirror. I looked for close-grained wood finer than all other wood. I used my tools to draw the fitting proportions in*

15. Ibid., pp. 211–12, with Latin original: "Nam solus homo repperit, qualiter defectum lucis ardenti candela suppleat, ut videat, et deficientem visum beryllis iuvet et arte perspectiva errorem circa visum corrigat, cruditatem cibi decoctione gustui aptet, foetores fumis odoriferis pellat, frigori vestibus et igne atque domo, tarditati vecturis et navibus, defensioni armis, memoriae scriptura arteque memorandi succurrat."

which the form of spoon might be perfectly manifested. Then I polished the surface of the spoon until, as you see, I got the form of spoon to shine with the form of mirror. Though it is a very beautiful spoon, it is a mirror as well. You find in it every sort of mirror—concave, convex, flat and cylindrical. The flat reflecting surface is on the bottom of the handle, the cylindrical mirror is the handle itself. The hollow of the spoon forms the concave mirror, its back the convex. . . .[16]

Documented Use of Concave Lenses

From Nicholas of Cusa's celestial heights of metaphysics and theology, it is more comforting now to descend to more mundane but far more explicit evidence of spectacle development and use as revealed in the more easily understood language of diplomats and merchants. Practically contemporaneous with the preceding quotations, we have the first and the only precise optical information discovered to date before the onset of the more abundant evidence beginning with the late sixteenth century. The first document, published by me thirty years ago, consists of a letter, dated 21 October 1462, by Duke Francesco Sforza of Milan to his resident ambassador in Florence, Nicodemo Tranchedini da Pontremoli. The text of this brief letter, packed with new optical evidence, follows.

Because there are many who ask us for eyeglasses that are made there in Florence, since it is reputed that they are made more perfectly [there] than at any other place in Italy, we wish and charge you to send us three dozens of the aforesaid eyeglasses placed in cases so that they will not break; namely, one dozen of those apt and suitable for distant vision, that is for the young; another [dozen] that are suitable for near vision, that is for the elderly; and the third [dozen] for [more] common vision. We inform you that we do not want them for our use because, thank God, we do not need them, but we want them in order to please this one and that one who asks us for them. Send them by the post of our couriers directly to our secretary, Giovanni Simonetta, and inform us of their cost so that we can reimburse you the money. Given in Milan, 21 October 1462.[17]

16. Nicholas de Cusa, *Idiota de mente. The Layman: About Mind*, trans. C. L. Miller (New York, 1979), p. 57; Latin original on p. 56: "Idiota . . . Volui facere coclear speculare: quesiui lignum valde unitum et nobile super omnia, applicui instrumenta: quorum motu elicui conuenientem proportionem in qua forma coclearis perfecte resplenderet, post hec perpoliui coclearis superficiem adeo: quod induxi in resplendentia forme coclearis formam specularem ut vides, nam cum sit perpulchrum coclear: est tamen cum hoc coclear speculare. Habes enim in eo omnia genera speculorum: scilicet concauum, connuexum, rectum et columnare, in base manubrii: rectum, in manubrio: columnare, in concauitate coclearis: concauum, in conuexitate: conuexum. . . ." I have used this translation because of the inclusion of the Latin text in facing page. Another translation, with some minor variants not crucial to the central meaning of the text, was published by M. L. Führer, *The Layman on Wisdom and the Mind* (Toronto, 1989). I am grateful to Professor Führer for helpful suggestions about Nicholas'writings.

17. This letter with English translation was first published in my article, "Eyeglasses and Concave Lenses in Fifteenth-Century Florence and Milan: New Documents," *Renaissance Quarterly* 29 (1976), p. 345. I have slightly

Tranchedini replied directly to Simonetta on 4 November, announcing the shipment of the three dozen pairs of spectacles accompanying his dispatch. The total cost was three ducats because he wanted them to be "absolutely perfect." He admonished the secretary, however, not to reveal the cost to the duke, being such an insignificant amount (*minuzoli*), and considering also that Sforza had been generous in the past in supplying him with money and gifts. Nevertheless, he urged Simonetta to inform the duke that his ambassadorial stipend (*provisione*) had not been paid for almost two years, forcing him to borrow several hundred ducats and scrape by "like a dog" in an expensive city, making him fearful of ending up in a debtor's prison. He also pointed out that in the course of the year he had spent his own money to purchase cloth for the duchess (Bianca Maria), costing nineteen ducats including transportation and customs duties, and for "eighteen pairs of high quality glasses," sent to the duke the past winter—making a total of fifty-four pairs in less than a year. Tranchedini had also used personal funds to employ special couriers to deliver ducal letters. But as he concluded the letter, the ambassador thought better of it and asked Simonetta to burn it immediately after he read it. Yet, on the verso of the letter next to the address, he added this postscript: "These spectacles are of four types. Let the Lord choose those he wants, and let me know so that I can send him as many as His Highness desires."[18]

amended my earlier translation. The original with a photographic reproduction was republished in my book, *Occhiali*, pp.12–13. The original text is reproduced here because of its importance: "Perché sonno molti che ne domandano delli ochiali che se fanno lì ad Fiorenza, attento che la fama é che se fanno in più perfectione che in veruno altro loco de Italia, volemo te te [sic] commettiamo che ne deby mandare tre docene de dicti ochiali, acconzati in schatole che non se possano rumpere; zoé una docena de quelli sonno apti et convenienti ad la vista longa, zoé da zovene; et un'altra che siano convenienti ad la vista curta, zoé de vechy; et la terza da vista comune. Li quali te aviso non volemo per nostro uso, perché per la grazia de Dio nuy non ne havemo bisogno, ma li volemo per compiacerne ad questo et quello che ne li domandano. Mandandoli per le poste de nostri cavallari, li quali drizaray in mano de Zohanne Symonetta, nostro secretario, et avisandone de quello costarano perché te manderemo li denari. Datum Mediolani XXI october 1462. Io[hannes] Petrus. Io[hannes] Simonetta. (Paris, Bibliothèque Nationale, *Fonds Italien*, Cod. 1595, fol. 291, reel 1762). Some of the documents here cited form part of the "Ilardi Microfilm Collection of Renaissance Diplomatic Documents ca. 1450–ca. 1500," Sterling Memorial Library, Yale University, a total of approximately two million documents in nearly two thousand reels. Relevant reels will be cited to facilitate consultation. A detailed reel Index of the Collection was published in *The French Descent into Renaissance Italy, 1494–95: Antecedents and Effects*, ed. D. Abulafia, (Aldershot, 1995), pp. 405–83. The reels can be borrowed on interlibrary loan by consulting the Index, which is also available on the Internet: "http://www.library.yale.edu/Ilardi/il-home-htm."

18. Tranchedini to G. Simonetta, Florence, 4 Nov. 1462, Milan, Archivio di Stato, Archivio Ducale Sforzesco, *Potenze Estere-Firenze*, cart. 270, reel 501 (henceforth abbreviated as ASM, PE-Firenze). Relevant portions of this dispatch were published in my article, "Eyeglasses and Concave Lenses," p. 346, n. 14 and in my book, *Occhiali*, p. 12, in the latter accompanied by a photographic reproduction of the entire dispatch, p. 15. Relevant portions follow: "El nostro Illustrissimo Signore, per soa lettera sottoscritta de vostra mane, me scrive gli mandi tre dozine d'ochiali et che gli drizi ad voy et avisi de quel [che] costano, che me manderà li denari. Mandovi dicti ochiali alligati ad questi, quali costano tre ducati perché gli ho voluti in totale perfectione. Non voglio ad verun modo dichiate el costo ad Sua Celsitudine, perché el facto mio non sta cum Soa Excellentia in questi minuzoli. Et quando oltra a la mia provisione ho voluto da luy denari, cavali et altre cose, non é stato scarso meco, ma factomi più che non ho meritato. Quello che voglio da voy é che me recomandiate strectamente ad Soa Sublimità, et quella avisiati che, per essere stato circa doy anni senza havere havuto cosa veruna de la provisione [che] me dà, mi trovo, oltra al stentare como cane, in debito de parechie centenara de ducati. . . . Qui é carestioso vivere. Io mi trovo la fameglia grande. . . .

It is clear that the ambassador was torn between pleasing his lord by inviting additional orders for spectacles and receiving his full salary. And his pleadings bore fruit at the beginning of the following year when his salary was increased from 30 florins @ s.32 to 30 ducats @ s.82 (f.76.88), but had to wait until the end of 1463 to have the entire yearly salary disbursed.[19] In the interval, he obviously had a cash flow problem, as we say today, although it is well known that monetary complaints by ambassadors were quite common at this time. On the other hand, the year before he claimed to be in danger of a debtor's prison (1461), he purchased a house in Florence for 830 florins and other properties in Pontremoli for 40 florins.[20] He was far from being destitute as he claimed!

These two brief letters of 1462 reveal new and fundamentally important data about the history of spectacles and the hitherto unsuspected role of Florence in their development. Remarkable is the speed with which the order for three dozen pairs of high-quality eyeglasses was received and filled—a turnaround interval of fourteen days, 21 October to 4 November. In good weather ducal couriers could travel the 298 kilometers between Milan and Florence to deliver an urgent message in about two days as a minimum, but for routine correspondence the most common delivery time was between five and seven days.[21] (Slower postal couriers used by merchant companies would travel that distance in ten to twelve days.)[22] The ducal request was not marked urgent and we can thus assume that it was delivered in about a week and it took approximately one week to fill it!

Et pur in quest'anno ho havuto a mandare a Madona [Bianca Maria] doe some de bianco et vermeglio, che me costò circa 19 ducati cum le victure et gabelle. Questo inverno anche gli manday al Signore 18 para d'ochiali fine, mandare de li mei cum soe littere etc. A tucto va denari, et non ne havendo da Soa Sublimità, non ne posso havere da altri. Siché pregate Soa Sublimità m'aiuti fin a la morte et ad quella enixe me recomandate. . . . Lecta questa, strazatella." Postcript: "Questi ochiali sono de quatro maniere. Veda el Signore de quali vole, et avisatemene, che gli manderò quanti piacerà ad Soa Celsitudine."

19. A ducal letter of 24 February 1463 ordered the masters of revenue to pay Tranchedini at the rate of 30 gold ducats per month instead of 30 florins as in the past, beginning on 1 January. With this salary he was obligated to keep a retinue of five or six horses depending on the rank of his diplomatic missions, but he was entitled to additional travel compensation for himself and his retinue (P. Ferrari, "Una missione del Trincadini a Bologna e a Roma e la sua nomina a consigliere segreto di Galeazzo Maria Sforza," Lunigiana, II, N. 2 (1911), pp. 11–16). Ferrari quotes from Tranchedini's diary, where these figures were recorded.

20. Ferrari, "Una missione," pp. 25–26, for various properties owned by Tranchedini in Florence, Milan, Pontremoli, and other places.

21. These figures were established after a rapid examination of three cartelle of the correspondence between Milan and Florence: ASM, PE-Firenze, cart. 269 (1457–58), 270 (1459–62), and 271 (1463–64), reels 500–502. In this period I found only two instances revealing a delivery time of two days. (I wish, therefore, to correct an error in my article, "Eyeglasses and Concave Lenses," p. 347, n.15 where I stated that the normal delivery time was two days.) The Milanese diplomatic courier service could be quite efficient in delivering urgent dispatches, especially when the couriers were prodded by the threat of hanging with a drawing of the gallows sometimes prominently displayed next to the addresses of urgent dispatches. Cosimo de' Medici once expressed amazement when he learned that a dispatch received by Francesco Sforza from Genoa was then forwarded to him in a total interval of five days: Nicodemo to Sforza, Florence, 20 Apr. 1458, ibid., cart. 269, reel 500.

22. For delivery times of mercantile correspondence in the middle of the fifteenth century, see P. Spufford, *Handbook of Medieval Exchange* (London, 1986), pp. 320–21.

No doubt such speed can be partially explained by the fact that the customer was one of Italy's most prestigious princes and an intimate friend and ally of Cosimo de' Medici, Florence's unofficial but effective ruler. And the order could have been filled by more than one shop. Still the manual grinding and polishing of seventy-two lenses and fitting them into thirty-six frames would have been a laborious and lengthy process that could have been executed at such rapid pace only if Florentine spectacle makers had stocks of glass/crystal blanks ready to be ground to specifications and a supply of partially finished frames ready to receive the lenses. We might go even further in suggesting that this Milanese order, soon to be followed by another of greater magnitude, as well as by later evidence of massive exports of Florentine spectacles discussed below, all point to the probable existence in Florence of spectacle shops with a supply of pre-assembled spectacles, especially those for the more common lower degrees of presbyopia. At any rate, this speed of execution can be a significant clue of the level of organization and sophistication of the Florentine spectacle making industry in the middle of the fifteenth century.

Startling also is the extraordinarily low cost of "absolutely perfect" spectacles fit for a duke and his courtiers—one ducat (82 *soldi*) per dozen, s.6.8 per pair![23] The ambassador himself, though heavily in debt, thought the total cost such a paltry sum as not to be worthy of reimbursement. Nevertheless, despite their superlative description, it would be safer to assume that these spectacles were of medium quality with clear glass lenses and well-constructed frames made of bone or other non-precious materials. They were suitable for gifts in larger quantities. For comparison, we can cite the following examples of a pair or two. Two decades earlier, a friar in the *Ospedale di S. Giovanni Battista detto di Bonifazio* in Via San Gallo, Florence, sold a pair with unspecified lenses and frames for s.15.[24] Contemporaneously with the duke's purchases, eyeglasses with horn frames cost from 12 to 16 *soldi* each as manufactured by the friars of the *Monastero del Paradiso* just outside Florence.[25] It would seem that spectacles made by friars were of higher quality as reflected in their prices.

In contrast, two recently discovered documents attest to the still higher prices charged

23. A memorandum by the masters of revenue addressed to Duke Galeazzo Maria Sforza, dated 27 April 1471, calculated the yearly value of the Milanese ducat from 1397 to 1471. In 1462 it was valued at £4 s.2 (s.82), gaining only one *soldo* from 1463 to 1466. (ASM-PE Roma, cart. 67, reel 827). In the ducal budget of 1463, partially published by M. Formentini, *Memoria sul rendiconto di Milano per l'anno 1463* (Milan, 1870), pp. 16–17, the ducat is still calculated at s.82, and Tranchedini's salary is still listed at 30 florins (p. 66).

24. Florence, Archivio di Stato (hereafter ASF), Ospedale di S. Giovanni Battista detto di Bonifazio, *Entrata e Uscita*, Reg. 282, fol. 2^{r}, 10 Mar. 1440: "Da un paio d'ochiali vendè frate Daliello [Daniele] a dì 10 di marzo, soldi quindici . . . s.15. Two other entries, fols. 2^{v}, show that the same friar sold an unspecified number of spectacles for s.29 and s.27 on 24 Mar. and 9 Apr. respectively of the same year. I am indebted to Lorenz Böninger for this reference.

25. ASF, *Carte del Monastero del Paradiso, Entrate e Uscite,* F.148 (1450–1461), fols. 12, 12^{v}, 14^{v}, and 15^{v}. That these were horn-rimmed glasses can be deduced from the fact that the friars purchased "corna per fare occhial," ibid., F. 149 (1461–1466), fol. 113^{v}.

for exceptionally fine products. Top quality spectacles had crystal lenses and cost as much as 60 *soldi* each as is illustrated by the sale of four pairs, shipped in 1521 by the Strozzi firm in Florence to their branch in Rome.[26] A pair of luxury-type glasses with silver-gilt frames and black leather case fetched 82.5 *soldi* in Florence in 1451, practically the entire cost of the three-dozen pairs shipped to the Sforza court.[27]

At these prices, skilled Florentine masons earning in 1462 an average daily wage of 17.2 *soldi di piccioli* could afford a pair of moderate quality whereas unskilled laborers, earning about half this amount, would most likely have opted for lower grade glasses with less expensive wooden frames.[28] The same was true of construction workers at this time in Milan where the ducal architect, Filarete, was proposing to pay 12 *soldi imperiali* to master masons and 5 to laborers.[29] In sum, as we have already noted for the preceding century, non-luxury spectacles were affordable for most individuals.[30] At this point, however, it is worth reminding ourselves that all calculations of this kind throughout this study are very approximate in terms of labor costs and more so for the cost of living because of many variables, including the fact that the majority of workers in Italy at that time were paid by piece work rather than by a definite daily wage.[31] As we collect more data on the prices of eyeglasses in Italy and elsewhere it may be possible to arrive at more precise conclusions.

In addition to the relatively moderate cost of the Milanese purchase, no less surprising is the duke's unequivocal statement that Florence had the reputation of making the best spectacles in Italy—the first evidence discovered to date of such Florentine leadership, which hitherto has been assigned to Venice. Could he have been misinformed? We must discard this possibility out of hand and state categorically that Francesco Sforza was the best-informed ruler in fifteenth-century Europe. He was the only ruler who maintained resident ambassadors in all principal Italian states and at the French royal court in addition to a network of special envoys in and outside Italy, who generated the

26. ASF, *Carte Strozziane*, 5th series, 102, *Entrata e Uscita di Lorenzo e Filippo Strozzi, propri*, fol. 50^{v}: "Giovedì, addì 19 di detto [September 1521]. A'nostri di Roma, lire dodici per loro a Piero di Matteo, ochiolaio, per 3 paia d'ochiali di cristallino et un paio di cristallo per mandare loro, f.1 s.14 d.4". It would seem that in this case the term "cristallino" might indicate artificial crystal whereas "cristallo" might signify natural rock crystal, which was very expensive.

27. Florence, Bibl. Nazionale Centrale, *Fondo Tordi, 2, Libro di Bese di Giovanni Ardingelli*, fol. 16^{v}: "Uno paio d'occhiali in una cas(s)a di chuoio nero guerniti d'ariento dorato, i quali costarono da Francesco di messer Stefano Bonaccorsi grossi xv d'ariento, a dì vi di novembre 1451, f.- lire iiii s.ii d.vi." I am indebted to Spallanzani for supplying the transcriptions of this and the preceding document.

28. For daily wages in the construction industry of Florence, see R. A. Goldthwaite, *The Building of Renaissance Florence: An Economic and Social History* (Baltimore and London, 1980), pp. 321–22, 437–38.

29. See *Filarete's Treatise on Architecture: Being the Treatise by Antonio di Piero Averlino, Known as Filarete*, trans. J. R. Spencer, vol. I (New Haven, 1965), book IV, fol. 24^{r}, p. 42.

30. See chap. II, p. 76.

31. For some of these variables, including changes in monetary values, and the approximate nature of calculations of the kind, see R. Goldthwaite and G. Mandich, *Studi sulla moneta fiorentina (Secoli XIII–XVI)* (Florence, 1994), particularly pp. 73–80.

most extensive body of correspondence of the age.[32] These ambassadors also acted as purchasing agents of special products for the duke and his family, and an active search of this correspondence with Venice and other states extending over the last half of the fifteenth century has not uncovered similar requests elsewhere. Indeed, in 1455 the duke had invited Angelo Barovier (1400–60), Venice's premier glassmaker and reputed inventor of artificial crystal, to reside with his son at his court for a short period, apparently to introduce the art of making crystal.[33] They surely could have informed the court of the latest developments in spectacle making in Venice and filled any orders. Furthermore, the dukes of Milan commanded some of the leading trade routes in all directions, which were constantly traveled by merchants ready to supply them with every imaginable product available anywhere. Finally, this Florentine leadership at this time is corroborated by so many other documents, many of them recently discovered and to be cited throughout this study, as not to leave any room for doubt.

In fact, a new document offers independent and prior confirmation of the Florentine leadership. Almost two years before Duke Francesco sent his order, his castellan of Vigevano, Iacobo de Policastro, sent the following letter to Cicco Simonetta, the duke's chief secretary, requesting two pairs of Florentine spectacles.

> *I cannot avoid burdening you [with this request] but I am compelled by my need. I need two perfectly made pairs of spectacles with good glass lenses and framed in bone, light and gentle [on the nose]. One pair is for me and the other to satisfy a confidential matter [strictissima cosa]. Therefore I beg you earnestly as much as I can to have them sent to me either from Florence, where I understand that they are made with utmost perfection, or from another source as you think best. I wish to inform you that I have purchased several pairs, none of which has proved satisfactory. I am certain that perfect ones will be sent to you.*[34]

This document reveals the difficulty of obtaining good eyeglasses locally. It also demonstrates the casual way in which glasses were often ordered in this early period since

32. For Milan's diplomatic institutions and its massive collection of diplomatic correspondence, see Ilardi, "Fifteenth-Century Diplomatic Documents in Western European Archives and Libraries (1450–1494)," *Studies in the Renaissance* 9 (1962), pp. 67–73 (Ital. trans. in *Rassegna degli Archivi di Stato* XXVIII (1968), pp. 349–403); L. Cerioni, *La diplomazia sforzesca nella seconda metà del Quattrocento e i suoi cifrari segreti*, 2 vols. (Rome, 1970); and F. Senatore, *"Uno mundo de carta." Forme e strutture della diplomazia sforzesca* (Naples, 1998).

33. L. Zecchin, "Cronologia vetraria veneziana e muranese fino al 1490," in his *Vetro e vetrai di Murano. Studi sulla storia del vetro*, vol. I (Venice, 1987), p. 51.

34. ASM, Archivio Ducale Sforzesco, *Carteggio interno, Pavia*, cart. 757: "Notarius Iacobus [de Policastro], castellano di Vigevano, to Cicco Simonetta: . . . Non posso fare di non dareve fatiga ma lo bisogno mel fa fare . . . Io ho de bisogno de due para de ochali che fossero in perfectione boni de vitro et circumdati de osso et che fossero lezeri et zentili, de li quali uno paro ne voglio per mi et l'altro per una mia strictissima cosa; et pertanto ve prego strictamente quanto più posso ve piacza faremile havere o per la via de Fiorenza, dove intendo se fanno perfectissimi o per ogne altra via dove meglore vi parerà; avisandone he ho facto comperare più para et non ho possuto trovare cosa che me satisfaza. So certo ad voy seranno mandati in perfectione, . . . Ex rocca Viglevani die XII decembris 1460." The request was repeated in another letter of 3 Feb. 1461. I am indebted to Nadia Covini for sending me the transcription of this document, which reached me as I was conducting the last revision of this chapter.

the castellan did not reveal his age and probably counted on Simonetta to know his age and use his judgment.[35] Its date is close enough to the duke's first request to allow us to speculate that these requests for Florentine spectacles were quite frequent at the Sforza court, as the duke makes clear in his letter, prompting the first multipair order. Francesco's close relations with the Medici rulers of Florence, no doubt, further encouraged this demand for the Florentine product.

For the history of optics, however, the most significant contribution of the first ducal request is the earliest, definitive revelation of the existence of spectacles with concave lenses to correct myopia a couple of generations before their first documented appearance in other sources. The phrase, "distant vision for the young," can only mean that the first dozen glasses ordered were to be fitted with concave lenses for myopic young persons. The casual way in which they were ordered suggests that these lenses were available at least in Florence even earlier, for one does not place an order in such specific terms without advance knowledge of the product's availability. On the other hand, the third dozen for "common vision" [*vista comune*] seem to designate the more common lower stages of presbyopia for ages forty to fifty, and in this sense "more" common vision, as it came to be known from the sixteenth century onwards.[36] In essence, then, the ducal request of October 1462 specified spectacles for two levels of presbyopia and one level of myopia.

Regrettably, Simonetta's acknowledgment of the receipt of the October order has not been found for it might have provided some insight on this early use of the phrase "*vista commune.*" In compensation, Tranchedini's own reply to him on 20 November reveals new and more specific data on the real optical needs of the ducal couple themselves. He wrote in part: "I am most gratified by what you wrote about our Lords' pleasure in receiving the eyeglasses I sent them, but I am even more gratified that they do not use spectacles for the elderly but those for the young, because this is also our need." Once again the ambassador repeated his refusal to be reimbursed or accept gifts of wine and other items in return, but he expressed this time his "extreme desperation" in not having his salary paid so that he could satisfy his debts amounting now to a "thousand ducats."[37]

35. The castellan had entered Francesco's service around 1433, seventeen years before Francesco became duke of Milan. He was appointed castellan in 1450. I estimate his age around 50 when he made the request. See E. Roveda, "Istituzioni politiche e gruppi sociali nel Quattrocento," in *Metamorfosi di un borgo: Vigevano in età viscontea-sforzesca,* ed. G. Chittolini (Milan, 1992), p. 71, which reveals that Iacobo in 1478 claimed to have served the Sforza for 45 years and had been castellan of Vigevano for 28 years.

36. The clearest description of "vista comune" known to me is that published 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 chamasi Vista Comune."

37. "Ad me é stato gratissimo el piacere scrivete hano havuto quelli nostri Illustrissimi Signori et Madona [de li] 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. Ma non me piace che Soa Celsitudine me mandi li denari che

Tranchedini's reply constitutes the first evidence 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. The fifty-one-year-old ambassador, a noted humanist and avid reader, also admitted being myopic and took care to have a good supply of "fine" or "perfect" spectacles at hand, taking advantage of his practically continuous residence in Florence since 1450. The inventories of his possessions in various houses he owned show these entries: Pontremoli (1468)—"two pairs of perfect eyeglasses" (*paria duo ocularriorum in perfectione*); Florence (1470)—"a box full of fine eyeglasses" (*una scatola piena de ochiali fini*); Rome (1472)—"a little leather box with several pairs of eyeglasses" (*una scatoleta de coio cum parechie paia de ochiali*); Pontremoli (1472)—"two spectacle cases, one green the other yellow" (*doe fodere o veste da ochiali, un verde l'altra gialla*).[38] If we consider that this is not likely to be a complete list, this ambassador was abundantly supplied with quality spectacles affordable even for one who claimed to be heavily in debt and "scraping like a dog."

Tranchedini's extensive personal experience with spectacle wearing and his some twenty-year service under the duke undoubtedly made him a good judge of the real optical needs of his lords. It will be remembered that he did not send spectacles only for "distant," "near," and "common," vision, as he had been instructed, but he also added an unspecified fourth category (*maniera*). One is tempted to speculate that the fourth category consisted of spectacles with weaker concave lenses designed for distance viewing. The duke was probably mildly myopic and could dispense with the inconvenience of holding a pair of glasses before his eyes or clamping them on his nostrils by simply placing the reading matter at a proper focal length. In this context, his earlier assertion that he had no need of spectacles (for reading) makes sense, but he needed them for distance. Since the invention of bifocals around the middle of the eighteenth century by Benjamin Franklin, such persons are prescribed spectacles with stronger concave lenses in the upper part for distant vision and weaker concave lenses below it for closer vision, although many (including this myopic writer) find reading without glasses easier and preferable.[39]

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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 non m'aiuti Nostro Signore Dio, se per mille ducati ussissi de li debiti me ritrovo adosso, il che me fa stare in extrema desperatione. . . ." (Tranchedini to G. Simonetta, Florence, 20 Nov. 1462, ASM-PE Firenze, cart. 270, reel 501). The upper left portion of this dispatch is torn, making necessary editorial interventions enclosed in brackets.

38. See P. Ferrari, "Inventari di oggetti appartenuti a Nicodemo Tranchedini," *Giornale storico della Lunigiana* VI (1915), pp. 105–06, 109, 112.

39. Franklin's priority in this invention, sometimes assigned to others, has been reaffirmed recently by C. E. Letocha, "The Invention and Early Manufacture of Bifocals," *Survey of Ophthalmology* 35 (1990/3), pp. 226–35. The author, a practicing ophthalmologist and a collector and historian of spectacles, also believes that Franklin was never nearsighted, but probably was a hyperope and later in life a presbyope, which would have required spectacles with convex lenses for distant vision and stronger convex lenses for reading. I am indebted to Dr. Letocha for this interpretation of Sforza's and Franklin's optical needs.

And if the duke followed the advice of his personal physician, the renowned Benedetto Reguardati, he could have tried to sharpen his vision by eating fennel, a commonly prescribed vision-enhancing remedy since antiquity.[40]

Apparently the advice was not followed or the remedy was found ineffectual because fifteen months later the duke made a third request for Florentine glasses, this time given orally to Tranchedini while the latter was temporarily in Milan during the month of January 1464. The ambassador returned to Florence on 4 February and two weeks later he wrote to Sforza excusing himself for the delay in sending the spectacles: "I [urge] Your Highness not to be surprised that I have not sent the eyeglasses you ordered because, [knowing] that you wanted to donate them, I have ordered them for all ages [*omne vista*], and they will be ready in six days. I believe that you will be well satisfied. And in the future Your Highness will know at least which ones to ask for."[41]

The fact that we lack the written request leaves us in the dark regarding the exact number of glasses ordered this time. Nevertheless, considering the size of previous orders (and of a subsequent one) and given the intention (here specifically stated for the first time) of giving spectacles away as gifts to persons of all ages, we can safely assume that this was a sizable order as well, perhaps another three dozen at least to satisfy the optical needs of a large court. In sum, in just two years (winter 1462–winter 1464), the duke had requested a total of about one hundred pairs of Florentine spectacles, not counting other likely requests during the same period or at other times for which documentation has not been discovered. Significant is also the time estimate for the execution of the order, six days, which is roughly the same interval estimated above for the first three dozens ordered in October 1462.

The full meaning of the expression *omne vista,* used in the third order, becomes clear in the light of 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 spectacles in such specific terms as to eliminate any doubt about the precise meaning of the above expression. Both the specificity and the uniqueness of the terminology used in this request—the

40. On the allegedly vision-enhancing properties of fennel, Reguardati wrote in his treatise, *Libellus de conservatione sanitatis*, ch. xlv, edited by G. Deffenu, *Benedetto Reguardati, medico e diplomatico di Francesco Sforza* (Milan, 1955), p. 93: "Omnis feniculus prodest visui et eius usus visum acuit. Et quidam antiquorum estimaverunt quod serpents in vere comedunt folia feniculi et fricant oculos per feniculum dum exeunt de cavernis ut eorum visus confortetur et corroboretur, propter debilitatem quam oculi eorum acquisiverunt ex longa mora terre in hyeme."

41. "Post datum. Non prhenda admiratione Vostra Celsitudine se non ho mandati li ochialli me comandò perhó 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 Vostra Sublimità de quali domandare quando ne vorà per l'avenire." This postcript was added to Tranchedini's dispatch to Sforza, Florence, 21 Feb. 1464, Paris, Bibl. Nationale, *Fonds Italien*, Cod. 1590, fol. 51, reel 1757. For the ambassador's presence in Milan during January, see Tranchedini to Sforza, 27 Dec. 1463, and Sforza to Cosimo de' Medici, 17 Jan. 1464, both in ASM, PE-Firenze, cart. 271, reel 502.

only document of this type found to date since the first mention of eyeglasses—merit full republication of its contents:

> *Because we earnestly desire to have the eyeglasses as noted in the list here enclosed, we instruct you that upon receipt of this letter you should endeavor to acquire them perfectly made according to the ages specified in the aforesaid list. Send them in a box, well arranged and separated with attached labels for each category, so that when we receive them we shall be able to distinguish one category from the other. Inform us of their cost so that we can make provision for the payment. Milan, 13 June 1466.*
>
> *XV pairs of eyeglasses for ages 30, 35, 40, 45, 50, [55 crossed out] thin.*
> *Item, XV pairs of eyeglasses for ages 40, 45, 50, 55, 60, 65, 70.*
> *Item, X pairs of eyeglasses for medium vision for the young.*
> *Item, X pairs for distant [vision] for the young.*[42]

This remarkably specific letter is the earliest and clearest evidence discovered to date that at least from 1466 spectacle makers and their clients were aware of the principle of diminishing visual acuity in five-year intervals from the age of thirty onwards, and had an elementary knowledge of progressive myopic stages, simply expressed as "medium" and "distant" vision for the young. (It should be added parenthetically that these two degrees of myopia remained fixed in spectacle-making practice at least until the end of the sixteenth century, as it will be noted in the last chapter.) Apparently the Sforza court was not yet in possession of this knowledge in October 1462 for it would have made sense to make their first known request in the more specific terms used four years later. Pending the discovery of earlier documents, it is tempting to conclude tentatively that a technological breakthrough might have taken place in Florence or elsewhere in the period 1462–66, which permitted spectacle makers to grind lenses graded more exactly for various age categories. We may conjecture that the phrase, *omne vista,* used by the

42. The list was attached to the original letter, which has not been found, but fortunately it was copied at the bottom of the letter registered in ASM, *Registri delle Missive,* Reg. 77, fol. 89v, reel 1167. The texts of both follow:

Nicodemo de Pontremulo

"Perché haveressemo caro havere li ochiali, li quali te mandiamo notati in la lista qui inclusa, volemo che havuta questa debii vedere de recattarli che siano in perfectione per le etate como dice dicta lista; et mandarneli facendoli mettere in qualche scatola ben asettati et separati l'una sorte da l'altra cum li scripti attacati, in modo che quando li habiamo sapiamo discernere l'una sorte da l'altra; avisandone de quello costarano perché te faremo provisione al pagamento. Mediolani XIII iunii 1466.

Io[hannes Simonetta]

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.

ambassador in connection with the third order was simply a less precise way of expressing the age categories specified in the fourth request.

Tranchedini, who by now had become something like an expert on the subject and could hardly walk in the center of Florence without passing several spectacle shops before reaching the Medici palace on Via Larga, was in a position to be aware of such a breakthrough and this explains the casual but precise manner characterizing the 1466 order. It would have made no sense at all to make such a precise request without prior knowledge and expectation of full compliance. In this context it is also significant to add that the adjective *fini,* attached to the first listed category means "thin" and not "fine" or high quality, another common meaning of the word applied to spectacles as shown in Tranchedini's own list of glasses cited above. Florentine opticians were thus instructed to make the lenses as thin as possible consistent with the lower stages of presbyopia from ages thirty to fifty (fifty-five crossed out!) while the word is properly omitted from the more advanced stages of presbyopia in the second listed category, which require thicker convex lenses. (One could almost say that a local optician wrote this order!) If the word were to be translated as "fine," it would lead to the ridiculous interpretation that only one of the four categories should be of high quality. On the other hand, the overlapping of ages or lens powers from forty to fifty in the first two categories remains an unresolvable puzzle.

Up to the discovery of the 1466 request it was thought that the first mention of ordering glasses for presbyopes by age category had appeared about the middle of the sixteenth century.[43] But a most recent discovery has uncovered another request by age category of the late fifteenth century. It consists of an entry in the diary of the Florentine ambassador, Luigi di Angelo della Stufa, sent to Egypt and the Holy Land in 1488. His chaplain, Ser Zanobi di Antonio del Lavacchio, kept the diary. Most of the diary has been published, but not the above-mentioned entry, which is really a memorandum of unspecified items (except for spectacles) promised to the friars of the Church of the Holy Sepulcher, with whom the ambassador and his entourage apparently resided for seventeen days.[44] The entry reads as follows:

> *Remember what I promised the friars at Jerusalem, especially the eyeglasses.*
> *First for the Commissary [of the friars], from [age] 40 to 50.*
> *For the guardian, from 35 to 40.*
> *For friar Iacopo of Germany [della Magnia], from 60 to 70.*

43. For earlier mentions in the sixteenth century without specific dates or documentation, see V. Ronchi, "A Fascinating Outline of the History of Science," *Atti della Fondazione Giorgio Ronchi* 30 (1975), p. 529.

44. Most of the diary was published by G. Corti, "Relazione di un viaggio al Soldano d'Egitto e in Terra Santa," *Arch. stor. italiano* CXVI (1958), pp. 247–65, but not fol. 1^{v} (containing the spectacle entry and fols. 33^{v}–35^{r}, and 90^{v}–96^{v}. A reading of the published and unpublished portions of the diary did not yield any other mention of spectacles. I am indebted to William J. Connell for this reference.

For friar Egidio da Piacenza, from 50 to 60.
For friar Gabriel, from 35 to 45.
And [for] other friars, up to twelve pairs.[45]

Despite its important role in confirming the practice of ordering glasses by age category before the sixteenth century, this document does not approach the marvelous specificity of the above Milanese correspondence, still unmatched in the early history of spectacles. We can assume that practically all the spectacles ordered by the friars were fitted with convex lenses for presbyopia whereas there could have been some with concave lenses for younger myopic friars among the twelve pairs. It is most disappointing that throughout the second half of the fifteenth century we find orders for eyeglasses, even massive ones, without mentioning ages even though it seems clear that age-related ordering had taken hold at least from the later decades of the century, judging from the above documents. It was not until the seventeenth century, however, that this practice was finally systematized in a book published by the Spanish notary, Benito Daza de Valdés.[46] It survives to the present time for "reading glasses," available by age in general stores, being but a small step removed from prescription spectacles, which date only from the end of the last century.[47]

Returning to the last Milanese order, its large size need not surprise given Galeazzo's well documented but unrealized ambition to outdo his father in everything. Unable to best his father in war, diplomacy, prestige, and respect of his peers, the twenty-two year old duke created instead one of the most splendid courts of his day with his lavish expenditures sapping "as much as half the income of Italy's wealthiest princely state."[48] His thousands of courtiers constituted a veritable consumption machine for supplies and luxuries of various kinds. At the beginning of his reign, he apparently could not

45. Luigi di Angelo della Stufa, *Ricordi di viaggi, 1488–89,"* ASF, *Archivio Guicciardini Corsi Salviati*, II Versamento R/19, fol. 1v: "Ricordo quello ò promesso a' frati d'Ierusale[mme], e masime ochiali.

In prima al chomesario, da 40 a 50.
Al guardiano, da 35 a 40.
A f[r]ate Iachopo della Magnia, da 60 a 70.
A frate Egidio da Piacenza, da 50 a 60.
A frate Gabriello, da 35 a 45.
E altri frati, insino a doci [dodici] paia."

46. *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), pp. 225–38.

47. See B. L. Gordon, "A Short History of Spectacles," *Journal of the Medical Society of New Jersey* 48 (1951/1), p. 7.

48. The most extensive study of Galeazzo's court is now G. Lubkin's *A Renaissance Court: Milan under Galaezzo Maria Sforza* (Berkeley/Los Angeles/London, 1994). Lubkin writes: "Literally thousands of men and women were entitled to consider themselves members of this court, and their numbers had broad social and economic impact. The ducal court was unquestionably the greatest center of consumption in the dominion. Although it may have produced little, it served a vital function as market for both staples and luxury goods. The duke spent huge sums on food, drink, jewelry, and clothes—as much as half the income of Italy's wealthiest princely state." (p. 250).

resist the temptation of presenting his courtiers with double the number of high quality Florentine spectacles ordered earlier by his father, and it is likely that there may have been other orders for which no records have been found. And his regard for this visual aid lasted well into his reign as it was shown by his interest in the relic spectacles of St. Bernardino of Siena (1380–1444), whose cap and spectacles had been sent to the ducal court two months after Bernardino's death at the request of his grandfather, Filippo Maria Visconti. They had been kept at the Castle of Pavia from which Galeazzo requested them in 1469,[49] although their final deposit seemingly was to be in one of the luxurious caskets for the relics of two hundred saints in the chapel of the castle at Pavia, commissioned in 1474 but never completed. He also commissioned a series of never executed frescoes to decorate reception rooms in the Castello di Porta Giovia in Milan (ca. 1471) in which his Seneschal General was to be depicted wearing spectacles as he surveyed the countryside for dining "al fresco."[50] But Galeazzo as well as his father was never portrayed wearing or holding eyeglasses, perhaps because they feared to diminish their warrior-like stance as the most powerful princes in Italy.

There is little doubt that by this time the possession of Florentine glasses at the Sforza court had become not just a matter of utility and preference over the local product, but also one of prestige or a status symbol. It would be, of course, ludicrous to suggest 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. And it would be equally absurd to suspect that they were simply intrigued by a device that had been in common use nearly everywhere in Europe for about two centuries or that the dukes had decided to become spectacle peddlers.[51]

Unfortunately, subsequent correspondence regarding this large order has not been found and this lacuna leaves us in the dark about the time frame required for satisfying the request. Equally disappointing is the fact that Tranchedini, who was so detailed and precise in listing his activities and possessions in his personal diary, never mentioned the

49. Galeazzo to Giovanni de Attendoli, Castellan of Pavia, Abbiate, 1 June 1469, and Attendoli to Galeazzo, ex castro Pavie, 1 June 1469, ASM, Archivio Sforzesco Ducale, *Reg. Missive*, Reg. 90, fol. 165, reel 1180, and ibid., *Potenze Sovrane*, cart. 1635. For correspondence in 1474 regarding the reliquaries, see C. J. Ffoulkes and R. Maiocchi, *Vincenzo Foppa of Brescia* (London, 1909), appendix, docs. 20–21, pp. 299–302, and also pp. 99–104 for commentary. More detailed treatment of St. Bernardino's spectacles will be provided in ch. V, p. 170–71.

50. The frescoes were to depict hunting and dynastic scenes in one of which the Seneschal General, Giacomo del Piccio or Pizo, normally called Piceto or Pizeto, is depicted as follows: "Piceto a cavalo che guardi con li ochiali dove se deve apparegiare 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), p. 182. The frescoes, if executed, have not survived, but the instructions for them have provided this information. It can be surmised that for such distance viewing Pizeto was using glasses with concave lenses.

51. This aspect has been treated in my article, "Doni di occhiali alla Corte sforzesca," *Ca' de Sass*, N. 113 (1991), pp. 52–56.

spectacle making shop or shops that filled the various ducal orders.[52] Surely, the manual grinding and polishing of four hundred lenses in the 1466 order with such precise gradations involved a long and laborious process (more so for concave lenses) until the development of manually operated machines in the early seventeenth century. We shall attempt to throw some light on this subject when we discuss in a subsequent chapter available evidence on the number of spectacle makers in Florence and on techniques of spectacle making in the fifteenth century.[53]

Although it is regrettable that our luck ran out at this crucial point of our inquiry, we should be grateful for the fortunate survival and discovery of a nearly consecutive but widely dispersed run of Milanese correspondence with such revolutionary data for the history of optics, spectacle making technology, and costume in the middle of the fifteenth century. Before presenting other recently uncovered evidence of a different type, therefore, it would be helpful to summarize the new data revealed by the Sforza orders as follows: 1. Florence was producing in large quantities not only convex lenses for presbyopes, but also concave lenses for myopes (i.e., about a half century before the latter were thought to have been developed); 2. Florence had become the leading manufacturer of readily available and affordable good-quality spectacles; 3. Florentine spectacle makers or "opticians" were well aware of the fact that visual acuity declines gradually after the age of thirty, and were constructing lenses progressively graded in five-year powers for hyperopes or presbyopes and in two powers for myopes, practically prescription lenses; 4. The dukes of Milan were ordering prestigious Florentine eyeglasses by the hundreds to give them away as gifts to their courtiers, the first record of such a phenomenon in the literature.

Spreading Demand for Florentine Spectacles

Although the above documents are the first discovered so far attesting to such a use of spectacles by the dukes of Milan, they could not have been a novelty either at their court or at the courts of their colleagues throughout the Italian peninsula, given the widespread diffusion of spectacles by this time. In fact, there is now even earlier evidence of their use by another reigning family, the Gonzaga of nearby Mantua, who were on intimate terms with the Sforza, commanded their army, exchanged personal visits, and

52. Portions of the ambassador's diary have been published or summarized by its fortunate possessor, the late P. Ferrari, "Inventari di oggetti," pp. 102–14, and "Una missione del Trincadini," pp. 3–33. His heirs, however, have refused access to the diary despite repeated requests by scholars and representatives of the Italian government except for a few privileged scholars, among whom is P. Sverzellati, who has published a detailed listing of its contents in preparation for her projected biography of the ambassador: "Il libro-archivio di Nicodemo Tranchedini da Pontremoli, ambasciatore sforzesco," *Aevum. Rassegna di scienze storiche, linguistiche e filologiche* LXX/2 (1996), pp. 371–91. In private correspondence Dr. Sverzellati has assured me that the identity of the Florentine opticians is not revealed in the diary.

53. See chap. V.

maintained resident ambassadors in Milan. Two years before Francesco Sforza ordered his three dozen pairs from Florence, Marquis Ludovico Gonzaga (46 years old) chided one of his courtiers on a mission to Rome that the latter and other personages, who had recently left at the conclusion of the Congress of Mantua, had simply forgotten to write back and keep him informed on affairs at the papal court. He lamented in a sarcastic vein that he was receiving so many letters from them that reading them daily so taxed his eyesight that he was forced to use spectacles![54] And although I have not been able to find any mention of eyeglasses in the exchange of personal letters between the two dynasties or in their ambassadorial correspondence for this period,[55] it might not be a mere coincidence that three months after Galeazzo Maria placed his order for two hundred pairs of eyeglasses, Marchesa Barbara Hohenzollern Gonzaga (43 years old) charged her son, Federico, to bring with him "a lot of spectacles" on his return trip from the thermal baths at Petriolo, near Siena. Federico assured her quickly that he would amply supply her with spectacles.[56]

The large number requested, as designated by the word *assai* ("many or a lot"), as well as the omission of age categories as noted for the much larger Sforza court with its many young courtiers, all suggest that the glasses might also have been intended as gifts to older courtiers once the visual needs of Ludovico and his wife were satisfied. Although Florence was not mentioned in the correspondence, Federico was expected to pass through this city on the way home and it is almost certain that Florentine spectacle makers were the suppliers. It is also significant that earlier that year Ludovico had complained of declining eyesight and had expressed his need for eyeglasses to the Abbot of the Benedictine Abbey of Polirone at San Benedetto Po near Mantua. Wishing to be helpful, the latter wrote to the Marquis in March 1466 enclosing two pairs of spectacles, made by one of the monks, *buon magistro de ochiali* (good master of eyeglasses), offering to send more if he found them satisfactory.[57]

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54. Ludovico to Giovanni Lochner, Mantua, 13 Feb. 1460, Mantua, Archivio di Stato (hereafter ASMA), Archivio Gonzaga, *Copialettere*, B. 2886, Reel 401: "Nui hora mai non habiamo altro che far si non ugni zorno legere littere vengono de là per forma che la vista non ce basta più et n'é stato bisogno tore li ochiali se dovemo suplire a legere tanto." First cited and quoted by R. Signorini, *Opus hoc tenue. La camera dipinta di Andrea Mantegna. Lettura storica, iconografica, iconologica* (Parma, 1985), p. 80, n. 145. I am indebted to my student, Paul Dover, for this reference.

55. In addition to the unpublished correspondence consulted both at the state archives of Mantua and Milan, I have also examined the five volumes of the ambassadorial dispatches of a series still in course of publication under the general editorship of Franca Leverotti, *Carteggio degli oratori mantovani alla Corte sforzesca (1450–1500)* (Rome, 1999–2000). The same negative result can be seen in E. Welch's "The Gonzaga Go Shopping: Commercial and Cultural Relationships Between Milan and Mantua in the Fifteenth Century," in *Leon Battista Alberti e il Quattrocento: Studi in onore di Cecil Grayson e Ernst Gombrich* (Florence, 2001), pp. 269–84.

56. Barbara to Federico, Goito, 18 Sept. 1466: "Quando venirai, vedi de portare de li ochiali assai"; and Federico to Barbara, Petriolo, 26 Sept. 1466: "de ochiali fornirò bene Vostra Signoria": ASMA, Archivio Gonzaga, *Copialettere*, B. 2889, Reel 409, and *Lettere originali dei Gonzaga*, B. 2099, Reel 372, respectively.

57. Abbot Bessarion [d'Aragona] to Ludovico, San Benedetto, 14 Mar. 1466, ASMA, Archivio Gonzaga, *Mantova e Paesi*, B. 2406. See Ilardi, "Renaissance Florence," pp. 524–26, for full quotation from this letter and other details

46. *Round Bridge Spectacle Leather (?) Frame with Lenses,* probably middle of the 17th century, Archivio di Stato, Cimeli 151, Mantua.

It is not possible to ascertain whether the Marquis took advantage of the Abbot's offer as his sight deteriorated further to the point that at the age of almost sixty he complained, again in a joking manner, that he could no longer write long letters because his glasses felt "heavy" (presumably alluding to the thicker lenses) and he wrote with difficulty.[58] Neverthless it is clear that the Gonzaga had a ready local supply of eyeglasses as well as the glass for making them because there is evidence of glass furnaces in Mantua, some in the ducal palace itself, at least from the fourteenth century.[59] Moreover, they also could have purchased glasses easily through Barbara's relatives in Germany, another leading center of spectacle making. It is also noteworthy that the Gonzaga made frequent purchases of gilded glass vases and other luxury items in Venice, but no orders for Venetian spectacles have been found.[60] Apparently, their preferred suppliers were Florentine spectacle makers.

Most recently archivists in Mantua have found a pair of bridge spectacles in excellent condition, complete with lenses (Fig. 46), among the notarial acts of 1518 by the Mantuan notary, Santino Fozia.[61] This is a rare find for in almost all cases in this period the lenses have not survived, but it is not possible to establish their provenance nor their exact date of production. An examination just completed by an optician from Florence has revealed that the lenses have +3.00 power, suitable for a sixty year old. The probable

about the Gonzaga order. The letter was published without the source by A. Luzio and R. Renier, "I Filelfo e l'umanesimo alla Corte dei Gonzaga," *Giornale storico della letteratura italiana* XV (1890), p.146, n. 1.

58. Ludovico to Zaccaria Saggi, Mantua, 7 Mar. 1473: ". . . Et s'el non fusse che li ochiali pur ne pesano et cum faticha se riducemo al scrivere, gli saria manchato poco che tu non ce havesti tirato a farte una littera como fue quella del falcono. . . ." Full quotation in Signorini, *Opus hoc tenue,* p. 80, n. 145.

59. A. Franchini, "Note su due antiche fornaci ritrovate nel Palazzo Ducale di Mantova," in *Archeologia e storia della produzione del vetro preindustriale,* ed. M. Mendera (Florence, 1991), pp. 99–106.

60. For the great number and variety of luxury items purchased in Venice by the Gonzaga, see A. Bertolotti, "Le arti minori alla corte di Mantova nei secoli XV, XVI e XVII," *Arch. stor. lombardo* XV (1888), pp. 278–84.

61. ASMA, *Cimeli,* 151. I am indebted to the Director of the Archive, Dr. Daniela Ferrari, for sending me a photograph of the spectacles with permission to republish it since it has been used as a logo for a book series published by the archive.

material of the frame appears to be leather or whalebone.[62] Similarly, we have no information on the provenance of the eyeglasses or magnifying lenses used by Federico's brother, Cardinal Francesco Gonzaga. They are listed in the inventory of his possessions after his death in 1483 as *Un ochiale de cristallo simplice* ("a crystal eyeglass or magnifying lens"); *Un ochio de cristallo simplice* ("a crystal magnifying lens"); *Una cassa da ochiali d'oro smaltata* ("a gold enameled spectacle case"); and *una cassa da occhiali d'oro* ("a gold spectacle case").[63]

In this same period, another direct order for Florentine spectacles came from another ruler, Iacopo III Appiani, Lord of Piombino, a small Tuscan principality south of Florence. In 1464 he ordered two pairs for his mother, costing s.6 d.8—half the price paid by Francesco Sforza two years earlier. Although we have no details regarding the type of glass or crystal used for the lenses or the material for the frames, we can deduce from the price that it involved a lower quality product.[64]

Besides ruling families, direct orders to Florence came also from prominent individuals such as the leading humanist at the Sforza court, Francesco Filelfo (1398–1481), who had been residing in Milan since 1439 under the patronage of both the Visconti and subsequently the Sforza dukes. In 1456 he requested an unspecified number of spectacles from his friends in Florence, Bartolomeo Scala and Andrea Alamanni. In his letter to the latter, he commented that he could not find spectacles in Milan *"whereas they abounded in Florence."* This request is particularly revealing because Filelfo had been professor of rhetoric at Padua and Vicenza (1416–17), had served as secretary of a Venetian embassy to Constantinople (1420), had lived in the Veneto region for about seven years, and maintained a steady flow of correspondence with Venetian patricians and intellectuals. He could easily have used his contacts with his Venetian friends to secure his glasses in the Veneto or perhaps he could have purchased them in Milan had he been less demanding because, as it will be shown below, eyeglasses were made in several places in Italy by this time. There can only be one likely explanation: he wanted excellent ones made in Florence, just as Francesco Sforza wrote six years later. His Florentine friends must have known his optical needs: at fifty-four he needed convex lenses for his presbyopia.[65]

62. Private communication (Oct. 2002) from Sig. Lino Di Nardo, proprietor of the Antica Occhialeria in Via San Gallo, Florence, whom I wish to thank for this act of friendship and devotion for the history eyeglasses. Other details about these glasses will be noted in ch. V, p. 168–69.

63. D. S. Chambers, *A Renaissance Cardinal and His Worldly Goods: The Will and Inventory of Francesco Gonzaga (1444–1483)* (London, 1992), pp.147, 158. The first two items seem to designate magnifying lenses because they were composed of single ("simplice") lenses as opposed to combined ("composte") lenses (spectacles), whereas the two cases were clearly designed for spectacles.

64. Archivio dell'Opera del Duomo di Firenze, XII.1.2, *Libro di debitori e creditori della compagnia Maschiani di Pisa,* current account of Iacopo III Appiani, Lord of Piombino, fol. 90s: "per II paia d'occhiali fatti in Firense a posta per la madre, portò Christofano di Benedetto spesiale, f. 0. 06. 08." This account was kept in papal florins. I am indebted to Sergio Tognetti for this reference.

65. For details on this request, see Ilardi, "Renaissance Florence," p. 523, and *Occhiali*, p. 26.

Other direct orders within Italy came from persons of wealth and with wide contacts who were in positions to order spectacles from anywhere in Europe. An exchange of letters from 1463 to 1465 between the exiled Florentine international banker, Filippo Strozzi, writing from Naples to request spectacles from his mother in Florence, demonstrates that a merchant/banker with European-wide commercial connections likewise preferred the Florentine product.[66] The wording of these requests suggests that they involved a few pairs for personal use because a commercial import would have specified the quantity and unit price or total cost, as we have seen. This personal practice continued after the ban of exile was lifted in 1466 and Filippo settled permanently in Florence (1470) to establish and personally direct a branch of his bank. In 1473 he sent two pairs of spectacles to his branch in Naples, destined for the secretary of Beatrice, daughter of King Ferrante and Queen of Hungary from 1476.[67] Two years later two other pairs followed for an unknown recipient and in 1476 another two pairs were sent for a courtier of Duke Alfonso, heir to the throne.[68] Clearly these orders add courtiers of another ruling family to the roster of princely courts seemingly addicted to Florentine eyeglasses, but they do not provide information on the type of glasses ordered or their cost.

Another order came from Ferrara, a princely state ruled by the Este but politically influenced and economically dominated by Venice, whose most influential *Visdomino* (consul) exercised exclusive jurisdiction over the large Venetian colony.[69] In 1451 the noted, elderly woodcarver, Arduino da Baiso, wrote to Piero di Cosimo de' Medici thanking him for his letter and the four pairs of eyeglasses received by means of Pigello Portinari, then manager of the Venetian branch of the Medici Bank and in the following year manager of the newly established branch in Milan. Arduino complained, however, that one pair arrived with broken lenses and all had lenses for "distant vision" (*ochiali da la dilonga*) except one for "near vision" (*da presso*), the only pair suitable for his needs. He asked Piero to send him up to eight or ten pairs with "thick lenses" (*grosse di vetro*). He requested that the glasses be made by a spectacle maker he had patronized "at other times" in the past to be pointed out to him by Arduino's friend, the famous goldsmith

66. See Ilardi, *Occhiali*, p. 26, for details on this correspondence, which was published in Alessandra Macinghi negli Strozzi, *Lettere di una gentildonna fiorentina del secolo XV ai figliuoli esuli*, ed. C. Guasti (Forence, 1877), p. 277, 347.

67. ASF, *Carte Strozziane*, Quinta Serie, F. 26, Ricordanze di Filippo e Lorenzo Strozzi in Firenze, fol. 114ᵛ, Filippo and Lorenzo Strozzi in Florence to the Strozzi branch in Naples, 1 Sept. 1473: "ii paia d'occhiali involti in charta: dateli al segretario di Madonna Beatrice per parte del maggiore [Filippo Strozzi]." The branch acknowledged receipt with a letter of 5 Oct. I am indebted to Marco Spallanzani for the discovery and transcription of this and the following two documents.

68. Ibid., fol. 146^r, same correspondents: 21 Jan. 1475, "Uno fardellino segnato di vostro segno, entrovi uno leghato di iiii camicie, 2 paia d'ochiali." Letter of receipt dated 16 Feb.; ibid., F. 30, fol. 122^v, same correspondents: 14 Aug. 1476, "ii pa[ia] d'occhiali ci domandasti per messer Rinaldo de lo Duca." Letter of receipt dated 22 Sept.

69. For Venice's influence in the Este principality of Ferrara/Modena, see T. Dean, "Venetian Economic Hegemony: The Case of Ferrara, 1200–1500," *Studi veneziani*, n. s., XII (1986), pp. 45–98.

Cola Spinelli d'Arezzo.[70] (This is perhaps another example of the close connection between goldsmiths and spectacle makers, which is revealed repeatedly by other sources of the age.)

This letter, known to some art historians for its artistic information since its first publication in 1869, has been ignored by historians of optics and was cited only once a century later in a rare publication by Enrico De Lotto, ophthalmologist and historian of spectacles, as perhaps the first documented order of glasses with concave lenses, a view which I first accepted and later (1993) corrected.[71] De Lotto argues that the phrase *da la dilonga* means concave lenses for myopes and that the thirty-five year old Piero, being himself myopic, had mistakenly sent such spectacles to the artist, perhaps ignoring his presbyopia. But Arduino's letter makes clear that the two had more than a passing acquaintance with each other, had corresponded in the past, and now with this letter the artist was not only importuning Piero with a second request for spectacles, but was also asking for his assistance to be rescued from the "bad air" of Ferrara and secure a commission to decorate the cabinets in the sacristy of San Lorenzo in Florence. It is more likely that Piero or the spectacle maker had not taken full account of Arduino's severe presbyopia, for he was probably in his late eighties, having been born in the second half of the previous century, and died in 1454. As is often the case at this time, the phrases *da presso* ("near") and *da la dilonga* ("distant") designated lower and higher degrees of presbyopia unless the qualifying words *da zovene* ("for the young") were added to the latter phrase in order to designate myopia, as we have seen in the above cited Milanese correspondence. In this early period of imprecise terminology, this was the practical way of distinguishing elderly from youthful vision when ordering glasses. It is reasonable to suppose, then, that for his work Arduino needed glasses allowing him to see clearly both

70. Arduino's letter, dated 25 Aug. 1451 [ASF, *Archivio Mediceo Avanti il Principato,* F. XIV, No. 29], consists of 37 lines in the original, of which only the first seven lines deal with eyeglasses as summarized above. The complete text was published only once by G. Milanesi, "Lettere di artisti," *Il Buonarroti* IV (1869), pp. 79–81, a rare periodical that ceased publication in 1894. The final nine lines, which do not mention spectacles, were republished in facsimile with accompanying transcription in another even rarer publication: C. Pini and G. Milanesi, *La scrittura di artisti italiani (sec. XIV–XVII) riprodotta con la fotografia. . . .* (Florence, 1876), unpaginated. The first seven lines were republished in Ilardi, *Occhiali,* pp. 22–24, which is now long out of print. In view of their importance and the rarity of preceding publications, I include below the first seven lines from the Milanesi transcription with minor changes after having checked the original text:

"Io sì ò ricevuto vostra letra e quatro para d'ochiali per le mane di Pesselo vostro fattore, de chuale ve rengrazio grandemente. Vero è che ve n'era uno paro ch'era roto li vetri; per la chuale ve prego che mi mandiate chualche vetri che siano bone. Io li voree che fuseno vetri che se vedese da presso, imperò che chueli m'avete mandati, sono ochiali da la dilonga, salvo uno paro che sono da presso. Fate che Chola d'Arezo oraffo ve mostre chuelo maestro che a me n'à dato per altre volte. Li fae bone: e perchè non s'abiono materia di ronpere chuesti vetre, io ve mando uno chasetino, dove abieno a stare; e dite al maestro che le fae, me le mande grosse di vetro: sono migliore. Mandatimene insino a otto o desse de chueli vetre. Avisatime del chosto: lo daroe a Pesselo."

71. E. De Lotto, *Dallo smeraldo di Nerone agli occhiali del Cadore* (Belluno, 1956), p. 28, which quotes about three lines of the seven mentioning spectacles but with the wrong date of 29 August and the old document number, 30. For my corrected current view, see Ilardi, "Renaissance Florence," pp. 522–23, n. 27.

at fairly close range or at "reading distance" and further away at "arm's length" depending on the distance of the object to be carved.[72]

Intriguing is also the fact that Arduino had continued to patronize this unnamed spectacle maker in Florence at other times in the past though he was born in Modena, had left Florence about thirty years earlier, and lived and worked for many years in Ferrara, where he could easily have obtained glasses from the many Venetian merchants residing in the area if not from a local spectacle shop or monastery. Or he could have ordered them through his brother, Alberto, another woodcarver, who lived in Venice from 1430 to 1451 and often collaborated with Arduino.[73] Yet he chose the rather circuitous route of writing directly to the son of Florence's unofficial ruler, who used his own agent Pigello Portinari, then residing either in Venice or Milan, for arranging the delivery of his spectacles from Florence and for the collection of the reimbursement. Clearly, those Florentine eyeglasses must have been worth the wait and the bother! But we do not know their cost. Nevertheless, the fact that an artisan, though an important one, could order first four pairs and soon after up to ten pairs of spectacles at a time points to their common availability and relatively low cost as well as to their fragility. It can also signify that in this age of imprecise lens grinding, Arduino needed several pairs at hand suitable for various distances under less than ideal lighting conditions. Clearly, he could have used bifocal or better yet, trifocal lenses, but the former were not available until the middle of the eighteenth century. What is the percentage of today's artisans who could afford to purchase this number of eyeglasses in two orders in quick succession?

That the ordering of multiple pairs for personal use was not as uncommon as previously thought is demonstrated by two other orders that are connected with Venice in an unusual and surprising way. In the spring of 1454, Bartolomeo Cederni (thirty-eight years old), an employee of the Boni Bank of Florence and a man of modest means with some influential connections, ordered six pairs of spectacles of unspecified powers. The request (dated 13 April) was received by his friend in Florence, Francesco Caccini, only on 16 May, which suggests that Cederni must have been away at some distance from the city.[74] This information was contained in Caccini's reply dated 20 May but sent seven days later, from which we also learn that along with the request Cederni had enclosed one florin (*largo*) to pay for the glasses. The order was filled by two spectacle makers at

72. Vasco Ronchi first alerted me to this interpretation in a private communication (1977) in which he criticized De Lotto for having intepreted Arduino's letter "troppo leggermente, con poca competenza ottica. Credo che sia escludersi che in essa [the letter] si faccia allusione a occhiali con lenti divergenti."

73. For a biographical sketch of Arduino, see *Dizionario biografico degli italiani* V (1963), pp. 300–01.

74. Caccini to B. Cederni, Florence, 20 May 1454, sent 27 May, ASF, Corporazioni *religiose soppresse dal governo francese, 78 (Badia fiorentina)*, F. 314, fol. 574: "Et con detta tua [of 13 April, received 16 May] ebbi in essa fiorino uno largo del quale insieme con Nicholò [Bartolini] n'ò tolto ochiali chome dicesti; cioé paia 6 et chostono in tuto grossi xvii; i 3 di sotto sono del maestro della dona e 3 di sopra sono d'un altro maestro." This letter reveals the existence of a spectacle maker, "maestro della dona," so far unmentioned in other sources.

the total cost of 17 groats (*grossi*), about 17 *soldi* per pair, more than double the cost of the spectacles first sent to the Sforza court eight years later.[75] This price would designate very fine glasses framed in non-precious materials.

This would be a straightforward request were it not for some complications in dating and interpretation caused by the total loss of Cederni's own letters, save for one that has nothing to do with our subject. It seems that the order was filled about a day or two after Cederni's scheduled departure for Venice on 18 May as an aide to his near relative and patron, Giannozzo Pandolfini, who with Piero di Cosimo de' Medici, had been appointed ambassador to Venice to strengthen the recently concluded Peace of Lodi (9 April 1454) and engage in discussions for a proposed general league of the Italian states.[76] Yet as late as 26 June Caccini wrote to Cederni that the glasses, which he now labeled three for "near" and three for "distant vision" (i.e., two levels of presbyopia or perhaps three pairs for myopia, though the phrase "for the young" was not used?), had been enclosed with a letter written to him six days earlier but he had been unable to find a person to deliver them in Venice.[77] They must have arrived in Venice soon after, however, because on 5 July Caccini wrote that he had received back from Cederni a box containing three pairs that were unsatisfactory and had to be returned for replacement. The spectacle makers promised to replace them with three "beautiful good" pairs within three days.[78] With remarkable speed this time, Cederni wrote on 12 July that he had received the three replacement pairs and was satisfied with their quality.[79]

It has been deemed necessary to relate the tedious progress of this request in more detail than desired because of the gaps in the correspondence. My more recent reading of the surviving unpublished letters has now established that Cederni had ordered the glasses weeks before he was chosen to accompany the Florentine embassy. It is almost

75. In 1454 the value of the florin was about 102 soldi and the groat was composed of ca. 6 soldi. See R. A. Goldthwaite and G. Mandich, *Studi sulla moneta fiorentina (Secoli XIII–XVI)* (Florence, 1994), pp. 94, 181.

76. Pandolfini was elected ambassador on 9 May to replace Neri di Gino Capponi, who had been elected earlier but was not able to accompany Piero de' Medici because of illness [Nicodemo Tranchedini to F. Sforza, Florence, 9 May 1454, ASM, *PE-Firenze*, cart. 267, reel 498]. The two ambassadors received their instructions the following day [ASF, *Signori, Carteggi, Missive, Legazioni e Commissarie, Elezioni e Istruzioni a Oratori*, Reg. 13, fols. 48r–49v, reel 43], but their departure was delayed and rescheduled for 18 May owing to the illness of Cosimo de' Medici [Diotisalvi Neroni to Sforza, Florence, 17 May 1454, ASM, *PE-Firenze*, cart. 267, reel 498].

77. This letter, sent on 30 June, was published in *Bartolomeo Cederni and His Friends: Letters to an Obscure Florentine*, ed. G. Corti and F. W. Kent (Florence, 1991), pp. 94–96: "Adì XX del pres[en]te ti scrissi et con quella ti madai una schatola con 6 paia d'ochiali, 3 da presso e 3 da lungha, e quali detti detto dì a Pandolfo [Pandolfini] che pe'llo primo gli mandassi. Intesi non ci à trovato chi chostà vengha." Kent's introduction (pp. 3–47) treats the few facts available about Cederni's rather modest career and his interaction with various friends and influential patrons.

78. Caccini to Cederni, Florence, 5 July 1454, ASF, 78 *(Badia Fiorentina)*, F. 314, f. 585: "Ebbi la schatola con 3 paia d'ochiali i quali ò renduti, et Nicholò Bartolini et io abiamo molto gravato el maestri; ne fanno 3 paia belli e buoni e chosì anno promesso, ma m'anno chiesto 3 dì de tempo e credo domane avelli e subito li mandorò."

79. Caccini to Cederni, Florence, 17 July 1454, ibid., fol. 597: "Et questo dì ò una tua di xii risposta a più mie et piacemi avesti la schatola e simile de l'ochiali essere buoni, et me ne governai per le mani de N. Bartolini chome mi dicessi nel principio."

certain, then, that the spectacles were meant for personal use and not for resale or to be distributed as gifts in Venice as it has been speculated.[80] In any case, it seems strange that Cederni was apparently unwilling to procure satisfactory replacements in Venice, certainly a major center of spectacle making, a solution that would have avoided delays, saved transportation expenses, and offered the additional advantage of testing them in person. It would seem that only a most fastidious person would behave in this manner unless he had established a trusting relationship with his Florentine optician.

Another order connected with Venice is even more puzzling and potentially more significant in demonstrating this apparently common fascination with Florentine spectacles regardless of delays, inconvenience, and additional expenses. In 1476 the wealthy Florentine merchant-banker, Filippo Strozzi (a spectacle wearer himself, as we noted above) was thanked for a dozen pairs of Florentine eyeglasses which he had sent at the request of one of Venice's leading patricians and diplomats, the fifty-four-year-old Zaccaria Barbaro. In the past I have been reluctant to place full faith in the authenticity of this unconfirmed request, which cannot be found in published and manuscript collections of the Barbaro and Strozzi correspondence and has never been mentioned by historians of the two families.[81] It was cited only from the private collection of Anton Francesco Gori by the Florentine super patriot, Domenico Maria Manni, who in the eighteenth century tried to assign the invention of spectacles to the mythical Florentine artisan, Salvino degli Armati, as noted in the first chapter.[82] That such a distinguished and much traveled Venetian merchant and diplomat would have ordered his eyeglasses from Florence, apparently preferring them to the Venetian product, seemed too good to be true in supporting the Florentine case. Yet, in the new light of Cederni's earlier

80. This speculation was offered by Kent, *Bartolomeo Cederni*, p. 94, and partially accepted by me ["Firenze capitale degli occhiali," pp. 199–200] on the basis of Caccini's letter of 26 June 1454, the only one published on this subject. I am indebted to Lorenz Böninger for pointing out this passage to me and to F. W. Kent for alerting me to the existence of the unpublished letters mentioning spectacles.

81. The latest book by A. M. Crabb, *The Strozzi of Florence: Widowhood and Family Solidarity in the Renaissance* (Ann Arbor, 2000), makes no mention of this letter and the author has graciously informed me that she cannot find it after a search of her files.

82. See ch. I, p. 15. Manni cited this letter of 26 June 1476 without quoting the exact text in two books: *Dell'invenzione degli occhiali da naso. Ragionamenti accademici* (Florence, 1729), p. 127, and *Degli occhiali da naso inventati da Salvino Armati Trattato istorico* (Florence, 1738), p. 79. I have not been able to find this letter in Florentine archives and libraries. 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) at whose court Filippo served as the principal royal banker and as a sort of promoter of Florentine artistic and literary culture. For a brief biographical sketch of Filippo, see now E. Borsook, "Ritratto di Filippo Strozzi il vecchio," in *Palazzo Strozzi metà millennio 1489–1989* (Rome, 1991), pp. 1–11. For his commercial and cultural role in Naples dating back to 1447, see the very informative article by M. Del Treppo, "Le avventure storiografiche della tavola Strozzi," in *Fra storia e storiogafia: Scritti in onore di Pasquale Villani* (Bologna, 1994), pp. 483–515. It is odd, therefore, that Barbaro's dispatches from Naples mention once only Filippo's brother and partner, Lorenzo, in a matter of little import: *Corrispondenze diplomatiche veneziane da Napoli. Dispacci di Zaccaria Barbaro, 1 novembre 1471–7 settembre 1473*, ed. G. Corazzol (Rome, 1994), p. 176. On Barbaro's career, see M. L. King, *Venetian Humanism in an Age of Patrician Dominance* (Princeton, 1986), p. 326.

transaction, combined with other direct orders to Florence made by persons able to obtain spectacles from various centers, this irretrievable letter appears to be more credible now although final judgment on its authenticity should await additional corroboration.

On the other hand, it would not be wise to conclude definitely at this time that persons residing in or near Venice habitually would prefer to order their glasses from Florence regardless of cost and delay rather than be satisfied with the local product. That such a conclusion might be premature or even inaccurate is perhaps indicated by some newly discovered documents, which show that at the beginning of the fifteenth century the firm of Francesco di Marco Datini of Prato and Florence was purchasing eyeglasses in Venice, not Florence, apparently for personal use. In July 1400 while Francesco was residing at Bologna for the next fourteen months to escape the plague then raging in Florence, he ordered four pairs of spectacles from Venice. In September he ordered another dozen of "most perfect" ones, costing six *soldi piccioli* each, and made by the "best spectacle maker in Venice."[83] This cost per pair was about the same as that paid by the duke of Milan for his "absolutely perfect" Florentine eyeglasses sixty-two years later, as indicated above. It should be noted that the senders repeatedly advised Francesco to test the glasses and return them if found unsatisfactory. At age sixty-five, Francesco needed reading glasses for his ledgers but also "spiritual spectacles" (*ochialli spiritualli*), as his agent in Venice had already admonished him six years earlier.[84] This is one of the earliest instances of spectacles being mentioned metaphorically.

The small quantities requested, the emphasis on quality, and the admonition to the recipients to test the spectacles, all seem to indicate that they were ordered for personal use by Francesco himself and his staff. Surprisingly, this is one of the few documented cases in which such an admonition is expressly stated. But had Francesco forgotten to

83. Prato, Archivio Datini, F. 721, Bindo Piaciti to Francesco di Marco Datini in Bologna, Venice, 24 July 1400 (received the 28th): "Degli ochiali vi fornirò e manderovigli per lo primo soficente"; ibid., same correspondents, 31 July (received Aug. 3rd): "Mandàvi più dì fa iii paia d'ochiali: aretegli auti"; ibid., same correspondents, 7 Aug. (received Aug. 10th): "Se gli ochiali non sono begli, faren fare com più destro de' begli e manderenveli"; ibid., Eredi di Zanobi e Antonio Gaddi to Francesco Datini & Co. in Bologna, Venice, 15 Sept. : "Li ochiali ci chiedesti vi mandiamo con questa in uno bossoletto: sono de' più perfetti si faccino qui e piaxeranovi. Costano soldi 6 piccioli il paio: direte se vi piaciono e se altrimenti li volesti e non vi piaciessono, li rimandate e manderenvi degli altri"; F. 713, Eredi di Zanobi Gaddi to Datini Co. in Bologna, Venice, 11 Sept.: "Gli ochiali per Franciescho vedremo di fornire perfettamente e per lo primo altro fante gli manderemo. Toremo di queli arotati, che sono perfetti vetri, e sono molto lodati. Pensiamo vi piaxeranno, ma vagliono 3 tanti che gli altri da dozina"; ibid., same correspondents, Venice, 18 Sept.: "Scrivemovi a dì 15 di questo per le mani de' nostri di là e mandamovi uno bossoletto, entrovi xii paia da vetri d'ochiali con cruscha, perchè si conservano meglio. Son perfettissimi e del migliore maestro ci sia; soldi vi piccoli costò la copia de' vetri e con patto che, non vi piacendo, gli rimandate indietro; quando li avete, rispondete e dite se vi paiono buoni". These documents were made available to me by Marco Spallanzani and Reinhold Mueller, Florentine and Venetian sympathizers, respectively.

84. Prato, Archivio Datini, F. 709, Bassano da Pessina to Francesco, Venice, 13 Oct. 1384: "Dove io dico che tosto vi farano bixogno gl'ochialli, intendete gl'ochialli spiritualli e in antro modo no la intendete". For Francesco's residence in Bologna and the spread of the plague, see F. Melis, *Aspetti della vita economica medievale (Studi nell'Archivio Datini di Prato)* (Siena, 1962), pp. 55–57.

take along a supply of spectacles when he left Florence a couple of weeks earlier or did he need additional ones? And why not order them in nearby Florence, a city he knew so well, from his regular spectacle shop? The evidence does not provide answers to these questions. We can speculate that perhaps at this time the quality of Florentine spectacles was not at the level of the Venetian product or that Datini did not wish to receive such a labor-intensive product delivered by persons coming from an infested area. (Although the plague had begun in Venice and Bologna in September 1399, by July both cities were free of the disease.) At any rate, it is gratifying to note that these relatively rare documents about such exports from Venice constitute at the same time the second record about eyeglasses so far discovered in the Datini Archives in Prato. The first was published almost fifty years ago and reveals that in 1402 Datini had donated a pair of spectacles costing 20 soldi to the Franciscan friar Bonifazio Ruspi residing in Corsica.[85] The Datini Archives should contain many more such records once they are combed systematically.

Another document of the following century, which has just come to light, reveals an order from Florence to Venice. At the end of 1555 Giovanni Rossi, a Venetian, wrote to his friend in Florence, Ludovico Domenichi, that he was sending him three pairs of eyeglasses with crystal lenses for reading and writing and an additional pair "of the same age for distant vision" (*per veder da lontano*) to be used for recreation away from his desk when he was tired of writing. Regrettably the cost was not specified in the letter because the spectacle maker was not available at the time of writing.[86]

Being forty years old (born at Piacenza in 1515), Domenichi had reached the age when presbyopia begins for most people, but he was also myopic, needing glasses for distance vision when engaged in activities away from his study. Having been awarded a doctor's degree in both laws by the University of Padua, Domenichi soon left the practice of law for a career as a writer and editor first for a Venetian printer (1543–45) and from 1546 for the Florentine printer, Giunta.[87] Obviously, his was a career that required a lot of reading and close work. It is possible that during his residence in Padua and Venice he might have patronized a spectacle shop in Venice and established such a relationship with the spectacle maker to justify importing his glasses from him without knowing the cost in advance even from a leading spectacle-making center such as Florence.

85. This entry in Datini's account books was published by I. Origo, *The Merchant of Prato Francesco di Marco Datini* (New York, 1957), p. 309: "Item, August 5, 1402. 20 soldi for the love of God, for a pair of spectacles for Fra Bonifazio." Fuller information about the friar is given in the preceding entry recording the gift of seven gold florins to him. Spallanzani supplied this reference.

86. Giovanni Rossi to Lodovico Domenichi, Venice, 4 Dec. 1555: "Vi mando ancora 3 para d'occhialj cristallini. Penso saranno per Vostra Signoria a proposito pel studiare, ma un paio di più vi mando dell'istessa età per veder da lontano, et saranno a punto a proposito per vagheggiare tal'hora che v'increscerà il scrivere. Il prezzo non si può dir per hora perché il maestro mi ha detto che non é in casa." (ASF, *Archivio mediceo del principato*, F. 3079, fol. 3). I am indebted to Sabine Eiche for this document and the transcription.

87. On Domenichi, see the long biographical entry by A. Piscini in *Dizionario biografico degli italiani* (hereafter, DBI, 40 (1991), pp. 595–600.

That such long-distance ordering did, indeed, present problems in satisfying individual needs has already been attested in the case of Arduino da Baiso, and it is more vividly demonstrated in another case of the sixteenth century. In 1532 the ailing musical theorist/composer/choirmaster, Giovanni Spataro (ca. 1458–1541) of Bologna, wrote to his friend and fellow musician/composer residing in Venice but Florentine by birth, Pietro Aaron (ca. 1480–ca.1550), complaining that he had been so sick that it took him eight days to finish writing the letter. He thanked him for the glasses Aaron had sent him from Venice, but he was forced to return them because "neither open nor closed" [i.e., one lens placed over the other in a rivet-type spectacles and used as a magnifying lens] could they satisfy his needs, and one lens had arrived broken. He urged his friend not to supply replacements because he "knew that he needed to be there" [in Venice] to test them himself.[88]

Surely Spataro made a wise decision. It is, indeed, surprising that after nearly three centuries of spectacle use we still find such examples of long-distance ordering especially from one spectacle-making center to the other or from a city like Bologna, seat of a famous university where spectacle wearing must have been very common. Moreover, Bologna had glass furnaces already from the end of the fourteenth century, some of which had been established by Tuscan glassmakers from Gambassi. In the same period Bolognese customs records reveal imports and exports of spectacles with frames made of "boxwood, ivory, and buffalo [i.e. bone or horn of buffalo]" on which a tariff of *one soldo and six dinari* (a shilling and six pennies) by the pound weight was levied.[89] It should be noted that this is the first instance encountered so far in which eyeglasses were taxed as merchandise by the pound weight and the first time that buffaloes have been mentioned as a source of materials for spectacle frames. It is well known, of course, that water buffaloes were raised from southern Italy to Tuscany during the Renaissance.[90]

It is almost certain, then, that Spataro could have purchased glasses suitable for a

88. Biblioteca Apostolica Vaticana, MS Vat. Lat. 5318, fols. 222^r–222^v, Spataro to Aaron, Bologna, 5 Apr. 1532: ". . . Io sono stato octo giurni a scrivere questa littera, tanto sono stato molestato da diversi mali. Circa li ochiali rengratio Vostra Excellentia, li quali non [né] aperti et non [né] serrati non sono boni per me, de li quali era uno vetro rotto, come Vostra Excellentia potrà vedere, perché così facti come sono, a quella li rimando, et molto mi doglio che habiati havuto fatica et danno. Circa li quali ochiali altro non fareti perché cognosco che seria bisogno che io fusse qua [là or lì] con li ochii mei male disposti. . . ." I am indebted to the late musicologist Edward Lowinski for this reference and photocopy of the original accompanied by his transcription, which I have amended slightly especially with the words within square brackets, designed to conform to the real meaning of the quotation. For brief biographies of Aaron and Spataro, see *New Grove Dictionary of Music and Musicians* vols.1 and 17 (London, 1980), pp. 2–3 and 818–19, respectively.

89. "Ochiali de busso, d'avuolio e de buvala per livra de pexo solidi 1 dinari 6" as quoted from the customs records by S. Nepoti, "Per una storia della produzione e del consumo del vetro a Bologna nel Tardomedioevo," in *Archeologia e storia del Medioevo italiano*, ed. R. Francovich (Florence, 1987), p. 137, and p. 141, for establishment of glass furnaces.

90. On various animals raised in Italy, see P. Jones, "Italy," in *The Cambridge Economic History of Europe, vol. I, The Agrarian Life of the Middle Ages*, 2nd ed., ed. M. M. Postan (Cambridge, 1971), pp. 378–83.

seventy-four year old locally. Yet this must remain an open question until the discovery of additional documents allows us to offer at least some likely explanations for this phenomenon. It may be that some of these examples may indicate a previously unnoticed trend pointing to a gradual development of personal relationships between spectacle wearers and opticians, a relationship that is common even at the present time despite the proliferation of chain stores selling glasses at lower prices.

Large Florentine Exports Within Italy

Notwithstanding the counter current indicated by the above direct orders placed in Venice during the fifteenth and sixteenth centuries, the fact remains that sources for the fifteenth century point to the dominant persistence of the Florentine phenomenon, as it might be called. Additional revealing examples are connected with Rome both in direct individual orders and in rather large exports. In 1473 the fifty-one-year-old Cardinal Iacopo Ammannati Piccolomini wrote from Rome to Lorenzo de' Medici expressing satisfaction in having received an unspecified number of "good spectacles for distant and near vision" by means of Donato Acciaiuoli, the cardinal's former student, noted humanist, and member of Lorenzo's ruling circle.[91] This direct order for almost certainly Florentine glasses, as it can be deduced from the context, is perplexing because at this time spectacles were being imported into Rome by the thousand preeminently by Florentines but also by Germans in second place.

The leading role of Florentine importers of spectacles into Rome has been recently revealed above all by a still ongoing examination of the surviving customs duties registers for the periods 1452–1462 and 1470–1480 (with some gaps) carried out by Professor Arnold Esch, retired Director of the German Institute in Rome. From this still incomplete examination, the following preliminary findings seem to indicate substantial similarity in volume and unit price to those found for such Florentine exports within and outside the Italian peninsula. As in other places in Europe, spectacles were often imported along with other merchandise (*mercia*) such as knives, scissors, and playing cards, in unstated quantities in boxes and listed with other boxes containing unspecified numbers of spectacle components, such as frames and glass blanks or ground lenses. In instances where they are listed as a separate category we can calculate the declared total value on the basis of the 5 percent duty levied on finished goods such as spectacles imported by land (*Dogana di terra or di S. Eustachio*) in contrast to 6½ percent tax assessed

91. This letter of 25 April 1473 is now available in a modern edition: Iacopo Ammannati Piccolomini, *Lettere (1444–1479)*, vol. III, ed. Paolo Cherubini (Rome, 1997), pp. 1699–1700. The cardinal wrote: "Poiché Donato nostro me ha proveduto bene de occhiali buoni da veder da lungha et da presso, farò pruova nello scrivere mio se così sono, . . ." The number of pairs is not specified, but the phrase "proveduto bene" seems to imply the receipt of more than one pair.

on bulk commodities normally arriving by water (*Dogana di Ripa*). The market price in Rome, however, was at least 10 percent higher than the declared value for finished goods. Regrettably, we can calculate only the approximate sale price of spectacles based on these few examples because the estimated value used by customs officials for categories of goods remained fixed while market prices could fluctuate.[92]

In 1475 Guglielmo da Firenze imported twenty-four pairs with a declared value of 100 bolognini (b. 4.16 per pair), paying a duty of 5 bolognini.[93] In 1479–80, he declared two shipments of boxes of unfinished eyeglasses and one box of lenses or glass blanks for spectacles.[94] Bernardo Salvetti imported two boxes of unfinished ones (1479, 1481) while in 1480 Gaspare da Firenze declared 200 unfinished pairs and a small box of unfinished ones.[95] Finally Luca da Firenze imported a box of eyeglasses in 1480.[96] Within this period Esch has also found other records of imports by Florentine merchants: "four hundred pairs of spectacle bone frames" (*para 400 de ossi da ochiali*); "300 unfinished spectacles" (*hochiali non forniti n° 300*); and a "box of glass and bones for spectacles (*vetri da ochiali et osso cassetta n° 1*).[97] In addition, Francesco Ridolfi imported in 1479 crystal sheets or blanks (*vetri cristallini*), some of which could have been used to make high quality lenses.[98]

After the Florentines, Germans (lumped together with the Flemish and Dutch) imported glasses most frequently and in large quantities as shown by the following entries. In just the first eight months of 1457 a total of 2,692 pairs were imported by three German merchants: Hericho della Magnia, 14 gross of spectacles (2,016 pairs!); Arlondo Todescho, 100 pairs of lower quality (*tristi*) spectacles with wooden frames, assessed 6

92. The incompleteness and limitations of these records have been admirably summarized recently by A. Esch, "Roma come centro di importazioni nella seconda metà del Quattrocento ed il peso economico del papato," in *Roma capitale (1447–1527)*, ed. S. Gensini (Rome, 1994), pp. 113–14.

93. Rome, Archivio di Stato, Camera Urbis, *Introitus et Exitus*, Reg. 52, fol. 74r, 7 Jan. 1475: "Gugliermo da Firenze b. 5 per conducta para 24 ochiali." The following archival citations refer to this series from which the references to Florentine spectacle imports were first published by A. Esch, "Importe in das Rom der Renaissance. Die Zollregister der Jahre 1470–1480," *Quellen und Forschungen au italienischen Archiven und Bibliotheken*, 74 (1994), p. 387. Following his indications, I inspected the documents to note especially the language of the entries to provide a means of comparison with similar records in other archives.

94. The following entries are all in Reg. 55: fol. 107r, 18 May 1479: "Gugliermo da Fiorenza b. 8 per conducta de una scatola de occhiali non forniti"; fol. 198v , 7 Feb. 1480: "Gugliermo fiorentino b. 7½ per conducta de una scatolina de hochiali non forniti; fol. 259v , 29 July 1480: "Gugliermo da Fiorenze b. 7½ per conducta de una scatola de vetri da hochiali."

95. Ibid., fol. 114v , 3 June 1479: "Bernardo Salvetti b. 6 per conducta de una scatolina de hochiali non forniti"; fol. 356r , 30 Mar. 1481: "Bernardo Salvetti . . . una scatola de hochiali non forniti"; fol. 195v , 27 Jan. 1480: "Gasparre da Fiorenze . . . 200 hochiali non forniti"; fol. 231r , 8 May 1480: "Gasparre da Fiorenza . . . una scatolina de hochiali non forniti."

96. Ibid., fol. 264r, 12 Aug. 1480: "Lucha da Fiorenza . . . una scatola de occhiali."

97. Esch, "Importe," p. 387, did not supply the archival citations or the names of the importers with specific dates.

98. Reg. 55, fol. 85r: 16 Mar. 1479, "Francesco de Redolfi . . . una cassa de cristallini."

bolognini; Adriano dal Mare, 4 gross of spectacles with wooden frames (576 pairs).[99] Of the three declarations only Arlondo's spectacles were not combined with other merchandise so that their total value of 120 bolognini would result in a cost per pair of 1.20 bolognini. This is a low value probably reflecting their lower quality and the fact that wooden frames fetched a lower price as revealed by the Florentine sale in 1415 noted at the beginning of this chapter.[100] The Germans also imported *vetri cristallini* such as one case in 1477, declared by Jacomo Tedescho.[101]

From the above admittedly small number of entries it is clear that Florentines and Germans dominated the spectacle business in Rome. Occasionally there are other importers such as a Frenchman in 1474 declaring seventy pairs with duty of b.6 (total value, b.120, b.1.71 per pair), and a Bolognese six years later importing 180 pairs assessed at b.8 (total value, b.160, b.0.88 per pair!).[102] Other Italian merchants are also listed as importers of *vetri cristallini*.[103] Crystal seems to have become common in this period and was imported into Rome by merchants of various origins.

Surprisingly, Venetian spectacle imports have not been discovered in significant numbers in the registers, though Venetian merchants appeared as importers of other items, largely Veronese textiles, Venetian satin, and glass or bone rosaries. But in the decade 1470–80 they also imported various glass products including boxes of *vetri cristallini*.[104] The fact that at times these *vetri cristallini* were packed into barrels along with other types of glass and glass rosaries indicates their small size; i.e., blanks suitable to be ground into lenses.

Finally, in a class by itself, there is also a Venetian import of a box of *occhi de vetro*

99. "Hericho della Magnia condusse a die decto [12 January] una bulleta de mercia, entravi xiiij grosse de occhiali; "Arlondo todescho condusse a die decto [6 July] C para de ochiali de legno tristi, pacò ducati—bolognini vi"; "Adriano dal Mare condusse a die decto [17 August] grosse iiij de occhiali de legno." Reg. 28 [formerly Reg. 16], fols. 2^v, 65^r, and 77^v respectively. These documents were originally cited from Reg. 16 by Esch, "Le importazioni nella Roma del primo Rinascimento (il loro volume secondo i registri doganali romani degli anni 1452–1462)," in *Aspetti della vita economica e culturale a Roma nel Quattrocento*, ed. A. Esch, et al. (Rome, 1981), p. 57. Germans also imported large quantities of books and almost monopolized baking, shoemaking, and innkeeping in Rome but there is no trace of them as spectacle makers (C. L. Maas, *The German Community in Renaissance Rome, 1378–1523* (Rome, 1981), passim).

100. See p. 75–76.

101. Reg. 54, fol. 46^r, 14 Mar. 1477: "Jacomo Tedescho ducati uno b.36 per conducta una cassa de vetri cristallini. . . ."

102. Reg. 52, fol. 57^r, 24 Nov. 1474: "Iohanne franzoso b.6 per conducta 70 para de occhiari": Reg. 42, fol. 7^r, 21 Jan. 1480: "Stephano da Bolognia, hocchiali forniti n° 180, b.8." The second declaration reveals a very low estimated total value. These eyeglasses might have had wooden frames, which could be sold as low as s.0.66 a pair as listed in the sale of Florentine spectacles in 1415. In this case, however, one has to take into account the relative value or correspondence between Florentine *soldi* in 1415 and Roman *bolognini* in 1480.

103. Reg. 52, fol. 90^v: 17 Feb. 1476, "Jacomo Ponzano . . . una cassa vetri crestallini; Reg. 53, fol. 133^v: 13 Feb. 1476, "Tadeo de Pezaro [Pesaro] . . . casie 3 vetri cristalini"; Reg. 55, fol. 8^v: 27 June 1478, Iohannis da Spoleti [Spoleto] . . . tre casse de cristallini"; fol. 131^r: 11 Aug. 1479, "Gelardo da Landi . . . una scatolina de vetri cristallini"; fol. 183^v: 23 Dec. 1479, "Francesco da Como . . . doi [casse] de cristallini."

104. Reg. 55, fol. 91^r: 1 Apr. 1479, "Domenicho Bartolomeo da Venetia. . . . 9 casse vetri cristallini"; fol. 123^r: 5 July 1479, "Francesco da Venetia. . . . 4 casse de vetro cristallino."

(glasses for eyes or eyeglasses).[105] This phrase was used interchangibly with the term *occhiali* in the fourteenth century as we have seen in the preceding chapter. Depending on the context, it could designate a magnifying lens as illustrated in the above-mentioned inventory of Cardinal Francesco Gonzaga's possessions. This ambiguity survived well into the following century, despite the almost universal adoption of the term *occhiali* for spectacles, as shown in a letter from Florence by Mattea Spinelli to her husband, Benedetto di Guaspare Spinelli: "You say that you are in the dark because you need a pair of eyeglasses (*paio d'ochi di vetro*)."[106]

On the basis of this evidence, then, it seems that Venetians occupied a distant third place as importers of spectacles after the Florentines and the Germans. Florentine leadership in this area is consistent with Florence's dominance of banking and commerce in Rome especially from the middle of the fifteenth to the middle of the sixteenth century, leading to Esch's conclusion that "Renaissance Rome was the Rome not of the Romans but of the Florentines."[107] Venice's relative weight in the Roman economy is also demonstrated by the fact that in the decade 1474–84, of ten Italian regional groups represented in the customs registers, Venetians ranked seventh in the quantities of goods imported into Rome while Tuscans (mostly Florentines) were first, closely followed by Lombards in second place.[108] It appears that for Venice the Roman market was not a high priority.

Yet, it might be wise not to emphasize the significance of this conclusion pending fuller exploitation of data contained in the customs registers, which usually noted the origin of the importers but not of their goods. Sometimes imports were handled collectively by brokers under the general category of *mercie* (merchandise) or *spezie* (spices), both of which subsumed a great variety of products including spectacles, without registering the identity of the importing merchants. It is instructive to point out in this context that widely used merchant manuals of this early period made no mention of spectacles. Perhaps it would have been too early for them to be included in Pegolotti's

105. Imported on 13 Mar. 1478 by Giovanni da Venetia, who paid a duty of b.18 for "a cassa de occhi de vetro", Reg. 54, fol. 112v. See A. Esch, "Roman Customs Registers 1470–80: Items of Interest to Historians of Art and Material Culture," *Journal of the Warburg and Courtauld Institutes* 58 (1995), p. 84, for summary citations of archival documents attesting to glass products imported by Venetian and other merchants during this decade. I am indebted to my graduate student, Claudia Chierichini, for obtaining photocopies of a number of these documents.

106. Mattea to B. Spinelli, Florence, 13 Aug. 1534, Yale University, Beinecke Library, *Spinelli Archive*, F. 164, box 129, fols. 2684–86: "Voi dite che siate al buio avendo bixogno d'un paio d'ochi di vetro. Ve gli manderò". I am indebted to my graduate student, Allegra di Bonaventura Hogan, for this reference.

107. "Das Rom der Renaissance ist das Rom nicht der Römer, sondern der Florentiner" in A. Esch, "Florentiner in Rom um 1400. Namensverzeichnis der ersten Quattrocento-Generation," *Quellen und Forschungen aus italienischen Archiven und Bibliotheken* 52 (1972), pp. 476–525, quotation p. 476; I. See also Ait, "La dogana di terra come fonte per lo studio della presenza di mercanti stranieri a Roma nel XV secolo," in *Forestieri e stranieri nelle città basso-medievali. Atti del Seminario Internazionale di Studio, Bagno a Ripoli, 4–8 giugno 1984* (Florence, 1988), pp. 29–43; M. Cassandro, "I banchieri pontifici nel XV secolo," and I. Polverini Fosi, "I fiorentini a Roma nel Cinquecento: storia di una presenza," the last two in *Roma capitale (1447–1527)*, ed. S. Gensini (Rome, 1994), pp. 207–34 and pp. 389–414, respectively.

108. See I. Ait, "La dogana di terra," pp. 29–43.

Pratica della mercatura, composed in the first half of the fourteenth century, but they ought to have been listed in two manuals of the following century when thousands of spectacles were exported within and outside Italy; namely, Giovanni di Antonio da Uzzano's *La pratica della mercatura* (1442), and *Il libro di mercatantie et usanze de' paesi*, written in the second half of the century by a Florentine merchant. Only the former mentioned mirrors and drinking glasses under *mercie and spezie.*[109]

Consequently, it is entirely possible that Venetian goods, including eyeglasses and related components, could have been imported by non-Venetian merchants although it does not seem likely that Florentines would import Venetian spectacles in significant quantities, neglecting their own ample supply as our other documents demonstrate. Adding to the confusion is the fact that often glasses exported from Venice did not have a Venetian provenance strictly speaking, but were exported through the *Fondaco dei Tedeschi* in Venice, which would have given them a German origin in most cases. In 1440, two Florentine merchants purchased twelve dozen spectacles framed in wood from a German merchant residing in Florence at the cost of s.66 each.[110] Even larger exports of glasses in the thousands through the Fondaco have just been found in the ledgers of a merchant in Arezzo covering the period 1466–78.[111] It is clear that these large exports could not have been absorbed by the local market, but were re-exported to other places, including Rome, and would not count as having a Venetian or a German origin. On the other hand, the fact that the names of Venetian spectacle importers into Rome have not yet been found in significant numbers by experienced researchers appropriately alerted may, indeed, indicate a conscious decision by Venetian spectacle makers to leave the Roman market to the Florentines and the Germans.[112]

109. F. Balducci Pegolotti, *La pratica della mercatura*, ed. A. Evans (Cambridge, MA, 1936), pp. 293–97, gives a long list of "spezierie" such as pearls, soap, sugar, elephant tusks, olive oil, tin, etc., but not spectacles or mirrors. Giovanni di Antonio da Uzzano, *La pratica della mercatura* in *Della decima e delle altre gravezze*, ed. G. F. Pagnini della Ventura, vol. IV (Lisbon and Lucca, 1766), passim, lists mirrors, drinking glasses, and raw materials for making glass under "merciai" and "speziali." *El libro di mercantie et usanze de' paesi*, ed. F. Borlandi (Turin, 1936; reprint Turin, 1970), (attributed to Giorgio di Lorenzo Chiarini), pp. 113, 142, 146, lists all sorts of commodities and products imported and exported by Florence and Venice, but without mentioning spectacles or mirrors! Esch, "Roma come centro di importazioni," p. 141, has nicely described the role of the "speziali" in Rome: "Con gli "speziali" nel testo romano non si intendono i mercanti di spezie, ma i mercanti e bottegai in genere che vendevano al dettaglio, nelle loro botteghe, tutte le cose possibili e immaginabili. . . ."

110. Florence, Archivio dell'Ospedale degli Innocenti, *Estranei* 17 (new signature 12797), account books of the Florentine "merciai," Agnolo d'Antonio and Francesco d'Aringho, for the year 1440, fols. 33ᵛ. and 69ᵛ. They purchased 12 dozen "occhiali di legno per s.8 per dozen, £ IIII, s.16," from Giovanni d'Ulmo della Magna, German "merciao" resident in Florence. I assume that these spectacles were manufactured in Germany, which specialized in wooden frames, and imported through the Fondaco dei Tedeschi. The price per pair corresponds exactly to similarly framed pairs. I owe this document to Marco Spallanzani and Lorenz Böninger.

111. These documents were found in 2005 by Andrea Mozzato in Arezzo, Archivio della Fraternità dei Laici. They will be published in a forthcoming issue of the *Atti della Fondazione Giorgio Ronchi*. I thank the discoverer for informing me of their existence.

112. In a private communication (1995), Professor Esch kindly commented on this question as follows: "I registri doganali non indicano la provenienza della merce ma solamente la provenienza dell'importatore (ed anche questo

In addition, there are other important reasons for postponing definite conclusions about the Roman data cited above. Besides the incompleteness of the records, which cover only the period 1450–85 with some gaps,[113] the partial research carried out so far, and the probable "slippage" caused by bribery of officials and contraband for easily concealed items of personal use such as spectacles, one must still take into account perhaps the most important missing figure; namely, the volume of such imports by the clergy, their households, and even important personages connected with the papal administration and visiting dignitaries as long-term papal guests, all exempt from duties with no trace in the customs registers for land-transported products, though water-borne goods imported by such persons were registered but untaxed.[114] In a city full of religious establishments with a supposedly high percentage of spectacle users, this omission represents a huge black hole through which hundreds or perhaps thousands of imported spectacles and their components could have disappeared.

The households of cardinals and popes, for example, could be quite numerous even without counting the lay contigents whose numbers are unknown. Just the number of clerics attached to cardinals would generally run from 40 to 70, but some cardinals had more: Guillaume d'Estouteville (91), Rodrigo Borgia (later Alexander VI, 139), and Sixtus IV (396).[115] How many of them used spectacles and magnifying lenses? Surviving inventories and expense accounts reveal that Guillaume d'Estouteville (who was very fond of luxury) used a "beautiful round magnifying crystal lens framed in gold for reading in a black case" and another similar crystal lens framed in silver in [another] black case.[116] His successful rival for the papal throne in 1458, Pius II, less extravagant in his life-style, used three crystal magnifying lenses for reading, framed in unspecified materials, though the payment of eleven cameral gold ducats to a Florentine goldsmith suggests framing in precious metals.[117] Even the more parsimonius Calixtus III, Pius'

non sempre). Nel caso degli occhiali, ho notato che venivano importati sopratutto da fiorentini (ed in alcuni casi da tedeschi). É possibile—tra migliaia di entrate—che a volte siano stati registrati anche alcuni veneziani, ma non in numero cospicuo, altimenti li avrei notati. Naturalmente non si può escludere che gli occhiali importati da un tedesco o da un bolognese fossero prodotti a Venezia. Questo, purtroppo, non si può dedurre dai registri doganali!" I am, indeed, grateful to Prof. Esch for this lucid statement of the problem.

113. The registers are listed by I. Ait, "La dogana di S. Eustachio nel XV secolo," in *Aspetti della vita economica e culturale a Roma nel Quattrocento,* ed. A. Esch et al., (Rome, 1981), p. 84.

114. A. Esch, "Navi nel porto di Roma. Esempi di carichi di merci nei registri doganali del Quattrocento," in *Medioevo mezzogiorno mediterraneo. Studi in onore di Mario Del Treppo,* ed. G. Rossetti and G. Vitolo, vol II (Naples, 2000), pp. 93–103.

115. For these figures and the difficulty of arriving at definite conclusions about the volume of imports, etc., see Esch, "Roma come centro di importazioni," pp. 133–43.

116. An inventory of the cardinal's effects in 1483 listed: "Item unum pulchrum cristallum rotundum ligatum in auro cum armis Rmi d., ad legendum aptum, in vagina nigra. Item unum aliud simile cristallum ligatum in argento, etiam in vagina nigra." See E. Müntz, *Les arts à la cour des papes pendant le xv^e et xvi^e. Recueil de documents inédits tirés des archives et des bibliothèques romaines,* vol. 3 (Paris, 1882), p. 290.

117. "1461. 2 juin. Honorabili viro magistro Simoni aurifici florentino flor. auri d. c. 11 pro valore trium peciarum cristalli ab eo empti pro usu personae s^{mi} domini nostri papae, s. ad legendum." Ibid., I (Paris, 1878),

predecessor, could not resist the pleasure of owning "two pairs of gold spectacles" and a "gold spectacle case."[118] To date, however, we have a definite record of only one fifteenth-century pope, Sixtus IV, who was reported wearing eyeglasses by the Neapolitan ambassador while dictacting a memorandum to him.[119] But such a scene must have occurred countless times in courts and chanceries of the age and would ordinarily pass in silence except that in this case the ambassador felt the need to mention it, perhaps to underline the attentiveness of the pope, who was sixty-eight at the time. Furthermore, it is known that inventories tended to list the more expensive items. In this age of multiple spectacle ownership there could have been many more relatively inexpensive eyeglasses not listed among the possessions of clerics of means.

It seems likely, also, that some members of this large exempt group would have been tempted to engage in a little business on the side, selling duty-free eyeglasses at bargain prices. In view of this multi-caused huge "slippage," therefore, it is prudent to consider the above figures as the bare minimum and even be bold in proposing that we double the number of spectacles imported into Rome in any given year. But could a city of about 35,000 souls absorb all the imported eyeglasses (especially if we double the imports in 1457, for instance, to about 5,000 pairs) in addition to the output of whatever local production there might have been?

Local production of eyeglasses has not even been mentioned by scholars, apparently because there are no records of spectacle makers in Rome for this century at least. The absence of artisans specifically listed as spectacle makers in lists of trades or guilds has been traditionally taken as a sign of no spectacle-making activity in any given region. Evidence presented in this study shows otherwise. It would have made no sense to import into Rome large quantities of unfinished spectacles and separate components such as glass/crystal blanks and bone [frames] for eyeglasses if there had not been local artisans ready to finish them, replace broken lenses, and repair misaligned or broken frames. Goldsmiths, a numerous group in Rome, could have performed this function along with other artisans working bone, base metals, horn, ivory, leather, and wood—in short, artisans working with various materials out of which spectacle frames were made at that time. There were also glass workers, making drinking glasses and bottles, who could have supplied the glass blanks.[120] And if monks in Pisa, Florence, and Mantua could

p. 316. The phrase "ad legandum" is probably a scribal, transcription, or typographical error and should read "ad legendum."

118. "Item duo paria occularium de auro. . . . Item una coperta occularium de auro." (1458). Ibid., I, pp. 216–17.

119. Anello Arcamone et al. to King Ferrante, Duke of Milan, et al., Rome, 12 Mar. 1482, ASM, PE-Roma, cart. 91, reel 851: "Soa S.tà . . . era contenta se scrivesse et disse al cardinale de S.to Gieorgio . . . che pigliasse carta et calamaro et io scriveva et Soa S.tà con li ochiali stava guardando et dittando. . . ." I am grateful to my graduate student, Marcello Simonetta, for this most recent find.

120. In the Parione and Ponte districts alone, two densely populated commercial zones, there were thirty-three and thirteen goldsmiths respectively. No spectacle makers have been discovered in notarial and customs records for the period 1450–80. See A. Modigliani, "Le attività lavorative e le forme contrattuali," in *Un pontificato ed una città:*

make spectacles as noted earlier, what would prevent their colleagues in Rome from following suit? There must have been some domestic production, though probably of modest proportion given Rome's reputation as a consuming rather than a producing city. So, if we double the yearly imports of spectacles, and add those manufactured locally, we will arrive at a total figure probably too large to be used within the city even if we consider the fact that moderately affluent individuals often owned several pairs, as we have seen. It seems likely, then, that the city also acted as a transit point for distribution elsewhere, especially to the outlying districts.

Additional discoveries may answer some of these questions and even serve to arrive at more realistic figures. Despite these limitations, however, the Roman records constitute the only ones discovered to date which document large imports of spectacles within Italy. These figures are to be compared to even larger exports of eyeglasses outside Italy from Florence, a gigantic one from Venice by a Florentine company, and to the massive exports to England during the same period, all to be treated in the next chapter. The Roman records also show that even adding the duty of 5 percent over the declared value per pair, ranging from b.1.71 to b.4.16, eyeglasses in Rome would sell at approximately the same price as other ordinary samples produced in quantities and sold in other Italian cities. A Roman artisan such as a shoemaker, earning at this time between 12 and 14 ducats (864 and 1,008 bolognini, respectively) per year, often with food and clothing provided, could have afforded to purchase a pair or two.[121] Their quality, however, would not likely have satisfied persons like Cardinal Iacopo Ammannati Piccolomini, who imported them directly from Florence with the aid of his friends in the Medici circle, as we have seen.

It is clear that by the end of the fifteenth century Italy generated more documents attesting to the widespread use of spectacles both for myopes and presbyopes than any other country in Europe. At the present state of our knowledge, England seems to be in second place in the volume of spectacles imported in a single year, as it will be noted in the next chapter.[122] Surprisingly, however, Italy is far behind in the number of archeological discoveries in this field. So far Italian archeologists have found only one spectacle frame in a dig (1982) of a well located in Via dei Castellani in the proximity of Palazzo Vecchio and the Uffizi. This is an area that is easily inundated during the periodic flooding of the nearby Arno, which may have deposited these spectacles and other debris of everyday life in the same way that the Thames did in London during the same period.

Sisto IV (1471–1484), ed. M. Miglio et al. (Vatican City, 1986), pp. 663–83, and E. Lee, "Gli abitanti del rione Ponte," in *Roma Capitale (1447–1527)*, ed. S. Gensini (Rome, 1994), pp. 317–443. On various trades and guilds in Rome at this time, see also A. M. Corbo, *Artisti e artigiani in Roma al tempo di Martino V e di Eugenio IV* (Rome, 1969), and A. Martini, *Arti, mestieri e fede nella Roma dei papi* (Bologna, 1965), pp. 281, 291, for "fornaciari del vetro," "bicchierari," and "bottigliari."

121. See A. Modigliani, "Le attività," p. 682, for these annual salaries in the Parione district. These calculations are made at the rate of 72 bolognini per ducat.

122. See ch. IV, p. 130.

44–45. *Rivet Bone/Antler or Ivory Spectacle Frame,* late 15th century, found in Florence, Soprintendenza Archeologica per la Toscana, Florence.

The find consists of a pair of rivet spectacles with curved handles and bone frame made probably in the late fifteenth century (Fig. 44), and found with other objects made of horn, bone, and ivory. The dig uncovered also many bones and horns of cattle and deer, among parts of other animals, in various stages of manufacture, which may well indicate the presence of artisans preparing these materials for various products, including spectacle frames.[123] In the last couple decades, however, Italian archeologists have become more active in pursuing medieval digs. It is hoped that in the near future they will discover more buried glass furnaces and glass objects so that the original home of eyeglasses can offer at least as rich a harvest as that already available in England, Germany, Belgium, Holland, and Croatia, as will be discussed in the following chapter.

123. I am indebted to Professor Guido Vannini of the University of Florence for a photocopy of a still unpublished and unpaginated article by Giuliano de Marinis, "Il pozzo di via de' Castellani: aspetti di vita nella Firenze rinascimentale," which is to appear eventually at an unspecified date in the *Archeological Review/Rivista di archeologia.* I am also grateful to Dr. A. Bottini, Soprintendente Archeologico della Toscana, for permission to republish the photograph of the spectacles and to Dr. P. R. Del Francia, who kindly gave me an illustrated "estratto" of the article with separate color photographs, and arranged a personal inspection of the artifact with exemplary courtesy in March 2001.

IV

International Trade in Spectacles

AS IT HAS been shown in the preceding chapter, archival documents discovered in the last few years have uncovered so much new information about the development of spectacles in Italy before the sixteenth century as to constitute a revolution in the history of this vision aid. Archeological finds, on the other hand, have been particularly helpful in enriching this history in some other European countries such as England, Germany, and the Netherlands. By contrast, when two diligent researchers—Richard Greeff and Moritz von Rohr—published in the second decade of last century most of what was known about the development of eyeglasses in this period, their conclusions were based on casual literary references and iconographical evidence. Both authors lamented the fact that archival evidence was negligible especially with respect to England, the Netherlands, Spain, and Venice. It remains in this state to the present day except for England.[1] They mentioned Florence only with reference to the disputed place of the invention, not even suspecting its later role as a center for eyeglass production and distribution in and outside the Italian peninsula. Ironically, now it has been Florence that has supplied the major and crucial part of the new archival documentation for this reexamination of an old subject.

Indeed, the late leading economic historian, Federigo Melis, was fond of emphasizing the fact that most of what we know about commercial relations among European countries and of their trade with the Levant in the late fourteenth and fifteenth centuries was necessarily based on the massive collections of account books, commercial letters, and contracts deposited in Italian archives, especially in Tuscany, which holds two thirds of these documents. Some of these collections are truly gigantic. The largest depository, the Datini Archives in Prato, has about 153,000 letters and about 600 account books just for the period 1365–1412 produced by the Datini bank and its branches. Other

1. R. Greeff, *Die Erfindung der Augengläser. Kulturgechichtliche Darstellungen nach urkundlichen Quellen mit 10 Tafeln* (Berlin, 1921), and two articles by M. von Rohr, "Contributions to the History of the Spectacle Trade from the Earliest Times to Thomas Young's Appearance, *Transactions of the Optical Society* 25/2 (1923–24), pp. 41–72, and "Additions to our Knowledge of Old Spectacles: A Summary of Papers Published in 1923–24 Relating to the Subject of the Thomas Young Oration of 1923," ibid., 26 (1924–25), pp. 175–87.

large collections are concentrated in Pisa and more so in Florence. Such vast private records were the result of the international activities of rather large merchant banking companies, common only in Tuscany. Their various branches kept books using double-entry bookkeeping and kept in touch by frequent letters dealing with all sorts of topics besides commercial news. These letters can be compared in comprehensiveness with diplomatic dispatches, of which Italy also holds the largest collections for this period, with the qualification that the former are commercially oriented whereas the latter are politically centered. In contrast, such private commercial collections in other countries are meager or inexistent, though some countries have abundant customs records but these lack the detail of the commercial letters.[2] This enormous imbalance in the volume and character of the surviving documentation forces us to view the history of spectacles largely through Florentine lenses, and make assumptions about lines of development in non-Italian areas based on meager and indirect evidence. Most frustrating has been the scarcity of Venetian sources (including customs records discarded in the nineteenth century), a case where indirect evidence and common sense point to a strong Venetian presence in the production of spectacles but we lack the documents to prove it.

In the last half-century, Melis and other Florentine economic historians have made much progress in analyzing the data contained in the Tuscan collections. Until this research is completed many years from now it will be impossible to reach definitive conclusions about the extent of spectacle production and trade in this period. Moreover, only in the last four years have some economic historians begun to make a concentrated effort to note transactions relating to eyeglasses while pursuing their primary interest in large-scale and more lucrative product exchanges such as woolens, silks, spices, wines, etc. Richard Goldthwaite, a leading authority on the economy of Renaissance Florence and its vast commercial records, has led the way in promoting this new interest among some of his colleagues, all of whom have now been eagerly searching these records and sharing their findings with me with rare generosity. This on-going research has already established that Florentine companies not only were selling spectacles in massive quantities within Italy, as we have seen in the preceding chapter, but they were also supplying other countries in even larger quantities.

Exports to the Levant

In 1482 Alamanno di Averardo Salviati purchased from the *ossai* (bone-smiths) Giovanni di Piero & Company, 1,100 pairs of Florentine spectacles and gave them in consignment

2. F. Melis, "I rapporti economici fra la Spagna e l'Italia nei secoli xiv–xvi secondo la documentazione italiana," in his *I mercanti italiani nell'Europa medievale e rinascimentale*, ed. L. Frangioni (Florence, 1990), pp. 251–56, and his book, *Aspetti della vita economica medievale (Studi nell'Archivio Datini di Prato)* (Siena, 1962), pp. 2–28, for a detailed description of these records.

to Giovanni d'Antonio Tornaquinci for sale in the Levant. Nine hundred pairs were purchased at £13 s.15 per hundred and 200 at £14 s.15 per hundred, approximately s.2.75 and s.2.95 per pair respectively. Adding duties (*gabelle*) of s.5 d.6, the total cost amounted to £27 s.9 d.6.[3] Two years later Tornaquinci reported having sold 1,084 of these spectacles as follows: 227 pairs in Skopje (Ischopia) for 454 Turkish aspers; and three lots in Adrianople—namely, 172 (268 aspers); 525 (892 aspers); 160 (268 aspers).[4] At the exchange rate of 48 aspers for one Florentine gold florin in 1484, the sale prices of the spectacles in the four lots were respectively in *soldi* per pair: 5, 3.90, 4.25, 4.20.[5] It would seem that in this case, also, eyeglasses were affordable for the vast majority of those needing them, though one cannot be certain because cost of living statistics are not readily available for the Levant.

In 1484 another Florentine *ossaio*, Taddeo di Tomaso, was also involved in another massive sale of 529 pairs of eyeglasses to Bartolomeo di Piero di Simone Guanti, a Florentine wool cloth merchant trading at Brusa, a thriving trading center and leading silk market in the Ottoman Empire about fifty seven miles southeast of Constantinople.[6] The sale was executed in two lots. One of 523 pairs cost £61 s.10 (s.2.35 per pair) and the other about a month later consisted of six pairs at the cost of s.14 (s.2.33 per pair). To the purchase price we must add the duty levied in Florence (£1 s.19) and the cost of transport from Florence to Pisa (£2 s.1).[7] The slightly lower cost of these spectacles

3. The transaction appears in the ledger of Alamanno di Averardo Salviati, 1482–91, Pisa, Scuola Normale Superiore, Archivio Salviati, serie II, 23, fol. 12s: "MCCCCLXXXII. Paia MC d'ochiali di Firenze abiamo in mano di Giovanni Tornaquinci in Levante deono dare a dì xiii dicembre fiorini ventisette, soldi iiii, denari 0 per loro a Giovanni di Pietro e compagni, ossai, per costo d'essi cho paia 900 a £.13 s.15 al cento apaia; 200 a £.14 s.15 al cento. . . ." Totals: £27 s.4 d.— + s.5 d.6 (gabelle) = £27 s.9 d.6. This sum was paid to Giovanni di Pietro & Company in Feb.–March 1483, ibid., fol. 10s.

4. Details of the sale of these glasses were recorded in the Tornaquinci account of Salviati's *giornale e ricordanze*, fol. 20v and were kindly communicated to me by Goldthwaite. I am also grateful to the Director of the Salviati Archives, Dr. Milletta Sbrilli, for supplying me with photocopies of the relevant documents.

5. The exchange rate of the aspers and the Florentine fiorino largo d'oro in oro in 1484 was derived from the figures given by H. Oshino, "Il commercio fiorentino nell'impero ottomano: costi e profitti negli anni 1484–1488," in *Aspetti della vita economica medievale* (Atti del Convegno di Studi nel X anniversario della morte di Federigo Melis, Firenze-Pisa-Prato, 10–14 marzo 1984) (Florence, 1985), pp. 86, 88.

6. The commercial activity of the Guanti firm with respect to textiles without mention of this trade in spectacles has been treated by Hoshino, "Il commercio fiorentino," 81–90. Goldthwaite discovered this and the following transactions.

7. Florence, Archivio di Stato, *Corporazioni religiose soppresse dal governo francese 79, No. 208*, Ledger of Bartolomeo di Piero di Simone Guanti, fol. 1s: "Taddeo di Tomaxo hossaio e compagni deono dare a dì XX di marzo 1483 [1484] fiorini quattro larghi d'oro in oro portó Lorenzo di Smeraldo per parte d'occhiali merchatati cho lloro per £12 il cento, valsono £24 s.8.

E a dì XXVI detto fiorini sei larghi in oro e soldi X piccioli portò Lorenzo di Smeraldo per resto, valsono £37 s.2.

A dì XXII d'aprile 1484 soldi XIV piccioli portò l' detto s.14. E per gabella di Firenze £1 s.19 e per vettura da Firenze a Pisa, £2 s.1." And fol. 1d: "Taddeo di Tomaxo e compagni al'incontro deono avere a dì XXVI di marzo 1484 per 523 paia d'occhiali cho una schatola d'entrovi per tutto £. sessantuno, soldi X piccioli per denari pagò in tutto £61 s.10.

6 paia d'occhiali a dì XXII d'aprile 1484,—soldi 14."

compared to those involved in the much larger Salviati transaction can perhaps be attributed to differences in quality and to bargaining positions so common in any commercial enterprise.

That the Levantine appetite for Florentine eyeglasses continued at least until the beginning of the next century is attested by a lengthy published letter by Giovanni Maringhi writing from Pera, the foreign quarter of Constantinople, to Ser Nicolò Michelozzi in Florence. Maringhi was a member in the firm Francesco de' Medici & Company, and also served as an agent in Pera for other Florentine merchant companies while the humanist notary Michelozzi served as his "manager" in the home office. In 1501 Maringhi reported a great craving for spectacles at Pera seemingly chiding Michelozzi for ignoring repeated requests for them as follows: *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.*[8] It is significant to note that the desired purchase price amounts to about s.2.48 per pair, right in the middle range of the prices calculated for the preceding two Florentine purchases.[9] An account for spectacles also appears in the inventory of the bankrupt Medici Company in Pera right after the death of Maringhi (1507).[10] Finally there is another account of 1520 regarding eyeglasses in Pera, this time held by Raffaello di Francesco de' Medici & Company.[11]

The above documents confirm the well-known Florentine commercial expansion in the Levant especially after the fall of Constantinople (1453). Although the bulk of Florence's trade within the Ottoman Empire consisted of exports of woolen cloth and imports of Levantine silk and spices,[12] this new evidence of exports of spectacles in such large quantities in a region overwhelmingly dominated by Venetian merchants with the Genoese in second place is, indeed, surprising. Yet we know that in this same period Venice exported large quantities of glass, crystal, mirrors, and glass products to the entire Middle East, taking advantage of the quality of its Murano glass, which was vastly

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Fol. 1d: "Taddeo di Tomaxo e compagni al'incontro deono avere a dì XXVI di marzo 1484 per 523 paia d'occhiali cho una schatola d'entrovi per tutto £. sessantuno soldi X piccioli per denari pago in tutto £61 s.10.

6 paia d'occhiali a dì XXII d'aprile 1484, s.14."

8. Giovanni Maringhi in Pera to Ser Nicolò Michelozzi in Florence, 29 October 1501 in *Florentine Merchants in the Age of the Medici. Letters and Documents from the Selfridge Collection of Medici Manuscripts*, ed. G. R. B. Richards (Cambridge, MA, 1932), p. 136.

9. In his letter, ibid., p. 149, Maringhi gives the exchange rate of 49 aspri per Venetian ducat, the dominant currency in the Levant. Since the value of the ducat in 1500 was 124 soldi, the price per pair was approximately s.2.48. For the exchange rate, see P. Spufford, *Handbook of Medieval Exchange* (London, 1986), pp. 82–84.

10. A notebook listed in the inventory has this first entry: "Eyeglasses belonging to . . . ," *Florentine Merchants*, p. 186.

11. "Remember the spectacles and keep an eye out for the old account which is still unsettled." Raffaello de' Medici to Filippo da Empoli and Antonio Bartoli in Pera, Florence, 4 January 1520, ibid., p. 223.

12. Florentine trade particularly with the Levant as revealed in the ledgers of the Guanti wool cloth firm mentioned above has been treated by Hoshino, "Il commercio fiorentino," pp. 81–90.

superior to that produced in the Levant.[13] In a report (ca. 1592) written for grand duke Ferdinand I of Florence, the annual value of glass products exported from Venice to Constantinople and to Alexandria in Egypt was listed at 10,000 and 5,000 ducats, respectively. Common glass and luxury opaque white glass vessels were included along with lamps for mosques, but spectacles were not listed probably because their total value was insignificant compared to that of the other exports.[14] It is possible, however, that eyeglasses were included in the general category of *merce* (merchandise), frequently mentioned in cargoes of Venetian ships to the Levant, because they were commonly sold in mercers' shops and by ambulant peddlers. In addition, the generic terms "glass" or "crystal" used in cargo lists may have included glass/crystal blanks to be ground into lenses and inserted into frames by local artisans as was the case in western countries.[15] On the other hand, the quality of Venetian glass depended in large part on the importation of large quantities of sodium-rich alkali Syrian ash, the best available, used both in glass and soap making.[16]

Indeed, the high probability that Venetian exports of eyeglasses as finished products classified under merchandise or as glass/crystal lens blanks listed under their generic terms, must have constituted a common complement of Venice's trade with the Levant seems to be confirmed by some recently discovered indirect evidence. A most unusual type of evidence is supplied by the codebook of Hayyim Saruq, a Jewish merchant and Ottoman subject, a resident of Venice for many years, who normally traded with the Levant. In November 1571, a little over a month after the Christian victory at Lepanto, he was sent to Constantinople by the Council of Ten of Venice to spy on Turkish affairs and military preparations. The codebook, apparently devised by Saruq himself under the Ten's instructions, made use of Jewish lexicon, calendar, and commercial terminology particularly applicable to normal exchange of products between Venice and the Levant so that the resultant letters, if intercepted and decoded, would seem to be the

13. For Venetian glass exports to the Levant, see E. Ashtor, "Aspetti della espansione italiana nel basso medioevo," *Rivista stor. Italiana*, 90 (1978), pp. 17–19, and idem, *Levant Trade in the Later Middle Ages* (Princeton, 1983), pp. 212–13, 466. Cf. also the most recent treatment by R. E. Mack, *Bazaar to Piazza: Islamic Trade and Italian Art, 1300–1600* (Berkeley, 2002), pp. 171–72.

14. G. Corti, "L'industria del vetro di Murano alla fine del secolo XVI in una relazione al granduca di Toscana," *Studi veneziani* XIII (1971), pp. 649–54. Spectacles are also not mentioned in two studies by R. J. Charleston, "The Import of Venetian Glass into the Near-East: 15th–16th Century," in *Annales du 3ème Congrès des journées internationales du verre* (Liège, 1964), pp. 158–68, and "The Import of Western Glass into Turkey: Sixteenth-Eighteenth Centuries," *The Connoisseur* 182/651 (May 1966), pp. 18–26.

15. For examples of these cargoes directed to Alexandria, see M. Sanuto, *I diarii*, ed. R. Fulin, F. Stefani, N. Barozzi, G. Berchet, and M. Alegri, 58 vols. (Venice, 1879–1903), vol. III (1880), cols. 1187–88: Dec. 1500, cristalli casse 3, veri c. 2, merze c. 24; vol. IX (1883), col. 37: Feb. 1510, cristalli c. 3, merze c. 15; vol. XII (1886), col. 78: Mar. 1511, merze c. 3; vol. XL (1894), col. 177: Oct. 1525, veri c. 6, merze c. 6. Likewise spectacles are not mentioned in the few references to Venetian glass exports to the Levant in the *Lettres d'un marchand vénitien Andrea Berengo (1553–1556)*, ed. U. Tucci (Paris, 1957), nos. 1, 9, 22, 99, 108, 149, 182, 189.

16. E. Ashtor and G. Cevidalli, "Levantine Alkali Ashes and European Industries," *Journal of European Economic History* 12/3 (1983), pp. 475–522.

usual chatter of one Jewish merchant with another; for example, the code word for "biscuits" (normal shipboard food) was *ochiali*, that for "artillery" was "Murano mirrors."[17] It is obvious that the word "eyeglasses" would not have been included if it designated an uncommon Venetian export. Although not a definite proof for our present purposes, this codebook may also be of interest to diplomatic historians for its apparent first use of the word "spectacles" as a code word.

Additional indirect evidence is provided by the following five recently discovered commercial letters. In April–September 1540 a total of 24,000 pairs of spectacles were exported in three lots from Venice by way of Ancona and Ragusa and from the latter overland through Sarajevo, Novibazar, and Edirne with Pera as the final destination. They were shipped by the commission agent, Francesco di Domenico Lioni, to Guglielmo da Sommaia, agent in Pera for the Florentine company, Sommaia & Girolami. The total cost, including expenses, amounted to £43 s.10 d.4, which comes to s.2.72 per pair. The spectacles were to be bartered for musk, such bartering being quite common for trade in the Near East.[18]

17. The code book was published by B. Arbel, *Trading Nations. Jews and Venetians in the Early Modern Eastern Mediterranean* (Leiden/New York/Köln, 1995), pp. 210–15, with analysis on pp. 145–51.

18. ASF, *Libri di commercio e di famiglia, n° 182: Copie di lettere de l'anno 1540 di messer Francesco Lioni segnato C.* The following transcribed excerpts from letters sent by Francesco Lioni to two correspondents about this transaction were kindly sent to me by Anna Affortunati. I have made some additions and changes after inspecting the original register. Fol. 4, "A Raugia [Ragusa], a Zanobi Bartoli. Addì X d'aprile 1540: .Io vi mando per il presente brighantino, patrone buono, una balla di panni segniata dello avanti e n° 1 e una cassetta drentovi 6 miara di ochiali. E più vi mando una balla di panni segniata dello avanti e n° 10 e alsì una cassetta drentovi 8 miara di ochiali e niente altro e in ella balla de' panni non c'è nulla. Fate d'averlle e le mandate in Pera a Ghuglielmo da Somaia e comp. a mio ordine e da lui vi valete delle spese e avisate cadauno. La casetta è segnata dello avanti segno e n° 8. Per aviso vi sia."

Fol. 9v, "In Pera, a Somaia. Addì XIX d'aprile 1540: . . . . Mandavi ancora in una cassa segniata dello avanti e n° 8, miara 8 di ochiali come per la fattura in questa vedrete; farete allo arivo d'essa d'averlli, che sono a conto del baratto del muschio che se ne mandò miara 12 a Luolo e miara 4 ancora ne resta, che vi si manderanno come prima si possa."

Fol. 23v, "In Pera, a Somaia. Addì XXI di maggio 1540: . . . Io vi mandai una cassa drentovi 8 scatole di ochiali per via di Raugia. Avanzorne 6 scatole per resto del mercato. Manderole in Ancona che vi sieno mandate per la barca dello Scarlatto e per il vostro ghaleone e ve ne manderò conto e n'arete aviso."

Fol. 45, "Im Pera, al Somaia. Addì IIII di luglio 1540: . . . E mi resta a mandarvi 8 scatole di ochiali auti al rincontro del muschio per resto delle miara 24, che ve li manderò colla nave Corese che viene in costà e n'avete conto di tutto. Per aviso."

Fol. 75, "Im Pera, al Somaia. Addì I di settenbre 1540: . . . Ancora ci sarà il conto di scatole 26 di ochiali chè scatole 12 se n'è mandate a Luolo al vostro Somaia e Pomaro e, il resto, si sono mandate a voi che l'ultime sono state 6 scatole in una cassa segnata di vostro e n° 9 per la nave Corese, patrone Pantaleone Mogardato. Farete d'averlla. E quali ochiali s'ebono a baratto del bossolo di muschio de' vostri Somaia e Girolami che, colle spese, detto conto monta lb. 43.10.4 d'oro e di tanti siate debitori. Provedetelo e aconciatelo stando a dovere e avisate se nulla mancassi."

Fol. 120, "Segue im Pera al Somaia. Addì xxx d'ottobre 1540. Nella cassa delli ochiali mandatovi per via de Raugia v'era drento alcune cosette che vanno a Vincenzio da Vinci [?]. Fare che l'abia."

Unnumbered fol., "Segue im Pera al Somaia. Addì xiii di febraio 1540 [1541]. Aconciasti il conto delli ochiali e avesti la cassetta mandatovi per la nave Corese; Iddio ve ne dia quella fine che per amore vostro ne desidero, che mi duole non ne chaviate quello strutto si pensava." This last letter seems to indicate that the company did not make the profit on the sale that it had expected.

These letters are remarkable both for registering the largest shipment of spectacles on record for a single transaction, and also because the total number seems to be exceptional even for a series of transactions in any given year at the present state of our knowledge. Unlike the Florentine records of shipments to the Near East cited above, however, these letters do not mention the origin of the spectacles. That an agent for a Florentine company in Venice exported eyeglasses from that port to be bartered by another agent of that company in the Levant does not prove that the spectacles were made in Florence because Florentine merchants habitually used Venice to export Florentine-made goods as well as goods made elsewhere. These goods, however, had to pay entry and exit duties and had to be sold only through Venetian citizens as required by the Venetian government.[19] These were onerous conditions which led Florence to use the direct sea route for Anconian and Ragusan ships or the longer sea route from Pisa and Leghorn mostly for Genoese ships whenever possible. More frequently Florentine goods traveled overland from Ragusa as noted above so as to escape pirates and other dangers of the sea.[20]

With these variables in mind, one can advance a plausible argument that such a massive number of eyeglasses could be assembled more easily for shipment in Venice than at any other place in Christendom. As we have noted in the first chapter, in 1446 the mercers' guild in Venice had complained of competition by non-members such as Germans and other foreigners, including Florentines, in the manufacture and sale of spectacles and other products without paying membership dues or customs duties. The glass or crystal blanks from Murano or elsewhere were ground and polished into appropriate lenses, which were then inserted into frames by shop owners/artisans of various specializations/subdivisions (*colonnelli*) of the mercers' guild along the *Merceria*—from spectacle makers themselves to frame and case makers working with various materials.[21]

Yet, the coordination of all these trades in grinding and polishing 48,000 lenses with the aid of primitive machines, their insertion into 24,000 frames in various stages of preparation while also filling other orders of varying magnitudes from domestic and foreign customers, all in about four months, would signify that Venice already had developed a spectacle-making industry on the scale of an early Luxottica or Safilo. If such

19. J-C Hocquet, *Denaro, navi e mercanti a Venezia 1200–1600* (Rome, 1999), p. 20, has emphasized the fact that Venice functioned as an emporium under strict control of the government and not as a free port of transit: "Gli stranieri che volevano inviare merci nel Levante tramite Venezia, dopo aver pagato i diritti d'entrata dovevano obligatoriamente venderle a Veneziani; solo questi ultimi godevano della facoltà giuridica di intraprendere traffici; ugualmente, chi avesse voluto acquistare prodotti orientali tramite Venezia, non avrebbe potuto acquistarli se non da cittadini veneziani."

20. For a brief synthesis of Florentine trade and trade routes with the Levant, see H. Inalcik, "The Ottoman State: Economy and Society, 1300–1600," in *An Economic and Social History of the Ottoman Empire, 1300–1914*, ed. H. Inalcik with D. Quataert (Cambridge, 1994), pp. 230–43.

21. See A. Manno, *I mestieri di Venezia: Storia, arte e devozione delle corporazioni dal XIII al XVIII secolo* (Cittadella, 1995), pp. 92–101, for the various subdivisions of the mercers' guild; and p. 98 for reproduction of the emblem of the horn smiths (peteneri) who made combs and spectacle frames; and p. 101 for that of the scabbard makers (vazineri) who made spectacle cases; pp. 179–81 contain a complete list of Venetian guilds and their subdivisions.

were the case, it would have left many traces of its existence, making life easier for modern researchers. It is more likely, therefore, that this gigantic order was filled partly by ready inventories in the shops, partly by accelerated production in Venice and surrounding territory, and partly by quickly arranged imports from more distant spectacle-making centers with Florence and Germany heading the list. Within a four-month period this combination of suppliers conceivably could have accomplished the task, and it is significant that the export agent apparently treated this order as routine, for his correspondence does not mention any difficulties in assembling the spectacles for shipment. Only Venice at this time had the kind of international commercial market capable of supplying such quantities. This reality may explain the absence of a direct shipment from Florence in this instance, unlike the preceding Florentine shipments to the Levant, and the willingness of the Sommaia & Girolami Company to pay the Venetian duties. Regardless of their origin, the cost per pair was average for large sales of the kind, as we have learned from other sources but, regrettably, it cannot be used as a point of comparison between the Florentine and Venetian spectacle-making industries.[22] If only the label "made in . . ." had been used at that time!

Equally surprising is the high demand for eyeglasses in the Levant, especially taking into account the high probability that the documents cited above may be the tip of the iceberg. In Venice alone there were sizable colonies of Levantine merchants, especially Turks, Jews, and Greeks, who also could have exported eyeglasses along with other merchandise to the Levant. Unfortunately, there has been no systematic search of account books in Florence or in other spectacle-making centers for evidence of additional exports to that area. In a way it is ironic that the very regions that in antiquity invented the process of making glass, supplied the best soda ash for its production, created glass objects of beauty treasured in the West up to the end of the fourteenth century, and nurtured leading optical theorists, should in the fifteenth and sixteenth centuries import good glass (even lamps for their mosques) and spectacles from the West. This can be seen as another symptom of the technological decline of the Middle East, already noted by scholars. Syria's celebrated glass industry was never able to recover after its destruction by Tamerlane in 1400.[23]

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22. The intricacies of Venetian money of account in this period, which can lead astray even experienced economic historians, are clearly explained by Mueller, *The Venetian Money Market*, Appendix D, pp. 610–25. Fortunately Goldthwaite also came to my rescue by performing the necessary calculations regarding the above order in a private communication as follows: "£43.s.10.d.4 is probably the lira di grossi of Venice, the standard money of account there, each £ being worth 10 ducats or florins. Hence: £43/10/4 di gr. VE = £43.5167 = fl.435.167 = £3263.75 picc. @fl.1 = £7½ = s.65275.05 di picc., which divided by 24,000 occhiali gives you 2.72 soldi for each . . ." Now this is clear!

23. For a discussion of evidence of this technological decline in various fields in the fifteenth century, see two articles by Ashtor, "Aspetti," pp. 5–29, and "The Economic Decline of the Middle East during the Later Middle Ages: An Outline," *Asian and African Studies* 15 (1981), pp. 253–86; and his posthumous collection of articles, *Technology, Industry and Trade: The Levant Versus Europe, 1250–1500* (Hampshire, 1992). Charleston, "The Import of Venetian

At the same time it is significant to underline the fact that merchants habitually sold the spectacles. The above evidence cited for Florence shows that they purchased them from *ossai* (bone-smiths), who made the frames and inserted the lenses either ground by them or by glass workers. Specialized spectacle makers (*occhialari*) are not mentioned in these documents. The Florentine evidence also suggests that spectacles produced in large quantities at lower cost commonly had frames made of bone, and we have seen that even the Pisan goldsmith firm mentioned in the preceding chapter used bones for the frames. The use of bone continued well in the next century as it is shown in a rare inventory of a spectacle-making shop (*occhialer*) of 1630 in Venice where we see registered about 600 pieces comprised of *ossi da occhiali* (bones for spectacles) and *veri in pezzi* (glass blanks) to be polished.[24] Wood framed glasses, however, could be produced at even lower cost as noted in the preceding chapter.[25]

Florentine Exports to Portugal

In addition to exports to various Italian cities and the Levant, Florentines were also exporting spectacles to western Europe. Most recently such records have been found in that mine of information on the economy of Florence for the period 1444–81, composed of some eighty ledgers of the Cambini Company, a middle level merchant banking firm with agents and associates spread from Constantinople to Flanders and England. The entries on spectacles so far recovered regard exports to Portugal of which the following two are especially significant for our purposes.[26]

In 1472 Giuliano di Francesco Cambini paid the sum of one florin *largo* for an unspecified number of spectacles made at the Monastery of St. Brigida al Paradiso, located just outside Florence. The payment was made on behalf of a Florentine merchant, Giovanni di Bernardo Guidetti, who resided in Lisbon and often acted as an agent for the Cambini

Glass," p. 158, stated this turnabout succinctly: "It is an accepted fact that in the Middle Ages the glass of the Islamic Near East was a treasured luxury commodity in the countries of Western Europe. . . . It is perhaps not so generally recognized that, probably from the turn of the 15th century onwards, the situation began to be reversed. No doubt the destruction by Tamerlane of the Syrian glass-centres in 1400 was largely instrumental in upsetting the previous balance."

24. F. Trivellato, *Fondamenta dei vetrai. Lavoro, tecnologia e mercato a Venezia tra Sei e Settecento* (Rome, 2000), p. 139, n. 23.

25. P. 76.

26. They were discovered by Sergio Tognetti, who has recently published a detailed monograph on this firm: *Il banco Cambini. Affari e mercati di una compagnia mercantile-bancaria nella Firenze del XV secolo* (Florence, 1999). See also his study of the local activity of this bank: "L'attività di banca locale di una grande compagnia fiorentina del XV secolo," *Archivio: storico italiano* CLV (1997), pp. 595–647. The casual way in which these documents can sometimes be found is illustrated by the fact that Tognetti, who heretofore had not noted exports of spectacles, discovered the first such document after my inquiry within an hour of our meeting in February 1999 while I was fruitlessly consulting another ledger of the Cambini firm. I am grateful to him for his kindness in sharing his discoveries with me and supplying me with relative transcriptions.

firm.[27] This monastery had a very active spectacle shop, which filled orders for the local market and for export to various cities in Italy.[28] Here we have an example of a monastic export outside Italy, which raises the question of the role of monasteries in artisan production for a distant market, a matter that requires further examination.

Four years later the Cambini Company sent a large shipment of silk cloth from the port of Leghorn to Lisbon aboard a Portuguese ship. The cargo, which was to be sold by the Cambini partner in Lisbon, the Florentine merchant-banker Bartolomeo di Domenico Marchionni, also contained a consignment of magnifying lenses and spectacles for various persons, some of high rank, listed as follows:

"One mounted crystal lens with handle" for Madonna Filippa of the Infante of Portugal.
"A box with eighteen pairs of spectacles for all ages" for Maestro Latone, a Jewish merchant in Lisbon.
"One mounted crystal lens with handle" for a Portuguese friar.
"Twelve pairs of spectacles" for the Bishop of Oporto.[29]

The specific mention of the persons destined to receive the various vision aids designates this as a special order, which most likely was filled in Florence. Besides the continuing use of magnifying lenses, this shipment also reveals the diffusion outside Italy of eyeglasses for "all ages" (first mentioned in the Milanese correspondence of 1464), which would include concave lenses for myopes.

More common in account books are shipments meant for the open market. In 1472 the Cambini Company sent a shipment of silk and twenty pairs of spectacles to its branch in Pisa, presumably for export to Portugal. Regrettably the combined cost of the shipment specified at the very small sum of one florin *largo* and fourteen *grossi* makes it impossible to calculate the cost of the glasses.[30] In 1477 the Cambini sent via Leghorn on a Portuguese whaler to its agent in Lisbon, Giovanni Guidetti, a little box containing eyeglasses without specifying quantity or cost.[31] A year later a debit entry reveals that

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27. "Giovanni di Bernardo Ghuidetti di Lisbona per suo chonto chorrente de' dare. . . . E a dì di giungnio [1472] f. uno, portò Giuliano Chanbini chontanti, disse per dare a' frati del Paradiso per ochiali, a uscita c. 167. . . . f. 1", (Florence, Archivio dell'Ospedale degli Innocenti [hereafter AOI], *Fondo Estranei*, n. 257, fol. 101s).

28. For the activity of this monastic spectacle shop, see below pp. 176–78.

29. The spectacle entry, dated 24 January 1476, reads as follows:
"1° occhio di vetro christallino legato in uno ghanbo" for "madona Filippa de l'Infante del Portoghallo."
"XVIII paia d'occhiali da ongni vista in una schatola" for "Maestro Latone."
"1° occhio christallino leghato inn uno ghanbo" for a Portuguese friar.
"12 paia d'occhiali" for the "vescovo di Oporto." (Florence, AOI, *Estranei*, N. 235, fol. 23v–24r).

30. "Merchatantie di nostra ragione deono dare. . . . E a dì XV detto [settembre 1472] f. uno g. 5 XIIII° portò Bernardo Chambini per pagare 20 paia d'occhiali e br. 20 di tafettà, cioè di fette, comprò per mandare a Pisa a Giuliano Chambini, a uscita c. 185, . . . f. 1.15" [one florin and 15 *soldi larghi*]. (Florence, AOI, Estranei, N. 257, fol. 144s).

31. "13 marzo 1477: spediti a Giovanni Guidetti di Lisbona. Da Livorno con il baleniere S. Antonio una schatolina d'ochiali" (Florence, AOI, *Estranei*, N. 235, fol. 62s).

s. 10 in gold currency were paid to the spectacle maker, Giovanni di Piero, for an unspecified quantity of eyeglasses sent to Piero Vaschi, Portuguese merchant in Lisbon.[32]

The following earlier records of spectacle shipments to Guidetti in Lisbon have also been found recently: in 1461, two boxes of twelve and two pairs respectively; in 1462, a box with 12 pairs; in 1466, two bone-framed mirrors and a box with twelve pairs of eyeglasses. None of these entries noted the prices.[33]

Another entry of 1459 records the cost of s.11 for the rather unusual export of "a pair of spectacles for horseback riding in the snow," requested by Nuno Fernandes, who was nicknamed "scientist of Portugal."[34] This may well be the first record discovered to date of the use of color lenses for spectacles, precursors of modern sunglasses. It is likely, however, that they might have been in use earlier because there was no problem in making color lenses with the addition of various substances to the glass mixture to produce various tints in glass. By the seventeenth century plane (and presumably also graded) colored glasses to shield eyes from the glare of the sun and of "white paper" while reading, as well as protect them from dust, etc., held tightly before the eyes by means of leather strips reaching behind the ears, were described as commonly available in a Tuscan art dictionary.[35]

Unfortunately, these documents relating to Portugal are often not sufficiently specific with respect either to quantities and/or prices. The surprisingly small stated quantities—

32. "Piero Vaschi di Portoghallo de' dare a dì XXX d'ottobre [1478] f.– s.10 a oro larghi, paghamo a Giovanni di Piero fa gli ochiali, chompramo da llui per mandare al detto a Lisbona, a uscita c. 164, f.– s.X d." (ibid., n. 237, fol. 163s).

33. "Mcccclxi. Richordo che oggi questo dì xviii di luglio, che noi mandamo a Lisbona a Giovanni Ghuidetti queste robe ch'è appresso per la nave Santa Maria Nazarete, padrone Rodericho Alfonso e per le mani di Ridolfo di ser Ghabriello di Pisa: una cassa invogliata . . . una schatolina, entrovi xii paia d'ochiali, una schatolina, entrovi ii paia d'ochiali"(Florence, AOI, Estranei, N. 223, *Ricordanze di Francesco e Carlo Cambini e compagni in Firenze,* fol. 29ᵛ); "Richordo questo dì xxii di gungno [1462], che noi mandamo a Pisa a Ridolfo di ser Ghabriello per Monte della Lastra, vetturale, questi drappi ch'è appresso e prima chon ordine le charichassi in sulla nave Nazarete per chonseg(n)are a Giovanni Ghuidetti a Lisbona: uno forzeretto verde, entrovi . . . ii Lucerne d'ottone e una chasettina, entrovi xii paia d'ochiali e una cintoluza d'ariento" (ibid., fol. 85ʳ); "Ricordo questo dì xiiii di marzo 1465 [1466], che noi mandamo a Pisa a Ridolfo di ser Ghabriello, per Francesco da Charcheri, vetturale, quanto apresso: . . . 2 specchi d'osso di messere Alfonso Iannis, una schatolina, enttrovi xii paia d'ochiali, del detto" (ibid., Estranei, n. 228, *Ricordanze di Francesco e Bernardo Cambini e compagni in Firenze,* fol. 21ᵛ). The transcriptions of these documents were supplied by Marco Spallanzani

34. "(5 giugno 1459). Chopia d'uno chonto mandato a messer Nugno Fernandi in Portoghallo: Chonto di chosto e spese di più robe fornite per messere Nuno Ferrandi e mandate in Portoghallo, come apresso: . . . per chosto d'uno paio d'ochiali da cavalchare per la neve, f.– s.11.0" (Florence, AOI, Estranei, N. 222, *Ricordanze di Francesco e Carlo Cambini e compagni in Firenze, fol. 22ʳ*). This document was first cited without exact archival reference by V. Rau, "Bartolomeo di Iacopo di Ser Vanni mercador-banqueiro florentino 'estante' em Lisboa nos meados do século XV," *Do tempo e da história,* IV (1971), p. 112. Spallanzani finally located the entry and kindly sent me the above transcription. I am also indebted to Goldthwaite for the published reference.

35. F. Baldinucci, *Vocabolario toscano dell'arte del disegno,* vol. II (Milan, 1809) pp. 9–10: "Fannosi occhiali ancora per confortar la vista, la quale non venga disgregata o affaticata dalla bianchezza della carta nello studiare, e questi si fabbricano di vetro piano colorito, più e meno carico di colore; servono in oltre per viaggio, affinché la virtù visiva, o l'occhio, né dal riflesso del Sole, né dalla polvere, riceva nocumento; ed a questo effetto sono loro aggiunte certe strisce di cuojo, che serrandogli alle tempie e alla testa fermangli agli orecchi."

in the dozen range rather than in the hundred and thousand often mentioned in other such exports—lead to the tentative conclusion that at least in these few cases the merchants were dealing in eyeglasses more for the convenience of their clients than for the pursuit of profit. The shipment of the pair of sunglasses mentioned above and the forwarding of another pair by the Cambini Company to Bologna in 1461 are particularly illustrative of this practice.[36] This may partly explain the hitherto lack of interest in these small exports amidst a much larger trade in such commodities as leather, paper, cloth, drinking glasses, etc., between Portugal and Tuscany in the fifteenth century, which also resulted in forging various cultural links between the two regions. At this time Lisbon became the commercial link between the Mediterranean, Flanders, and England—a trade largely dominated by Florentine and Genoese merchants.[37] And the same lack of specificity also applies to a rare Venetian record of a shipment of spectacles as part of a cargo of "false pearls," and mirrors, among other glass products, shipped from Venice to Cadiz in 1647, some of which were probably destined for Lisbon as well.[38]

Exports to England

In view of the above-mentioned Florentine exports to various places in Italy, the Levant, and Portugal it is surprising that no specific and conclusive evidence has been found of Italian or more specifically Florentine large scale spectacle exports to other countries in western Europe such as France, the Low Countries, England, or central Europe. Once again a combination of factors, including insufficient or total absence of surviving records, and lack of interest by researchers may account for this lacuna. England, especially, presents a puzzle because of the comparatively abundant import records found to date and its lively trade with both Venice and Florence. Already England was importing eyeglasses by the thousands at the end of the fourteenth century as noted in a preceding chapter.[39] In the fifteenth century we have references to luxury spectacles in wills dated 1416 and 1423, while three entries in account books of 1463, 1514, and 1518 listed more moderately priced ones.[40]

36. "A dì ii detto [giugno 1461] mandamo . . . uno paio d'ochiali [a Bologna] . . ." (AOI, Estranei, N. 223, *Ricordanze di Francesco e Carlo Cambini e compagni in Firenze*, fol. 98^v).

37. For these commercial relations without mention of eyeglasses, see two articles by F. Melis, "I rapporti economici," and "Di alcune figure di operatori economici fiorentini attivi nel Portogallo nel xv secolo," both in his *I mercanti italiani*, pp. 251–76, 1–18, respectively. For a recent analysis of this trade, also with no mention of spectacles, see M. Berti, "Le aziende da Colle: Una finestra sulle relazioni commerciali tra la Toscana ed il Portogallo a metà del Quattrocento," in *Toscana e Portogallo. Miscellanea storica nel 650° anniversario dello Studio Generale di Pisa* (Pisa, 1994), pp. 57–106. Cultural relations have been amply assessed in *Cultural Links between Portugal and Italy in the Renaissance*, ed. K. J. P. Lowe (Oxford, 2000).

38. Trivellato, *Fondamenta dei vetrai*, p. 240.

39. Ch. II, p. 71–73.

40. For these references, see M. Rhodes, "A Pair of Fifteenth-Century Spectacle Frames from the City of London," *Antiquaries Journal* 62/1 (1982), pp. 64–65.

More intriguing, however, are fifteenth-century records registering imports in large quantities in London and other ports. A searcher's account, dated 10 May 1428–10 February 1431, gives an inventory of apparently smuggled alien ("Dutch") goods "found in a keel in a creek at Wolferton" near the port of Lynn, which was frequented mostly by northern European traders but also by some Italians, particularly silk merchants from Lucca.[41] The cargo included wool, rabbit-skins, and other items among which there was a barrel of "hardware or haberdashery" consisting of such items as thimbles, shoe laces, curtain rings, jet and glass beads, and even "a dozen of lewd calendars," whatever they might have been. The barrel also contained "12 dozen glasses [blanks or lenses] for spectacles," valued at 5d, and "one dozen spectacles" valued at 3d.[42] Whether the glass units were simply blanks ready to be ground to specific powers for reading (less likely for distant vision) or were already ground as lenses it is not possible to determine from the phrase, *vitri pro spectaculis*. Nevertheless, either case presupposes the existence in the region of some artisans capable of grinding the blanks and/or fitting the lenses into locally manufactured frames, for it would make no sense importing a gross of such blanks/lenses for a product that could not be assembled locally. This is the first reference to imported glass specifically designed for spectacles found in England to date and may constitute the earliest evidence of the presence of local spectacle makers or "opticians," a question to which we shall return later. Also remarkable is the low value placed both on the blanks or lenses and on the finished product itself.

Customs accounts for the port of London, however, supply the most compelling evidence of truly massive imports in the fifteenth century. Stuart Jenks' forthcoming edition of the entries for the period 1390–1450 will show that five gross of spectacles and six baskets or boxes (*coffynes*) of them were imported in 1428 while eleven gross were imported the following year.[43] Some citations of other import accounts have been published as follows: in 1438, "5 gross of spectacles cases"; in 1442–43, "20 dozen spectacle cases"; in 1446, "5 dozen spectacle cases" on a ship from Danzig, and "1 gross of spectacles" on a ship from Antwerp; in 1494, "4 gross of spectacles" imported by Henry Hill and "12 gross of spectacles imported by Barth Mowger.[44]

41. See *The Making of King's Lynn: A Documentary Survey*, ed. D. M. Owen (London, 1984), pp. 44–49, for foreign merchants trading in Lynn, and pp. 362–66 for the text of the account.

42. Ibid., pp. 364–65: "12 duodenarum vitri pro spectaculis precii 5d" and "unius duodene spectaculorum precii 3d." This reference was supplied by Elizabeth Leedham-Green through John Dreyfus and Charles Letocha.

43. London, Public Records Office [hereafter PRO], *Tonnage and Poundage*, E122/74/11, m. 10, 28 Dec. 1428: "De Johanne Arnoldson . . . 6 coffynes spectacules" and "De Hugone Scarle . . . 5 grossis spectacules"; ibid., m. 23, 8 Aug. 1429: "De Jacobo Tidmanson . . . 11 gross spectacules." The imports for 1390–91 were treated in ch. 2. I am again indebted to Jenks for the transcriptions.

44. See A. MacGregor, "Bone, Antler and Horn Industries in the Urban Context," in *Diet and Crafts in Towns: The Evidence of Animal Remains from the Roman to the Post-Medieval Periods*, ed. D. Serjeantson and T. Waldron (Oxford, 1989), Appendix, pp. 123–24, all taken from London, PRO, Customs Accounts. They are listed as follows: 1438, Petty Custom, E.122/73/10, fol. 12^v; 1442–43, Tonnage and Poundage, E. 122/77/4, m. 6; 1446, Import Ledger, E.122/73/20A, fols., 4^v, and 20^v; 1494, Imports and Exports, E.122/79/5, m.1^v or 2, and m.8^v, respectively.

Even much larger numbers of imports into the port of London were declared between 8 November 1480 and 21 July 1481. These records show that in this interval of only eight and a half months alien merchants, many with Dutch names operating ships with homeports mostly in Flanders and Holland, imported 4,320 spectacle cases and 6,072 pairs of spectacles.[45] The latter figure constitutes the third largest trade after the 24,000 pairs exported in 1540 from Venice to the Levant as mentioned above, and the 17,652 pairs imported from Italy to London in 1663.[46] Finally, in a two-month period in 1509, customs records show the importation of 1,872 pairs of eyeglasses.[47]

The entries give the total valuation of a merchant's declaration, which usually included several items, so that the exact value of the imported spectacles cannot be calculated from the duty of 6¼ percent levied on alien goods.[48] Their original cost, however, seems to have been relatively low or at least moderate even taking into account the low customs valuations normally placed on imported goods during this period. A book of rates for 1507 lists a duty of 3s 4d per gross on imported spectacles while another book for 1582 gives the following rates per gross: 10s for spectacles, 13s 4d for gilt spectacle cases, and 6s 8d for not gilt ones.[49] By way of comparison, we know that in 1545 Henry VIII purchased ten pairs of eyeglasses for 3s 4d, just 4 pence per pair, while the daily wage for a carpenter working solo outside of London was 5.25d in 1500.[50]

The ten pairs might have been included among the forty-four pairs listed in the inventory of Henry's movable possessions made after his death two years later. Here also the materials for the frames were not specified except for ten silver-gilt pairs, two "garnished with gold" and one of horn. Sixty-two spectacle cases were also listed, most made of leather but five were silver-gilt, two gold, and one in "Morisco worke." His fourteen magnifying lenses (including one green stone "to read with") were more commonly framed in silver or silver-gilt, one "garnished with gold," and one framed in wood.

45. See H. Cobb, *The Overseas Trade of London: Exchequer Customs Accounts, 1480–1* (London, 1990), entries 17, 33, 37, 82, 84, 94, 159, 183–84, 186 for spectacle cases, and 26, 30, 35, 60, 70, 85, 94, 139, 153, 157, 159, 179, 181, 184–85 for spectacles. It is to be noted that my figures as given above differ from those cited by Cobb, p. xxxvi, who wrote that "alien merchants imported some 30 gross of spectacles and 26½ gross of spectacle cases," as approximate quantities, whereas my figures are the result of an actual count. I am indebted to Cobb for his kind assistance in interpreting the nature of these imports.

46. For this shipment to London, see below p. 138–39.

47. Rhodes, "A Pair," p. 66, based on data published by N. S. B. Gras, *The Early English Customs System* (Cambridge, MA, 1918), pp. 560, 562–63, 570, 575, 580.

48. Cobb, *The Overseas Trade*, p. 13–30.

49. Gras, *The Early English Customs*, p. 703, for the rates of 1507, and *A Tudor Book of Rates*, ed. T. S. Willan (Manchester, UK, 1962; repr. New York, 1970), p. 57, for the 1582 rates.

50. See C. B. Fryer, "Ophthalmics in the Reign of Henry VIII," *Ophthalmic Antiques*, No. 47 (April, 1994), p. 7, and D. L. Farmer, "Prices and Wages: 1350–1500," in *The Agrarian History of England and Wales*, ed. E. Miller, *vol. III 1348–1500* (Cambridge, 1991), p. 471.

Several had leather cases.[51] This inventory differs from most Italian ones in that it omits the estimated value of the listed items, thus depriving us of the possibility of knowing the prices of luxury spectacles owned by the king.

The most unusual use of spectacles by this acquisitive and luxury-loving king, however, was a pair of rivet eyeglasses bolted to the visor of a helmet, which came with a suit of armor donated to Henry by Emperor Maximilian I in 1514, when the king was 23 years old.[52] Unless he wore this specially constructed pair just to keep dust from his eyes while indulging in his passion for tournaments, such use of glasses at this age might have been an indication of myopia. Presumably, he needed them to see more clearly the rapidly approaching adversary although no actual evidence has been found of their use, given the potential danger of fractured glass/crystal pieces entering the eyes as a result of a violent blow on the head. On the other hand, another view holds that these spectacles were decorative rather than practical and that this small set of armor would not have fit Henry and was rather used by a jester at his court.[53] Whatever use the king made of this set of armor with a bespectacled visor, we can still conclude from the above evidence that he had a life-long experience with eyeglasses, which was not recorded in portraiture. It was not an image that he and other Renaissance rulers wished to convey. Unlike in the case of the Sforza dukes, it seems that the above vision aids were designed primarily for personal use, not as gifts to courtiers.

While the above sources do not reveal the provenance of Henry's spectacles, except for those attached to one of his helmets, we now have new documents placing glasses most probably made in Florence within the highest circles of his court. According to these documents, two of the King's highest officials in 1527 received luxury spectacles as gifts from the London branch of the Florentine company of Giovanni Cavalcanti and Pier Francesco de' Bardi. The recipients were the Cardinal Archbishop of York, Thomas Wolsey, Chancellor of England, and the Treasurer of the Royal Chamber, Henry Wyatt. The former received a pair of silver-gilt spectacles in a gold-gilt case along with two red velvet purses with gold buttons, and the latter a pair of silver spectacles in a silver-nielloed case.[54] The fact that the home office of the company in Florence (and not a

51. *The Inventory of King Henry VIII: Society of Antiquaries MS 129 and British Library MS Harley 1419*, ed. D. Starkey (London, 1998): the items for spectacles, spectacle cases, and magnifying lenses are listed in the Index by numbers, too long to list here, under the category "Spectacles and reading aids."

52. The helmet, made by Konrad Seusenhofer of Innsbruck, is now on display in the Royal Armouries Museum, Leeds, IV. 22. The attached spectacles have been described as follows by Fryer, "Ophthalmics," p. 7: "The spectacles, which are of the riveted pattern, are now unglazed, and are attached to the visor by 2 bolts, each through the lower part of the frame. The eyeshape is circular, about 3.6 cm in diameter which gives a spectacle P. D. of 70 mm. The rim, which is made of brass, is 10 mm thick with decorations around the edges."

53. This view is held by Letocha, private communication, 2004.

54. Florence, Archivio Ginori Lisci (Palazzo Ginori), 217. Libro di conti, 1526–27: Questo libro è di Giovanni Chavalcanti e Pier Francesco de' Bardi e compagni di Londra e chiamasi libretto giallo segnato F, del partito fatto

branch elsewhere) was debited for the expense and that niello was a Florentine specialty leads one to believe that the spectacles were made in the city, though it is theoretically possible that they could have been purchased elsewhere. Since only the total cost of £4 s.13 d.4 in sterling is listed in the transaction, we cannot ascertain the unit price of the eyeglasses. This is the only direct evidence to date of the presence in England of eyeglasses almost certainly made in Florence. The firm of Cavalcanti and Bardi was a prominent supplier of luxury goods and military supplies at Henry's court and its close connection to the Medici rulers in Florence and the two Medici popes — Leo X (1513–21) and Clement VII (1523–34) — allowed it to assume a financial and semi-diplomatic role between Florence, Rome, and London. It is possible that a thorough examination of the firm's twenty-seven surviving registers may reveal other entries regarding eyeglasses.[55]

As noted previously for the fourteenth century, however, the known quantities of imported spectacles are not likely to represent the total number entering England. The customs accounts have not survived in their entirety, regard only the port of London, and have not been fully studied by scholars.[56] They also exclude possible imports by English merchants. Then we should add likely imports into other ports, such as Lynn as we have seen, and especially Southampton. The surviving Port Books of Southampton have not been fully examined, but the few published ones have noted spectacle imports of undetermined quantities in the fifteenth century and of one gross in 1509, the latter valued at 6s 8d (0.5d per pair). They also contain entries for unclassified glass (*vitri*) and

con la maestà del Re e chomunità di Firenze. Fol. 10 sinistra: ". . . Scarxelle e ochiali di nostro conto, dare, a dì vii di marzo [1527], per valuta di ducati xx d'oro si fa boni a' nostri di Firenze, per costo di ii scarxelle di velluto chermisi con bottoni d'oro e d'una paio di ochiali niellati d'argento e un paio dorati, mandatici in una chaxa di drappi, posto debino avere, in questo, 2 lb. 4 s. 13 d. 4."

Fol. 2, in the account of Francesco Mannelli e Giovanni Cavalcanti e comp. di Firenze. . . . "E, a dì detto [15 Feb. 1527], d. xx d'oro larghi per costo di ii scarselle di velluto chermisi fornite d'argento dorato e ii chaxette da occhiali fornite d'argento messi in una caxa di no. 65, posto. . . ." Fol. 10 destra: . . . . "Scarxelle e ochiali di contro deono avere, a dì 20 di maggio [1527], lb. quatro s. xiii d. iiii di sterlini, se ne fa debitore spese a causa che le dua scarxelle e 'l paio di ochiali dorati si donorno al cardinale da parte di Giovanni Cavalcanti quando se li deliverò e drappi d'oro, e l'altro paio di ochiali niellati si donò a mesere Arrigo Wyatt, trexoriere, posto dette spese dare, in questo, 5. . . . lb. 4 s. 13 d. 4." Fol. 5, "Spexe e donativi che si sono fatte e faranno deono dare. . . . E. . . . 2 scarxelle di velluto chermixi fornite d'oro e un paio di ochiali d'argento dorati, cioè la caxa, donato al cardinale quando se li deliverò li drappi d'oro e per la monta d'un'altra caxa de ochiali d'argento nellata a mesere Arrigo Wyatt, posto. . . ." Fols. 17 and 40 mention "Arrigo Wyatt, texoriere delle Chamera del Re," and "cardinale Tommaso di York," respectively. There seem to be some contradictions or ambiguities in the descriptions of the gifts, which may be the result of scribal practices in posting the various elements of the transaction since rechecking of the transcription gave the same readings. My translation has tried to reconcile these divergences. The transcriptions were sent to me by Goldthwaite, who took the precaution of having them checked by Spallanzani.

55. A most recent account of the firm's activity in England is provided by C. M. Sicca, "Consumption and Trade of Art between Italy and England in the First Half of the Sixteenth Century: The London House of the Bardi and the Cavalcanti Company," *Renaissance Studies* 16/2 (2002), pp. 163–201. No spectacles, however, are mentioned in the article. The author has confirmed this fact in a private communication (2002) where she wrote: "Spectacles are never mentioned in the Cavalcanti and Bardi papers that I have seen, and more generally I have never seen mention of any glass product exported by them."

56. For comments on the incompleteness of these records, see Cobb, *The Overseas Trade*, pp. xiii–xiv.

haberdashery with the former probably including glass blanks for lenses and the latter spectacles themselves, if the barrel of haberdashery discovered at Lynn is any guide.[57] Indeed, the fact that eyeglasses were imported by the dozen or gross, often mixed with similarly measured inexpensive products such as brushes, beads, playing cards, and even printed primers, all forming an amorphous merchandise known as haberdashery sold by peddlers, point to their abundance and low cost as we saw in Italy.[58] Taken together, all these probabilities plus the likelihood of undeclared shipments through evasion and bribery of officials despite the low duty rates, would lead to the conclusion that the above quantities are likely to understate grossly the actual volume of spectacle imports.

Clearly, these known massive imports along with presumed ones show that there was a great appetite for eyeglasses in England, which probably could not be satisfied by imports alone. In fact, the story of the diffusion of spectacles across the Channel is incomplete without considering domestic production, which has been assumed to be negligible because spectacle making does not appear in a list of trades in London as late as 1422. So far only two spectacle makers have been identified for the entire fifteenth century—a certain Matthew (1441–3) and one Paul van (de) Bessen (active 1458–9), both "Dutchmen" residing in Southwark, a suburb of London with a large presence of German/Dutch/Fleming artisans including eleven goldsmiths as of 1440.[59]

Is Southwark unique? It is reasonable to suppose that other enclaves of aliens at or near seaports (such as the Italian colony in Southampton, for example)[60] would have had a certain number of artisans willing to satisfy the demand for spectacles, giving rise in time to a cadre of native artisans similarly trained and ready to spread into the outlying districts. And one need not be listed as a spectacle maker to make or repair spectacles, if the Italian experience is applicable elsewhere, as I venture to guess that it is. Frames may last a long time, as archeologists have shown, but they bend out of shape and lenses break and need to be replaced; surely, local artisans must have done this repair work for the thousands of spectacles in circulation. After all, if Italian goldsmiths, bone smiths,

57. For the fifteenth century, see A. A. Ruddock, *Italian Merchants and Shipping in Southampton, 1270–1600* (Southampton, 1951), pp. 85–6, who gives no figures, and *The Port Books or Local Customs Accounts of Southampton for the Reign of Edward IV,* ed. D. B. Quinn with the assistance of A. A. Ruddock, vol. I, 1469–71, vol. II, 1477–81 (Southampton, 1937–38). The second volume does not list spectacles but has frequent entries regarding mirrors, glass or glasses, and haberdashery. For the sixteenth century: *The Port Book of Southampton 1509–10,* 2 vols., ed. T. B. James (Southampton, 1990), I, p. 55: "i gros' spectac'li vali vis viiid," imported by Nicholas Corun in the ship of John Bushell, 25 Dec. 1509. For numerous entries under haberdashery, glass/glassware, and mirrors, see glossary and index of commodities, pp. xxii–xxxvii. I owe this last reference and the next one to H. Cobb.

58. On this question, see the informative chapter by P. Needham, "The Customs Rolls as Documents for the Printed-Book Trade in England," in *The Cambridge History of the Book in Britain,* vol. III, 1400–1557, ed. L. Hellinga and J. B. Trapp (Cambridge, 1999), pp. 148–63.

59. M. Carlin, *Medieval Southwark* (London and Rio Grande, 1996), pp. 149–52. Carlin calls the second spectacle maker "Arnold van Bessen," while Rhodes, "A Pair," p. 66, calls him Paul. It could be an error in transcription or they were two brothers practicing the trade.

60. For the Italian colony in Southampton, see Ruddock, *Italian Merchants,* pp. 157–61.

and monks could rivet or bridge two magnifying lenses together to produce spectacles, why could not their colleagues all over Europe do the same?

Once we are willing to accept this assumption, which seems to be supported by ever increasing evidence in Italy and elsewhere, then the presence or absence of artisans who describe themselves as spectacle makers is not the indispensable proof for the existence of a spectacle-making industry, however modest, in any given region. Even the absence of a well developed glass industry, as seems to be the case in England at this time,[61] is not an insurmountable obstacle—glass blanks can be imported as they were in Lynn and in other places and the materials for frames (bone, horn, ivory, leather, wood, and metal) were available everywhere. One can be bold, therefore, in stating that an adequate number of artisans in England were making and repairing spectacles for at least two centuries before Charles I granted a charter in 1629 giving official birth to the Worshipful Company of Spectacle Makers in London. In fact, the original membership of the new Company was comprised of thirteen spectacle makers, who had been members of the Brewers' Company. But glasses continued to be made or were sold in London by members of other Companies (guilds) such as the Grocers and Merchant Tailors, and the Turners (turners of wooden rings to hold the lenses) not to mention itinerant peddlers at least up to the early eighteenth century. With all these variables, estimates of the number of spectacle makers even within the area of their greatest concentration in London can be way off the mark.[62]

As in the case of the Roman customs records treated in the preceding chapter, the English records cited above reveal the more or less exact nationality of the importers or of their agents but not the origin of the merchandise itself. The London entries for 1480–81, however, make an exception for imports of mirrors, many of which were labeled "Nuremberg mirrors," attesting to their fame unless in some cases this designation referred to type rather than provenance. These mirrors were imported by the thousands, one shipment alone comprising 48 gross (6,912)![63] It has been established that most importers of spectacles had Dutch names, captained ships with home ports in Holland and Flanders, two early spectacle makers mentioned above were "Dutch," and Flemish spectacle peddlers seem to have been ubiquitous in London. These facts have led scholars to

61. For a succinct historical background on the little that is known about the glass industry in England prior to its accelerated growth under the influence of immigrant continental glass workers in the early reign of Elizabeth, see E. S. Godfrey, *The Development of English Glassmaking, 1560–1640* (Chapel Hill, 1975), pp. 3–15.

62. The few records about the English spectacle making industry in this period, which survived the Great Fire of London in 1666, have been analyzed recently by G. C. Clifton, "The Spectaclemakers' Company and the Origins of the Optical Instrument-Making Trade in London," in *Making Instruments Count: Essays on Historical Scientific Instruments Presented to Gerard L'Estrange Turner*, ed. R. G. W. Anderson, J. A. Bennett, and W. F. Ryan (Aldershot, 1993), pp. 341–64. See also her *Directory of British Scientific Instrument Makers 1550–1851* (London, 1995). Many if not most instrument makers also made spectacles or spectacle lenses.

63. Cobb, *The Overseas Trade*, no. 60; see also nos. 37, 84, 94, 178–79 for other large imports of Nuremberg mirrors.

assume that the imported spectacles were manufactured in the Low Countries and/or in Germany. Finally, it can also be argued that if the Germans (lumped together with the Dutch and the Flemish) were competing with the first place Florentines and the distant third place Venetians as importers of spectacles into Rome during the same period, they could easily have occupied first place in nearby England. All this evidence is compelling but it does not establish conclusively the origin of *all* the imports, in my view.

One can now offer an alternative view. The new evidence attesting to Florentine leadership in the production of best quality spectacles, and Florence's massive exports of eyeglasses to Rome and the Levant, and in smaller quantities to Portugal, all point to the possibility that the Florentines would have been able to compete with the "Dutch" in the English market as well. If, as we have documented, some Italian princes and persons of means with widespread contacts throughout Europe preferred Florentine spectacles, one can then venture the tentative hypothesis that wealthy Englishmen may also have developed a craving for the fine Florentine product, especially with a sizable English colony in Rome and the influential Florentine colonies in English ports.[64] The gifts of Florentine luxury spectacles to Chancellor Wolsey and Treasurer of the Chamber Wyatt, mentioned above, may not have been an isolated instance. Quantities of high and perhaps even lower quality spectacles could easily have been included in the cargoes of Florentine galleys sailing yearly after 1425 from Porto Pisano, loaded with alum, various "luxuries," and additional commodities picked up en route at various French and Spanish/Portuguese ports. The galleys unloaded mostly at Sluis in Flanders, and arrived nearly empty at Southampton where they loaded superior quality wool for Florence's thriving home textile industry. Venetian galleys made parallel voyages with oriental spices and Murano glass being some of their major staples. The Flemish/Dutch market, then, tied two trading zones with England—one from the Mediterranean dominated by Italians (Genoese, Florentines, Venetians, etc.), which intermingled and competed with another trading zone composed of northern German Hanseatic merchants, who normally made London rather than Southampton their chief port. Florentine merchant-bankers dominated the credit market at Bruges and through their Italian branches, especially the ones in Venice, connected the northern market with the Levant as well.[65]

64. For the significant English colony of merchants and artisans residing in Rome, and clerics at the papal curia, see M. Harvey, *The English in Rome, 1362–1420: Portrait of an Expatriate Community* (Cambridge, 1999).

65. The multilateral character of this trade has been treated in a number of publications, of which I have found the following most informative: Ruddock, *Italian Merchants;* W. B. Watson, "The Structure of the Florentine Galley Trade with Flanders and England in the Fifteenth Century," *Revue belge de philologie et d'histoire,* 39 (1961), pp. 1073–91 and 40 (1962), pp. 317–47; M. E. Mallett, "Anglo-Florentine Commercial Relations, 1465–1491," *The Economic History Review,* 2nd ser., 15/2 (1962), pp. 250–65, and idem, *The Florentine Galleys in the Fifteenth Century* (Oxford, 1967); G. Holmes, "Florentine Merchants in England 1346–1436," *Economic History Review,* 2nd ser., 13 (1960), pp. 193–208; M-R Thielemans, *Bourgogne et Angleterre: Relations politiques et économiques entre les Pays-Bas bourguignons et l'Angleterre, 1435–1467* (Bruxelles, 1966); and V. Harding, "Cross-channel Trade and Cultural Contacts: London and the Low Countries in the Later Fourteenth Century," in *England and the Low Countries in the Late Middle Ages,* ed.

Given this intermingling of trading zones and credit balances, merchants could and did buy and exchange products of various origins using ships and agents of equally diverse nationalities. In fact, Florence's volume of trade was so huge in this area that its small fleet was insufficient for the task even taking into account the goods shipped by land. Intense competition for this carrying trade developed among other fleets, especially Genoese and Venetian, but also among non-Italian ones such as Catalan, Basque, Portuguese and later in the century English, Flemish/Dutch, and German ships as they ventured more frequently in the Mediterranean.[66] There is a record of a galley in 1474 unloading cargoes in Southampton owned by twenty-five merchants![67] Under these circumstances it is difficult if not impossible to ascertain the provenance of particular products sold in a given market especially with the almost complete absence of merchants' account books in fifteenth-century Britain, the sort of wonderfully detailed source so abundantly present in Tuscany.[68] Perhaps additional research in customs and other records will be able to throw some light on this question. One fact, however, seems to be certain: the importation and sale of large quantities of spectacles at seemingly low or moderate prices as shown by the Italian and English records demonstrate that eyeglasses were far more widely diffused than has been thought up to now, at least from the late fourteenth century onwards. They were no longer the vision aids used almost exclusively by scholars, professionals, and merchants, but they were also widely used by persons in all walks of life, including women.

This uncertainty about the primary origin of spectacle imports into England and the respective role of domestic production at the hands of indigenous and/or foreign artisans, is now somewhat alleviated by new evidence showing that in the early seventeenth century England itself had become an exporting country. Surprisingly, this time the customers were no less than the members of the Medici grand ducal family of Tuscany! These shipments, at least partly destined for personal use, were made through the Florentine ambassador in London, and they can be summarized as follows: "a box of spectacles" (1607); "several pairs" (March, 1609); "ten dozen pairs of spectacles" (July, 1609); "twenty-four pairs with various lens dimensions and for various ages" (August,

C. Barron and N. Sauls (New York, 1995), pp. 153–68, and the concise but informative "Introduction: England and the Low Countries, 1327–1477," pp. 1–28, written by Barron.

66. The competitive nature of this carrying trade has been recently established from Italian sources, especially the Datini Archives in Prato, by F. Melis, "Di alcune figure di operatori economici fiorentini attivi nel Portogallo nel xv secolo," in his *I mercanti italiani nell'Europa medievale e rinascimentale,* ed. L. Frangioni (Florence, 1990), pp. 12–13.

67. *The Port Books or Local Customs Accounts of Southampton,* vol. II, pp. xxxiv–xxxv. Harding, "Cross-channel Trade," pp. 162–63, emphasizes this point as well: "Merchants did not necessarily ship with compatriot masters, and indeed it would have been impossible for many of them to do so: Italian and to a lesser extent Hanseatic merchants seem to have shipped goods from their Low Countries depots to London with English and Netherlandish masters."

68. The lack of these account books has been noted by Cobb, *The Overseas Trade of London,* xiv, n. 22.

1610); "four pairs of spectacles with black bone frames in two small high quality ivory spectacle cases" (September, 1610); "four pairs of big lenses for spectacles to be framed in leather at Paris" (November, 1610); "twelve pairs of spectacles" (January, 1611); "ten pairs of spectacles" (December, 1630); and "boxes of spectacles" (September, 1633).[69]

One cannot generalize from this small sample regarding particular clients about the extent of English spectacle exports to Italy or elsewhere and gauge their quality especially in the absence of any mention of prices. And we are almost a century away from the time when English eyeglasses became famous for the quality and precision of the lenses largely as a result of the work of John Marshall (1693) and Edward Scarlett (1723). On the other hand, unless this new evidence is an anomaly, it could be a hint that the quality of English spectacle production had already advanced to such a degree as to attract the attention of a prominent court on the continent. Whatever the reason, it is clear that three successive grand dukes—Ferdinand I (1587–1609), Cosimo II (1609–21), and Ferdinand II (1621–70)—and their respective spouses craved English eyeglasses. In the eighteen-month period—from July 1609 to January 1611—they imported at least 164 pairs (120 in July 1609 alone), not counting the undetermined number packed in boxes, which may well have raised the total to 200 pairs or more. Four pairs of larger lenses had to be sent to Paris to be framed and boxed in leather because it was claimed that such mounting and cases were not available in London. This is an interesting detail in itself.

In view of what has been discovered lately about the pre-eminence of the Italian and especially Florentine spectacle-making industry, it is difficult to believe that the grand dukes would not have been able to secure excellent spectacles closer to home. Indeed, after Galileo established residence in Florence in October 1610, the Medici glassworks in

69. ASF, *Archivio Mediceo del Principato*: Cosimo Baroncelli to Belisario Vinta, 12 June 1607: "una cassetta entrovi occhiali," N. 5157, fol. 652; Ottaviano Lotti to Andrea Cioli, 22 March 1609: "Quanto agl'occhiali già penso di mandarne alcune paia," ibid., N. 4189, unpaginated; Lotti to Vinta, 22 July 1609: "dieci dozzine di paia d'occhiali," ibid.; Lotti to Vinta, 25 Aug. 1610: "Ordina V. S. Il.ma [. . .] diverse sorte d'occhiali, cioè maggiori, et minori quanto alla circonferenza, et per età differenti; et la mostra per le 24 paia di servizio di Madama Ser.ma la Granduchessa Madre è comparsa, di maniera che io con ogni diligenza attenderò a fargli spedire, et gli manderò; non sò già se qua usino d'incassar la luce [occhi or lenti] in corame, ma almeno non doverà mancare osso nero per il medesimo rispetto," ibid.; Lotti to Vinta, 23 Sept. 1610: "[. . .]. Io mando per oggi in mano del S.r Segretario Cioli le quattro paia d'occhiali con osso negro per servizio di V. S. Ill.ma, i quali sono drento a due piccoli cassette delle megliori, che usino qua, perchè d'avorio. . . . Et n'occorre dire a V. S. Ill.ma che qua non s'incassano gl'occhiali, o i vetri di esse in corame, come usa in Parigi, di maniera che s'è scelto osso negro per tale effetto, come la commandò," ibid.; Lotti to Vinta, 4 Nov. 1610: "Oggi [. . .] mando in mano al s.re segretario Cioli quattro paia di luci [lenses] delle grandi per occhiali da incassarsi a Parigi con corame per servizio di lei . . . ," ibid.; Lotti to Cioli, 20 Jan. 1610 [1611]: Lotti announces sending twelve pairs of eyeglasses, ibid. Ottavio Cappelli to Cioli, 18 Dec. 1630: "[. . .]. All'arrivo d'Inghilterra del sig. Guglielmo Cotton procurerò farmi consegnare il fagottino con le X para occhiali che V. S. mi scrive, . . ." ibid., N. 1803; Cappelli to Cioli, 12 Sept. 1633: "Ho ricevuto le scatole di occhiali che manda il sig. [Pier?] Salvetti per V. S. Ill. ma [. . .]," ibid. The last two registers are also unpaginated. These records were made available to me by Nicholas Wilding and Niccoló Capponi, researchers for the Medici Archive Project in Florence, directed by Edward Goldberg. The Medici records from this series can now be accessed on the Internet.

the city were making efforts to produce high-quality optical lenses for telescopes, necessarily better than spectacle lenses, with the aid of immigrant Venetian master glassmakers. These lenses produced by Galileo and his artisans eventually rivaled in quality those produced in Venice itself.[70] The city gradually became a center for the production of scientific and optical instruments as part of its renowned artisan industry, which continued to prosper despite a decline of its commercial and banking activity.[71]

The large number of these known spectacle imports by the Medici, combined with the likelihood of other imports for which documents are lacking, would point to the conclusion that the spectacles were not purchased solely for personal use and certainly not for resale, but also for distribution among their courtiers. We have already encountered this practice in the Sforza court in the middle of the fifteenth century. Perhaps we may see here an ironic reversal—whereas in the fifteenth century owning a pair of spectacles made in Florence became a status symbol, more than a century later it might have been prestigious to be sporting a pair from distant England at a princely court famous for its luxury and artistic taste at a time when the Mediterranean was gradually being dominated by English ships. At any rate, this is yet another striking, individual example of long-distance spectacle ordering but on a larger scale than usual.

Indeed, that vanity may have played a role in the above imports by the Medici can be further deduced from the fact that just a little later in the seventeenth century England was importing eyeglasses and lenses in massive quantities from Italy, chiefly through the port of Leghorn. This port had been developed by the enlightened grand dukes as a free port and emporium for goods imported into the Mediterrenean area from Northern European ports, the Atlantic ports and the American colonies, and the Far and Near East—a sort of a prototype global market. It was used by merchant ships of various nationalities with the English and their main competitors, the Dutch, predominating, all seeking to escape the entry and exit duties of Venice and Genoa, both in relative decline.[72]

Spectacles and lenses were part of this trade alongside the much more lucrative traffic in Middle Eastern raw silk, oriental spices, western textiles and manufactured products, metals, etc. We have the figures for such exports from Italy to England for two closely positioned years. In 1663 London imported 1,471 dozen spectacles (17,652 pairs)

70. This activity will be treated in ch. 6.

71. The continued prosperity of Florence's artisan industry in the seventeenth century has been recently pointed out by R. A. Goldthwaite, "Il contesto economico," in *La grande storia dell'artigianato, III, Il Cinquecento* (Florence, 2000), pp. 22–23.

72. English expansion in the Mediterranean has been treated from English and Italian sources in the following publications by G. Pagano De Divitiis: "Il Mezzogiorno e l'espansione commerciale inglese," *Archivio storico per le province napoletane*, 3rd ser., xxi (1982), pp. 125–51; "Il Mediterraneo nel xvii secolo: l'espansione commerciale inglese e l'Italia," *Studi storici* I (1986), pp. 109–48; "Il porto di Livorno fra Inghilterra e oriente," *Nuovi studi livornesi*, I (1993), pp. 43–87; and *English Merchants in Seventeenth-Century Italy*, trans. S. Parkin (Cambridge, 1997).

at 15s per dozen (1.25s per pair), and 289 dozen (3,468) lenses at £12 per dozen (£1 per lens).[73] This is the second largest volume of spectacle exports in a single year after the 24,000 pairs exported from Venice to the Levant in 1540. The high cost of the lenses indicates superior quality crystal lenses finely ground and polished for use in telescopes and microscopes. London, in fact, was emerging at this time as a center for the sale and production of scientific instruments.[74] In 1669, only spectacle imports are listed—587 dozen (7,044 pairs) at the same cost per dozen, 15s. Presumably these spectacles and lenses were made in more than one center in Italy, although some could have been imported from other countries given the cosmopolitan character of Leghorn. At any rate, this is the first instance found to date of large shipments of spectacles and lenses directly to England, rather than via Bruges in the fifteenth and Antwerp from the sixteenth century onwards. There also seems to be direct evidence that in some cases spectacles made or purchased in Venice were exported from Leghorn to the Levant on English ships.[75] Some of these intriguing doubts about the origin of imported spectacles into Britain hopefully will be clarified as economic historians continue to comb the several thousand commercial letters and account books produced by the numerous Italian merchant companies doing business at all the major centers of western Europe connected in some way to the great emporia of Bruges and Antwerp.[76]

In the meantime we can turn for additional evidence to the outstanding work of English archeologists, who have been diligent in uncovering an extensive body of whole spectacle frames and fragments but without lenses. If archeologists cannot ascertain the primary origin of these frames, they have revealed some details about the type of spectacles the English wore. Of the nine frame fragments discovered so far, five in London and four in excavations of religious houses elsewhere,[77] two found on the banks of the Thames in the city of London are the most complete and have been studied in detail.

73. These imports of 1663 and 1669 are listed in tables 4.8 and 4.9 by Pagano De Divitiis, *English Merchants*, pp. 144–45. Professor Pagano de Divitiis has kindly informed me (Aug. 2002) that the manuscript (British Library, Add. Mss. 36785, pp. 144–45) lists only "Italie" as the place of origin.

74. Clifton, "The Spectaclemakers' Company," pp. 341–64.

75. Pagano De Divitiis, "Il porto di Livorno," p. 51, mentions "occhiali e vetrerie, cioè articoli di Venezia," as being included in the cargo destined for the Levant without citing quantities.

76. The general lines of this ongoing research have been suggested by F. Melis, "Contributo alla storiografia economica della Fiandra e del Brabante da fonti italiane della seconda metà del Trecento e degli inizi del Quattrocento," in his *Mercanti italiani*, pp. 345–66.

77. The fragments of bone frames found outside London have been noted in the following publications: J. Geddes, "The Small Finds," in J. N. Hare, *Battle Abbey: The Eastern Range and the Excavations of 1978–80* (London, 1985), p. 151, No. 27; G. Lloyd-Morgan, "Organic Artifacts," in S. W. Ward, *Excavations at Chester: The Lesser Medieval Religious Houses. Sites Investigated 1964–1983* (Chester, 1990), pp. 177–78. A metal frame with an ornamental nose bridge possibly of the 16th century was found in Coventry: C. Woodfield, et al., "Finds from the Free Grammar School at the Whitefriars, Coventry, c. 1545–c. 1557/58," *Post-Medieval Archaeology*, 15 (1981), pp. 92–93. Tudor school books found at this site list some English sentences to be translated into Latin, among which the following two mention spectacles: "They that be hooke nosed haue this aduantage that theyre spectacles shall not lightly fal fro them," and "Syght dulled by age muste be holpe by spectacles," as quoted on p. 154.

The Trig Lane frame found in 1974 has been studied by Michael Rhodes and the material analyzed by Philip Armitage whereas the Swan Stairs frame uncovered in 1994 has been studied by Judith Stevenson, all of the Museum of the City of London where these frames are on view.[78] In both cases, the frames are of the rivet type with some interesting differences in manufacturing details and they appear to be made of the metacarpal bones of bulls, although a most recent reexamination has raised the possibility that they are made of antler.[79] The shape of the frames and the context suggest the mid fifteenth century as an approximate date for both.

The Netherlands and Germany

Across the Channel, archeologists have also been discovering similar fragments of rivet-type spectacle frames. In Belgium, excavations at Raversijde, Ostend, in progress since 1992 have uncovered a fragment of a bone (rivet?) frame of the fifteenth century.[80] In Holland, archeologists have been particularly successful since 1972, taking advantage of a law giving them the right to explore building sites before construction begins. A nearly intact straight-handle rivet bone frame of the second quarter of the fifteenth century was found (1972) along the foundations of the Souburg Castle (later called Aldegonde Castle) at Vlissingen near Middleburg. Another straight-handle frame made of horn was discovered in 1986 in a garbage pit dating from the early fifteenth century near the site of the ruins of an Augustinian monastery founded at Windesheim (four miles south of Zwolle) ca. 1386 and totally destroyed in 1572. Three other fragments of approximately the same date—two straight handles of willow wood and one partial bone rim—of rivet frames have been found in excavations (1990–94) at a castle ("Huis ter Kleef") in Haarlem, which was begun in the thirteenth century and destroyed in 1573. The archeological museum in Haarlem, where these fragments are exhibited, also has a pair of Nuremberg wire spectacles, probably of the sixteenth century, with an interesting variation: the two disks have an insert to provide a tighter fit for the lenses, which were cut too small for the rims.[81]

Most unusual is another pair of straight-handle rivet spectacles of the early fifteenth century found about five years ago in a trash pile revealed by an archeological dig along a street no longer extant in the city of Bergen op Zoom. The houses along this street

78. See M. Rhodes, "A Pair," pp. 57–67, followed by an appendix, "Note on the Source of the Material used in the Manufacture of the Spectacles," pp. 67–70, written by Armitage; and J. Stevenson, "A New Type of Late Medieval Spectacle Frame from the City of London," *London Archaeologist*, 7/12 (1995), pp. 321–27.

79. Private communication from Stevenson to C. Letocha and Ilardi (Nov. 1996).

80. R. J. S. MacGregor, "Belgian Bone Spectacles," *Ophthalmic Antiques*, No. 60 (July 1997), p. 1.

81. P. Aangenendt, "Brillenvondst bij opgravingen in Haarlem," *Oculus* (September 2000), pp. 12–14. I am most grateful to the author for sending me a copy of this very informative article together with color photos and drawings to scale of the fragments as well as an English translation from the Dutch executed by his sister, Carla.

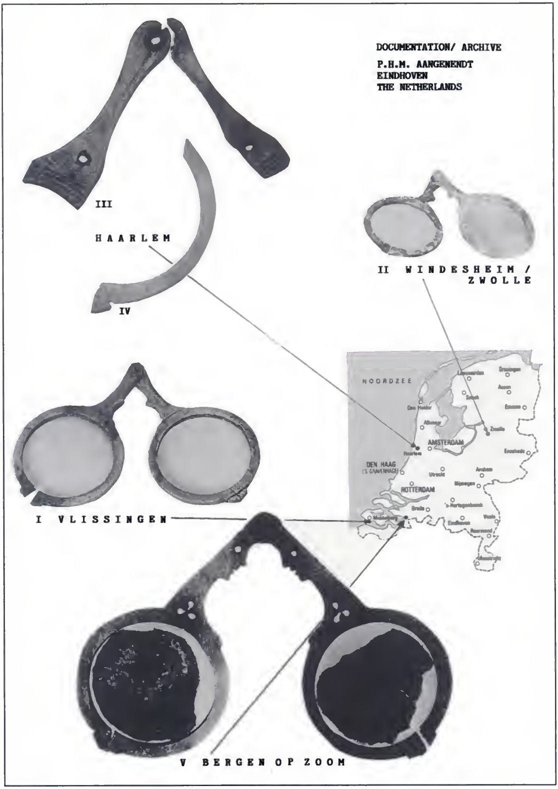
were inhabited at that time by clerics officiating in a nearby church. Remarkably, the two lenses survived almost in their entirety but fell out of their frames almost immediately after recovery, and they are so encrusted with detritus that they have lost their transparency even when a strong light is shone on them. It has been determined, however, that they are convex lenses but their power is impossible to gauge. The bone frame handles, held together by a brass alloy rivet, present a feature never before seen in other archeological finds or in artistic representations; i.e., the upper inner sides of the handles, which are designed to clamp on the nose, are decorated with two carved human faces complete with one eye represented by a hole just above the nose where it should be. This hole is in addition to the customary three holes drilled into the lower part of the handles, close to the top part of the rims. The two faces may be merely decorative, but they may also have been designed to ensure a better grip on the nose and to provide pinhole vision for clearer distance viewing (Fig. 41).[82]

As informative as these archeological finds may be, they tell us nothing about the provenance of the spectacles. It is tempting to speculate that they were made locally despite the fact that the earliest evidence for the existence of a glass industry in Holland occurs in the third decade of the sixteenth century. Recent research has established that Lucas van Helmont was the first to produce Venetian-style glass, the famous *cristallino*, a nearly colorless glass resembling rock crystal, in Antwerp in 1537.[83] This city, in fact, became one of the first in the Low Countries to establish a thriving glass industry mostly run by Venetian and other Italian glass/mirror makers. Other glass-making centers soon followed—Liège (1568), Amsterdam (probably by 1571, definitely by 1597), Middleburg (1581). It seems that Antwerp served as a catalyst in the spread of the glass industry throughout the Netherlands and beyond. Here Italian commercial influence was the strongest and largely explains why Italian became the lingua franca of the merchant community.[84] Before the sixteenth century even ordinary table glassware was a sign of relative wealth in this region, and it was imported mostly from Germany and Italy, but also from France and Belgium. German "green glass" made with sand and potash, called

82. I wish to express my appreciation to Mr. Marco Vermunt of the Archeological Service of Bergen op Zoom for permission to publish the photographs and to the photographer, Mr. P. J. K. Louwman. Details about this find and the transmission of the photographs were handled by my ever-alert and indefatigable friends in Eindhoven (Netherlands), Paul and Carla Aangenendt, whose kind collaboration has vastly enriched my knowledge of early Dutch spectacles. Paul also published a succinct summary of these discoveries in his article, "Rivet Spectacles in the Netherlands," *Ophthalmic Antiques* 79 (April 2002), pp. 4–5.

83. See J. Veeckman and C. Dumortier, "La production de verres à Anvers: Les données historiques," in *Majolica and Glass from Italy to Antwerp and Beyond: The Transfer of Technology in the 16th–17th Century* (Antwerp, 2002), p. 70, and the Introduction, pp. 13–22, by David Whitehouse, who summarized many the findings as delivered at a conference on this subject held in Antwerp.

84. P. Subacchi, "The Italian Community in 16th-Century Antwerp," ibid., pp. 23–58: "47% of Italian merchants were from Genoa followed by Lucca (17%), Florence (10%), Milan (8%), Venice (5%), and Cremona (4%)"(p. 24); H. E. Henkes, "The Influence of Antwerp on the Development of Glass Production in the 16th and 17th Centuries in the Northern Netherlands," ibid., pp. 155–59.



41. *Rivet Spectacles in the Netherlands,* 15th century Photographs of archeological finds, Documentation / Archive, assembled by Paul Aangenendt, Eindhoven, The Netherlands.

waldglas, dominated the market for utilitarian objects whereas Italy led the way with its colorless glass for more refined products.[85] There must have been, however, an earlier significant domestic production at least in Antwerp, where glass/mirror makers were enrolled in the St. Luke's guild from 1442, along with artists.[86]

These recent findings, which establish earlier dates for the development of the glass industry in the Low Countries, fit more closely with the date of the invention of the telescope in Middleburgh ca. 1608. The region as a whole had a sufficient pool of foreign and indigenous glass/mirror makers capable of grinding and polishing lenses for telescopes and microscopes.[87] Both instruments require better quality glass/crystal and finer grinding and polishing of lenses. It is more probable in my view that there were spectacle makers in the Netherlands much earlier among various artisans and in monasteries, who used imported glass/crystal blanks and local materials for the frames. But this must remain an unsupported assumption until we find confirming documentation. Regrettably, researchers have not yet discovered account books or customs records attesting to the production of eyeglasses in this early period, and historians of the glass industry normally ignore optical glass and lenses. Whatever domestic production there might have been, it has left so few traces in the historical record as to cast doubt on the possibility that it alone could produce the thousands of spectacles exported to England on Dutch ships. It is more likely that German and Italian spectacles made up the bulk of these exports.

Central and south Germany, in fact, offers more abundant and certain evidence of an early developed spectacle-making industry and even earlier glass-making furnaces. Early spectacle makers have been noted in Frankfurt am Main (1450), Strasburg (1466), and Nuremberg (1478). And although the earliest documented date for Regensburg is 1560, the advanced state of its eyeglass-making industry by this date suggests an earlier beginning.[88] This region was already well known from the early Middle Ages for its hundreds of glass furnaces originally connected with monasteries and later transferred to more isolated locations in the forests so as to avoid the danger of fires in the towns. The abundance of wood from the surrounding extensive forests, including the Black Forest, which supplied both fuel for the furnaces and ashes for the glass mixture as well as the vicinity of rivers for the needed sand and facility of transport, plus abundant deposits

85. A summary but informative account of Dutch glass production was published by Jan M. Baart, "Una vetreria di tradizione italiana ad Amsterdam," in *Archeologia e storia della produzione del vetro preindustriale,* ed. M. Mendera (Florence, 1991), pp. 423–37. Surprisingly, the glass industry in Holland is not even mentioned by J. de Vries and Van der Woude, *The First Modern Economy: Success, Failure, and Perseverance of the Dutch Economy, 1500–1815* (Cambridge/New York, 1997).

86. Veeckman and Dumortier, "La production de verres à Anvers," p. 69.

87. The role of Middleburg has been highlighted by A. Van Helden, *The Invention of the Telescope* (Philadelphia, 1977), p. 24.

88. M. von Rohr, "Contributions to the History of the Spectacle Trade from the Earliest Times to Thomas Young's Appearance," *Transactions of the Optical Society* 25/2 (1923–24), pp. 44–45.

of quartz and silica, made the region an ideal location for the production of glass. From 1977 onwards archeologists have been successful in identifying many of the remains of these glass furnaces.[89]

Moreover, these cities developed some of the earliest rules regulating the spectacle-making trade in 1510 and 1520, which in the middle of the century were incorporated into regular guild regulations at a time when in Italy there were no such specialized guilds, and artisans of various crafts could make and sell eyeglasses. In Nuremberg the spectacle makers were not allowed to organize a sworn guild but were granted permission to form a "closed craft," which forbade its members to leave the city but protected their monopoly. In Regensburg the craft was organized into a free sworn guild. Whether closed or open, these craft guilds enacted the usual regulations about quality and prices and the journeymen had to produce masterpieces of horn spectacles, one pair for nearsightedness and another for farsightedness, for promotion to the master's level. At Regensberg they also had to produce the tools themselves for making the masterpieces. Finally, as early as 1507 there was an embryonic form of division of labor among glass workers supplying the blanks, some of them specializing in grinding and polishing them into finished lenses.[90]

From the scanty evidence surfaced so far we gather that the prices for ordinary eyeglasses were relatively low and affordable for those in need of them, as we have seen in other countries. At the South Bavarian monastery of Tegernsee, one of the earliest glass-producing centers in the area, we have a record showing that in 1492 and 1495 a pair with concave lenses cost about 7 farthings. (This sale also shows that spectacles for myopes were known in Germany by this date as they were earlier in Italy.) In 1583, spectacles purchased by the dozen fetched these wholesale prices per pair or unit: 5 dozen leather spectacles, 4 farthings; 2 dozen gilt horn spectacles, 9½ farthings; 6 dozen ordinary horn spectacles, 3 farthings; 6 dozen single lenses framed in horn, 3 farthings each.[91]

Luxury-type glasses, of course, would cost much more. The Elector Augustus of Saxony (1526–86) paid "50 Reichs-Thaler (about 12 guineas)" for a pair of Venetian eyeglasses with gold frame, and £3 for "some quadrilateral spectacle lenses made in London" plus £1 5s. 6d. for freight.[92] It should be added here that by the next century lenses made in London were very popular in Germany for their quality, to the point that

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89. An extensive summary of the current state of knowledge regarding these glass-making centers in southern Germany has been published by A. S. Gai, "La produzione del vetro preindustriale in Germania sud-occidentale. Stato delle ricerca e prospettive," in *Archeologia e storia della produzione del vetro preindustriale,* ed. M. Mendera (Florence, 1991), pp. 375–410.

90. Rohr, "Contributions to the History," pp. 45–47. For the masterpieces, see A. von Pflugk, *Ein Beitrag zu unseren Kenntnissen der Meisterstücke der alten Brillenmacher" Zeitschrift fur ophthalmologische Optik* XXX (1942), pp. 16–21. See also F. Rossi, *Brillen vom Leseglas zum modischen Accessoire* (Munich, 1989), pp. 36–42, for a succinct summary based on published sources.

91. Rohr, "Contributions to the History," p. 47.

92. Ibid., p. 44.

some spectacle makers in Nuremberg sold eyeglasses with the false label, "London," marked on their lenses.[93] This is another indication that English lenses might have achieved a higher quality earlier than it is believed to stimulate such forgeries in a city known for its spectacle-making reputation.

While Elector Augustus seemed to have been interested mostly in "high-fashion" glasses, a century later Duke August of Brunswick-Wolfenbuttel, a scholarly ruler with one of the most extensive private libraries in Europe, was much more serious in securing good spectacles for his failing eyesight. In 1630 he ordered through his agent in Augsburg, Philip Hainhofer, "two pairs of spectacles for daily use suited for someone of 50 years," from the noted spectacle maker Johann Wiesel. As henceforth Wiesel became his regular supplier, he asked the duke to be more precise in describing his requirements. This was accomplished by sending Wiesel a piece of thread as a measure of the reading distance and a sample of the text itself. The duke also ordered special purpose glasses—a pair to shield his eyes from the wind while riding; a pair with attached mirrors to see those riding behind him; "perspective tubes" or small telescopes to provide greater magnification of reading matter as his vision deteriorated further from 1643 onwards because of developing cataracts.[94] Clearly the duke wanted the best vision aids for his needs, and the way they were satisfied shows that by the middle of the seventeenth century it was fully realized that ordering glasses long distance by age category was a most imprecise practice. With these reading distance measurements we are very close to contemporary practice. This seems to have been an independently established modus operandi without reference to Daza de Valdés book, *Uso de los antojos* (1623), whose circulation was really limited to Spain.[95]

Germany, then, can be considered to be one of the earliest and most important centers for the production of spectacles. Although we lack production figures, we can hardly be mistaken by maintaining that spectacle makers were able to meet domestic demand and export the surplus in quantity along with the renowned Nuremberg mirrors, which rivaled in quality and in some cases surpassed Venetian mirrors. We have already seen that Venetian guild regulations mentioned exports of German spectacles to Venice, and Roman customs records established German importers in second place after the Florentines during the fifteenth century. At the same time, Nuremberg mirrors were mentioned frequently by the thousand in English customs entries, and it is very likely that hundreds of the spectacles imported into England in this early period were manufactured in Germany rather than Holland or Flanders as it has been generally

93. R. J. S. MacGregor, "London in Germany," *Ophthalmic Antiques* 58 (Jan. 1997), p. 1.

94. See *A Treasure House of Books: The Library of Duke August of Brunswick-Wolfenbüttel*, ed. H. Schmidt-Glintzer in collaboration with W. Arnold, trans. M. Green (Wiesbaden, 1998), pp. 140–45; and I. Keil, *Augustanus Opticus. Johann Wiesel (1583–1662) und 200 Jahre optisches Handwerk in Augsburg* (Berlin, 2000), p. 384.

95. See chap. VI, pp. 226–29 for a discussion of this book.

supposed. The wire spectacles of Nuremberg became popular throughout Europe. Two archeological finds of such spectacles in the 1960s—one of the early sixteenth century in Esslingen and the other of the seventeenth century in Böttingen—show that the wire was hammered by hand and then bent to accommodate the lenses in the earlier sample whereas the wire in the later frame was worked in a machine.[96] Leather and horn were probably more commonly used, as they are the only frame materials mentioned in a popular German book of trades published in 1568.[97]

France and Spain

We are much more informed about glass production in France, which as in other countries, originated mostly in monasteries from the thirteenth century onwards. Glass furnaces were spread throughout the country with the heaviest concentrations in Normandy and Provence. Recent research has also uncovered a rather strong Italian presence and influence in glass production beginning from the second quarter of the fifteenth century. A still incomplete count lists twelve immigrant Italian glass-worker families in the fifteenth century, twenty-five in the sixteenth, and nine in the seventeenth, with the earliest concentration beginning in Provence.[98]Although the influence of Venetian production techniques was strong nearly everywhere, the workers came mostly from bordering Piedmont and nearby Altare in Liguria, a center that (unlike Venice) actually encouraged emigration of glassworkers.[99]

It is clear that France at this time had ready availability of glass for lenses, raw materials for spectacle frames, and knowledge of the latest glass technology supplied by an extensive colony of Italian artisans to create a spectacle-making industry of its own. Regrettably, we lack sufficient documentation to make definite statements about its extent or level of production. One of the leading researchers of the French glass industry, Danièle Foy, has highlighted the fact that he has not found any evidence of spectacle manufacture in Provence, and suspects that glasses were imported in this region from nearby Catalonia, where documents point to the existence of spectacle makers.[100] (Just

96. Information from brief descriptions published in *The Optician* (June 7, 1968), p. 590.

97. J. Amman and H. Sachs, *The Book of Trades [Ständebuch]*, ed. B. A. Rifkin (New York, 1973), p. 65. The English paraphrase of the poem, supplied by Rifkin, describes the trade of spectacle maker as follows: "THE SPECTACLE MAKER makes eyeglasses of different strengths for people from forty to eighty; the frames are of leather or horn."

98. J. Barrera, "L'influence italienne sur la verrerie de la moitié nord de la France," in *Archeologia e storia*, pp. 345–67. See p. 347 for a most useful map of France with the names and relative dates of Italian glassworker families noted for each region of France. See also F. Jannin, "Les fours a verre d'Argonne et l'influence italienne," ibid., pp. 369–74.

99. D. Foy, *Le verre medieval et son artisanat en France méditerranéenne* (Paris, 1988), pp. 63–75, which lists additional names of Italian glassworkers and their origin.

100. Ibid., p. 272. Foy, incidentally, is one of the few historians of glass who mentions optical glass, but only in passing without any real knowledge of the history of spectacle making.

as easily, they could have been imported from nearby Italy.) Archeological evidence, as in Italy, has been negligible. Consequently, Foy and other researchers have been forced to resort to anecdotal evidence of special purchases by usually affluent individuals of luxury-type glasses or magnifying lenses as revealed in orders of payments to goldsmiths and others, who framed the lenses in precious or semi-precious metals. Wills and household inventories, and literary texts by François Villon (1461), Charles d'Orleans (ca. 1463), Jean Meschinot (1493), Rabelais (1522), among others, have supplied additional evidence. I have already cited some of these references for the fourteenth century in order to demonstrate the early diffusion of spectacles in France.[101] Many more additional examples have already been published from the nineteenth century onwards and there is no need to repeat them here because they would not add anything of substance to our story.[102] These were the type of sources on which all of us relied before the discovery of the detailed entries in the Florentine account books or in the less detailed notations in customs records.

Strictly speaking, however, these mentions in wills and inventories only demonstrate that Frenchmen were using magnifying lenses and wearing glasses, some of which could have been imported into France. But it is ludicrous to believe that in such an advanced country with a well developed glass industry manned by many Italian glassworkers, wedged-in by two spectacle-making centers (Italy and Germany), boasting one of the leading international trade fairs at Lyon and seat of the most famous university in Europe in Paris, would have lacked artisans and monks to rivet together the handles of two magnifying lenses to produce spectacles and repair them as needed. It is more realistic to think that there was a spectacle-making industry of significant proportions before 1465 when, in a revue of armed merchants and artisans held in Paris before King Louis XI, spectacle makers (*lunettiers*) were mentioned for the first time as a distinct entity marching with mercers and rug weavers under the forty-ninth banner.[103] Apparently, as in other countries in this early period, spectacle makers had not yet succeeded in forming a guild of their own, but the fact that they were specifically mentioned on this occasion suggests that they had been active in the trade for some time.

101. See ch. II, pp. 64–66.

102. See M. de Laborde, *Notice des émaux, bijoux et objects divers, exposés dans les galeries du Musée du Louvre, II^e partie, documents et glossaire* (Paris, 1853), pp. 163–64; J. Rouyer, *Coup d'oeil réstrospectif sur la lunetterie précédé sur l'origine du verre lenticulaire et sur les instruments servant a la vision,* 2nd ed. (Paris, 1901), pp. 102–05; P.Pansier, *Histoire des lunettes* (Paris, 1901), pp. 25–28, and idem, "Les lunettes à Avignon au xv^e siècle," *Cahiers de pratique medico-chirurgicale* (Sept.–Oct., 1933), pp. 207–13; Madame A. Heymann, *Lunettes et lorgnettes de jadis* (Paris, 1911), especially pp. 5–14; A. Bourgeois, *Les besicles de nos ancètres* (Paris, 1923), pp. 15–30 with citations of many works of art, pp. 32–41; M-A. Dollfus, "Les lunettes et la profession d'opticien d'après le comptes de XIV^e et XV^e siècle," *Archives ophtalmologiques* XXVII/7 (1967), pp. 707–11; and M. Beaulieu, "Les 'lunettes' en France aux XIV^e et XV^e siècles," in *Santé, médicine et assistance au Moyen Âge* (Paris, 1987), pp. 229–45. Pansier and Heymann supplied most of the evidence, which has been repeated ever since.

103. Rouyer, *Coup d'oeil,* p. 122.

A century later, in 1545, they were associated with the mirror makers. Finally, in 1581, King Henry III issued letters patent renewing earlier guild regulations of unspecified dates, which had not been enforced for some time, and associated mirror and spectacle makers with the makers of toys and trinkets (*bimbelotiers*). Articles XI and XII of the renewed regulations applied specifically to spectacle makers. They were allowed to make "spectacles with glass, rock crystal, and crystal [*cristalin*] lenses for all degrees of eyesight, well polished on both surfaces, and make frames of leather, horn, and other materials . . . but not of paper." Article XII is repetitive in part but specifically adds tin or pewter as another material for the frames.[104]

It is obvious that by this time, spectacle making was well established in France. In fact, just about the time these regulations were enacted, the well-informed Venetian writer on various trades and professions, Tommaso Garzoni (1549–89), mentioned only two places where "perfect" eyeglasses were made, France and Venice.[105] This admission by a Venetian is comparable to an acknowledgment by a New Yorker writing today that there is another city in the world as great as New York! Also, the fact that in 1610 the English-made lenses requested by the grand dukes of Tuscany had to be sent to Paris for mounting in leather frames may point to a Parisian specialization in this type of frame.[106]

In Spain, as in France and Italy, glass production had its roots in ancient Roman times and later developed largely in monasteries. In addition to the usual natural resources for making glass, Spain had the best lime soda ash in Europe, known as "barilla," which was exported to other glass making centers, including Venice, but was second in quality to Syrian soda ash. The major region for glass production was Catalonia, especially Barcelona, but there were other centers spread from Andalusia up the eastern coast north to Roussillon (along with the island of Mallorca) with another concentration in Castile, in localities near Madrid. According to contemporaries, the quality of Spanish glass and crystal, especially in Catalonia, was very high. It rivaled that of Venice, especially after master glassmakers from Venice and Altare emigrated first to Aragon and then Castile in the late sixteenth century.[107]

104. Ibid., pp. 122–30, contain the texts of the articles. Article XI reads as follows: "Item, Lesdits Maistres, dudit Mestier pourront faire Lunette de verre, crystal de roche et cristalin de toutes vues bien polies des deux côtez, faire les chassis d'icelles de cuirs, cornes et autres étoffes, bien et dûement faits et non de papier, sur peine de confiscation." Article XII: "Item, Lesdits Maitres pourront faire toutes sortes de Bezicles de verre, crystal et crystalin, polies des deux côtez, tant en corne, qu'en étain. . . ."

105. T. Garzoni, *La piazza universale di tutte le professioni del mondo,* vol. I, ed. G. B. Bronzini, with P. de Meo and L. Carcereri (Florence, 1996), discorso LXIIII, "De'vetrari, o biccherari, occhialari, et finestari," p. 658: "In Francia se ne fanno de' perfetti [occhiali], e così a Venetia, dove in Merciaria si trovano i maestri di questo mestiero. . . ."

106. See above, p. 137.

107. See A. W. Frothingham, *Spanish Glass* (New York, 1963), pp. 11–65, for a general treatment. According to Charleston, "The Import of Venetian Glass," p. 160, already "at the end of the 15th century Barcelona was making enamelled glass which rivalled the Venetian. . . ."

Clearly, Spain had the necessary natural resources and a skilled work force to be a major player in the production of eyeglasses. Regrettably, this statement cannot be fully documented because the industry has left few traces in the literature and there have been no archeological finds to my knowledge. So far, only two spectacle makers (*mestres d'ulleres*) have been identified in Barcelona—Jacme Berenguer (active, 1422, 1435), and Pere Del Maig (active, 1436). But there must have been others in Barcelona before these dates because in 1403 the city exported to Alexandria in Egypt and to Beyrouth in Syria fifteen gross of eyeglasses (2,160 pairs), and two small cases with unknown quantities in 1408. It is taken for granted that they were manufactured locally or at least in Spain, but one cannot entirely discount the possibility that some of them may have been made outside Spain and re-exported.[108] But it was only in 1596, apparently, that the guild of spectacles makers was organized in Barcelona, according to present knowledge.[109]

With the exception of the above recently discovered (1967) records, the only collection of available data about early Spanish eyeglasses was published by Moritz von Rohr in 1925! Rohr also republished some of the Spanish paper watermarks depicting spectacles dating from 1387 to the end of the fifteenth century, already published in Catalan by J. P. Simon. It is likely that the paper was manufactured in Spain.[110] And beginning in the early fifteenth century, there are frequent representations of spectacles in works of art.[111] By the early seventeenth century, the wearing of spectacles in public became popular in Spain as a matter of prestige and noble rank—the bigger the spectacles, the higher the rank. In order to facilitate such public use of eyeglasses, not customary in other countries, the use of strings or cords wound around the ears to hold them comfortably in place was developed in the late sixteenth century, apparently first in Spain.[112]

Eventually, the use of eyeglass-cords was exported by Italian and Spanish Jesuit missionaries in the Far East, where eyeglasses had been introduced in China by western merchants by the end of the fourteenth century to be used alongside long-existing magnifying lenses of rock crystal.[113] Already by 1521 there is reliable evidence that there was a high demand for spectacles in the Far East according to the journal kept by Antonio

108. These figures were published by C. Carrère, *Barcelone, center économique à l'époque des difficultés, 1380–1462*, vol. I (Paris, 1967), p. 382.

109. Borja Devesa, J. M., *Historia gráfica de la ótica* (Barcelona, 1990), p. 42, illustrated with works of art. Reproductions of other works of art were published by J. M. Enoch and M. L. Calvo, "Una evidencia del uso de lentes correctoras in la España del s. XV," *Revista espanola de fisica* XII/2 (1998), 55–57.

110. Rohr, "Additions to our Knowledge of Old Spectacles," pp. 175–78. I have been unable to obtain Simon's publications.

111. Many are reproduced by Devesa, *Historia*, pp. 46–73.

112. Heymann, *Lunettes*, pp. 44–48.

113. K. Chiu, "The Introduction of Spectacles into China," *Harvard Journal of Asiatic Studies* 1/2 (1936), pp. 186–93; and S. Shirayama, "The Introduction of Spectacles into Japan," *Ophthalmic Antiques* no. 35 (Apr. 1991), pp. 4–5. See also J. Needham, *Science and Civilisation in China*, vol. 4, *Physics and Physical Technology* (Cambridge, 1962), pp. 118–122, for the western introduction of spectacles into China, and pp. 92–117 for a fuller treatment of glass, lens, and mirror technology in China in earlier centuries.

Pigafetta (ca. 1492–ca. 1534), who accompanied Magellan in his circumnavigation of the globe (1519–22). He noted that in a small island off Borneo, the natives prized "iron and spectacles" (*occhiali*) more than all other goods offered for barter or exchanged as gifts. It should be added, however, that spectacles were mentioned only on this occasion whereas mirrors were frequently exchanged and an equivalent word for them appeared in some of the native vocabularies, which had no equivalent word for spectacles.[114] And there is also new tentative evidence that a Spanish viceroy of New Spain might have introduced spectacles in the New World in about 1590.[115] Spain also produced the first systematic treatise on the use of eyeglasses, published in 1623 by Daza de Valdés, who mentioned Madrid, Seville, and Lisbon, but (surprisingly) not Barcelona as centers for spectacle production.[116] In conclusion, then, although Spain offers negligible documentary sources for its own history of spectacles, its influence in their diffusion in two continents outside Europe is undeniable.

Croatia and Hungary

Finally, it is useful and desirable to include in this survey two countries—Croatia and Hungary—that are usually neglected in the history of spectacles. Marine archeologists have salvaged and studied the contents of a shipwreck dated sometime after 1582 near the Island of Gnaliæ off the upper Adriatic coast of Croatia. The cargo included some twenty wooden boxes holding about three hundred pairs of spectacles with leather frames and wide nose bridges, typical of this type of frame. "Some of the better preserved lenses had a refractive power of +3.0 to +3.5 Diopters," according to Vjekoslav Dorn, Professor of Ophthalmology at the University of Zagreb and a diligent historian of early spectacles. The potassium content of the lenses suggests a northern European or more precisely German origin in contrast to the sodium content of better-preserved glass objects also recovered, which is more typical of Venetian manufacture. Interestingly, the spectacles are of two sizes with the smaller one presumably meant to be used by

114. A. Pigafetta, *The First Voyage Around the World (1519–1522): An Account of Magellan's Expedition*, ed. T. J. Cachey Jr. (New York, 1995), pp. 76–77: "At that place the people highly esteem bronze, quicksilver, glass, cinnabar, wool cloth, linens, and all our other merchandise, although iron and spectacles more than all the rest." Mirrors are mentioned starting in Brazil: pp. 9, 11, 15–17, 31, 36, 84 ("three large mirrors"), 87, 89, 91, 105 with equivalent word in a native language, 114. Gilt glass drinking cups were also exchanged frequently along with scissors, knives, and combs. Apparently the ships were well supplied with these commodities.

115. See M. L. Calvo and J. M. Enoch, "Early Use of Corrective Lenses in the Spanish Colonies of the New World: Reference to Viceroy Luis de Velasco (son)," of imminent publication in the journal *Optometry and Vision Science*. I am grateful to professors Calvo and Enoch for supplying me with the printout of the text.

116. B. Daza de Valdés, *The Use of Eyeglasses*, ed. P. E. Runge (Sarasota, Florida, 2004), p. 138. Daza also mentioned the loops around the ears to hold spectacles in place: "I also warn you that if your wear them attached to your ears with loops, you should not use steel or silver frames because they slip and slide down the nose. They do not stay in place as well as leather frames" (p. 135).

women.[117] This appears to be the only published archeological find in southern Europe to which we can add the unpublished one in Florence for the fifteenth century, discussed in the third chapter.[118] Together with similar archeological discoveries in Germany, Holland, and England, they vastly illuminate the history of spectacle manufacturing, which heretofore had to be largely deduced from artistic representations.

As noted in the preceding chapter, Croatia is also comparatively rich in documentary and artistic evidence of early spectacles. Its many cultural, artistic, economic, and political links with Italy[119] and especially with Venice, who by the middle of the fifteenth century had made the Adriatic a "Venetian lake" and her main trade route to the Levant, would make it a major market for spectacles produced in Venice with almost certain competition from other centers such as Nuremberg and Florence. Once again this is an assumption for which we have no direct evidence because the surviving documents do not mention the origin of the eyeglasses. Only three documents have been discovered for the fifteenth century. In 1450 a certain Vitko Zuimoviæ claimed to have been robbed of a "silver spectacle case with a pair of spectacles," with a total value of 5 perpers and 7 groschen, which indicates a luxury product.[120] Three years later another silver case for eyeglasses was mentioned in another document. In 1482 at an auction for the sale of the effects of an herbalist of Dubrovnik, among the items offered for sale by his widow were "38 pairs of fine spectacles" with a total value of one ducat and 18 groschen.[121] In the last case we have another confirmation of the relatively low cost of ordinary spectacles and of the fact that they were sold by a non-spectacle maker as well. And this list could be continued with more frequent documents for the sixteenth century, among which one interesting find of a wire-rimmed pair in a tomb of a patrician in the Franciscan monastery in Split shows biconvex lenses of "good quality glass," with a power of +4.0 and +4.25 diopters.[122] When we add the numerous artistic representations by local and Italian artists in churches and museums to be treated in Appendix III, we can conclude that in Croatia and nearby areas, spectacles were widely diffused at least by the middle of the fifteenth century.

Hungary, on the other hand, boasts the first archeological find of a pair of leather-framed spectacles in Europe dating from the late fifteenth century. It was discovered

117. See V. Dorn, "A Contribution to the History of Spectacles in Croatia," *Documenta ophthalmologica* 86 (1994), pp. 180–81, for additional comments about the size of the frames and other technical details with illustrations. The materials recovered now form part of the archeological collections in Biograd-on-Sea and in the National Museum in Zadar.

118. See pp. 114–15.

119. These links, especially in the arts, form the subject of a collection of essays: *Quattrocento adriatico: Fifteenth-Century Art of the Adriatic Rim*, ed. C. Dempsey (Bologna, 1996).

120. Dorn, "A Contribution," 173–74. At this time, a Venetian ducat, the dominant currency of the region, was worth 3 perpers and 1 perper equaled 12 groschen.

121. Ibid., 174–75. The three documents are cited from the Historical Archives in Dubrovnik.

122. Ibid., 178 with illustration, p. 180.

in 1928 (twenty-five years before the first such discovery in Wienhausen), apparently unintentionally hidden within the frame of an altarpiece in a provincial church and discovered during restoration work in Budapest. The lenses did not survive, but the frame made of tanned ox hide and coated with black varnish is in excellent condition. Another pair, dated from the end of the fifteenth century to the beginning of the sixteenth, was found in 1948 during excavations in the ruins of the royal palace of Buda, partly destroyed during the Second World War. This pair has an ornamental metal frame with ornate and curved handles connected by a rivet. The lenses have a +1 power suitable for a mildly presbyopic person. Both pairs are now exhibited at the Hungarian National Museum.[123]

The above treatment of spectacle production and commerce in countries outside Italy has tended to show the value of customs records and archeological discoveries for the early history of eyeglasses. Regrettably, from these sources alone no definite conclusions can be reached about the level of the spectacle industry in each country. We can only reason with some confidence that all countries of western and central Europe had both the material resources and the skilled labor force to produce such a simple device as a pair of spectacles without even considering monastic production. In fact, I would venture the tentative hypothesis that by the end of the sixteenth century eyeglasses were perhaps almost as common in these countries as desktop computers are in developed countries today. They were affordable for the vast majority in need of them but perhaps not as commonly as in Italy. As in Italy, however, even persons of modest means would have owned several pairs largely because one pair was usually not sufficient to perform all the tasks at different focal distances. It is my hope that as economic historians continue to chip away at the huge mountain of account books and commercial letters in Tuscan and particularly Florentine archives, we may well become better informed about the prevalence of spectacles in western Europe as a whole. But this work will require a generation or two of concentrated effort on the part of duly alerted researchers who are sufficiently interested in these far less lucrative transactions in international commerce.

123. These spectacles are fully described with accompanying photographs by S. Györffy, "Two Antique Fifteenth-century Spectacles Found in Hungary," in *Transactions of the International Ophthalmic Optical Congress, 1961* (London, 1962), pp. 266–67.

V

The Art of Spectacle Making

THE NEW documents discovered for this study, as well as the recent archeological finds treated in the preceding chapters, have given us a critical mass of original sources for a better understanding of the quality and gradation of spectacle lenses for both presbyopia and myopia and the type of materials used for the frames. Heretofore we had to depend almost exclusively on works of art and on the relatively few samples in museums and church reliquaries normally dating from the sixteenth century onward. We have learned that various materials were used for the frames—metals (including gold and silver), wood (usually boxwood and beech wood), bone, horn, ivory, leather, and whalebone. Leather and horn seem to predominate from the sixteenth through the seventeenth century. In this chapter I will discuss the technology in making spectacles frames and the spectacle-making trade with particular attention to Florence where we have an abundance of original sources. Lens-making technology will be treated in the next chapter as a prelude to the invention of the telescope, which required higher quality lenses.

Frame Making

Regrettably, early records in Florence and elsewhere give little information on the actual process of spectacle-frame manufacturing and none on lens preparation. No written manuals have survived supposedly because the practices of the trade were normally transmitted orally from one generation to the next, as was customary at this time. The most specific of these surviving records—the song of the Florentine *occhialai* of the early sixteenth century quoted below—described the making of frames from (cattle) horns, but did not mention the actual grinding and polishing of the lenses graded for the various strengths connected to progressive ages. Among the *occhialai* listed in Appendix I we have bone smiths, one strongbox maker, and friars. Evidence cited earlier showed that goldsmiths made frames, usually with precious metals, but in at least one case—the Pisan company of 1445—they assembled the whole product with bone frames. Significantly, the three partners of this company bound themselves by oath under grave penalties not to divulge the secret of the spectacle-making process. But what could this secret be in making by now such a commonly worn optical device so easily manufactured by dozens of artisans in Tuscany? Most likely the secret had to do with a special tool or process to provide a more precise grinding and polishing of the lenses just a few years before we have the first documentary evidence of the production of concave lenses in nearby Florence. Since concave lenses had to be thin in the middle, they required special care to grind and polish so as to avoid breakage. It is tempting to speculate that this company had developed a special tool to facilitate this process, the secrecy of which had to be protected by an oath.[1] Surprisingly, Tommaso Garzoni (1549–89) did not mention spectacle frames among the great variety of artifacts made by goldsmiths, whom he placed on top of the scale of artisans for their skill and ingenuity. Judging from his list alone one can easily see that making a spectacle frame or even assembling the entire pair would have been child's play for such skilled artisans.[2]

In France the guild of makers of mirrors, eyeglasses, and toys were allowed to make spectacles with lenses of glass, rock crystal, and manufactured crystal framed in leather, horn, pewter, and other materials except paper. The fact that in 1610 the grand duke of Tuscany imported spectacle lenses from England and had them framed in leather in Paris speaks well for the quality of English lenses and French leather frames and shows a degree of specialization. About the same time, French leather workers and saddle makers displayed leather-framed spectacles in their blazons.[3]

From these hints we may surmise that artisans working various materials for the frames may have inserted the lenses already ground by glass/crystal workers. In some cases, perhaps, fully qualified *occhialai* who had had experience as glassmakers may have ground the lenses themselves. They could also have fashioned their own frames from horn flats, leather, and bones suitably prepared by other artisans, who had the experience and tools for the proper treatment of these raw materials. One can see here the emerging profession of the modern optician, who purchases prescription ground lenses from lens makers and inserts them into various types of frames available from a number of producers, ready for customer fitting.

Whatever role particular artisans had in manufacturing the entire product, it is clear that all of them also acted as vendors. As such they had to belong to a mercers' guild as in Venice and perhaps in other places, and to the *Medici/Speziali* guild in Florence. The latter virtually dominated the commercial life of the city because almost everyone

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1. For details, see ch. III, p. 76–77.

2. T. Garzoni, *La piazza universale di tutte le professioni del mondo,* ed. G. B. Bronzini with P. DeMeo and L. Carcereri, vol. I (Florence 1996), Discorso LI, "Degli orefici," pp. 582–86.

3. See Chap. IV, and Madame A. Heymann, *Lunettes et lorgnettes de jadis* (Paris, 1911), plate 13, between pp. 58–59.

engaged in producing articles for sale in a shop/store or on the street had to be a member. Its membership, in fact, included a bewildering variety of artisans (including glass workers, spectacle makers, and goldsmiths) in subordinate positions, who also held concurrent membership in other guilds of collateral usefulness to their principal activities.[4] Likewise, non-Florentines and foreigners who sold goods in Florence had to be members, as was the case in Venice and probably elsewhere as well.[5]

In the absence of more specific information from original written sources, our knowledge of spectacle-frame manufacturing comes almost exclusively from the detailed examination of surviving early frames carried out by archeologists, as already noted in the preceding chapter. Two archeologists at the Museum of the City of London, Michael Rhodes and Philip Armitage, have published the results of their close examination of the Trig Lane rivet bone frame spectacles of the middle of the fifteenth century found in London in excavations carried out in 1974–75. Their conclusions follow:

> *The frames are constructed from two identical units each of which has been cut in one piece from a bone plate. Dr. Philip Armitage has demonstrated that the two plates required must each have been removed from the metacarpal bone from the forelimb of a bull. . . . Both units consist of a circular rim intended for a lens of c. 30 mm. diameter, with a small outward protrusion on one side, and a short handle opposite this on the other side of the rim. The two units are united by a rivet which pierces the extremities of their handles.*[6] (Fig. 43)

The plates were ground to the thickness of about 2.5 mm. and polished. A pair of heavy-duty dividers or compasses, possibly with a cutting tool attached, marked and cut the rims with attached handles, leaving a small three-toothed protrusion opposite the handle. The protrusion was split in the middle for the insertion of the lens in the previously grooved rims and the split was closed by a "double twist of 0.23 mm. diam. copper wire around the outer 'cuts'." The iron rivet-hinge with washers on both sides connecting the extremities of the handles allowed the frame to be positioned tightly on the bridge of the nose or on the nostrils, a sort of a primitive pince-nez. The clamping over the nose was facilitated by the presence of three "v"-shaped notches carved on both sides of the rims where they joined the handles.

4. 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 also been highlighted 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.

5. For a specific mention of a foreign vendor, who came to Florence to sell spectacles and other merchandise in the market place and in the streets, see ASF, *Arte dei medici e speziali, filza* 15, fol. 121^r, 18 Nov. 1624: "Giacomo di Francesco Milo savoiardo, vende occhiali e altro in mercato e per Firenze." I am indebted to Orsola Gori for this reference.

6. See M. Rhodes, "A Pair of Fifteenth-Century Spectacle Frames from the City of London," *Antiquaries Journal* 62/1 (1982), 57. The following discussion is based on this article, pp. 57–73, with an appendix by Armitage, pp. 67–70.

31. Piazza, Paolo, *Supper at Emmaus,* ca. 1590, Sacristy, Duomo, Castelfranco Veneto (Treviso).

43. *Suggested Construction of Bone Spectacle Frames from Metacarpal Bones of Bulls,* 15th century, Museum of London.

This construction permitted the two halves to be folded with one lens on top of the other to form a magnifying lens approximately double the power of the single lenses, assuming that they were convex in shape. In the folded position, the eyeglasses could also be stored in appropriately shaped cases to be carried about as it can be seen in paintings of monks, who are shown with spectacle cases dangling from their waist cords. They could also lie astride temporarily over one ear, ready to be used when needed, as some paintings demonstrate (Fig. 31), much the same way that a chain smoker places a cigarette over the ear ready to be lit. Finally, two exactly matching triangular shaped clusters of three small holes were drilled at the base of the handles where they joined the rim. They might have had a decorative purpose, but Rhodes has also advanced the hypothesis that they were designed for more distance viewing by taking advantage of the phenomenon of pinhole vision already known in ancient times.

If the above analysis is correct in all its details, one can conclude that the first pair of spectacles was simple in design but multifaceted in its use. The most serious drawback was the uncomfortable tilted position the head had to assume in order to hold the spectacles securely in place, especially as the rivet loosened somewhat through repeated use. They could also be held by the rivet in front of the eyes, as it was often done, but this method negated one of the main advantages of spectacles over magnifying lenses—the use of both hands for close work or writing. On the other hand, the weight of the Trig Lane frame was light, only an estimated 5 grams without the lenses.

A pair found in 1994 at Swan Stairs in the City of London of approximately the same date as the Trig Lane pair, and likewise deposited in the Museum of London, provides a slightly different design of rivet spectacles. They have been analyzed by Judith Stevenson, former Assistant Curator of Early London History and Collections.[7] The frames of this pair are about 10 mm shorter than the Trig Lane pair, have slightly narrower rims, and shorter handles, which are moderately curved on one side and present four grooves on the opposite side. This design permitted attaching nose pads on the curved side, if desired, which were tightly secured by wire or thread wound around the grooves. The shorter handles and the supposed use of nose pads would indicate a conscious effort to solve the problem of comfort in wearing spectacles and prevent their tendency to fall off. Otherwise, they are identical in other respects to the Trig Lane pair and to other bone frames found elsewhere with small variations dictated by local preferences, ingenuity, or fashion.

It should be noted, however, that shortly after publishing her analysis, Stevenson came to suspect that the frames were made of antler rather than bone, considering the fact that archeologists find it impossible to distinguish bone from antler in small objects.

7. J. Stevenson, "A New Type of Late Medieval Spectacle Frame from the City of London," *London Archeologist* 7, No. 12 (1995), pp. 321–27.

Although "bone and antler are basically the same type of material," antler is more durable and easier to shape. Moreover, a modern replica maker of ancient spectacle frames reported that it was "almost impossible" to find bull metacarpal bone sufficiently large for cutting the plates for the frames whereas larger pieces of antler were easier to find.[8] In either case, both materials were readily available during the Middle Ages.

While archeologists are in the process of rethinking and re-examining these small objects hitherto classified as bone, it is worth remembering that in fifteenth-century Italy bone was commonly mentioned as material for frames. The Pisan goldsmith firm made spectacles with bone frames and Florentine bone workers / merchants (*ossai*) sold bone-framed eyeglasses in large quantities.[9] Did Italian bulls have larger metacarpal bones? These sources, regrettably, do not mention the specific animal species that supplied the bone — a comparable large animal could have been the buffalo, which is known to have been raised in central and southern Italy at this time. We have already mentioned spectacle frames made of buffalo horn or bone recorded in the Bolognese custom records of the early fifteenth century.[10] In the sixteenth century, however, a source is specified along with another way of constructing bone frames. According to Garzoni, who wrote a well informed and widely read account of trades and professions of his day, the bones for spectacle frames were extracted from young or castrated steers. The rims were heated to facilitate the insertion of the lenses, which suggests that the frames were extracted in one piece and the rims connected by means of a round bridge, in the same way horn frames were made. This method eliminated cutting the rims and tying the two halves together.[11]

The straight-handle rivet spectacle, framed in bone or antler, was the first form developed and was common throughout Europe, being simply the riveting together of the handles of two framed magnifying lenses. It was the model depicted by Tomaso da

8. Private communication (1996) to C. Letocha, passed on to me. Stevenson wrote: "In my article I state that they [the frames] are probably made from bull metacarpal, based on the Rhodes and Armitage identification for the Trig Lane spectacles, and also based on the identification of the Swan Stairs spectacles made by our animal bone experts in the Museum of London Archaeology Service. However, these bone specialists were not certain if the frames were made from antler rather than bone. Antler and bone are invariably impossible to distinguish between in small objects particularly where the external cortex has been removed, which is usual. Bone and antler are basically the same type of material. Since I wrote the article, various other pieces of information have led me to suspect that the Swan Stairs spectacles are more likely to be made from antler. Firstly, a visit from a replica maker, said that he had found it almost impossible to find a bull metacarpal large enough to fit the frame shape onto and to cut to the right shape, as suggested by Armitage (1982). He found it easier to obtain large pieces of antler, and also found antler easier to work. Additionally antler is more durable than bone. Secondly, this idea of easier working and greater durability is being recognised by archaeologists and object specialists who are now beginning to think that many artifacts once classified as bone may in fact be made of antler."

9. See chap. III, p. 77 and chap. IV, pp. 118–19.

10. See chap. III, p. 106.

11. T. Garzoni, *La piazza universale*, vol. I, Discorso LXIIII, *"De' vetrari, o biccherari, occhialari, et finestrari,"* p. 658: "Gli ossi da occhiali sono di manzo tenero, o di castrato, et bisogna scaldar l'osso al fuoco a chi vuol mettervi gli occhiali dentro."

Modena on the nose of Cardinal Hugh of Provence in 1352 (Fig. 66). Wood was another early material used for the frames. Though not as durable as bone or antler, it was easier to procure and shape resulting in lower-cost eyeglasses as shown in the Florentine transaction of 1415.[12] The archeological find at the nunnery choir in Wienhausen (1953)[13] demonstrates three other types of frame construction, all made of wood, which can be dated from the late fourteenth to early fifteenth century. The first type has straight handles with no notches on either side and a decorative cloverleaf design on one of the handles in place of the triangular cluster of three holes. The frame was made from a slat of boxwood, 2 mm thick, cut by a pair of compasses and a knife. An inner groove in the rims accommodated the lenses, inserted through a split in the rim, and subsequently secured by a thread as in the bone frames. This type is essentially identical in construction to the Trig Lane pair.

The other two types were made of less expensive lime and linden wood slats. Type II retained the split rims for lens insertion but had curved handles for better comfort and fit on the nose—a sort of primitive bridge. Type III shortened the "bridge" and did away with the split rim. These were formed by two identical slats with the inner edges of each rim cut on an angle so that when the two slats were glued together the resulting groove held the lenses tightly in place. In both types a rivet centrally secured the curved handles.[14]

A third type of spectacle-frame material used from the fourteenth century was horn, presumably cattle horn. In this case, we are fortunate in having a fairly complete description of horn frame making in a Florentine carnival song of the early sixteenth century.

We are all masters of spectacles
perfect and natural ones.

We have various spectacles
of every sight and every age;
willingly we will teach this art
to maidens and to married women
and to veiled widows
who want to learn to make spectacles

If there were a child
who would also want to learn,
we would teach him the whole art:

12. See chap. III, p. 76.
13. See chap. II, p. 68.
14. The three types are described and illustrated by H. Appuhn, "The Oldest Spectacle Frames and Other Utensils for Daily Life," trans. of the booklet, *Der Fund vom Nonnenchor* (Wienhausen, 1973) by Henry Obstfeld and published in *Ophthalmic Antiques Extracts 1986–1996*, ed. R. J. S. MacGregor, pp. 7–9.

first straighten the horns,
then cut and drill them,
until he knows how to make spectacles.

Because they are made by
necromantic artifice and the planets
of Mercury, Jupiter and Mars,
herbal juices and very secret,
they make men wise
when they use these spectacles.

We put the horn to soak,
so that it bends more easily;
this done, the marrow
will flow out and then it is cut;
then we clean it and thus it is bound
in the glass and the spectacles are made.

For the age of thirty and forty
these are made of crystal;
these others from age fifty
to sixty, are clear and thin;
for seventy they are for near [vision],
women, these big spectacles.

Those who have a husband, who is old
and jealous, need
certain mirror glasses
through which they see their shame:
they will make them appear to dream,
when they wear these spectacles.[15]

The song listed the basic operations in preparing horn flats for frame making—soaking, cleaning, cutting, drilling, and fitting of the lenses into the rims connected by a round bridge or bow all in one piece. A high bridge will act as a spring on the nose while splitting it will add flexibility. Archeologists and modern horners are able to supply details about the manufacturing steps of horn frames as the following description of the process by Judith Stevenson shows.

15. *Canti carnascialeschi del Rinascimento,* ed. C. S. Singleton (Bari, 1936), song LXXXV, pp. 114–15. My own translation with revisions by S. U. Baldassarri.

Horn is related to hair, in its composition, and is also a natural 'plastic' in that it can be moulded. Horn is usually cut in half or slit down one side and then it is flattened using heat, either with or without the aid of water. Thus, it can be soaked, to soften the material before being heated and pressed into shape, or it may be boiled, or it can be dry pressed. After moulding the horn regains its rigidity, and may be cut, drilled, polished etc. Spectacle frames could be formed from flattened strips of horn, cut into shape with knives, saws and compass-like inscriber/cutters. . . .[16]

Although less durable than either bone or antler, horn's malleability made it an ideal and popular material for many household items other than spectacle frames, including buttons, beads, inkwells, drinking cups, lantern panes, powder containers, chess pieces, combs, handles for knives and swords, etc. The technique for framing single magnifying lenses was similar: "A section of horn having been made ready by the usual technique of cutting, heating, polishing and making of a groove, is then heated sufficiently to take the glass. Contracting as it cools, the horn fixes the glass firmly at all points."[17]

Requiring extensive facilities for the lengthy preparation before horn pieces could be made suitable for manufacturing these items, it is believed that the horners acted as suppliers to other trades such as spectacle makers who cut the frames from the horn flats. The development of vulcanized rubber and plastics from the nineteenth century onwards reduced considerably the demand for horn products, but in England the Worshipful Company of Horners, founded in the fourteenth century, is still active today.[18] Horners or horn smiths were also very active in Colonial America; a few still practice the trade at the present time. One of them made a spectacle frame out of a cow's horn at our request in 1997.[19] Unlike elephant ivory, which was similarly prepared and shaped into spectacle frames, bovine horns or bones were readily and abundantly available. And so was antler, which was chiefly supplied by the annual deer shedding in nearby forests and to a lesser extent by the carcasses of slaughtered animals.[20]

16. Private communication (1996) from Stevenson to Letocha, passed on to me.

17. P. Hardwick, *Discovering Horn* (Guildford, Surrey, 1981), pp. 145–46.

18. The interaction of horners with other artisans was confirmed in a private communication (1996) by the Archivist of the Worshipful Company of Horners of London, Adele Schaverien to Letocha, and passed on to me. She wrote in part: "A large part of the medieval horners' trade was supplying the semi-manufactured flattened sections of horn, which they sold on to Combmakers, Tin-plate Workers for the lantern panes, and no doubt to Spectacle Makers. It does seem most likely the spectacle-maker, or the spectacle-frame maker, would purchase these 'plates' or 'flats' as they were called and avoid the unpleasant occupation involved in producing these flattened sections of horn."

19. The horner is Roland F. Cadle, who made the frame in June 1997 at his shop in Ohio, and the whole process was videotaped in color by Charles Letocha.

20. For details on the working of these materials for various products, see three publications by A. MacGregor, *Bone, Antler, Ivory and Horn: The Technology of Skeletal Materials since the Roman Period* (Totowa, N. J., 1985); "Bone, Antler and Horn Industries in the Urban Context," in *Diet and Crafts in Towns: The Evidence of Animal Remains from the Roman to the Post-Medieval Periods*, ed. D. Serjeantson and T. Waldron (Oxford, 1989), pp. 107–28; and "Antler, Bone and Horn," in *English Medieval Industries: Craftsmen, Techniques, Products*, ed. J. Blair and N. Ramsay (London and

From the early sixteenth century onwards, leather became another popular material for spectacle frames. Like horn, it required lengthy preparations as is evident from the following description:

Pieces of leather must be boiled in wax mixed with resin and glue. Once boiled in this manner, the leather preserves whilst it is moist, sufficient pliability to enable it to be moulded, and when it is dry it possesses a hardness and rigidity nearly equal to that of wood to which it is preferable by reason of its lightness. Because wet leather expands, lenses which have been carefully edged to size can be fitted into the wet frame which contracts, as it dries out, to hold them firmly."[21]

A Nuremberg shoemaker, Hans Sachs, described the trade of spectacle makers alongside that of tanners in 1568. A spectacle maker shop was illustrated in a woodcut by Jost Amman, under which Sachs penned this poem:

I make good spectacles, clear and light, aimed at many ages,
From forty up to eighty years, so that sight is preserved.
The frame from leather or horn, in which the polished glasses are fitted.
Through these one can see brightly and sharply.
Whoever needs them can find them here.[22]

Six pairs of well-preserved leather nose-spectacles were found in the study of another Nuremberger, the patrician humanist, Willibald Pirkheimer (1470–1530), friend of Erasmus and Albrecht Dürer. They are dated from about 1520 and are now preserved at the Wartburg Castle, where Luther took refuge and translated the New Testament into German (1521–22), and serve as a point of reference for the genre.[23] Leather frames were comfortable to wear especially when the bridge was split into three or four strips and even more so when in the course of the eighteenth century it was replaced by a steel-spring bridge riveted to the leather rims. This improvement lightened the frame and provided a spring-like action for better grip on the nose.[24]

Rio Grande, 1991), pp. 355–78. For a brief account of personal experience in working these materials for spectacle frames by a modern replica maker, see G. Walsh, "Spectacles Through the Ages and Period Inaccuracies," *Optometry Today* 41 (2001), p. 36.

21. Quoted by H. Obstfeld, "Leather Spectacle Frames," *Ophthalmic Antiques* 37 (Oct. 1991), p. 3.

22. Ibid., p. 2, as translated by Obstfeld from J. Amman and H. Sachs, *The Book of Trades [Ständebuch]*, ed. A. Rifkin (New York, 1973), p. 65. An illustration of the trade of tanner with another descriptive poem is on p. 64.

23. R. J. S. MacGregor, "Autumn in Jena," *Ophthalmic Antiques* 86 (Jan. 2004), p. 12.

24. See T. H. Court and M. von Rohr, "On the Development of Spectacles in London from the End of the Seventeenth Century," *Transactions of the Optical Society* 30/1 (1928–29), pp. 8–14. Presumably the leather for the frames and spectacle cases was prepared by the *cuir brouilli* process, an ancient technique commonly used in the Middle Ages and early modern period. For the preparation of leather for all sorts of objects from ancient time through the nineteenth century, see J. W. Waterer, "Leather," in *A History of Technology*, vol. II, ed. C. Singer et al., (New York and London, 1956), pp. 147–87, and idem, *Leather and the Warrior*, ed. L. Merrifield (Northampton, 1981), pp. 67–70.

By this time, however, their relatively ungainly appearance gave way to the more elegant frames made from whalebone and tortoiseshell, both of which required extensive preparations as well. "Whalebone is a pliable horn-like material. . . . Being durable, flexible and very light it was an excellent material for the frames of eyeglasses. The whole frame could be fashioned out of one strip. . . . In use the whalebone eyeglasses cling to the nose with a pince-nez like action." Whalebone was in ample supply since a single whale could have as many as 400 plates of bone or 1.75 tons.[25] Also widely used from the seventeenth century onwards was tortoiseshell, a natural plastic made from the shell of the marine turtle, known as the Hawksbill Turtle, found mostly in the Caribbean region. Its durability and beautiful appearance made it an ideal material for many products besides spectacle frames until the supply lessened as the animals became protected since 1973 so as to prevent the cruel manner followed in killing them and harvesting the turtle's plates undamaged.[26]

Various metals were also used for frames from the late fourteenth century as represented in surviving paper watermarks. The earliest of these representations in 1387 shows wire spectacles with elastic pressure on the nose while those of the following century were apparently made of steel with similar elastic pressure on the nostrils. The lenses were apparently glued into the metal rings or held in the middle of two rings riveted together at opposite ends.[27] And, of course, we have already encountered luxury eyeglasses and magnifying lenses mounted in frames of gold and silver or gilded metals. But the most popular and least expensive metal frames that could be easily produced in large quantities were the wire frames, apparently first developed in Nuremberg late in the sixteenth century. This city dominated the market well into the eighteenth century. Greeff succinctly described the manufacturing process first by hand and later by water-driven machines as follows.

Two large, round glasses, having a diameter of about 35 mm. are set into a smooth wire, which forms a loop at the upper-inner part of both sides and ends in the highly springy link. The wire (silver-plated copper-wire, called leonic wire), of which the link is made, is so elastic, in fact, that the pinchers remain on the bridge of the nose of themselves. To prevent the wire from pressing too much on the bridge of the nose it is wrapped round with silk of

25. See R. J. S. MacGregor, "Whalebone Spectacles," *Ophthalmic Antiques* 43 (Apr. 1993), p. 6, for the quotation and other information about eyeglasses with whalebone frames.

26. R. S. J. MacGregor, H. Orr, D. C. Davidson, and S. Eadon-Allen, "Real Tortoiseshell," *Ophthalmic Antiques* 41 (Oct. 1992), pp. 3–8, for full information on the preparation of tortoiseshell for spectacle frames.

27. Pictures of the watermarks were reproduced by M. von Rohr, "Additions to Our Knowledge of Old Spectacles: A Summary of Papers Published in 1923–24 Relating to the Subject of the Thomas Young Oration of 1923," *Transactions of the Optical Society* 26 (1924–25), pp. 175–78. Other spectacle watermarks found in Milanese notarial records of 1457, 1474, and 1486 are not sufficiently detailed for definite establishment of the frame material. For these reproductions, see U. Monneret de Villard, "Le filigrane delle carte milanesi dalle più antiche alla fine del xv secolo," *Arch. Stor Lombardo*, ser. VIII, V (1954–55), pp. 44, 46.

different colours for the different kinds, on the inside, at the spot where, otherwise, it would touch the bridge. . . . On the inside the wire is provided with a slit or groove for holding the rims of the glasses. On some of these wire settings the name of the firm is imprinted.[28]

The above citations, though not exhaustive, are intended to provide a representative sampling of the various frame materials used and their relative efficiency and comfort. But such spectacles remained simply "nose" spectacles; i.e., they all rested precariously on the bridge of the nose or nostrils with the head held in such a position for close work so as to minimize the danger of falling off. Various methods were tried to remedy this problem, from a long central wire attached to the bridge whose loop was fastened to a button inside the head cap to threads attached to side holes in the lens rings so that they looped around the ears, a fashion particular popular in Spain. Two pairs with silver frames "to gird around the head," were donated in 1485 as ex-voto offerings to the Church of the SS. Annunziata in Florence, but they are no longer extant.[29] Rigid and extendible, hinged temple pieces ending in large rings resting on top of the ears for better comfort were invented probably by Edward Scarlett in London in the early eighteenth century, which in turn gradually developed into the regular ear rails of the present by the end of the nineteenth century.[30] Whatever the discomfort of wearing nose spectacles, it is clear from the sources that they were produced in large quantities and thousands of wearers were able to extend their daily activities past the age of forty by finding various remedies to cope with their imperfections.

Even more problematic, however, was the lot of the minority myopic population that could hardly take long walks without holding their head high enough to prevent their spectacles from falling down on the uneven streets of the age unless they found a secure way to attach them firmly to their noses. It was a ridiculous as well as an impractical posture for them, which largely explains the existence of only a few pictorial representations of such bespectacled persons walking and looking into the distance. The most common solution for myopes was the use of monocular, concave lenses with a handle, known as perspective glasses, which could be carried inconspicuously in pouches and taken out when needed for distance viewing. In essence, myopes had to be content with blurred, distant vision unless they chose to use the impractical remedies of the age.

Documented events in the life of Pope Leo X (1513–21), who was severely myopic and needed concave lenses of approximately ten diopters, reveal the various ways such seriously handicapped persons used to cope with daily activities. With his degree of

28. R. Greeff, et al., *Katalog einer Bilderausstellung zur Geschichte der Brille* (Amsterdam, 1929), p. 209.

29. They are listed as "due paia d'ochiali da cignere alla testa; pesorono once tre, e d. sei" in the "inventario di ex-voto d'argento all'Annunziata di Firenze (1447–1511)," *Testi dei "Servi della Donna di Cafaggio,"* ed. E. M. Casalini, OSM, I. Dina, and P. Ircani Menichini (Florence, 1995), p. 281. I am indebted to Lorenz Böninger for this reference.

30. For a discussion of the development of the various types of frames, see Court and Rohr, "On the Development of Spectacles," pp. 9–12, and Greeff, *Katalog*, pp. 211–13.

myopia, Leo could see objects clearly up to 4 inches away without using corrective lenses; beyond this distance, his vision became progressively blurred.[31] Yet, after his elevation to the papal throne, he dispensed with wearing spectacles in public for unknown reasons. Perhaps the public wearing of glasses with such thick lenses and awkward frames was considered demeaningly inappropriate for his supreme office. His poor unaided vision, however, created embarrassing moments especially during public audiences, giving rise to irreverent if amusing jokes. It was rumored that he saw only through the eyes of his private chamberlain and personal treasurer, Giovanni Lazzaro de Magistris (nicknamed *Serapica*), who arranged audiences and spectacles for papal amusement.[32] The humanist Mario Equicola reported that the Pope had received him soon after his inauguration at the age of 38 (19 March 1513), adding sarcastically that "His Holiness is in good health and does not wear spectacles because he sees with the assistance of the Cardinal of Aragon and of Divine Providence."[33] A month later, the poet Ludovico Ariosto was granted an audience during which he kissed the papal foot and was graciously heard, but he doubted that Leo really saw him because he no longer wore spectacles after his elevation to the pontificate.[34]

In private, the pope continued to use spectacles. In a three-month period following his coronation, his personal expense accounts show a total sum of 56 ducats spent on spectacles (May, July) and 25 ducats on a monocle (June).[35] Regrettably, the number of pairs and the price per pair are not noted, but 56 ducats in just two months spent for eyeglasses is an enormous sum even if Leo had intended to imitate the Sforza dukes by donating some of them to his courtiers. It will be recalled that the 36 pairs purchased by Francesco Sforza in 1462 had cost only three ducats (about 7 *soldi* a pair), ordinary ones fetched 2 to 3 *soldi*, and luxury pairs framed in precious metals cost one ducat or more. It is likely, therefore, that a significant number of these spectacles were of middling quality

31. I am grateful to Charles Letocha, a practicing ophthalmologist, for helping me to understand Leo's visual problems as revealed by the sources cited in this and subsequent paragraphs.

32. D. Gnoli, "Le cacce di Leone X," *Nuova antologia* XLIII (1 Feb. 1893), pp. 441–45.

33. Mario Equicola to Marchioness Isabella D'Este Gonzaga of Mantua, Rome, 23 Mar. 1513: "La S.ta di N. S. sta sana et non opera occhiali che jà ci vede per ingegno di Mons. Ill.mo di Aragona [Cardinal Ludovico d'Aragon, son of King Ferrante of Naples] et providentia divina." Quoted in A. Luzio and R. Renier, *Mantova e Urbino* (Turin, Rome, 1893), p. 210.

34. Ariosto to Benedetto Fantino in Ferrara, Rome, 7 Apr. 1513: È vero che ho baciato il piè al papa, e m'ha mostrato de odir volontera: veduto non credo che m'habbia, ché, dopo che è papa, non porta più l'occhiale." L. Ariosto, *Lettere*, ed. A. Stella (Milan, 1965), No. 14, pp. 28–29. It should be added that the letter has a sarcastic tone partly motivated by disappointment in not having been offered some sort of office by the pope, who was an old friend of the poet.

35. A. Mercati, "Le spese private di Leone X nel maggio-agosto 1513," *Atti della Pontificia Accademia Romana di Archeologia, Memorie*, II (1927), pp. 99–112. The entries are as follows: "Et a di 21 [May] ducati 6 di camera pagati per mano del Thesoriero per conto de ochiali"; "E a di decto [8 June] ducati 25 pagati per mano del Thesoriero ad maestro Sano per ochiale de N. S."; "Et a di decto [6 July] ducati 50 pagati ad mastro Raphaello per ochiali." This person may not be Raphael, the painter, because in the next entry the painter was paid 50 ducats di camera and is called "mastro Raphaele de Urbino Pintore."

to be given away as gifts at the beginning of his pontificate, and that those purchased for personal use were composed of the clearest crystal lenses, ground and polished to perfection, and framed in precious materials. The latter's frames were probably made by goldsmiths, who along with musicians, were most prominent at his court. The large sum disbursed for the monocle would also signify a work of art to satisfy the exquisite artistic taste of a pope known for his vanity, luxury, and lavish extravagance. As a point of comparison, we should note that in the same period the sums of 50 ducats were paid for a mule and 15 ducats for a mare.[36] The monthly salary of his hunting scouts (*montieri*) amounted to 10 ducats, that of his hunting-dog keepers, 4 ducats.[37] Clearly, they could affort a pair or two of the lower priced eyeglasses.

It is ironic that such a myopic individual should be a passionate observer and sometime active participant in hunting and hawking, both of which required quick and keen vision. There were hunts organized each autumn in the Roman countryside in which sometimes more than a thousand horsemen took part. A good number of cardinals and the pope himself took part in hunting attire, utterly oblivious of sacerdotal decorum or pontifical gravity.[38] Contemporary and near contemporary sources reveal that the pope used an optical device, generally described only as a "crystal concave lens," which allowed him to see distant game better than his fellow hunters and observe distinctly various species of birds flying over the hills of Fiesole from the Medici Palace on Via Larga in Florence. Since no spectacles or single lenses can give these results, it has been speculated that he probably used a combination of a strong concave lens held close to the eye, aligned with a weaker convex lens about 12 inches away.[39] Such a combination could give a three-fold magnification and was apparently arrived at empirically by several others during the sixteenth century, as it will be discussed in the following chapter. It was a telescope without a tube, but hardly anyone was aware of its wider significance until Galileo trained this lens combination enclosed in a tube to the sky.[40] If Leo used such an instrument, he would have been an observer rather than a participant in the hunt. For personal hunting at closer quarters, he used a monocular (concave)

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36. Ibid., pp. 101, 104. On Leo's lavish expenditures and the splendor of the Leonine Age of Gold in Rome, which recalled the magnificent age of his father (Lorenzo the Magnificent) in Florence, see the detailed account given by L. von Pastor, *The History of the Popes from the Close of the Middle Ages*, 3rd ed., R. F. Kerr, vol. VIII (London, St. Louis, 1950), especially pp. 71–383.

37. D. Gnoli, "Le cacce di Leone X," *Nuova antologia* XLIII (1 Feb.1893), p. 444.

38. Ibid., pp. 433–58, continued in 15 Feb. 1893 issue, pp. 617–48, for a very detailed treatment of Leo's passion for hunting, and Pastor, *History of the Popes*, VIII, pp. 157–66 for additional details.

39. These sources have been extensively quoted and interpreted by G. Boffito, "L'occhiale e il cannocchiale del papa Leone X," *Atti della Reale Accademia delle Scienze di Torino* LXII (1927), 555–60. The same speculation was also expressed by G. Albertotti, "A proposito della lente biconvessa di Papa Leone X," *Atti del Reale Istituto Veneto di Scienze, Lettere ed Arti* LXXXIX, 2nd part (1929–30), pp. 539–42.

40. For an admirable treatment of various efforts to use a combination of concave and convex lenses to achieve better distance vision during the sixteenth century, see A. Van Helden, *The Invention of the Telescope, Transactions of the American Philosophical Society*, vol. 67, pt. 4 (Philadelphia, 1977), pp. 18–19.

lens. During a hunt in 1518 the pope dismounted and lanced a very large deer, trapped within the encircling cloth barriers, while holding his monocular lens close to the eye with the other hand. The sight of this obese pope, dashing frantically with lens in hand to dispatch a desperate and hazily visible animal yearning to escape, was one to behold and clearly made an impression on the eyewitness reporter.[41] Had photography been invented at that time, we would have a rare image!

The pope also used the concave monocle sometimes during private audiences and to examine at shorter distances designs or objects requiring closer scrutiny. In Raphael's portrait of Leo and the two cardinals (1518), the pope is shown holding in his left hand a biconcave lens framed in polished metal (gold?) with handle, whose power has been calculated at about 10 diopters. Such a lens held a bit away from the eye would have allowed him to read and examine the illuminated Bible resting on the table in front of him; if held close to the eye, as one would wear eyeglasses with negative lenses, he could see clearly interlocutors farther away. (In fact, today some nearsighted persons in their forties, like Leo, try to avoid using bifocals by simply sliding their spectacles a bit away from the eyes for reading and repositioning them closer to the eyes for distance.) Presumably Raphael represented the Pope at the moment when his reading was interrupted by the beginning of a private audience, granted in the presence of the two cardinals, Giulio de' Medici and Luigi de' Rossi, who look outward to a distant point. The concave lens in his hand, then, could also have been used to have a clearer view of the visitors, giving his reluctance to wear spectacles in public.[42]

Alternatively, the pope used a convex lens to magnify fine details as all of us do to the present day. Records show that he possessed at least one of these lenses, a round one with a diameter of about 7 cm., which was framed in polished black ebony.[43] In 1519 Leo

41. Antonio de Beatis to the Marchioness Isabella of Mantua, Rome, 1 May 1518: "Et tra le altre fere che morsero in la dicta Magliana ci ammazaro un cervo grossissimo serrato in le tele in pochissimo loco, dove el Papa intrò ad piede con lo speto a la mano et in l'altra lo occhiale." Quoted by A. Luzio, "Isabella d'Este ne' primordi del papato di Leone X e il suo viaggio a Roma nel 1514–1515," *Arch. Stor. Lombardo* XXXIII (1906), p. 160, n. 3. Pastor, *History of the Popes*, vol. VIII, pp. 161–62, believed that the pope had "spectacles on nose" in this instance. The document is clear in stating that he had a lens in the other hand so that by holding it close to the eye he could see more clearly a rapidly moving target at close quarters. A pair of spectacles perched on the nose would have fallen off and their use would have been contrary to the pope's practice of not wearing them in public.

42. The various interpretations of this painting have been reviewed and assessed in the light of the clearer details uncovered by its cleaning in the 1980s and the discovery of new sources by N. H. Minnich, "*Raphael's Portrait* Leo X with Cardinals Giulio de' Medici and Luigi de' Rossi: *A Religious Interpretation*," *Renaissance Quarterly* 56/4 (2003), pp. 1005–52. For clear color reproductions of the restored painting, see A. Natali, "Leone come Giulio? Tracce per un'indagine sull'invenzione del ritratto di Leone X con due cardinali," in *Raffaello e il ritratto di Papa Leone: Per il restauro del'Leone X con due cardinali' nella Galleria degli Uffizi* (Milan, 1996), pp. 51–66.

43. G. Albertotti, "A proposito della lente biconvessa di Papa Leone X," pp. 539–42, provided the calculation for the strength of the concave lens shown in the painting, and cited documents revealing the existence of at least one more lens, a convex one, owned by Leo. These lenses were mentioned in several inventories of the pope's possessions up to one dated 1766; after this date they disappeared, according to Boffito, "L'occhiale e il cannochiale del papa Leone X," pp. 555–60, who cited the same documents.

used such a lens to examine theatrical scenery designed by Raphael.[44] A century later Jacopo da Empoli painted the pope's portrait in the act of examining Michelangelo's designs for the façade of San Lorenzo while holding a monocular lens at short distance from his eye.[45] It should be added that Leo does not fit the typical personality of myopes, who are usually introverted, bookworms, "nerds," shunning sociability. On the contrary, he was a bon vivant who loved books, patronized the arts, literature, and the theater, but also enjoyed "parties" and was given to baser amusements such as "taking pleasure in coarse and foolish buffoonery."[46] Surely, he was a myopic pope in the full sense of the term, one not likely to understand the distant significance of German discontent with the emerging Luther.

Complete Specimens

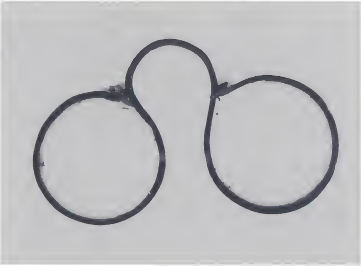
Although Leo's vision aids and his use of them are amply documented in the sources, we cannot examine directly either the lenses or their frames because none of them has survived. This is hardly surprising given their presumed quality and luxury, which would have attracted the acquisitive instinct of others. Likewise, archeological finds of spectacle frames, of course, lacked lenses. In a couple of cases small portions of lenses have survived, but they are so encrusted as to be worthless for analysis. Fortunately, however, the survival of a few perfectly preserved specimens with lenses intact, once owned by less exalted individuals, presents the opportunity for closer analysis. One specimen was found in 1986 at the State Archives of Mantua among the acts (dated 17 August 1518) of a notary, Fozia Santino, who was active for forty years after 1510. The style of the spectacles and the probable material for the frame suggest a later date, perhaps middle of the seventeenth century. Most likely they belonged not to the notary but to a person who later consulted the acts.

A recent analysis of this pair by a Florentine optician reveals that the frame consists of a single 3-mm. band of material (possibly whalebone) surrounding two biconvex spherical lenses held in place by two thin brass wires attached at the base of a round bridge. The dioptometer has established that the surfaces of the lenses are perfectly spherical and have a power of +1.50 each, a total of about 3 diopters. The diameter of the rims is about 37 mm., that of the lenses, 34 mm. The semicircular bridge measures 40 mm. and the distance between the two rims is about 22 mm., roughly the same distance for today's glasses. Their total weight of 8 g. makes them far lighter than the lightest

44. V. Golzio, *Raffaello nei documenti, nelle testimonianze dei contemporanei e nella letteratura del suo secolo* (Vatican City, 1936; rev. ed. 1971), p. 94: "E il Papa mirando con el suo occhiale la sena che era molto bella, de mano de Rafaele, et representavasi bene per mia fè ferara de prospective. . . ." [A. Paolucci to the Duke of Ferrara, Rome, 8 March 1519].

45. This painting is in the Casa Buonarroti in Florence.

46. Pastor, *History of the Popes* 8, p. 156.



47. *Round Bridge Spectacle Leather Frame with Lenses*, early 17th century, Archivio di Stato, Perugia.

contemporary ones (14 g.), which at the present are made with titanium frames and acrylic lenses (Fig. 46).[47] We should recall also that the Trig Lane frame without lenses weighed about 5 g. Perhaps Renaissance eyeglasses were not the heavy devices that we have been imagining to date!

Another most recent archival discovery of a pair of late sixteenth or early seventeenth century glasses was found among the acts of a notary of Perugia, Giovanni Cristoforo Petrogalli, who was active from 1537 to 1583, a contemporary of the Mantuan notary. This pair measures 8.5 cm. and has glass lenses of ca. 3 diopters. The frame is also made of a single band of material similar in construction and appearance to the Mantuan spectacles. The archivists have labeled it dark horn, but it is more likely whalebone, which would shift their date to the seventeenth century (Fig. 47).[48]

Regrettably, this kind of analysis is not possible when good specimens are found among saints' relics owing to the sacred character of the objects, which forbids handling and direct, close examination. There is nothing new, of course, in the association of saints and eyeglasses. The fashion in works of art of representing saints anachronistically with spectacles, especially St. Jerome, is well known and will be further documented in this study. Far less attention has been paid, however, to portraits of bespectacled saints born after the invention of spectacles and to their preservation as relics. There are at least two

47. See ch. III, p. 97.

48. A black and white photograph with the above description was published in the multi-authored volume, *Gentium memoria archiva: Il tesoro degli Archivi* (Rome, 1996), p. 180, No. 106. I wish to thank the present Director of the Archivio di Stato di Perugia, Dr. Paola Monacchia, for sending me a color computer photograph of the spectacles and the authorization to republish it. I am indebted to L. di Nardo for alerting me to this find.

saints of the fifteenth century who are known to have worn eyeglasses—St. Francesca Bussa (Francesca Romana, 1384–1440, canonized in 1608); and St. Bernardino of Siena (1380–1444, canonized 1450). With regard to St. Francesca we know only that two witnesses at her first canonization interrogatory proceedings (1440–1453) testified that she read her devotional books with eyeglasses, but these have not survived as relics.[49] There are no visual aids in her iconography despite the fact that she is frequently represented with an open or closed book and depicted with other saints, like St. Bernardino of Siena, whose pictorial connection with eyeglasses has been well established.[50]

In fact, in the iconography of St. Bernardino, he is usually shown with a dangling spectacle case from his belt, which became almost his trademark. But the saga of one of his pairs, apparently attached to his cap and sent to Milan at the request of Duke Filippo Maria Visconti just two months after the friar's death, makes an interesting story by itself. The glasses and cap were kept at the Visconti castle in Pavia as part of a collection of some two hundred relics, which along with an equally celebrated collection of codices of ancient and medieval authors, became a "tourist" attraction. Both collections were shown with pride on ducal orders to visiting dignitaries, who were duly dazzled.[51] One of the admiring "visitors" was the French king, Louis XII, who captured the duchy (1499–1500) and decided to transfer most if not all the codices to France. The relics, including the cap and glasses, had been transferred just before the invasion to the Cathedral of Pavia for safekeeping, but after this date they disappeared and we have no knowledge of their present location.[52] Only a rough drawing survives and it shows two large rims connected by a round bridge. It was drawn by the scribe on the lower right side of the resolution by the Concistoro of Siena, which authorized by a vote of 142 to 22

49. A lengthy biographical sketch, "Francesca Bussa (Francesca Romana)," was published by A. Esch in DBI, 49 (Rome, 1997), pp. 594–99. One witness testified in 1440 that Francesca "sepius consueverat orare et scripturas divinas in vulgari sermone legere cum ocularìis, in eius manibus tenendo dictas scripturas;" and in 1451 another testified that the saint recited the "offitium cum ocularibus." *I processi inediti per Francesca Bussa dei Ponziani (Santa Francesca Romana, 1440–1453)*, ed. P. T. Lugano (Città del Vaticano, 1945, pp. 55 and 279 respectively).

50. See G. Brizzi, "Contributo all'iconografia di Francesca Romana," in *Una santa tutta romana. Saggi e ricerche nel VI centenario della nascita di Francesca Bussa dei Ponziani (1384–1984)*, ed. G. Picasso (Monte Oliveto Maggiore, Siena, 1984), pp. 265–359.

51. Many documents on the famous Visconti-Sforza library and relics at the castle of Pavia were published by G. d'Adda, *Indagini storiche, artistiche e bibliograpfiche sulla libreria visconteo-sforzesca del castello di Pavia, Parte Prima* (Milan, 1875), and in his *Appendice alla parte prima* (Milan, 1879), especially pp. xiv, 19, 22, 24–25, 27, 29, and 44. A fairly complete description of the codices and an account of their dispersal in French and other libraries in Europe and even in America was published by E. Pellegrin, *La bibliothèque des Visconti et des Sforza ducs de Milan, au XV^{e} siecle* (Paris, 1955). The interplay of the role of images and the degrees of central authority exercised by the dukes of Milan has been perceptively treated by E. S. Welch, *Art and Authority in Renaissance Milan* (New Haven and London, 1995).

52. A list of the transferred relics was compiled on Sept. 2, 1499, by Jacobus Gualla (+ 1499?), a lawyer employed by the cathedral: J. Gualla, *Papie sanctuarium*, ed. posthumously by Paulus Morbius (Pavia, 1505), fols. 89^{v}–92^{v}, in which the "birrectum et ocularia sancti Bernardini de Senis" appears on fol. 91^{v}.

the transferal of Bernardino's cap and glasses to Milan along with a codex listing the miracles already attributed to Bernardino.[53]

It is remarkable that this relic was especially venerated both by Filippo Maria and his grandson, Galeazzo Maria, two eccentric tyrants hardly noted for their piety.[54] The incongruity deepens when we remember that this fiery and popular Franciscan Observant preacher fulminated in his sermons throughout Italy against witches, Jews, and sodomites, and Galeazzo was particularly known for the last category and other sexual exploits.[55] Finally, there once existed one or two pairs of his glasses with spectacle-cases in the monastery of the Osservanza at the outskirts of Siena. They are listed in Origo's biography of the saint (1962) and even in the *Enciclopedia Bernardiniana* (1984), but a visit to the monastery in 1997 only served to ascertain their disappearance.[56]

Bernardino's familiarity with spectacles was practical and seems in no way associated with any first-hand knowledge of optics, a discipline that had been greatly developed by his Franciscan predecessors in the late thirteenth century. This lack of familiarity with the subject is further demonstrated by one of his sermons delivered in 1427 in which he castigated the evil work of witches, whom he accused of using all sorts of magic tricks to entice and kill children at the behest of the devil. One of their favorite evil devices was the concave mirror, which made things appear and disappear, made them seem larger or smaller and inverted, etc. The audience was urged to denounce the witches to the Inquisitors so that they, too, could disappear into ashes! His description of the operation of the concave mirror lacks any reference to optical theory but is familiar to anyone who has used a shaving or make-up mirror. It can be argued, however, that the occasion of a sermon to a general audience would not lend itself to such theorizing and his Latin sermons written for confessors and preachers make some brief mention of visual theory.[57] The friar himself may have used the concave mirror as a magnifier for

53. Siena, Archivio di Stato, *Concistoro, Deliberazioni*, 27 July 1444, Reg. 471, fol. 22r. A summary of the resolution was published in the *Mostra bernardiniana nel V centenario della canonizzazione di S. Bernardino, maggio-ottobre 1950* (Siena, 1950), p. 50.

54. For Galeazzo's special regard for this relic, see chap. III, p. 94.

55. For Bernardino's sermons on these topics and moral corruption in general, see F. Mormando, *The Preacher's Demons: Bernardino of Siena and the Social Underworld of Early Renaissance Italy* (Chicago and London, 1999). On Galeazzo's sexual proclivities, including homosexuality, see G. Lubkin, *A Renaissance Court: Milan under Galeazzo Maria Sforza* (Berkeley, Los Angeles, London, 1994), especially pp. 113–15, 196–202.

56. I. Origo, *The World of San Bernardino* (New York, 1962), reported seeing "two pairs of spectacles in their cases," p. 251, and *Enciclopedia Bernardiniana*, vol. 3 (Aquila, 1984), p. 310. Father Remigio de Cristoforo, archivist of the monastery who helped me in the search, informed me that as far as he knew the spectacles had never been part of the relic collection in the monastery. I also wish to thank Prof. Mauro Cresti of the University of Siena who, likewise, assisted in the search.

57. One such passage attesting to his acceptance of the intromission theory occurs in his *Quadragesimale de evangelio aeterno*, sermon LIV, in his *Opera omnia*, vol. 5 (Florence, 1956), p. 16: "Quod quidem in oculo patere potest; nam visio, cum in parva pupilla oculi sit, tamen cum ea maximi cernuntur montes; et in parvo speculo, sicut et in magno, magna imago expresse et integre cerni potest."

his reading, writing, (and grooming?), as the following quotation may suggest, though there seems to be no written evidence of such a use.

> *Oh, if you want to see that sometimes things are not what they seem, I know because I have had a mirror in which one sees two faces upside down and this cannot be true. And using the same mirror, placed closer to you, one sees only one face head up, as it truly is. And if you place it even closer to you, it seems that the face was very big and the facial hair appear very big and thick. And so everything appears big—the nose, the eyes, and the mouth. And this making one thing appear as another, how does it come about? It is the work of the devil, the teacher, who makes fireflies seem to be lanterns. This is because this type of mirror has its facing surface [curved] on the opposite side of other mirrors.*[58]

We are more fortunate with two saints in the following two centuries. St. Filippo Neri (1515–1595) of Florentine origin who spent most of his life in Rome left us three pairs of eyeglasses in excellent condition and all three were analyzed by the late Albertotti, professor of ophthalmology. Both the one pair in the *Palazzo Massimo* and the two pairs in the sacristy of the *Chiesa Nuova*, all in Rome, exhibit convex lenses of 3.5 diopters. Albertotti could not be absolutely certain about his analysis because he had to measure the lenses through the glass of the reliquary cases and he could not examine the frames, which he pronounced common in style for the period (Fig. 52).[59]

Similar access impediments are presented by a pair of spectacles with a reconstructed round bridge, half of a pair (rim with lens and attached part of a round bridge), and a magnifying lens with a long handle, all used by St. Joseph Calasanctius (José de Calasanz, 1557–1648, canonized 1767). Of Aragonese origin, he settled in Rome in 1592 where he founded a religious teaching order of priests known as the Piarists or Scholopi devoted to the free education of poor children. These schools are thought to be the first examples of free education in Europe and they are still operative in Italy, Europe, and three other continents. A friend of Galileo, he also suffered the displeasure of some high Church officials when the scientist's theories were condemned by the Holy Office, but he probably used his friend's advice in securing good lenses to carry out his teaching

58. "Oh, se tu vuoi vedere che talvolta pare quello che non è, io so che io ho auto già specchio, nel quale è paruto a chi vi mira, che vi sieno due visi volti sotto sopra: questo pure non può essere vero. E con quello medesimo specchio avendotelo acostato un poco più a te, non se n'è veduto altro che uno, e quello col capo di sopra, come è vero. E acostandotelo un poco più, pareva che 'l viso fusse grandissimo, e' peli che altri ha nel viso parevano grandissimi e grossi. E così ogni cosa parevano grandi: el naso e gli occhi e la bocca. E di questo fare, che paia una per un'altra, donde è venuto? È venuto dal diavolo che n'è maestro, e dimostra luciole per lanterne. Questo tale specchio ha auto il suo petto a contrario degli altri specchi. . . ." Bernardino da Siena, *Prediche volgari sul Campo di Siena, 1427,* vol. II, ed. C. Delcorno (Milan, 1989), predica XXXV, pp. 1010–11.

59. G. Albertotti, "Gli occhiali di S. Filippo di Palazzo Massimo," *Atti del Reale Istituto Veneto di Science, Lettere ed Arti,* LXXXIX/2 (1929–1930), pp. 329–35. In 1999 I saw the two pairs in the sacristy but not the single pair at the Palace because the latter was open to the public only on March 16th each year, the date of a miracle attributed to the saint on behalf of a member of the Massimo family. The picture on page 173 was taken through the glass of the reliquary, from which I can guess that one pair has a leather frame and the other appears to be horn.

52. *St. Philip Neri's Spectacles*, mid 16th century, reliquary, Chiesa Nuova, Rome.

duties up to the time of his death at the age of ninety-one. But this must remain pure speculation because it has not been possible to ascertain either the quality of the lenses or the material of the frames.[60]

Florentine Opticians

With the above evidence in mind, we can now turn to the spectacle-making trade and its practitioners, whom we have already called "opticians" anachronistically for convenience because the term "optician" derived from the French *opticien*, which was coined ca. 1640 according to present knowledge.[61] In this case we are stymied once again by the paucity of sources practically everywhere in this early period except for that persistently

60. The relics are visible in the Archivio Generale of the Church of San Pantaleo in Rome. The archivist, Father Valeriano Rodriguez, kindly served as a guide. I am also indebted to professors Tom and Libby Cohen for alerting me to these relics. For a brief biography of the saint, see Q. Santoloci, *San Giuseppe Calasanzio: Un grande amico dei fanciulli*, 2nd ed. by L. Capozzi (Rome, 1994).

61. *Oxford English Dictionary*, 2nd ed. (1989), online edition.

abundant depository of commercial and trade documents—Florence—to which we now must turn by necessity. Taddei in his pioneering work on the Florentine glass industry, published fifty years ago, devoted only six lines to Florentine spectacle-makers and listed by way of example just two spectacle-makers (*ochialari, occhialai*) as they appeared in the Florentine *Catasto* of 1457, two others as members of the *Medici e Speziali Guild* (1499), and two vendors in 1561.[62] A most recent publication listed one in the *Catasto* of 1427 and seven in that of 1480.[63]

How could these dozen spectacle-makers so far identified for the entire fifteenth century manufacture and export thousands of pairs of eyeglasses, as our newly discovered sources have clearly revealed? We can now answer this question with far more confidence than before because many additional names of *occhialai* have been discovered and also because now we have established that other craftsmen made and sold glasses, and that some monasteries had their own spectacle-making shops and sold the product on the open market. On the basis of all this new data I can now offer the first attempt to list the names of spectacle makers in Florence from the early fifteenth to the middle of the sixteenth century together with the location of their shops in most cases.[64]

During this period Florence had at least fifty-two spectacle makers, counting four friars making spectacles in two monasteries, but excluding two unnamed in the *Catasto* of 1457 [1458] listed by Taddei (not found in the source he cited), and another unnamed in the census of 1552.[65] It should be emphasized, however, that they constitute a minimum number of those exercising the trade because I have restricted the list only to artisans definitely identified as *occhialai*. Their names were found mostly in the last three or four years by a number of researchers while pursuing other interests. No systematic search has ever been undertaken of the multitude of sources available in Florence alone, excluding its environs, a task that would occupy many years of labor by a number of dedicated researchers. And the records themselves are incomplete. For instance, the Census of 1562 normally listed the profession of the inhabitants when they lacked the last name or other items of identification such as a nickname or a place of origin. It listed only independent women engaged in business or trade, which left out perhaps many who worked in various shops as those of the *occhialai*, of whom only two are so identified in

62. G. Taddei, *L'arte del vetro in Firenze e nel suo dominio* (Florence, 1954), p. 64.

63. M. L. Bianchi and M. L. Grossi, "Botteghe, economia e spazio urbano," in *Arti fiorentine: La Grande storia dell'artigianato*, vol. II, ed. F. Franceschi and G. Fossi (Florence, 1999), pp. 60–61. Neither in this summary treatment of their findings nor in their far more detailed articles do the two authors list the names of the spectacle makers: Grossi, "Le botteghe fiorentine nel catasto del 1427," *Ricerche storiche* XXX/1 (2000), pp. 3–55; and Bianchi, "Le botteghe fiorentine nel catasto del 1480," ibid., pp. 119–70.

64. See Appendix I, pp. 253–56, for the entire list of names and shop locations accompanied by archival citations.

65. P. Battara, *La popolazione di Firenze alla metà del '500* (Florence, 1935), p. 56, lists only one unnamed spectacle maker in 1552! I was not able to find the names in the *Catasto* register as given by Taddei, *L'arte del vetro*, p. 64.

this Census.[66] The tax declarations themselves (*Catasti*), notoriously understated, as such records tend to be, listed the actual shops and their owners but hardly ever the number of workers in the shops. It is obvious that many more workers, including women and semi-retired persons, were making eyeglasses than those reflected in the records.

Yet, despite these limitations, we can make the following observations derived from this first list of Florentine commercial *occhialai*, excluding the friars.[67] Spectacle making was more commonly practiced in the quarters of S. Giovanni and S. Croce. In the former, they were concentrated in the last tract of Via Calzaioli, leading from Piazza Duomo to Piazza Signoria. Their shops were next to those of hose makers and shoemakers, followed by the shops of the doublet makers (*farsettai*). One could comfortably stroll, say from the Medici Palace on *Via Larga*, pass in front of the Duomo, meander through this street of apparel vendors (a miniature Regent Street of Renaissance Florence?), and try on a pair of glasses on the way to the Palazzo Vecchio.[68] And some of these *occhialai* had considerable experience — Piero di Iacopo and Buonaiuto di Giovanni, sixteen years (1413–29 and 1456–72, respectively); Laurentius olim Francisci Iacobi, fifteen (1466–81); and Lorenzo di Francesco, eleven (1465–76)—judging from their recorded activity thus far, which may not reflect its full extent. Buonaiuti's son, Giovanni, was practicing the trade in 1491, apparently in the same shop, after his father's death.

Production figures are lacking; however we can make some approximate calculations in an attempt to explain the massive exports of eyeglasses from Florence in this early period. The list shows six active *occhialai* in 1525, who were aided by seven workers (*garzoni*) and four clerks (*fattori*). Each *occhialaio* was expected to earn a conservatively estimated yearly salary of at least £175 (3,500 *soldi di piccioli*). To make this sum, he would have to sell 7,000 pairs a year at 2 *soldi* each with a 25% profit (½ *soldo*). The six of them could then produce 42,000 pairs a year.[69] A similar calculation could be made for the total production of the six spectacle-making shops with nine *occhialai* named in the Catasto of 1480 as they appear on the list. And yearly Florentine production would be higher if we accept the almost certainty that there were more active spectacle makers both in 1480 and in 1525 than appear on the list without even considering the output of various other craftsmen and friars who made or assembled eyeglasses. Although we have noted that ownership of multiple pairs per person was not uncommon at this time, it would be logical to assume that large quantities of this yearly production could not be absorbed by a city of 60,000 inhabitants.

To be sure, there are a number of variables that would impact on these estimates

66. See *I fiorentini nel 1562. Descritione delle bocche della città et stato di Fiorenza fatta l'anno 1562*, ed. S. M. Trkulja (Florence, 1991), pp. xi, 4^{v}, 41^{r}, and 53^{v}.

67. See Appendix I, p. 253, for additional comments.

68. See Bianchi and Grossi, "Botteghe," p. 56, for a map showing distribution of artisan shops in 1480, and p. 52 for a similar map for the Catasto of 1427.

69. I am indebted to Richard Goldthwaite for proposing this calculation.

such as the type of lenses (glass or crystal) and the materials for the frames, which would drive up unit prices normally ranging from 2 to 16 *soldi* to as much as 80 *soldi* for luxury type pairs. These estimates, therefore, will have to be refined or corrected as new documents are discovered, but for the present they can offer reasonable explanations for the thousands of spectacles exported by Florence in this period. Perhaps we should add that these approximate calculations could also be made for other major spectacle-making centers such as Venice if similar lists of spectacle makers had survived.

In addition, Florence offers the only detailed account of monastic spectacle-making production for this period. The S. Brigida monastery (*al Paradiso*) just outside the city was able to preserve a fairly complete set of account books and a summary Table of spectacle sales from which we gain a unique graphic view of a rather active rhythm of spectacle production.[70] Founded in 1392 by Antonio Alberti in his villa (*Paradiso*) at Pian di Ripoli just outside the walls of Florence, once a meeting place for early Florentine humanists, this monastery was the first of the Birgittine order (also, Order of St. Savior) in Italy, and the second after the posthumous foundation of the mother monastery in 1384 at Vadstena in Sweden by Katherine, daughter of St. Bridget of Sweden (d. 1373, canonized in 1394). This order was composed primarily of cloistered nuns and a small number of monks/priests living in separate quarters, with the priests providing spiritual ministry and guidance and the nuns supplying the domestic needs of the monastery, all under the direction and rule of the abbess. The Rule's constitution envisaged a maximum membership of eighty-five members—sixty nuns and thirteen priests plus four deacons and eight lay brothers—in addition to an unspecified number of uncloistered brethren and sisters providing the bulk of the manual labor. In this case, however, two of the three spectacle makers, friars Martino and Tomaso, were ordained.[71] The account books, kept in the name of the abbess, registered income and expenses from the sale of products made within the monastery and rents from its properties, the surplus income being destined to charity according to the Rule's enjoinment of poverty.[72] A significant number of the glasses were undoubtedly used within the walls of the monastery given its rather large membership. But the records also show that some of them were sold outside Florence by traveling brothers themselves or through merchants—Mantua (1459–61), Vicenza (1461), Rome (1463), and at least one foreign country, Portugal in 1472.[73]

70. The table is reproduced in Appendix II, p. 259.

71. Martino is called "nostro di clausura" and "nostro sacrato" beginning in 1460 (ibid., F. 148, fols. 54^{r}, 55^{v}), and Tomaso di Marcho "nostro consagrato" since 1465 (F. 149, fol. 48^{v}). Friar Antonio was not given that designation, indicating his lay status. See A. Guidotti, "Produzione di occhiali (lenti, montature, custodie) nella Firenze del '400: i documenti del monastero di S. Brigida al Paradiso, Parte I: 1452–1474,"*Atti della Fondazione Giorgio Ronchi* LVIII/5 (2003), pp. 695, 699.

72. For the life of St. Bridget, the foundation of the Order, and a summary of its Rule, see B. Morris, *St. Birgitta of Sweden* (Woodbridge, UK and Rochester, N. Y., 1999), especially chap. 7.

73. ASF, Monastero di S. Brigida detto del Paradiso, *Entrata e uscita*, F. 148, fol. 46^{r}, 25–30 Oct. 1459, sold by friar Zanobi in Mantua for the merchant Antonio as noted in more detail on 30 May 1460, fol. 54^{v} and on 28 Jan. 1461,

Regrettably, neither the Table nor the complete set of eyeglass accounts known to date gives us precise production figures or unit prices except for a few entries. We have the prices per pair only in the following instances: s.12 and s.12.5 (1453); s.16 d.4 and s.11 (1454); s.22 (1455); s.12.8 (sold in Rome, 1463); and s.9, two sales to the sisters of San Piero Maggiore in Florence (1463), and s.9 for two pairs with cases for the abbess of San Maseo in Pisa (1467).[74] Spectacle cases were sold for s.2 d.6 for up to one dozen (1465) and s.2 each in a sale of 108 cases (1465).[75] As it can be seen, the most common price per pair was around s.12 with the sisters in San Piero Maggiore and the abbess in Pisa perhaps getting a discount from a monastery ruled by women. Apparently prices were mentioned in these sales of spectacles because they were special orders, requiring better materials and extra care in the production process.

Since the records show that the only material purchased for the frames was horn, most likely cattle horn, the main variables in pricing would have been the quality and clarity of the glass and the more meticulous grinding and polishing of the lenses. The expense accounts, however, throw no light on the quality of the materials. They simply recorded expenditures for *vetri d'ochiali, vetro per fare hocchiali, ochi di vetro* ("glasses for spectacles, glass to make spectacles, eye-glasses"), and *corno per fare occhiali* ("horn to make spectacles").[76] There is one entry for "thirty-one pairs of glasses from Germany," costing s.20, s.0.645 a pair, for friar Tomaso, one of the spectacle makers.[77] These were surely glass disks or blanks imported from Germany probably because they were easier to shape and grind into desired curvatures for lenses. A century later (1589) the well-informed Garzoni stated flatly: "The glass easiest to work with and one that is more suitable for various curvatures, is without doubt the German. The glass made at Murano is second, but it is harder to work with; and rock crystal is the hardest of them all."[78] This entry seems to signify that these characteristics of German glass were already known in the middle of the preceding century, and once again testifies to the availability of types of glass imported from distant centers for a variety of purposes. But this must remain another supposition because the character and quality of the materials were not recorded in these books and there is no indication that crystal was used for the lenses.

F. 149, fol. 2^{r}. (For some unknown reason, in this case the friar is acting as a carrier for the merchant). For Vicenza, see ibid., F. 149, fol. 11^{r}, 14 Dec. 1461; for Rome, ibid., fol. 25^{r-v}, two sales, 21 Apr. 1463 (Guidotti, "Produzione di occhiali," pp. 695–96; for the sale in Portugal, see above ch. IV, pp. 125–26).

74. F. 148, fols. 12^{r-v} (1453); 14^{v}, 15^{v} (1454); 16^{r} (1455); F. 149, fol. 25^{v} (1463); 33^{r-v} (1463); and F. 147, fol. 86^{r} (1467) (Guidotti, "Produzione di occhiali," pp. 692–93, 698).

75. F. 149, fol. 50^{v} and 52^{r} respectively (Guidotti, "Produzioni di occhiali," p. 699).

76. F. 148, fols. 127^{v}, 130^{r}, 131^{v}, 161^{r} (1454–1457).

77. Ibid., fol. 132^{r}, 11 Nov. 1454: "A paia trentuno di vetri di Magna si comperarono per frate Tomaso . . . per tutto soldi venti; comperò frate Zanobi."

78. T. Garzoni, *Piazza universale di tutte le professioni del mondo*, vol. I, Discorso LXIIII, "*De' vetrari, o biccherari, occhialari, et finestrari,*" p. 658: "Il vetro poi più acconcio al lavorare, et che fa anco più viste, è senza dubbio il tedesco. Il secondo è quel da Murano, ma è più duro da lavoro; il christallo di montagna è il più duro di tutti."

Spectacles with crystal lenses, especially ones with quartz crystal, would have cost much more, about s.60 or more each, as we have noted elsewhere.[79]

Considering the lack of specificity in production levels and unit pricing, we can only make some rough estimates pending the discovery of additional evidence. Perhaps we would not be straying too far from reality if we surmise that the most common type of eyeglasses produced by the friars would have had glass lenses of moderate quality, fetching a price of about s.7 a pair, the unit price charged for those sent to the Sforza court in the middle of the century. Accordingly, there was no need to register the quantity and unit price in each of the entries except for the special cases noted above. Extending our speculation further, we could divide by s.7 the total net income shown in the Table for the period 1454-60 (£248 s.12 = s.4,972), and tentatively establish a total production of 710 pairs for the 5-year and three-month period.[80]

Admittedly, this total is not comparable to the thousands of spectacles produced and exported by merchants in one or more transactions in a single year at this time. On the other hand, we have to keep in mind that in this limited period only in 1459 were the three friars active at the same time. In other years the two ordained friars, Martino and Tomaso (and in 1456 only Martino), were making glasses while also attending to their ministerial duties.[81] Furthermore, they were not likely to be driven by the profit motive. Assigning a less conservative unit price, of course, would result in a higher production figure. At any rate, despite their limitations, these spectacle accounts remain the only such records of this magnitude in fifteenth-century European monastic history, and they rival in scope and extent, but not in specificity, the customs and commercial accounts of the age. It is not known whether other Birgittine monasteries in Italy and elsewhere made glasses and, in fact, literature about the Paradiso monastery does not mention spectacle making at all.

If Florence with such an abundance of commercial account books cannot provide more exact estimates of the magnitude of its extensive spectacle-making industry, what can we say of other major centers such as Venice where such records for this period are nonexistent? Surely the many thousands of spectacles distributed throughout Europe at this time occasionally needed lens replacements and frame repairs, which would have to be provided locally in most cases. The inescapable conclusion, already stated in preceding chapters, should be reiterated here: adequate eyeglasses were made in significant quantities throughout Europe by local artisans working with native or imported materials although available documentation precludes even gross estimates of production figures.

Despite these uncertainties, some of which may be cleared by the discovery of additional documents, one overriding fact emerges from the above evidence: by the end of

79. See chap. III, pp. 85–86.

80. For details of these calculations, see Appendix II, p. 259.

81. The entries for each year in F. 148 list the names of the friars making spectacles.

the fifteenth century, Florence and similar urban areas were awash with eyeglasses in varying degrees. Perhaps there is no better way to illustrate their pervasive use than to cite two sermons delivered in Florence by the most famous preacher of that century, the Dominican Girolamo Savonarola. Both of them discussed eyeglasses at length, focusing on their symbolic and metaphorical aspects. In the first, delivered in the cathedral in December 1494, the preacher exhorted Florentines to wear good and clear spectacles so that they could see clearly the common good for the reform of the government following the expulsion of the Medici from power. They were to shun spectacles with colored lenses, which signified passion and corruption. Only one page of the total eleven printed pages comprising this sermon was devoted to spectacles, but it demonstrated a fair understanding of the function of reading glasses with convex lenses. "There are those who see little," he declared, "and so they wear glasses to see better because through spectacles small letters appear bigger. This is because the species [images] of the letters that enter the eye by means of the active light [lume] strike on the glasses and here they spread, widen, and appear bigger."[82]

Two years later (November 1496), he delivered a very long sermon at San Marco, "On the Art of Dying Well," comprising thirty-five pages in print, four of which were devoted to eyeglasses, again with a symbolic and metaphorical meaning. It was a common theme, in medieval and Renaissance sermons and devotional literature to stress the imperative of leading a good life as the best preparation for the inevitable death and the attainment of salvation through faith sanctified by God's grace. Meditation on death and on the afterlife taught the faithful that the pursuit of earthly goods and pleasures distracted them from the true good and salvation. Savonarola advised that one way to escape this distraction was to wear "eyeglasses of death" (*occhiali della morte*). With good spectacles one would clearly see what was good; with poor ones, the contrary. Eyeglasses with yellow lenses showed everything yellow, the color of envy and avarice; with red ones, one saw red, symbolizing anger and vengeance. The emphasis was on the quality of these "spiritual" glasses for a clearer vision of temptation and death. Since they tended to fall often, Savonarola advised that it was necessary to attach them to a cap with a clasp, as he probably had learned from personal experience.[83] But for this particular audience, he

82. G. Savonarola, *Prediche italiane ai fiorentini*, vol. I, *Novembre e Dicembre del 1494* (Perugia-Venice, 1930), Predica Sestadecima, 17 Dec. 1494, pp. 227–238: "Sono alcuni che veggano poco e però tolgano gli occhiali per vedere meglio, perché mediante l'occhiale la lettera piccola si demostra maggiore e questo nasce perchè le spezie delle lettere che vengano all'occhio mediante el lume percuotano nello occhiale e quivi si diffondano e si dilatano e paiano maggiori." (p. 233).

83. "Se tu hai adunque buoni occhiali, lo intellecto tuo vedrà sempre bene, e così e *contra* se tu li arai cattivi. . . . Li occhiali gialli sono li fantasmati della invidia, o vuoi della avarizia. . . . Li occhiali rossi significano adunque l'ira e la vendetta. . . . Tu hai intesa questa regola delli occhiali della morte; ma perché li occhiali cascano spesso, bisogna metterli la berretta o qualche uncino, per attaccargli che non caschino." (G. Savonarola, "Dell'arte del ben morire, fatta a dì 2 di novembre 1496," predica XXVIII, in *Prediche sopra Ruth e Michea*, ed. V. Romano, vol. II (Rome, 1962), pp. 262–97, quotations pp. 379–80, 382).

had a simpler explanation of the operation of spectacles: "He who reads with spectacles has an open book in front of him and the spectacles between his eyes and the book; and by means of the active light (*lume*), the species or images of the letters travel to the spectacles and from the spectacles to the eyes."[84]

These five pages in the two sermons do not represent the first use of eyeglasses in a symbolic or metaphorical sense, as I have noted earlier, but they constitute the longest such use as far as I can gather. As an eloquent and charismatic preacher, who had a towering influence in the political and social life of the Florentine Republic for three years before his execution in 1498, Savonarola knew his audience—"men and women of all ranks and conditions, although assuredly most of them were lay people of modest station and education."[85] How could he have held the attention of such an audience for this long, symbolic discussion of spectacles if he had not been certain that the subject was thoroughly familiar to them? Unfortunately we have no portrait of Savonarola wearing or holding a pair of spectacles, and none of his glasses survived the dispersal and destruction of his personal goods following his execution. This robs us of the opportunity to examine them for the power of the lenses and the composition of the frames.[86] With his rather prominent, humped nose, he certainly needed a clasp under the cap to hold them in place especially if he wore a rivet-type frame. His grandfather, Michele Savonarola, a practicing physician, author of medical treatises, and professor of medicine at the University of Ferrara, had the same nasal features but wore glasses with a round bridge frame resting on the upper nasal bone (Fig. 38).[87]

It is likely, however, that Savonarola could have delivered the above sermons in many other cities in Italy and elsewhere with varying degrees of familiarity with spectacles among his listeners. But the fact that he chose to speak at such length on this subject in Florence, rather than earlier in other centers, may be more than a coincidence. It may be another indication of Florence's prominent place in the manufacture and commerce of spectacles during the fifteenth century, at least. It seems that this role may have slipped away from Florence during the sixteenth century, as it can be gathered from Garzoni's statement that during his time "perfect" eyeglasses were made in France and Venice,

84. Ibid., p. 379: "Colui che legge con li occhiali, ha dinanzi el libro aperto e li occhiali tra li occhi e il libro, e il lume, per la cui virtù, le specie, ovvero similitudine delle lettere, vengono allo occhiale e da lo occhiale a l'occhio."

85. D. Weinstein, "*The Art of Dying Well* and Popular Piety in the Preaching and Thought of Girolamo Savonarola," in T. Marcel, R. G. Witt, and R. Goffen, eds., *Life and Death in Fifteenth-Century Florence* (Durham, 1989), p. 90. The entire article, pp. 88–104, provides a perceptive analysis of this sermon in the context of his preaching and ideology. For the friar's thought and influence in Florence, see Weinstein's fundamental book: *Savonarola and Florence: Prophecy and Patriotism in the Renaissance* (Princeton, 1970).

86. At the San Marco Museum, the surviving personal possessions of the friar do not include his spectacles. See G. Rasario, "Savonarola e le sue 'reliquie' a San Marco," in *Savonarola e le sue 'reliquie' a San Marco. Itinerario per un percorso savonaroliano nel Museo*, eds. M. Scudieri and G. Rasario (Florence, 1998), pp. 52–59.

87. His portrait painted in 1455 by an unknown artist hangs in the Biblioteca dell'Archiginnasio in Bologna.

38. Anonymous, *Portrait of Michele Savonarola*, 1455, Biblioteca dell'Archiginnasio, Bologna.

limiting himself to single out two famous spectacle makers in Venice—Lorenzo and Pietro in Merceria. He did not mention Florence.[88]

Why Florence?

As I have noted earlier, this hitherto unsuspected prominent role of Florence in the production of quality eyeglasses is attested by an abundance of sources outside Florence itself, beginning with the Milanese ambassadorial correspondence of the middle of the fifteenth century. The huge mass of Florentine archival commercial records, only recently partially combed for new evidence, confirms and adds a great number of crucial details about what we had already learned years earlier from non-Florentine archives. This fact is significant in the context of the long-held view of Venetian pre-eminence in

88. Garzoni, *La piazza universale*, Discorso LXIIII, Vol. I, p. 658: "In Francia se ne fanno de'perfetti, et così a Venetia, dove in Merciaria si trovano i maestri di questo mestiero, fra quali al presente son famosi Lorenzo occhialaro all'Occhial grande a San Salvatore, et Pietro occhialaro all'Angiolo a S. Giuliano."

this field, which has been accepted on the basis of a few documents of the fourteenth and sixteenth centuries. As it now seems clear that this Florentine leadership was confined mostly to the fifteenth century, we must ask the question: what forces were at work in Quattrocento Florence to make it a leader in this field? It is a question that has intrigued all of us who have become interested in the early history of spectacles. It is time now to reflect again on this topic, refine views previously stated in my earlier publications in the light of the new documents discovered in the last four or five years, and propose new hypotheses.[89]

Florence had a fast-developing glass industry, whose origin goes back at least to the early thirteenth century. The bulk of it was concentrated in the hill towns of the Valdelsa (Gambassi, Montaione, Colle di Valdelsa, San Gimignano and others), a region with abundant resources of oak trees to fuel the glass furnaces while sand for the glass mixture came from the Arno and the Pisan beaches. Over the centuries Colle di Valdelsa came to specialize in the production of crystal, so that at the present it produces 95% of the crystal in Italy and 14% worldwide.[90] Recent archival and archeological studies have documented the existence of at least nineteen centers of glass production in Tuscany by the end of the fifteenth century, the largest such concentration than in any other region in Italy. Like other prominent glass production centers such as in Altare above Genoa, and unlike Venice, its workers (often designated collectively as *gambassini*) were free to emigrate and set up glass furnaces elsewhere, which they did in Italy from Sicily to Lombardy and in several countries in Europe.[91] Largely through the efforts of these immigrants, Milan became an important center of glass products of common use in the fifteenth century and even rivaled Venice in the following century as an exporter of luxury objects ornately carved out of rock crystal extracted from the nearby Swiss Alps.[92] This is yet another illustration of the migration of expert technicians spreading processes and techniques of production although the most valuable techniques were kept and transmitted orally within the family.

89. I have attempted to answer this question in my articles, "Renaissance Florence," pp. 532–41, and less extensively in "Firenze capitale degli occhiali," pp. 208–09.

90. See A. Pansera, "Colle Val d'Elsa o del 'progettare cristallo," and M. Galgani, "La produzione di vetro preindustriale a Colle e in Valdelsa," in *Colle di Val d'Elsa, la città del cristallo,* ed. S. Pacini (Colle di Valdelsa, 2001), pp. 8–15, 36–43, respectively. The recently established Museo del cristallo at Colle is the only museum in Italy devoted to crystal. It is worth a visit!

91. For a good summary of the latest findings about glass production in Valdelsa and the diffusion of glass furnaces throughout Italy from this region, see now M. Mendera, "Produrre vetro in Valdelsa: L'officina vetraria di Germagnana (Gambassi –FI) (Secc. XIII–XIV)," in *Archeologia e storia della produzione del vetro preindustriale,* ed. M. Mendera (Florence, 1991), pp. 15–50. See also M. Spallanzani, "Un progetto per la lavorazione del vetro in Mugello nel secolo XV," *Archivio stor. Italiano* CXL (1982), pp. 569–602. For Altare, see M. Calegari and D. Moreno, "Manifattura vetraria in Liguria tra XIV e XVII secolo," *Archeologia medievale* II (1975), pp. 22–26.

92. M. P. Zanoboni, "Giovanni da Montaione e la manifattura vetraria a Milano," *Arch. Stor. Lombardo,* ser. XII, VI (2000), pp. 43–66, and P. B. Conti, "Note a margine del 'Mailänder Briefe . . .' di H. Simonfeld. Gli Scala e altri cristallieri 'milanesi'," ibid., V (1998–1999), pp. 545–62.

Glass production was promoted and protected by the Florentine state already from the beginning of the fifteenth century. After 1434 the Medici strengthened this mercantilist policy in an effort to ensure a native supply of utilitarian products such as drinking glasses, bottles, fiaschi, etc., and promote the export of the surplus out of the region. No other Florentine industry was similarly protected from outside competition.[93] Although the sources do not make specific mention of the production of optical glass or crystal suitable for spectacle lenses in the fifteenth century, it can be assumed that some of the native clearest glass was selected for such purposes. The exemption of Venetian crystal from import restrictions is also significant in this context. Moreover, glass blanks for spectacles lenses could have been imported, as the above-cited records of the S. Brigida monastery show regarding such imports from Germany.

It is clear that Florence had a skilled workforce of major proportion for its glass industry. Some of these glassworkers, most of whom were called *bicchierai* (drinking glass makers), from whose ranks the spectacle makers are believed to have sprung, may have developed an advanced method for a more precise grinding and polishing of blanks to produce convex lenses graded for semi decades as well as concave lenses for two degrees of myopia as requested in the Milanese order of 1466. It is not known to what extent the Medici promoted and sponsored these innovations for personal reasons because myopia ran in the family. Pictorial and archival evidence, however, can only establish this condition for five of them: Lorenzo the Magnificent (1469–92) and his son Giovanni (later Pope Leo X, 1513–21), Ferdinand I (1549–1609), and the two queens of France, Catherine (1519–89) and Maria (1573–1642). It is known, however, that many members of the family had large protruding eyes, a condition sometimes indicative of myopia, and so did the Tornabuoni family, related to the Medici by marriage, including Lucrezia, wife of Piero di Cosimo. Yet we have no pictorial representation of a Medici person either holding or wearing eyeglasses, except for Leo X's portrait by Raphael showing him holding a framed concave lens for distance viewing as mentioned above.[94]

From the middle of the sixteenth century the grand dukes spared no expense in attracting some of the finest Venetian glassmakers to foster the production of artistic vessels, mirrors, and fine quality optical glass for telescopes and microscopes in open rivalry with the glassmakers in Murano. Perhaps even earlier, the art of mirror making

93. Taddei, *L'arte del vetro*, 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 pure sembrerebbe non dovesse avere, nell'economia dello stato, grande rilievo" (p. 26).

94. G. Pieraccini, *La stirpe de' Medici di Cafaggiolo*, vol. III, pp. 59–66, for the vision problems affecting the Medici. One of Lorenzo's letters of 1479 again attests to his use of spectacles (Lorenzo de' Medici, *Lettere*, vol. IV (1479–1480), ed. N. Rubinstein (Florence, 1981), p. 165. The well informed contemporary chronicler, Bartolomeo Cerretani, reported in his *Storia fiorentina*, ed. G. Berti (Florence, 1994), p. 186, that Lorenzo "era grande, bella persona, brutto viso, la vista corta, le charne nere così e chapelli. . . ." It is interesting also that a few hours before Lorenzo's death in 1492, an attending friar at his bedside used a pair of spectacles placed over Lorenzo's mouth to ascertain that he was still breathing (p. 184).

had also been stimulated by the return of Florentine and Italian workers, who learned to make lead-backed mirrors in Germany and practiced this trade in Florence according to two Florentine carnival songs of the sixteenth century.[95] This effort was intensified in the early years of the seventeenth century as the grand dukes sought to make Florence the Mecca for all kinds of talent, attracting to their court intellectuals of all disciplines and leading practitioners of the mechanical arts from everywhere in Italy and Europe. Among the finest Venetian glassmakers that settled in Florence were Bortolo d'Alvise and the brothers, Jacomo and Alvise Della Luna.[96] Glass furnaces and other laboratories in various arts were established in the Medici Palace, the Boboli gardens, and the Casino in Via San Gallo.

From the third decade of the seventeenth century, Florence was producing better quality optical glass and lenses than those available in Venice itself. Florentine glass-blowers invented new and more accurate methods of shaping glass by means of the controlled flame of oil lamps, and working under the direction of scientists like Galileo and Evangelista Torricelli, they constructed instruments such as alcohol thermometers and mercury barometers with exact gradation.[97] It was, indeed, an early example of state controlled enterprises closely supervised by the grand dukes themselves, who were the only princes in Italy at this time that had the necessary financial resources. Some of

95. Giovambatista Gelli, "Canzona de' maestri di far specchi:" "Donne, se ben per l'abito mostriamo / esser di molto lunge e stran paese, / nativi pur di vostra terra siamo; / onde co' figli e ogni nostro arnese / a Fiorenza torniamo, / poiché ciascun di noi per fama intese, / ch'è quel ch'assai ne piace, / ch'è oggi, più che mai fu giustizia e pace. // La Magna abbiáno assai tempo abitato, / ai panni, al volto, all'arte il conoscete; / ivi imparammo e qua n'abbián recato / l'arte del far gli specchi che vedete; // . . . de'vetri lavorati / fate dunque d'avere e piombo in carte: / come s'appicchi dreto / vel mostrerem, ma in luogo piú secreto. // Vuol esser bianco il vetro e ben pulito / dinanzi e dreto, il piombo puro e netto, / perché poi l'un l'altro insieme unito / rendin miglior lo specchio e piú perfetto / . . . ." in C. S. Singleton, *Canti carnascialeschi del Rinascimento* (Bari, 1936), pp. 351–53. In another song, "Canto degli specchiai," by Antonfrancesco Grazzini, the migrant workers mention their Italian origin and their settling in Florence after having learned the trade in Germany: "Donne, di far gli specchi, / come si può veder, maestri siamo, / ch'oggi in Firenze a lavorar vegnamo. // 'Talian sián tutti quanti per nazione, / né perso ancor l'abbiamo, / benché nella Tedesca regione, / chi nati, e chi gran tempo stati siamo; / e di lá ne portiamo / un mestier sí mirabile e sí bello, / che non ha 'l mondo paragone a quello. // Noi ci vogliam fermare in questa parte, / dove è sí bella stanza, / e mettere in Firenze la nostra arte, / che tutte quante l'altre al mondo avanza; . . . //" ibid., pp. 407–09.

96. These intense efforts by the grand dukes have never been evaluated in a systematic way by researchers. For brief treatments, see Taddei, *L'arte del vetro*, pp. 56–72; two articles by R. A. Goldthwaite, "Artisans and the Economy in Sixteenth-Century Florence," in *The Medici, Michelangelo, and the Art of Late Renaissance Florence* (New Haven and London, 2002), pp. 85–93, and "Il contesto economico," in *La grande storia dell'artigianato*, vol. 3, *Il Cinquecento*, ed. F. Franceschi and G. Fossi (Florence, 2000), pp. 9–23. For the seventeenth century, see also P. Malanima, "La Firenze degli artigiani nell'economia toscana," ibid., vol. 5, *Il Seicento e il Settecento*, ed. R. Spinelli (Florence, 2002), pp. 25–36.

97. See two articles by S. A. Bedini, "Lens Making for Scientific Instruments in the Seventeenth Century," *Applied Optics*, 5/5 (1966), pp. 687–94, and "The Makers of Galileo's Scientific Instruments," in *Atti del Symposium internazionale di storia, metodologia, logica e filosofia della scienza, "Galileo nella storia e nella filosofia della scienza"* (Vinci, 1967), pp. 89–115. See also P. Galluzzi, "Il mecenatismo mediceo e le scienze," in *Idee, istituzioni, scienza ed arti nella Firenze dei Medici*, ed. C. Vasoli (Florence, 1980), pp. 189–215, and S. Contardi, "L'artigianato fiorentino al servizio della scienza," in *La grande storia dell'artigianato*, vol. V, pp. 85–100.

them did not disdain to work with their hands alongside the practitioners.[98] It can hardly be a coincidence that a Florentine abbot, Antonio Neri, published in 1612 the first comprehensive manual on all phases of glass production and related processes, based largely on Venetian practices and his own experiments as he worked alongside Venetian masters in Florence, Pisa, and Flanders, but he never visited Venice itself.[99] There were few secrets left to be revealed about glassmaking after the publication of this book, except for the individual techniques employed by master craftsmen, which died with them.

It is obvious that the interests and predilections of the Medici rulers coincided with the needs of the workers. In Florence, a city of artisans par excellence, one can hardly imagine an artisan working past the age of forty without using magnifying lenses and/or spectacles not to mention the minority of them needing concave lenses for distance. Vasari speaks of eyeglasses metaphorically in connection with the use of wax moulds made of the cavities to be designed by engravers or carvers working on metals, cameos, precious stones, and most commonly crystal.[100]

Among the artisans, in fact, artists would have been particularly interested in improving the quality of vision aids and, in the process, of vision itself. It has long been established that in the first quarter of the fifteenth century Florentine artists "rediscovered" the principles governing linear central point perspective by the application of geometric optics based on Euclid's *Elementa*, transmitted and developed by Alhacen and his followers in the thirteenth century, Bacon, Pecham, and Witelo. Moreover, most of the Greek and earlier Arabic writings on optics, whether used or not by Alhacen, were available in Latin translation by the late thirteenth century, and by the middle of the following century Alhacen's *De aspectibus* appeared in an Italian translation by an unknown author.[101] This translation was literally copied by the Florentine sculptor, Lorenzo Ghiberti, in the third section of his *Commentarii* (1448–54), along with Italian translations of other ancient and medieval optical sources. Ghiberti, however, was primarily interested in the anatomy and physiology of the eye for a deeper understanding of the process of vision and the certification of images through measurements, calculations, and comparisons

98. This practice by grand duke Cosimo II and his son, Francesco, was reported by Venetian ambassadors in Florence. See relations by Andrea Gussoni (1576), and by Giovanni Michiel and Antonio Tiepolo (1579) in *Relazioni degli ambasciatori veneti al Senato*, ed. A. Segarizzi, vol. III, part I (Bari, 1916), pp. 207–41 and 243–82, respectively.

99. A. Neri, *L'Arte vetraria 1612*, ed. R. Barovier Menstasti (Milan, 1980). The introduction, translated into English by M. Pellegrini, is full of information about Neri's activities

100. G. Vasari, *Le vite de' più eccellenti pittori scultori e architettori: nelle redazioni del 1550 e 1568*, vol. IV, ed. R. Bettarini and P. Barocchi (Florence, 1996), "Vite di Valerio vicentino, di Giovanni da Castel Bolognese, di Matteo dal Nasaro veronese e d'altri eccellenti intagliatori," pp. 620–30: "Costoro apersono la via a quest'arte tanto difficile, poiché intagliando in cavo, che è proprio un lavorare al buio, da che non serve altro che la cera per occhiali a vedere di mano in mano quel che si fa, . . ." (p. 620). See pp. 700–01 for an explanation of this metaphor relating to wax moulds helping engravers to "see" as if they had used spectacles.

101. See *Alhacen's Theory of Visual Perception*, ed. A. Mark Smith, vol. 1 (Philadelphia, 2001), pp. lxxx–lxxxi, and p. clx for the Italian translation in one manuscript at the Vatican Library.

of shapes and distances. This interest led him to highlight reflection in mirrors of various shapes and hint that the eye functioned like the *camera obscura* in projecting images. Following Pecham, he mentioned presbyopia, myopia and the use of magnifying lenses, but the word *occhiali* does not appear in his *Commentarii*.[102]

Finally, the arrival in Florence of Ptolemy's *Geographia* in 1400, and its translation into Latin five years later, spurred interest in the prospective projection of map-making and the use of the Ptolemaic grid to determine space, scale, and distances in artistic compositions.[103] The dissemination and popularity of the *Geographia* can be gauged by the fact that at least twelve editions were published by 1515, when Ptolemy's other major work, *Almagest*, was first printed.[104] In the following quotation, Jim Bennett has eloquently commented on the influence of this book and the consequent increased use of observational and measuring instruments among mathematical practitioners first in Florence and later elsewhere:

> *The manipulation and representation of three-dimensional spatial properties proved to be a powerful technique—not only in the usual mathematical sense that it had applications to many different problems, but also because it gave practitioners an impressive ability. They could condense estates, provinces, countries, empires to sheets of paper. These could be handled and reviewed immediately and directly, yet encoded in their geometry were the spatial relationships of the originals, and the consequences of these relationships could be extracted by the practitioner. He could present the whole earth and even the heavens to a single view, and could form and reform the representation of the terrestrial or celestial sphere through alternative projections. It was a skill appropriate to the European culture of the age, concerned with exploration and expansion in addition to more traditional territorial definition and representation.*[105]

While these Italian translations served to propagate optical theories in artisan circles in Italy, intellectuals such as Biagio Pelacani da Parma (ca. 1347–1416) were probably the most direct source for their dissemination in the learned world. He taught medicine

102. It has been established that only about one hundred pages or 2% of the *Commentarii* can be regarded as the original contribution by Ghiberti, and these pages have nothing to do with perspective, according to the latest research summarized by D. Raynaud, "Le fonti ottiche di Lorenzo Ghiberti," in *Nel segno di Masaccio*, pp. 79–86. See also three chapters in *Lorenzo Ghiberti nel suo tempo*, vol. II (Florence, 1980) by G. Federici Vescovini, "Il problema delle fonti ottiche medievali del *Commentario Terzo* di Lorenzo Ghiberti," pp. 349–87; D. Gioseffi, "Il *Terzo Commentario* e il pensiero prospettico del Ghiberti," pp. 389–405; and C. Maltese, "Ghiberti teorico: i problemi ottico prospettici," pp. 407–19. For his treatment of reflection and mirrors, see *I commentarii*, ed. L. Bartoli (Florence, 1998), especially pp. 233–47. In a convulated way he mentioned presbyopia and myopia (pp. 181–82), and magnifying lenses for the elderly (p. 293).

103. S. Y. Edgerton, Jr., *The Heritage of Giotto's Geometry: Art and Science on the Eve of the Scientific Revolution* (Ithaca and London, 1991), pp. 150–54.

104. J. Bennett, "Projection and the Ubiquitous Virtue of Geometry in the Renaissance," in *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, ed. C. Smith and J. Agar (London, 1998), p. 30.

105. Ibid., p. 28.

at Pavia and Piacenza from 1374, and philosophy and astrology at Bologna up to 1388 and also at Padua in various periods from 1377 to 1411. (It may be significant that Witelo studied canon law at the University of Padua in the years 1262–68 and apparently began his study of optics there as well.)[106] In 1388–89 Pelacani was teaching at the *Studium* in Florence and taking part in the erudite conversations held among Florentine intellectuals at the *Villa del Paradiso degli Alberti*, which a few years later became a Birgittine monastery with an active spectacle-making shop—seemingly a mere coincidence with no known optical significance at all. In his lectures at various universities, which appeared in several treatises from 1377 to 1397 (*quaestiones perspectivae, quaestiones de latitudine formarum, quaestiones dialecticae, quaestiones physicorum*), Pelacani underlined Alhacen's mathematical approach to vision. He discussed the practical geometric method of measuring distances and proportions in things seen and drawn including the use of mirrors as aids to "certify" vision.[107] Likewise, the Sienese painter/architect/engineer, Francesco di Giorgio Martini (1439–1501/2), followed the same advice in his treatise, "Geometry and Methods of Measuring Distances, Heights and Depths." It is known that his precepts had considerable influence on Leonardo.[108]

Actually, many of the mathematical and geometric ideas of Greek-Arabic origin were already taught in the secondary schools of Italian towns—the so-called abacus schools—frequented by children for two or three years from about the age of ten before undergoing more advanced training either in the artisan shops or at the universities. The generally recognized founder of this *abachist* instruction was the Pisan mathematician, Leonardo Fibonacci (ca. 1170–ca. 1250), whose writings—*Liber abaci* (1202), *Practica geometriae* (1220), *Flos* (1225), and *Liber quadratorum* and some other treatises now lost—heavily influenced instructional manuals. He introduced Hindu-Arabic numerals and decimals to the West along with the solution of practical problems in calculating volumes, distances, height of towers and of other inaccessible places, proportions, coin and weights conversions, and all sorts of other measurements and calculations useful in the daily activities of merchants and artisans. Florence became one of the leading centers in Europe in this practical mercantile/artisan education along with Venice, in

106. *Book V of Witelo's Perspectiva: an English Translation with Introduction and Commentary and Latin Edition*, ed. A. Mark Smith (Warsaw, 1983), p. 16.

107. For Pelacani's theories, see now four publications by G. Federici Vescovini, " Le Questioni di 'Perspectiva' di Biagio Pelacani da Parma," *Rinascimento*, 12 (1961), pp. 163–243; "La prospettiva del Brunelleschi, Alhazen e Biagio Pelacani a Firenze," in *Filippo Brunelleschi: La sua opera e il suo tempo*, vol. I (Florence, 1980), pp. 333–48; "Biagio Pelacani da Parma e l'impostazione gnoseologica delle sue questioni di prospettiva," in her collected studies, *Studi sulla prospettiva medievale*, 2nd ed. (Turin, 1987), pp. 239–72; and "Biagio Pelacani: filosofia, astrologia e scienza agli inizi dell'età moderna," in *Filosofia, scienza e astrologia nel Trecento europeo: Biagio Pelacani parmense*, ed. G. Federici Vescovini and F. Barocelli (Padua, 1992), pp. 39–52, and pp. 181–207 for a list of Pelacani's writings compiled by Vescovini.

108. Francesco di Giorgio Martini, *Trattati di architettura, ingegneria e arte militare, Geometria e modi di misurare distance, altezze e profondità*, vol. I, ed. C. Maltese (Milan, 1967), pp. 117–140; pp. 125–26 for instructions on using the mirror.

whose territory (Treviso) the first printed manual (*Arte del Abbaco*) was published anonymously in 1478.[109]

It could be argued, then, that practically all the theoretical underpinnings and the necessary mathematical knowledge for developing a "new" perspective allowing artists to create exact spatial and depth dimensions, the third dimension, on a finite flat or curved surface through the use of geometry and a vanishing point were present in Europe and especially in Italy by the early fourteenth century. Giotto had already arrived at an empirical or intuitive geometrization of space in the Arena Chapel frescoes in Padua (ca. 1305–06) probably by utilizing commonly known geometric tools taught in the secondary schools. Yet it took another century to fully develop Renaissance perspective in painting. One is reminded that it took several centuries of use of magnifying lenses before someone without any knowledge of optical theory realized that they could be pinned centrally by the handles to make the first pair of spectacles!

It seems that a bridge was needed to connect optical theories and perhaps higher mathematics taught at the universities to pictorial practice. Two intellectuals, both graduates of the university of Padua, appear to have provided the necessary connection — the Florentine physician, mathematician, and geographer, Paolo dal Pozzo Toscanelli (1397–1482) in Florence and his fellow student, the Venetian physician, mathematician, and astrologer, Giovanni Fontana (ca. 1395–ca. 1455) in northern Italy. Fontana wrote and illustrated a treatise, *Bellicorum instrumentorum liber, cum figuris et fictitys litoris conscriptus* (*Book of Instruments of War, written with figures and false letters,* ca. 1420), in which he discussed mirrors, optical "tricks" and magic lanterns among his war instruments. And he had intimate connections with Venetian and northern Italian painting circles, being a friend of Jacopo Bellini (father of Gentile and Giovanni), and father-in-law to Andrea Mantegna. He also dedicated a treatise on perspective (now lost), *Libellus ad Jacopum Bellinum* (ca. 1430), to Jacopo.[110]

In Florence Toscanelli had provided the same function a few years earlier and with more immediate success since he is credited with teaching optical theory to Filippo Brunelleschi (1377–1446), Masaccio (1401–28, probably through Brunelleschi), Leon

109. R. A. Goldthwaite, "Schools and Teachers of Commercial Arithmetic in Renaissance Florence," *Journal of European Economic History,* I (1972), pp. 418–33; and F. Camerota, "Perspectiva pratica," in *Nel segno di Masaccio: L'invenzione della prospettiva,* ed. F. Camerota (Florence, 2001), pp. 19–21, for a succinct summary. For Venice, see F. J. Swetz, *Capitalism and Arithmetic: The New Math of the 15th Century, Including the Full Text of the Treviso Arithmetic of 1478,* trans. D. E. Smith (La Salle, Illinois, 1989). For a perceptive view of the connection between these schools and the world of business and art both from the artists' execution and the public appreciation of artistic productions, see M. Baxandall, *Painting and Experience in Fifteenth Century Italy: A primer in the Social History of Pictorial Style,* 2nd ed. (Oxford, New York, 1988), especially pp. 86–108.

110. Edgerton, *The Heritage of Giotto's Geometry,* pp. 119–25. The manuscript was published by E. Battisti and G. S. Battisti, *Le macchine cifrate di Giovanni Fontana con la riproduzione del Cod. Icon 242 della Bayerische Staatsbibliothek di Monaco di Baviera e la decrittazione di esso e del Cod. Lat. Nouv. Acq. 635 della Bibliothèque Nationale di Parigi* (Milan, 1984).

Battista Alberti (1404–72), and Leonardo da Vinci (1452–1519). An anonymous, brief treatise, *Della prospettiva* (ca. 1460), variously attributed both to Toscanelli and Fontana has special significance in connecting the theoretical and practical artistic worlds of Florence and Venice, both being inspired particularly by the writings of Pelacani. The text was directed to the instruction of an apprentice painter, who was taught the scientific and practical elements of vision in the usual tripartite division—direct, reflected, and refracted. Reflection through plane, convex, and concave mirrors occupies the greater part of the text, fols. 5^r–19^r out of a total of 23 folios. Particular attention was given to the relative placement and spatial relationship of the eye, the object to be observed, and the mirror. Under refracted vision, the author briefly mentioned spectacles for the elderly and for those with "weak vision" (possibly myopes), explaining that the "images [*similitudini*] that pass through the glass of the spectacles, which is more dense than the air, are refracted and show letters larger than they are, so that one can read what was not seen before."[111] There is nothing new either in this view of refracted vision or in the other two sections. The treatise is simply a brief recapitulation of current optical theories for a beginning artist.

Whether Toscanelli was the author of the treatise or not, it is clear that he had learned these theories as a student at Padua and was ready to serve as a consultant on their application when he returned to Florence about 1424. He might have advised Brunelleschi just a few months later when the architect/sculptor/engineer used a twelve-inch square plane mirror to reflect the image of the Baptistery in Florence to be reproduced on his painted panel of the same size, thus establishing single point linear perspective and the vanishing point. Others date the experiment in 1415–16, crediting the architect with an independent discovery on the basis of the optical theories mentioned above.[112] It is also possible, but not definitely established, that Toscanelli may have influenced Leon Battista Alberti in adopting the Ptolemaic grid to design the perspective grid (the framed window or veil), to be used by artists as the best means of organizing space and placing objects and figures in that space as outlined in the latter's treatise *On Painting* (1435–36), the first systematic treatment of perspectivist art.[113] And perhaps

111. P. dal Pozzo Toscanelli, *Della prospettiva*, ed. A. Parronchi (Milan, 1991), pp. xxxi–xlviii, quotation p. li: "Et peró li vecchi et quelli che hanno debile visione usano gli occhiali, perché le similitudini che passano per lo vetro delli occhiali, che è denso più che l'aere, si spezzano et dimostrano la lettera più grossa che non è, la quale può leggere che prima non la vedeva."

112. See L. Vagnetti, "La posizione di Filippo Brunelleschi nell'invenzione della prospettiva lineare: precisazioni ed aggiornamenti," in *Filippo Brunelleschi: La sua opera e il suo tempo*, vol. I (Florence, 1980), pp. 279–306, and G. Arrighi, "Le scienze esatte al tempo del Brunelleschi," ibid., pp. 93–103.

113. The bibliography on the discovery of single point perspective and its application in art is quite extensive. I limit myself to cite two fundamental books with ample bibliographies by S. Y. Edgerton, *The Renaissance Rediscovery of Linear Perspective* (New York, 1975), and *The Heritage of Giotto's Geometry*. For the latest bibliography and various articles summarizing the many contributions on this topic, all accompanied by an abundance of well chosen illustrations, see the collaborative volume, *Nel segno di Masaccio: L'invenzione della prospettiva*, ed. F. Camerota (Florence, 2001).

we should simply add another of Toscanelli's probable but more contested contributions—his later correspondence with Christopher Columbus, which apparently played a role in the mariner's attempt to find a western route to the Spice Islands in the Orient. Clearly Toscanelli served as a catalyst in more than one field of knowledge, though the exact dimension of his role cannot be established with the same mathematical certitude that he cherished.

While Brunelleschi's use of the plane mirror for the purpose mentioned above was probably the first recorded instance, the use of mirrors by artists especially in drawing self-portraits goes back to antiquity according to Pliny. It is reported that Giotto painted himself and Dante with the aid of mirrors.[114] Benozzo Gozzoli painted himself at least three times in his *Procession of the Magi* in the Medici Palace in Florence.[115] Mirror-aided self-portraits were also painted by Alberti, Masaccio, and Domenico Ghirlandaio among others in Italy. In Flanders the use and depictions of mirrors were frequent and it is known that Jan van Eyck painted several self-portraits, but they are more numerous in the sixteenth century with Albrecht Dürer, perhaps, holding the frequency record.[116]

The more easily made and more readily available convex mirrors were sometimes used for self-portraits to take advantage of their distorting properties in order to achieve special effects, such as in Francesco Parmigianino's *Self-portrait in a Convex Mirror,* 1524. Another special effect was demonstrated two centuries earlier by Pietro Lorenzetti, who painted meteor showers in his Passion cycle (ca. 1316) in the Lower Church of San Francesco in Assisi. In this case "each gold star contained a circular convex mirror embedded in its center to lend a convincing twinkle"; in fact, a number of these pieces of glass with silver backing have been found near these frescoes.[117] The capacity of these mirrors to reflect larger scenes was demonstrated by painters when they included them

114. For Pliny and Giotto, see F. Camerota, "L'esperienza di Brunelleschi," in *Nel segno di Masaccio,* p. 27. Recent research has placed doubt on the authenticity of this story. See Y. Yiu, "The Mirror and Painting in Early Renaissance Texts," *Early Science and Medicine,* X/2 (2005), pp. 189–91.

115. C. Acidini Luchinat, "The Medici and Citizens in 'The Procession of the Magi:' A Portrait of a Society," in *The Chapel of the Magi: Benozzo Gozzoli's Frescoes in the Palazzo Medici-Riccardi Florence,* ed. C. Acidini Luchinat, trans. E. Daunt (London, 1994), pp. 363–70. The author noted (p. 367) that one these portraits has "the penetrating fixity of expression often found when self-portraits are executed using a mirror."

116. Vasari, *Le vite,* vol. III (Florence, 1996), p. 130 for "Masaccio," p. 316 for Ghirlandaio, but in the Vita of Alesso Baldovinetti where Vasari noted: [Ghirlandaio] ritrasse accanto a se stesso Alessio Baldovinetti nella cappella de' Tornabuoni in S. Maria Novella." Four self-portraits of Ghirlandaio have been identified as listed by E. Borsook and J. Offerhaus, *Francesco Sassetti and Ghirlandaio at Santa Trinità, Florence* (Doornspijk, 1981), p. 41. For Jan van Eyck, see L. Campbell, *The Fifteenth Century Netherlandish Schools* (London, 1998), pp. 215–17; for additional examples of self-portraits, see J. Pope-Hennessy, *The Portrait in the Renaissance* (New York, 1966), passim, and F. Ames-Lewis, *The Intellectual Life of the Early Renaissance Artist* (New Haven and London, 2000), pp. 209–44. J. Woods-Marsden, *Renaissance Self-Portraiture: The Visual Construction of Identity and the Social Status of the Artist* (New Haven and London, 1998), offers a fuller discussion of autonomous self-portraits only in Italy.

117. The presence of these mirrors was established following a cleaning of the frescoes in 1974. See R. J. M. Olson, "Pietro Lorenzetti's Dazzling Meteor Showers," *Apollo* 149 No. 447 (1999), pp. 3–10, p. 6 for the quotation.

in shops of moneychangers and goldsmiths perhaps as monitoring devices in the same way that close-circuit television cameras are used today in public buildings (i.e., Quentin Metsys, *The Moneychanger and His Wife,* 1514, and Petrus Christus, *Saint Eligius,* 1449).[118]

Alberti encouraged artists to use plane mirrors as aids for their compositions: "*I do not know how it is that paintings that are without fault look beautiful in a mirror; and it is remarkable how every defect in a picture appears more unsightly in a mirror. So the things that are taken from Nature should be emended with the advice of the mirror.*"[119] Much influenced by Alberti, the Florentine-born architect, Antonio di Piero Averlino, known as Filarete (ca. 1400–ca. 1469), borrowed his perspectivist construction techniques such as the use of the window, veil, and mirror-aided observations in his *Treatise on Architecture* (1461–4). Filarete felt that using the mirror made drawing "easier," though he implied that it could be done without it as the following passages demonstrate.

> *If you should desire to portray something in an easier way, take a mirror and hold it in front of the thing you want to do. Look in it and you will see the outlines of the thing more easily. Whatever is closer or farther will appear foreshortened to you. Truly, I think that Pippo di Ser Brunellesco discovered perspective in this way. . . . It is also good to draw with a mirror as I have said. If you have two of them reflecting in each other, it will be easier to draw whatever you want to do, that is, what you wish to portray. . . . The mirror is a good aid in this, because by means of it you can discern very well the lights and shades.*[120]

Leonardo da Vinci was more specific in proffering the same advice: "*I say that when you are painting you ought to have by you a flat mirror in which you should often look at your work. The work will appear to you in reverse and will seem to be by the hand of another master and thereby you will better judge its faults.*"[121] He displayed this technique also in a good number of his drawings, which show an image and its mirror version in its entirety or in portions of it.[122] He even asserted boldly that the flat mirror was the "master of painters" and advocated its use not just as an aid in drawing but also as an integral part of the creative process itself, as the following passage makes clear.

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118. The various uses of convex mirrors by artists has also been discussed by D. Gioseffi, "Complementi di prospettiva, 2," *Critica d'arte* V (1958), pp. 102–05.

119. L. B. Alberti, *On Painting and on Sculpture. The Latin Texts of de pictura and de statua,* ed. and trans. C. Grayson (London, 1972), book II, 46, p. 89.

120. *Filaret's Treatise on Architecture,* trans. John R. Spencer, vol. I (New Haven and London, 1965), B. xxxiii, pp. 305, 315, 308 respectively.

121. *Leonardo on Painting: An Anthology of Writings by Leonardo da Vinci with a Selection of Documents Relating to His Career as an Artist,* ed. M. Kemp, trans. M. Kemp and M. Walker (New Haven and London, 1989), p. 203.

122. K. H. Veltman with K. D. Keele, *Studies on Leonardo da Vinci I: Linear Perspective and the Visual Dimensions of Science and Art* (Munich, 1986), pp. 352–54.

When you wish to see whether your whole picture accords with what you have portrayed from nature take a mirror and reflect the actual object in it. Compare what is reflected with your painting and carefully consider whether both likenesses of the subject correspond, particularly in regard to the mirror. You should take the mirror as your master, that is a flat mirror, because on its surface things in many ways bear a resemblance to a painting. That is to say, you see a picture which is painted on a flat surface showing things as if in relief: the mirror on a flat surface does the same. The picture has but one surface and the mirror the same. The picture is intangible inasmuch as something which appears round and detached cannot be braced by the hands, and the mirror does the same. And if you recognize that the mirror by means of outlines and shades and lights makes things appear to stand out, you, who have among your colours stronger light and shade than those in the mirror, will certainly, if you know how to put them together well, make your picture, also, look like something from nature seen in a large mirror.[123]

Kim Veltman, who has studied Leonardo's extensive use of mirrors, believes that they became an alternative to the perspective window, aptly concluding "that the man of mirror-writing was equally a man of mirror painting."[124] Leonardo also adopted a third alternative in projecting and studying images—the *camera obscura*—which was commonly known at this time and used without lenses or mirrors until later in the sixteenth century. His notebooks contain "no less than 270 diagrams of the camera obscura," accompanied at times by explicit comparisons of its function to that of the human eye, a suggestive idea that he probably borrowed from Ghiberti's *Commentaries*.[125] His intense interest in vision aids for various purposes led him also to design a machine (the *sagoma*, mould or frame) which operated by means of cogs and pulleys for grinding and polishing concave mirrors. The mirrors were to be used for astronomical observations (hint of a reflecting telescope?) as well as for industrial purposes such as heating water in boilers in dyeing factories and pools [*pessciera*], and as burning devices for soldering metals.[126]

123. *Leonardo on Painting*, p. 202. This passage is headed by the title: "How the mirror is the master of painters."

124. Veltman, *Studies on Leonardo da Vinci I*, p. 353. See Yiu, "The Mirror and Painting," pp. 187–210, for additional textual evidence regarding the use of mirrors by Leonardo and other artists.

125. K. Veltman, "Leonardo and the Camera Obscura," in *Studi vinciani in memoria di Nando di Toni* (Brescia, 1986), pp. 81–92, and *The Literary Works of Leonardo da Vinci Compiled and Edited from the Original Manuscripts by Jean Paul Richter, Commentary by Carlo Pedretti*, Vol. I (Oxford, 1977), pp. 133–34, 159, 168–75. For a reconstruction of Leonardo's drawings of the *camera obscura*, see J. H. Hammond, *The Camera Obscura: A Chronicle* (Bristol, 1981), pp. 13–14.

126. *The Literary Works of Leonardo da Vinci*, II, ed. Pedretti, pp. 19–21 and P. Galluzzi, *Mechanical Marvels: Invention in the Age of Leonardo* (Florence, 1996–97), pp. 54–56, 191. It is not clear whether Leonardo would have used concave mirrors as a heat source or conventional wood burning stoves, which he also designed, to heat the water and regulate the hot-cold mix for Duchess Isabella of Aragon's bathtub in Milan as shown in his sketches of 1499 (C. Pedretti, *Leonardo Architect*, trans. S. Brill (New York, 1985), pp. 328–29. On the other hand, Vasco Ronchi believes that Leonardo's probable use of concave mirrors for astronomical observations as noted in the *Codex Atlanticus* would not achieve the desired magnification. See his *Scritti di ottica* (Milan, 1968), the chapter on Leonardo da Vinci, pp. 26–27.

It has been calculated that "Leonardo left ca. 200 drawings of machines or parts of machines related to the making of mirrors."[127]

In addition, Leonardo designed "lamps with lenses" for nocturnal illumination.[128] For a closer observation of the moon, Leonardo advised looking through a convex-concave lens with the concave side close to the eye, resulting in what it known today as a diverging meniscus lens for distance viewing: "Make glasses [*ochiali*] in order to see the moon large," he noted on the first line of his notebook on astronomy.[129] He also claimed to have invented a process for making flexible and unbreakable crystal, apparently having the characteristics of modern plastic or Plexiglas.[130] Perhaps we should add simply as a curiosity that magnifying lenses placed in front of lighted candles were used to intensify night illumination in colonial America and these gadgets can be found in American museums.[131]

It is hardly necessary to add that Leonardo knew and most likely used the most common vision aids of the age, such as spectacles with convex lenses for presbyopia (which he described) as well as magnifying lenses for which he recorded their construction and use.[132] Furthermore, he seems to have made some of his own spectacles judging from the above cited phrase — "make glasses" etc., and another notation referring to the purchase of brass for spectacles, obviously referring to the frame which he was certainly capable of fashioning. He also sketched three men's faces with eyeglasses (ca. 1490) and his miscellaneous notes contain other references to eyeglasses that seem to have escaped

127. See S. Dupré, "Optics, Pictures and Evidence: Leonardo's Drawings of Mirrors and Machinery," in *Early Science and Medicine: A Journal for the Study of Science, Technology and Medicine in the Pre-modern Period* 10/2 (2005), special issue: *Optics, Instruments and Painting, 1420–1720: Reflections on the Hockney-Falco Thesis*, ed. S. Dupré, p. 216. Dupré maintains that "Leonardo was only concerned with the burning properties of concave mirrors, not with their imaging properties" (p. 235).

128. Pedretti, *Leonardo Architect*, p. 327: "Leonardo also designed 'night lights,' not only with ordinary candleholders, candelabra and lamps more or less elaborately decorated, but also lamps with lenses and above all a table lamp whose intensity could be regulated, with an ample reservoir and a screen."

129. *The Notebooks of Leonardo da Vinci*, I, p. 291; continuing his notes on astronomy, he wrote: "If you wish to prove that the moon appears larger than it is when it reaches the horizon, you take a lens convex on the one side and concave on the other and place the concave side to your eye and look at the object beyond the convex surface; and by this means you will have made a true imitation of the atmosphere which is enclosed between the sphere of fire and that of water, for this atmosphere is concave towards the earth and convex towards the fire." For further discussion of Leonardo's attempts to scan the heavens with more powerful lenses, see chap. 6, pp. 239–42.

130. L. Brescia and L. Tomio, "Leonardo da Vinci e il segreto del vetro cristallino, pannicolato, flessibile e infrangibile," *Raccolta vinciana* XXVIII (1999), pp. 79–92.

131. Such lamps can be seen in the American Historical Museum in Amherst, Mass., and in the Historical Museum in Deerfield, Mass. Globes filled with water with candles in front of them were also used to intensify the light. A more elaborate lamp consisting of a candleholder with a 5-inch magnifier attached to an arm was offered on eBay in 2005. These lamps bear no date. Perhaps the designers of these lamps had read medieval and Renaissance optical sources!

132. *The notebooks of Leonardo da Vinci arranged, rendered into English and introduced* by E. MacCurdy, Vol. I (New York, 1938), pp. 234–35, 249 for spectacles and 264 for description of presbyopia; vol. II, p. 166 for construction and use of a crystal magnifying lens.

notice.[133] Particularly interesting is his sketch of a rivet-type pair with strings attached to the upper portion of the handles, presumably to be wound around the ears. Next to this sketch, he wrote: "To know better," which shows his high regard for this humble optical aid for the pursuit of knowledge. It would have made an admirable motto for a spectacle shop then and it would have resonance even today![134] He depicted Ludovico il Moro, Duke of Milan, holding spectacles to his eyes with his left hand in the act of banishing Envy fed by Slander while Justice stands in front ready to protect him with her black robe (ca. 1494).[135] At last, with this allegorical drawing we have the only member of the Sforza ruling family depicted with spectacles despite the fact that Ludovico's father and brother had earlier imported hundreds of eyeglasses from Florence, as we have seen.

On the other hand, one cannot say with certainty that all the machines and processes Leonardo described were original to him or whether they were ever put into practice. Galluzzi and Marinoni, for instance, have demonstrated that some of these drawings were simply "dreams" or imaginary contraptions perhaps to be explored further for eventual realization.[136] These additional explorations, however, may have been recorded in the estimated three quarters of his notebooks that were dispersed and lost after his death. In essence, present judgments on Leonardo's contributions are really based on the approximately 6,500 extant pages of his notebooks, containing "ca. 100,000 sketches, diagrams and drawings."[137] It is also unknown how many of these notebooks or separate sheets were circulating without attribution from the sixteenth century onwards.

Nevertheless, whatever role Leonardo might have played in the improvement of optical aids, we know that other artisans had preceded him in advancing the quality of lenses and mirrors from the beginning of the fifteenth century. It has already been shown that more precisely graduated lenses were available in Florence in the middle of the century, but it would not be surprising if documents were found attesting to their

133. The men's faces are reproduced by G. Lopez, *La roba e la libertà: Leonardo nella Milano di Ludovico il Moro* (Milan, 1982), p. 165. Another interpretation holds that the sketches represented "studies in perspective of the optic and auditory nerves converging within the brain," all of which resulted in drawings resembling the shape of rivet spectacles clamped before the eyes (*Leonardo da Vinci: Anatomical Drawings from the Royal Library Windsor Castle* (New York, 1984), p. 51, and p. 53 for the drawings). For the other references, see *The Notebooks of Leonardo da Vinci Compiled and edited from the Original Manuscripts by Jean Paul Richter*, vol II (London, 1883; repr. New York, 1970), pp. 428, "a support for the spectacles"; 431, "spectacles with the case"; 433, "spectacles"; 437, "brass for the spectacles." I have not made a full search of his notebooks for other references, but I am confident that like many other persons in his time he owned several pairs of eyeglasses and a number of magnifying lenses.

134. Pedretti, *The Literary Works*, I, p. 389, for the sketch and the logo or motto.

135. A. E. Popham, *The Drawings of Leonardo da Vinci* (New York, 1945), pp. 119–20, No. 109B. A better reproduction in color was published by Lopez, *La roba*, apposite p. 254.

136. P. Galluzzi, "The Career of a Technologist," and A. Marinoni, "Leonardo's Impossible Machines," in *Leonardo da Vinci Engineer and Architect* (Exhibition Catalogue) (Montreal, 1987), pp. 41–109, and 111–30, respectively.

137. On Leonardo's use of images, see K. H. Veltman, "Visualisation and Perspective," in *Leonardo e l'età della ragione*, ed. E. Bellone and P. Rossi (Milan, 1982), pp. 185–210.

availability there or elsewhere even earlier. These advances were made possible by the production of purer glass in Venice and the development in the early 1450s of a type of glass so clear as to resemble rock crystal, aptly named *cristallino* by Venetian glassmakers. Glass mirrors became ever popular by the end of the century and were imported by the thousand, as we have noted earlier, but without displacing polished metal mirrors, which continued to be used well into the seventeenth century. The fascinating aspects of mirror images in general were already commonly mentioned in medieval literary sources.[138] Germany (Nuremberg especially) and Venice led the way in the production of glass mirrors, with the latter becoming predominant in the sixteenth century with its famous crystal mirrors.[139] Garzoni mentioned both places, citing German "small" mirrors as being of lesser quality. He described their manufacture in both metal and glass / crystal in some detail as well as their varied shapes and uses from magicians' tricks to surveying, and as aids for the design of buildings and for perspective paintings, the last considered by him as another form of trickery.[140]

It is clear that by the middle of the fifteenth century mirrors of various shapes as well as magnifying lenses and spectacles for close work were commonly available and used by people in all levels of society. It is equally clear, but impossible to quantify, that the improvement of vision through these aids must have led to increased production in all segments of the population from students and scholars to artisans and housewives especially in an age when indoor tasks were performed under mediocre to poor lighting conditions. In addition, we should consider an enhanced level of personal comfort that makes life worth living, for what is more basic to daily existence than clear vision? It is no wonder, then, that artists, who were particularly concerned with the process of

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138. These improvements at this time have been treated by three recent books: B. Goldberg, *The Mirror and Man* (Charlottesville, 1985), pp. 138–42; S. Melchior-Bonnet, *The Mirror: A History*, trans. K. H. Jewett (New York and London, 2001; original French ed. 1994), pp. 13–34, with special attention to France and northern Europe; and M. Pendergrast, *Mirror Mirror: A History of the Human Love Affair with Reflection* (New York, 2003), pp. 54–157 especially. All three give a significant number of instances where mirrors were used by artists during the Renaissance and earlier. For an exhaustive discussion of mirrors in medieval literature, see now the collaborative volume, *Miroirs et jeux de miroirs dans la littérature médiévale* (Rennes, 2003).

139. See L. Zecchin, "Specchi di vetro cristallino," in his *Vetro e vetrai di Murano. Studi sulla storia del vetro*, vol. III (Venice, 1990), pp. 165–69. For the birth of the *cristallino* in Venice around 1450, see his two articles: "Il vetro 'cristallino' nelle carte del Quattrocento," *Vetro e silicati* VII/38 (1963), pp. 21–24, and "Nascita del cristallo veneziano," ibid., XI (1967), pp. 20–23.

140. Garzoni, Discorso CXLV, "De'speculari, et specchiari," in *La piazza*, III (1996), pp. 1090–91: "Servono i specchi finalmente a illuminare i luoghi oscuri, a voltare alcune sorti d'ombre al roverscio di quel sito, in che sono, a misurare con la vista le altezze, le profondità, et le distanze, come ampiamente ne discorre in un suo trattato m[aestro] Abramo Colorni Hebreo, ingegnero del serenissimo duca di Ferrara, a porre in prospettiva, a risguardar le figure, et a tant'altre cose nella professione della prospettiva, che sono degne di somma meraviglia"; p. 1096: "Né i specchiari hanno troppo da vantarsi, perché le lor opere sono fragili come il vetro, et l'honore, et la gloria è tutta apparente, e sofistica, come sono le cose di perspettiva. . . ." Garzoni commented again on this connection between the science of perspective and the art of mirror making in his Discorso XXXV, "De'perspettivi, overo optici", vol. I (1996), pp. 374–75.

vision, should be enthusiastic users of optical aids as the above evidence indicates. And their endeavors could only have been fully appreciated by an audience capable of having clear vision. In fact, a prominent art historian has recently speculated that the use of eyeglasses may already have greatly influenced the character of Trecento Sienese art soon after they became available as the following statement explains:

> *There are no documentary notices connecting the painters of this study with eyeglasses, but the logic of the situation suggests their utility. I have already remarked that the tempera technique required meticulous execution, but the character of trecento Sienese art placed still greater demands on vision. The refinement of halo designs, whether incised or stamped, called for close attention to detail, just as did the rendering of increasingly lavish textiles. I cannot prove my hypothesis, but given the availability of eyeglasses in Pisa (in a convent, moreover, where Simone Martini worked, c. 1319) and in Florence, it is hard to believe that painters did not make immediate use of them. Indeed, were I unduly rash, I might propose that the invention of an aid to vision made a major contribution to the character of Sienese trecento art.*[141]

A parenthetical question for our purposes is whether fifteenth century artists, in addition to using plane and convex mirrors for self portraits and as aids in composition, also used concave mirrors to project images to frame their pictures on or about 1425 as a prominent contemporary artist, David Hockney, maintains with the collaboration of a noted optical scientist, Charles M. Falco. This is a complex matter requiring the expert knowledge of practicing artists, art historians, and optical physicists. From a layman's point of view it can be argued that since artists knew the properties of various shapes of lenses and mirrors, and the image projection capabilities of the *camera obscura,* it would have been a natural progression for them to experiment with these commonly available devices as Leonardo has been shown to have done. If an artist of his caliber advised painters to make the mirror a "master" of their craft, why would other painters fail to take his advice when they were already using the grid to frame a composition, itself an artificial means to help them draw an artificial image in the third dimension to trick the eye? Surely he and most of his colleagues were capable of "eyeballing" an image or a scene and draw it accurately to scale without vision aids, and Leonardo himself condemned those who could not draw without them![142] At the same time he warned that

141. H. B. J. Maginnis, *The World of the Early Sienese Painters* (University Park, 2001), p. 111. One can add that artisans could also have used magnifiers before and after the invention of spectacles.

142. "There are some who look at the things produced by nature through glass, or other surfaces or transparent veils. They trace outlines on the surface of the transparent medium. . . . But such an invention is to be condemned in those who do not know how to portray things without it, nor how to reason about nature with their minds. . . . They are always poor and mean in every invention and in the composition of narratives, which is the final aim of

the eye alone was not a "true judge," but the artist needed to use perspective to verify the accuracy of what was seen.[143]

Indeed, the painter/mathematician, Piero della Francesca (1416?–92), had demonstrated this capability in his *De prospectiva pingendi* (ca. 1472–75), the first systematic mathematical treatise for painters. This treatise greatly influenced Leonardo himself and his tutor in mathematics, friar Luca Pacioli, as shown especially in the latter's *Summa de arithmetica, geometria, proportione et proportionalità* (1494; 2nd ed. 1523). It is really a shop manual and reads like one, so different from the more general humanist treatment of the subject with many classical references written by Alberti. It is full of calculations and instructions for perspectivist constructions without the use of mirrors—just mathematics and geometry. Actually it is surprising that in the last quarter of the fifteenth century he could still write that "many painters" negated the value of geometric perspective to certify images because they did not understand the role played by lines and angles in determining distances and proportions.[144] His mastery of geometric forms and calculations is also demonstrated by his other two treatises, *Trattato d'abaco* and *Libellus de quinque corporibus regularibus.* Surely these publications were meant for practicing artists and for merchants/bookkeepers in the tradition of the schools of the abacus. It is noteworthy, however, that Piero suffered from weak vision in his later career, forcing him to give up painting and concentrate on mathematics. This suggests that his visual problems were of the kind that could not be ameliorated by the use of spectacles or mirrors, which would have been readily available to him in Florence and elsewhere.[145]

Obviously, visual aids served only to facilitate the process without robbing the artists of their ultimate creativity, just as typewriters and word processors today assist novelists and poets but do not make them. If particular Renaissance artists did not make use of them, as some have argued, it had to be a deliberate decision, as in the case of Piero della Francesca. Falco, however, has calculated the various perspective points at which some artists, beginning with Jan van Eyck and Robert Campin in Flanders, shifted the focus of the concave mirror projecting the image. This question has occasioned a series of

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this science," Leonardo as quoted by M. Kemp, *The Science of Art: Optical Themes in Western Art from Brunelleschi to Seurat* (New Haven and London, 1990), p. 163.

143. *Leonardo on Painting: An Anthology of Writings by Leonardo da Vinci with a Selection of Documents Relating to his Career as an Arstist*, ed. M. Kemp, trans. M. Kemp and M. Walker (New Haven and London, 1989), p. 58: "Perspective comes into action when judgement is lacking with respect to things that diminish. The eye can never be a true judge for determining with certainty the closeness of one thing compared to something else when the top of the second thing appears to the eye of the observer to be placed at the same level, unless by the use of the intersection, mistress and guide of perspective."

144. Piero della Francesca, *De prospectiva pingendi*, ed. G. Nicco Fasola (Florence, 1942), Book III, pp. 128–29: "Molti dipintori biasimano la prospectiva, perchè non intendono la forza de le linee et degli angoli, che da essa se producano: con li quali commensuramente onni contorno e lineamento se descrive."

145. For perceptive comments on Alberti and Piero, see J. V. Field, "Alberti, the Abacus and Piero della Francesca's Proof of Perspective," *Renaissance Studies* 11/2 (1997), pp. 61–88.

international conferences and debates without definitive results so far, at least from the point of view of some of the critics.[146]

The fact that comparatively few account books, journals, and shop inventories of artists have survived, in contrast to the extant vast number of such sources in merchant and patrician circles in Florence alone, has made it difficult to ascertain how prevalent the use of vision aids was in the actual practice of the trade. Indeed, treatises and manuals cited above discussed reflection more than refraction with the result that eyeglasses are hardly mentioned, whereas mirrors of various shapes are treated in detail, especially with respect to their practical use. Spectacles were apparently taken for granted, not meriting any particular treatment, especially since no current optical theory had developed to explain their exact function. Were it not for their mention in so many commercial account books, we could get the impression that few artists used them.[147]

Fortunately, the survival of a rather comprehensive and relatively rare expense account book covering only the last half (1542–56) of Lorenzo Lotto's active career is useful in revealing additional clues about shop equipment of a prominent artist. In 1549 he paid the enormous sum of 22 Venetian *lire* for a "big crystal mirror" ordered from Venice to replace a broken one while he was working in Ancona.[148] Since we do not know enough about the dimensions of mirrors and their relative prices for this period, we cannot speculate about the size of this one, but the big sum paid indicates a large size and excellent quality keeping in mind that some mirrors found in glassmakers' inventories a century later cost from ca. 2 to 6 *lire* each.[149] (Andrea Palladio, who was paid 5–6 lire per day to supervise the rebuilding of sections of the Doge's Palace after the destruction caused by the fires of 1577, would have had to work four days to purchase such a mirror).[150] Other disbursements for Lotto's shop included 4 *soldi* for a pair of spectacles, 10 *soldi* for two pairs for distance, 6 *soldi* to repair a spectacle case, 28 *soldi* for a brass

146. D. Hockney, *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters* (New York, 2001), in which Falco supplied the scientific evidence. Falco has published a number of papers and has a website where additional papers and comments are posted: http://www.optics.arizona.edu/ssd/FAQ.html The most persistent critic of the thesis, David G. Stork, has also published several articles in rebuttal with additional papers and comments kept current on his own website: www-psych.stanford.edu/~stork/FAQs.html.

147. The relative scarcity of artists' account books and shop sources has been treated recently by A. Thomas, *The Painter's Practice in Renaissance Tuscany* (Cambridge, 1995), pp. 297–308.

148. L. Lotto, *Il "Libro di spese diverse" con aggiunta di lettere e d'altri documenti* (Venice-Rome, 1969), pp. 138–39: "Adì 5 otobre del 49, die haver mastro Marco profumier in Ancona. . . . Et die haver per un spechio grande de cristallo che mi prestete, el qual fu rotto et jo mandai / a Venezia per un altro, quale fu rotto medisimamente dai barcaroli, che costò in Venetia lire / vintidoi de venitiane." Lotto was reimbursed by the ship owners for having broken the mirror in transit but it is not clear whether he was able to purchase another similar mirror at a later time. I am indebted to Richard Goldthwaite for this reference.

149. See F. Trivellato, *Fondamenta dei vetrai. Lavoro, tecnologia e mercato a Venezia tra Sei e Settecento* (Rome, 2000), pp. 282 (1685), "doi spechi da 36 spianadi, £5 s5;" p. 287 (1689), "1 spechio di quarte 2 in circa con soazea nera di pever, ducati 1 (=£6 s4)." This more expensive mirror was 34 cm in length, one "quarta" measuring 17cm. (ibid., p. VIII).

150. S. B. Datta, *Women and Men in Early Modern Venice: Reassessing History* (Aldershot, 2003), p. 126.

spectacle case for two pairs, plus an additional 6 *soldi* to repair other cases.[151] It should be added that Lotto not only wore spectacles but he also depicted them in at least four of his paintings (Appendix III).

In sum, these few entries in Lotto's account book and the evidence presented above demonstrate that mirrors were used by most or many artists to project images and/or control the accuracy of their visual observations. We can also assert with some confidence that they were commonly found in their shops and that there was nothing secret or mysterious about their use given their frequent mention and availability. In Lotto's case it is difficult to believe that he would have paid such a sum to place a mirror in his shop simply for personal grooming, especially since he was known to have experienced difficulties in earning a living despite his popularity at the time.[152] It is also likely that had he kept an account of his expenses for the first half of his career, we would find other references to mirrors and eyeglasses. It so happens that Hockney and Falco used one of Lotto's paintings, *Husband and Wife* (ca. 1523–24), as confirmation of their theory but they apparently were unaware of the existence of the account book.[153]

Some questions, however, have been raised about the clarity of fourteenth and fifteenth century mirrors in projecting images for artistic purposes, judging from the poor quality of the relatively few samples of such mirrors deposited in museum collections.[154] These reservations cannot be entirely accepted in my view because comparing the clarity of metal mirrors 500 years old and ravaged by time with that of presumably new or fairly new mirrors used by Renaissance artists would not be an accurate comparison. Surely, Renaissance artisans knew how to grind and polish metal mirrors to produce adequate image projections for their needs. Otherwise they would have been constantly frustrated and they would not have advocated their use. Such frustration would have been recorded in the manuals cited above, thus conditioning the advice that artists such as Alberti and Leonardo gave to their fellow practitioners. It is more consonant with the above evidence, therefore, that the mirrors of the age were not perfect but were substantially adequate for artistic practice. On the other hand, the evidence on the use of concave mirrors to project clear images for pictorial compositions seems to be scanty or

151. Lotto, *Il "Libro,"* p. 243, 12 Sept. 1545: "un par de ochiali, £– s4"; p. 254, July 1544, "doi para de ochiali da veder luntano, £– s10," and "conzar la cassa de li ochiali, £– s.6"; p. 255, June 1545, "cassa da ochiali dopij de laton, £2 s8," and "conzar l'altre casse, £– s6."

152. On this question, see especially B. Berenson, *Lorenzo Lotto* (London, 1956), pp. 143–60.

153. D. Hockney and C. M. Falco, "Optics at the Dawn of the Renaissance." Paper delivered at the 8th International Conference on "Education and Training in Optics and Photonics," Oct. 6–8, 2003, pp. 2–4.

154. See S. J. Schechner, "Between Knowing and Doing: Mirrors and Their Imperfections in the Renaissance," *Early Science and Medicine* 10/2 (2005), pp. 137–62. Schechner concluded (p. 162): "Perhaps artists used mirrors as tools for self-portraits, as aids to perspective, as judges of the penultimate product, or as symbols, but their use of mirrors as projection equipment to achieve remarkable naturalism in their art is as chimerical as an argument for the existence of the unicorn. . . ."

missing altogether except for the paintings themselves, as Falco has contended.[155] More conclusive is the textual and pictorial evidence regarding the use of concave mirrors as burning devices and as reading aids, as I have discussed in the first chapter[156] and as demonstrated in some of the paintings listed in Appendix III. We need more conclusive data regarding the use of mirrors at this time in the hope of resolving these doubts and uncertainties, hopefully with less passion on all sides.

More germane to our study, however, is the likelihood that some of the debated questions just mentioned were also occupying the minds of leading intellectuals and artisans especially in Florence and perhaps to a lesser extent in other commercial and university cities. We know that artisans/merchants' shops, so conveniently concentrated in the quarter of S. Giovanni in Florence, served as meeting places for colleagues and various customers including intellectuals. No other city in Europe had such a high proportion of shops per inhabitants—1540 in 1427 (one for each 24 inhabitants for a population of 37,144) and 1660 in 1480 (one for each 25 inhabitants, population 41,590).[157] And no other city allowed artisans to operate relatively free of guild restrictions (especially through membership in more than one guild), all exerting themselves to outdo competitors and excel in the market place. The celebrated versatility, ingenuity, and enterprising spirit of the Florentine artisans were known throughout Europe and still survive today in the often cited phrase, the "Florentine hand." Moreover, the admiration for the skills of individual artisans is evident from chronicles, memoirs, and histories from the time of Giotto, culminating in Vasari's celebration of the lives of his colleagues—a unique phenomenon of the age. In brief, Florentine society respected and honored the practitioners of the "mechanical arts," in some cases almost at the level of those in the liberal arts.[158]

This was one aspect of Florence that was highlighted in a *relazione* (final report) of Marco Foscari, the Venetian ambassador to Florence, in 1527. He pointed out that all

155. See A. M. Smith, "Reflections on the Hockney-Falco Thesis: Optical Theory and Artistic Practice in the Fifteenth and Sixteenth Centuries," ibid., pp. 163–85, for a balanced assessment of this thesis and for the probable, role of Renaissance artists in discovering image projection: "But it was never my intention to demonstrate that Hockney and Falco are right. It was, rather, to demonstrate that they are not necessarily wrong in light of my contention that, if image-projection had been discovered by the early fifteenth century, it is more likely to have been discovered by artists than by Perspectivist opticians. Consequently, if Renaissance artists did make that discovery, they did so in spite of, not because of, what they learned from Perspectivist sources" (p. 183).

156. See pp. 41–46.

157. For these figures, see M. L. Bianchi and M. L. Grossi, "Botteghe, economia e spazio urbano," in *La grande storia dell'artigianato*, vol. II, p. 37. For the role of the artisans' shops as meeting places and for the interaction between artisans and intellectuals in Florence, see F. Franceschi, "La bottega come spazio di sociabilità," ibid., pp. 45–83, and R. A. Goldthwaite, "Realtà economico-sociale e status culturale dell'artigiano," ibid., pp. 9–25. The population figures appear in D. Herlihy and C. Klapisch-Zuber, *Tuscans and their Families: A Study of the Catasto of 1427* (New Haven and London, 1985), p. 74, table 3.5.

158. For a concise and eloquent statement of the economic, social, and cultural roles of Florentine artisans, see R. A. Goldthwaite, "La cultura economica dell'artigiano," in *Arti fiorentine: La grande storia dellartigianato*, vol. I, *Il Medioevo* (Florence, 1998), pp. 57–75.

Florentines could be considered "artisans" because, regardless of wealth and political rank, they did not disdain to work with their hands in their shops alongside ordinary workers. They all had some role in the councils of the republic within the structure of the 21 guilds so that they were quite content and believed to be equals with the magnates. (This was in obvious contrast with the status of Venetian artisans, whose guilds were strictly economic and social organizations without any political role.) But there was a drawback to this intense shop-motivated life, he noted—it, along with other factors, had made the Florentines "timid" and weak to the point that they could not provide adequate defense of their city from foreign attack.[159]

The shops of painters, sculptors, and architects were particularly suitable for interaction between artisans and intellectuals owing to the higher theoretical content of these crafts, although the clear distinction between artisans and fine artists gradually evolved in the late Renaissance.[160] Humanists also served as consultants to artists on the handling of classical themes and so did theologians for biblical topics. The friendship of Brunelleschi with Paolo dal Pozzo Toscanelli and with L. B. Alberti, himself a practicing architect and theoretician, is illustrative of this phenomenon.[161] The same can be said of the collaboration between Leonardo and Luca Pacioli, and of the latter's borrowing from the treatises on mathematics and perspective written by his friend, Piero della Francesca.[162] Lorenzo Ghiberti's compilation of the writings of mostly medieval theorists on optics and catoptrics, virtually a shop manual, must have occasioned frequent discussions in his shop. Spectacles and other vision aids must have been discussed in Vespasiano da Bisticci's bookshop, near the Palazzo della Signoria, a common meeting place for humanists.

Admittedly, all these interactions cannot be documented as fully as we would like, but they do not seem to be unrealistic on the basis of some direct testimonies or on the

159. "Relazion fatta per Marco Foscari, 1527" in *Relazioni degli ambasciatori veneti al Senato,* vol. III, ed. A. Segarizzi (Bari, 1916), pp. 3–98: "Li fiorentini, dunque, sono debili uomini: prima per natura, poi per accidente. Per natura sono debili, perchè sono timidi o perchè s'essercitano li fiorentini nella mercanzia ed arti manuali e mecaniche ed altri vili essercizi. Perchè a Fiorenza tutti sono artefici, i quali lavorano ed operano con le proprie mani; e li primi, che gubernano el Stato, vanno alle loro botteche di seda e, gettati li lembi del mantello sopra le spalle, vanno alla caviglia e lavorano con il rocchello . . . e, medesimamente dell'arte della lana, li vecchi che governano il Stato, spartono e cernono la lana e li figliuoli revedeno li panni e fanno gli altri essercizi, dalli vilissimi e sporchi adietro. . . . *Adeo* che, essendo tutti li fiorentini impliciti in questi essercizi vili, non possono essere se non timidi e vili. . . ." (pp. 17–18).

160. The latest views on this question have been admirably summarized by R. M. Comanducci, "'Buono artista della sua arte'. Il concetto di 'artista' e la pratica di lavoro nella bottega quattrocentesca," in *La grande storia dell'artigianato,* II, pp. 149–65.

161. On this interaction, see G. Tanturli, "Rapporti del Brunelleschi con gli ambienti letterari fiorentini," in *Filippo Brunelleschi: la sua opera,* vol. I, pp. 125–44, and F. Camerota, "Perspectiva pratica," in *Nel segno di Masaccio,* pp. 19–24.

162. See especially two articles by J. V. Field, "Mathematics and the Craft of Painting: Piero della Francesca and Perspective," in *Renaissance and Revolution: Humanists, Scholars, Craftsmen and Natural Philosophers in Early Modern Europe,* ed. J. V. Field and F. A. J. L. James (Cambridge, 1993), pp. 73–95; and "Alberti, the Abacus and Piero della Francesca's Proof of Perspective," *Renaissance Studies* 11/2 (1997), pp. 61–88.

basis of common sense itself. The revolution in art style initiated by that remarkably creative generation that included Brunelleschi, Masaccio, Donatello, Lorenzo Ghiberti, and Luca della Robbia could not have failed to be the "talk of the town" in shops, piazzas, and markets. The act of seeing and perceiving, then, would have been a common popular topic among artists and intellectuals and it seems likely that it would have involved participation by spectacle and mirror makers as well. If we accept Jacob Burckhardt's concept of the "discovery of the world and of man" as a leading component of Renaissance civilization, then mirrors and lenses admirably fulfilled this dual function. This mix of art, science, technology, and the humanist's historical perspective as developed by Petrarch and Leonardo Bruni, combined with the practical mercantile mind ready to measure objects, calculate, and balance account books according to the precise tool of double-entry bookkeeping (another Florentine invention), came to fruition in this most creative of centuries for Florence.[163] It is no wonder that later in the century Marsilio Ficino attempted to put it all together, as it were, in his system of Neoplatonic philosophy by seeking to reconcile Plato, Aristotle and other ancient philosophies and cosmological theories with Christian revelation.[164]

It is evident that by the end of the fifteenth century Florence had created a new mindset more disposed to question, experiment, and innovate. This new attitude had a pivotal role in laying the foundations for modern science, culminating in Galileo's achievements in the seventeenth century. One crucial factor in these foundations was the ability to visualize spatial relationships on a flat or curved surface and the concomitant use of shading to create the third dimension. With these tools machines could now be more precisely drawn than ever before according to the rules of geometric perspective and the use of chiaroscuro so that they could be seen as a whole as well as in cutaways and "exploded views" of their components before they were built. Actually, Sienese artists/engineers—Mariano di Iacopo, called Taccola (1381–ca. 1458) and Francesco di Giorgio Martini (1439–1501)—were among the first to use this technique, which was expanded and refined by Leonardo shortly after. Whether these improved mechanical drawings by artists/engineers resulted in actual working machines constructed with the aid of competent mechanics before the development of more advanced algebraic

163. On some of these interactions, see especially two seminal books by M. Baxandall, *Painting and Experience in Fifteenth Century Italy;* and *Giotto and the Orators: Humanist Observers of Painting in Italy and the Discovery of Pictorial Composition, 1350–1450* (Oxford, 1971, new ed. 1986). Cf. also P. Burke, *The Italian Renaissance: Culture and Society in Italy,* revised paperback edition (Princeton, 1987). This comparative study puts great stress on the Tuscan and especially Florentine creative genius.

164. All the essays in the book *Science and the Arts in the Renaissance,* ed. J. W. Shirley and F. D. Hoeniger (Washington, 1985), deal with these interactions. Many of their ideas, however, can be traced to two brilliant essays by E. Panofsky, *Renaissance and Renascenses 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, 1962), pp. 33–65. I have discussed these issues in my article, "Renaissance Florence," pp. 538–40, where I cite additional bibliography.

formulas for greater accuracy in the seventeenth century remains a disputed point.[165] At any rate, it is believed that the absence of a precise third dimension and geometric perception in drawings made by artists and engineers in eastern civilizations was one of the major reasons for their lagging behind the West in science and technology after 1500. In essence, this new tool served to end the inferior status of western scientific and technological thought during the Middle Ages in relation to the East, which did not develop comparable techniques despite its prior exposure to ancient optical writings.[166] It was certainly an influential factor in the rise of Europe over other continents, along with other factors such as the competition for resources and markets among its more centrally organized nation-states, their superior weaponry, and their relatively favorable geographical position. The merits and consequences of western global dominance since the Renaissance are still debated by historians.

In recent decades, in fact, there has been a decided tendency to emphasize the reciprocal influence of the humanistic disciplines and the "mechanical arts," in practically all of which Renaissance Florence led the way or played an initial major role as Athens had done among the Greek states two millennia earlier. I venture to say that the new evidence presented in this study about the manufacture and propagation of vision aids by Florentine artisans and merchants supports this interaction. Pamela Long has admirably compressed the major findings of this ever-growing body of publications in the following 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 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.*

165. Skepticism about the construction of actual working machines out of geometric drawings before the seventeenth century's progress in mathematics has been expressed by M. S. Mahoney, "Diagrams and Dynamics: Mathematical Perspectives on Edgerton's Thesis," in *Science and the Arts in the Renaissance*, pp. 198–220.

166. For the achievements of the Sienese artists/engineers, see Edgerton, *The Heritage of Giotto's Geometry*, pp. 126–47, with his reply to Mahoney, pp. 15–16, and Galluzzi, *Mechanical Marvels*, pp. 24–46. The latter reviews the latest scholarship and is beautifully illustrated. On the influence of images in the development of early modern science in its several fields see now a collection of essays: *The Power of Images in Early Modern Science*, ed. W. Lefèvre, J. Renn, and U. Schoepflin (Basel, Boston, Berlin, 2003).

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.[167]

While the creative mindset in fifteenth-century Florence has been fully documented and universally accepted, its equally creative counterpart in Venice has received full attention mostly with respect to the skills and versatility of its artisans of glass products in general, still celebrated worldwide. The extent and quality of its spectacle making industry in this early period, however, have been difficult to gauge because we lack the necessary documentation not only in Venice itself but also in depositories outside the borders of the republic. In the nineteenth century Venetian archivists discarded the customs records of the republic, robbing us of a precious source that has been so fruitful in Rome and England, for instance! On the other hand, if production and exports of Venetian eyeglasses had been so massive as to rival those of Florence in the fifteenth century, they should have left traces in account books and customs records in non-Venetian depositories comparable to those found for Florentine exports. Yet more than three decades of searching, aided more recently by other researchers, including some Venetian scholars, has unearthed only the few findings already noted but nothing of significant import to change the heart of the matter.[168]

Why would the leading glass industry in Europe allow itself to assume a relatively secondary role in spectacle making during the fifteenth century but, apparently, not in the sixteenth? It had to be a conscious decision rather than negligence in gauging the market. Individual merchants might misjudge market demand for a certain product, but it is inconceivable that the Venetian glass industry as a whole could or would ignore the clear need everywhere for vision aids. After consultation with a number of scholars, I will have to repeat here the answer I gave to this question a decade ago; i.e., at this time spectacle making was not a high priority for Venetian *occhialai* and other qualified artisans. Can there be any doubt that if they had given it a higher priority they could have out produced everyone else and could have matched if not surpassed the quality of Florentine spectacles as they apparently did in the following century?

This is not to say that eyeglasses, and fine ones too, were not produced in significant quantities in Venice during the fifteenth century, though we lack the figures. But I repeat my hypothesis that Venetian glass makers apparently would rather concentrate their efforts in producing utilitarian objects such as drinking glasses, bottles, beads, and the

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167. 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 p. 505. Cf. also two other articles in the same volume: C. Cast, "Humanism and Art" pp. 412–49, and C. V. Palisca, "Humanism and Music," pp. 450–85.

168. I wish to thank in particular three historians of Venice, Maria Francesca Tiepolo, Reinhold C. Mueller, and Francesca Trivellato, for their generous assistance in this search.

like, which were more easily produced and lucrative in large volume along with luxury products for the affluent classes such as mirrors, crystal goblets, and other vessels of artistic caliber, which fetched high prices with corresponding larger profit margins. In other terms, it was more remunerative for the Venetians to supply the clear glass and "cristallino" blanks for others to shape, grind into lenses, and fit into frames. Lens and frame making were labor intensive, but the finished product did not fetch the price commensurate to the labor expended except for luxury-type spectacles. This seeming anomaly can be explained in part by competitive pressures by all sorts of artisans making or assembling spectacles along with monks in Italy and elsewhere.

It may be that in the sixteenth century with the growth in urban population and the increasing literacy of the general public, partly as a result of the spread of the printing press and the Protestant Reformation's emphasis on Bible reading, the use of eyeglasses in all trades and professions assumed more massive proportions. At this point, one can further speculate, Venetian spectacle makers could no longer neglect an ever-expanding market and achieved a leadership position, as one would expect. By that time, also, the Renaissance movement was in full swing in Venice and Venetian artists had the same need for visual aids as their Florentine colleagues a couple of generations earlier. It is significant that by the middle of the sixteenth century, Venice had become "the most important publishing centre in Italy for texts on perspective, with 64 titles prior to 1600."[169] Moreover, as we shall see in the next chapter, the development of scientific optical instruments led to increased demand for the purest and clearest glass, in the production of which Venice had long excelled but had to face Florentine competition even in this field, as noted above. Whether this hypothesis will be confirmed, amended, or demolished will depend on the discovery of additional documents.[170] Perhaps others can think of other factors that may have played a role.

169. See Kim H. Veltman, *The Sources and Literature of Linear Perspective*, vol. I, "The Sources of Perspective," ch. 2, p. 5 of printout (forthcoming volume) made available by the author on this website: http://www.sumscorp.com/perspective/Vol1/ch2.htm. The titles included classical texts as well as contemporary treatises.

170. My hypothesis was accepted by the late Astone Gasparetto, a leading authority on the history of the Venetian glass industry, during our meeting in Venice in 1991. I first stated my views on this matter in my article, "Renaissance Florence," p. 537.

VI

From Terrestrial to Celestial Vision

The sixteenth century produced no breakthroughs either in lens technology or in theories of vision. Present scholarly investigations speak more of appropriation and digestion of earlier knowledge than innovation. Nevertheless there were small, incremental improvements in the production and quality of lenses and mirrors, especially in connection with attempts to construct devices for long distance vision, which led to the development of scientific instruments like telescopes and microscopes early in the next century. We also have the first serious efforts to investigate the working of lenses and the first hesitant steps to understand the process of vision by comparing the human eye to the *camera obscura*. This digestion and appropriation of earlier advances was enormously facilitated, of course, by the rapid spread of the printing press, which printed manuscript versions of ancient/medieval texts and just as important, provided exact duplication of drawings and instruments. These efforts finally led to the breakthroughs in astronomy and optics by Galileo and Kepler at the turn of the seventeenth century.

From Optical Tubes to Telescopes

A powerful impetus to develop improved vision aids through more advanced lens technology came from the desire, more frequently noticeable in the sixteenth century, to extend the vision capabilities of ordinary spectacles for much longer distances. Aside from the desire to scrutinize the heavens already present in primitive times, there were other prospective practical uses of such long-distance viewing devices for military and naval purposes, distant views of landscapes for painting, topographical maps, and surveying, and closer observations of nature in general, the last especially being one of the hallmarks of the Renaissance. After almost three centuries of experience with eyeglasses and progressive improvements in the clarity of mirrors, it would be logical to assume that spectacle and mirror makers would experiment with a suitable combination to produce a more powerful vision aid. The combinations of two convex lenses or convex and concave lenses should have come to mind more readily, perhaps, than a combination of lenses with mirrors to spectacle/mirror makers as well as to designers of optical instruments for long distance viewing. The evidence for these attempts has been recently collected and admirably analyzed in considerable detail by Sven Dupré so that only a succinct summary particularly pertinent to the history of spectacles need be included in the present study.[1]

Frequently, the terminology given in the sources is confusing and/or imprecise so that we have to guess at the intentions and results. In view of Leonardo's fertile mind, ready to question and experiment, it would be surprising if he had not tried some of these combinations. Yet from the surviving notebooks we only have the cryptic notation: "Make glasses to see the moon large." Whether he intended to use a single convex lens or one combined with a concave lens aligned at a suitable distance, it is impossible to fathom. The same type of uncertainty faces us in visualizing the device that Leo X was said to have used to watch distant hunting chases or birds flying over the Fiesole hills observed from the Medici Palace in Florence. In both of these instances, even a single biconvex lens of about 2 diopters held at 25 cm distance from the eye would magnify an image ca. 1.8×. "This is about the weakest magnification of the old spyglasses, sufficient for attentive people to perceive a little more detail than with the naked eye."[2] But a few years later the Italian physician, Girolamo Fracastoro (1478–1553), discussed greater magnification with ordinary spectacle lenses for observation of the moon:

> *If anyone looks through two spectacle lenses, one placed on top of the other, he will see everything much larger and closer.*
>
> *Indeed, certain spectacle lenses are made of such density, that if someone looks through them at the Moon or at another star, he will judge them to be so close that they do not even appear to exceed the steeples themselves [in height]. This is why one should not be surprised if the same also occurs through the parts of the [heavenly] orbs.*[3]

It seems that Fracastoro had in mind the superimposition of two convex lenses, whose compounded magnification was already known soon after the invention of the rivet-type spectacles, which facilitated this process. We should not exclude the possibility, however, that spectacle makers were also experimenting with a concave-convex lens

1. S. Dupré, "Galileo, the Telescope, and the Science of Optics in the Sixteenth Century: A Case Study of Instrumental Practice in Art and Science," Doctoral dissertation, University of Ghent, 2002, especially chaps. 5 and 6. Articles by Dupré already published or accepted for publication will be cited below in appropriate sections. I am indebted to the author for sending me copies of his published and unpublished materials.

2. See J. Rienitz, "'Make Glasses to See the Moon Large': An Attempt to Outline the Early History of the Telescope," *Bulletin of the Scientific Instrument Society* 37 (1993), p. 8. Rienitz comments on a drawing published by P. Joanne David SJ, in his *Duodecim specula* (Amsterdam, 1610), a theological treatise, which shows a man observing the moon "by means of a biconvex lens in his outstretched arm. . . . Assuming the conventional visual distance of 25 cm and a focal length of 45 cm (2.2 dioptres, a frequently used spectacle glass) we get a magnification of 1.8×."

3. G. Fracastoro, *Homocentrica: Eiusdem de causis criticorum dierum per ea quae in nobis sunt* (Venice, 1538), fols. 18^v and 58^r, as quoted and translated by A. Van Helden, *The Invention of the Telescope* (Philadelphia, 1977), p. 28.

combination separated by a suitable distance that gives a clear, erect image rather than with a combination of two convex lenses similarly placed, which inverts the image. It seems more likely that the evidence referring to Leonardo and Leo X points to the concave-convex combination. In brief, the magnification produced by convex lenses was well established and the fact that concave lenses allowed myopes to see far was equally well known. It was natural, therefore, to think that a combination of the two aligned at the appropriate distance would result in an instrument capable of seeing distant objects enlarged and well defined. It was surely within Leonardo's capabilities to experiment with this combination.

This idea of a compound tubeless *occhiale* (eyeglass) had probably occurred to a number of spectacle makers and others purely by ad hoc experimentation, and circulated to a limited number of persons for various uses including those with poor vision not much improved by ordinary spectacles. It is significant in this context that in his account of the invention and later development of the telescope, published by Giovanni Sirtori in 1618 but written in 1612, he claims that the idea of combining a concave with a convex lens came from an unnamed customer to the shop of a certain Johannes Lippersein (Hans Lipperhey?), allegedly the only spectacle-maker in Middleburg in the province of Zeeland in the Netherlands. The customer's behavior in testing the finished lenses and placing a concave and a convex lens in alignment before one eye at a suitable distance led the spectacle-maker to discover the principle of the telescope by enclosing the combination into a tube so as to concentrate the light rays.

> *In the year 1609 [sic] there appeared a genius or some other man, as yet unknown, of the race of Hollanders, who, in Middleburg in Zeeland, visited Johannes Lippersein, a man distinguished from others by his remarkable appearance, and a spectacle-maker. There is no other [spectacle-maker] in that city, and he ordered many lenses to be made, concave as well as convex. On the agreed day he returned, eager for the finished work, and as soon as he had them before him, raising two of them up, namely a concave and a convex one, he put the one and the other before his eye and slowly moved them to and fro, either to test the gathering point or the workmanship, and after that he left, having paid the maker. The artisan, by no means devoid of ingenuity, and curious about the novelty, began to do the same and to imitate the customer, and quickly his wit suggested that these lenses should be joined together in a tube. And as soon as he had completed one, he rushed to the court of Prince Maurice and showed him the invention. The prince had one [or, had been acquainted with one] before, and lest it should be suspected that [the device] was of military value, and very necessary, had kept it a secret. But now that he found by chance that it had become known he disguised [his prior knowledge], rewarding the industry and good intentions of the artisan. . . .*[4]

4. Translated by Van Helden, *The Invention*, p. 50.

Historians who have researched the pre-history of the telescope have not ascertained the accuracy of this story in all its details. For our purposes some of the above statements can be questioned. Aside from the date, a year later than the established date of the "invention" of the telescope, it seems unlikely that Middleburg, the leading commercial and industrial center in the region, would have had at this late date only one spectacle-maker. The glass industry in the Netherlands had been founded around the middle of the sixteenth century in Antwerp with the aid of Venetian and other Italian glass/mirror makers. It quickly spread to other cities such as Middleburg (1581) and Amsterdam (1597). In a few years, these cities achieved renown for the quality of their product, especially glassware, some of which was exported even to Venice.[5] Surely, there must have been spectacle wearers among these glassworkers and in the general population of such commercial centers especially since we have seen the records of thousands of eyeglasses reaching English ports aboard Dutch and Flemish ships a century earlier as noted above.[6] Those spectacles needed to be replaced or repaired from time to time by qualified local artisans. Even more dubious is the statement that a spectacle maker at the beginning of the seventeenth century needed to be shown by a customer the alignment of a concave lens with a convex one for distance viewing. Finally, the very fact that the prince already possessed or had seen such a device shows that other spectacle-makers in Holland and/or elsewhere had already thought of the combination enclosed in a tube. Significant also is the detail that the prince, commander of the Dutch forces of the Seven Provinces in revolt against the Spanish monarchy, thought of the usefulness of the device for military purposes rather than as an astronomical instrument for searching the heavens.

At this point it may be of interest to mention, parenthetically at least, that some miniatures in medieval manuscripts show figures looking at the skies through a long tube mounted on a stand or held in the hand, perhaps as a result of reading ancient sources as noted in chap. I. The first type of these miniatures, dated 982, illuminates a text by Gerbert (later, Pope Sylvester II, 999–1003), in which the mounted tube is focused towards the pole star. The second type occurs in a thirteenth century manuscript and shows the astronomical observer looking at the sky through such a sighting-tube with clearly marked sections apparently meant to slide into one another just as in a seventeenth-century telescope. The prevalent explanation is that these were not telescopes but simply tubes to concentrate the light rays taking advantage of the century-known phenomenon of pinhole vision. Yet such an eminent scholar as Derek J. Price has written

5. See Jan M. Baart, "Una vetreria di tradizione italiana ad Amsterdam," in *Archeologia e storia della produzione del vetro preindustriale*, ed. M. Mendera (Florence, 1991), pp. 423–37. New findings about the Dutch glass industry have been summarized by D. Whitehouse, "Introduction," in *Majolica and Glass from Italy to Antwerp and Beyond: The Transfer of Technology in the 16th–Early 17th Century*, ed. J. Veeckman, et al. (Antwerp, 2002), pp. 13–22.

6. See chap. IV, pp. 128–36.

that "such pictures must give rise to the suspicion that the instrument in question is actually some sort of telescope with lenses, and although the evidence is weak, it cannot be summarily discarded merely because of the great improbability of the invention having been made so early."[7]

Half a century after these lines were published, we may add that such a suspicion has gained a greater measure of probability given the more recent findings about the use of convex lenses in antiquity and the optical quality both of the Egyptian statuary lenses (concave and convex) and of the Visby convex lenses in the island of Gotland, which date to the eleventh and twelfth centuries.[8] Would it be totally foolhardy, then, to speculate that one or two convex lenses might have been inserted in these sighting tubes to provide greater magnification, the latter combination anticipating the telescope later described by Kepler? The reversal of the images would not have mattered for celestial observation. It seems hardly credible that these illustrations, and the ancient sources on which they were probably based, should have escaped the attention of readers for centuries, or that if known, they did not stimulate a response of some sort such as inserting lenses into the tubes.

The correspondence of the Florentine Raffaello Gualterotti (1548–1639), a minor poet at the Medici court and an amateur astronomical observer, with Galileo offers more than one response. Having learned that Galileo suspected that Gualterotti had written in opposition to his views, he wrote in April 1616 to point out that in his writings he had expressed the same disagreements already voiced in conversations they had had in past years. First of all, he restated his view that he considered himself to be the inventor of the telescope rather than the "Fleming" to whom Galileo had given the credit for the invention. To support his claim, he proceeded to list his observations of Jupiter, Venus, the Moon, etc., carried out over the past several years with his three telescopes (*occhiali*). In addition, he reluctantly reiterated his view, which he had expressed in a conversation they had in Florence two years earlier, that the earth could not possibly rotate around the sun, on the basis of observations made with an instrument trained to the sky in Florence for six years from 1568 to 1574. The instrument consisted of a brass tube about 8.16 meters in length (*dodici braccia di lunghezza*) equipped with "two lenses not dissimilar" to those later used by Galileo for his telescopes; i.e., a plano concave-eye-lens and a plano-convex one for the objective. The tube was attached to a measuring quadrant for the purpose of testing the Copernican theory about the rotation of the earth around the sun. It seems that the tube was made by Gualterotti while the quadrant was designed by Egnazio Danti (1536–86), Dominican bishop, mathematician, architect, engineer,

7. D. J. Price, "Precision Instruments to 1500," in *A History of Technology*, ed. C. Singer, et al., vol. III, *From the Renaissance to the Industrial Revolution c. 1500–c. 1750* (New York and London, 1957), pp. 593–94, with reproduction of two miniatures, p. 595. See also Van Helden, *The Invention of the Telescope*, p. 9

8. See chap. I, pp. 36–40.

instrument maker, astronomer, and cosmographer for Grand Duke Cosimo de' Medici from 1563 to 1574, and later professor of mathematics at the university of Bologna. (The letter is not clear on their respective roles in carrying out this experiment.) During the six-year period neither he nor Danti was able to detect any movement of the polar star as recorded by the graduated quadrant, which seemed to prove that the earth was stationary just as Aristotle had argued. (Presumably, this was only a three-power instrument, the maximum magnification obtained through the use of spectacle lenses in the early telescopes, which was not sufficient to observe the tiny movements of the star.) Gualterotti added that he had intended to make a more powerful instrument as he had revealed to his friend during their conversation.[9]

This autograph letter is puzzling in tone and content. It is the only evidence known to date that such an instrument, clearly resembling the composition of the "Dutch" telescope, had been constructed in Florence 40 years earlier and had been used for celestial observations. We need other corroborating documents to accept it at face value for it is odd that contemporaries did not take note of an experiment lasting six years and that no mention of it appears in any of Danti's writings.[10] Gualterotti's claims for his priority of the invention rested more firmly on the use of his three *occhiali* for his celestial observations made "many years earlier," obviously before 1608.

In another letter to Galileo, written in April 1610 about a month after the publication of the *Sidereus nuncius*, he revealed that in 1598 he had constructed such an instrument with low magnification to be used in joust and war.[11] But seven years later he wrote a treatise in which he stated that he had observed the stars through "the dark barrel of a musket" with no mention of lenses.[12] It is difficult to understand the reason he would want to look at the stars with a lens-less tube if he had observed them in 1568 with one

9. The letter, dated 3 April 1616, was addressed to Galileo in Rome where he was attempting (in vain, as it turned out), to oppose placing Copernicus' book, *De revolutionibus*, on the Index of Prohibited Books. It was published in *Le opere di Galileo Galilei* (Ristampa della ed. nazionale. . . .), vol. XII (Florence, 1934), pp. 252–54. It was republished with extensive comment and an illustrated reconstruction of the instrument by P. Solaini, "Storia del cannocchiale," *Atti della Fondazione Giorgio Ronchi* LI/6 (1996), pp. 833–39, 858–59.

10. Tom Settle, a leading interpreter of Danti's thought, has assured me that no mention of this experiment appears in his writings and he has expressed doubt about the accuracy of Gualterotti's account. It may be a case of being too good to be true (private communication, Apr. 2005). For a detailed analysis of this episode, see Settle's forthcoming article, "Danti, Gualterotti, Galileo and their Telescopes?" soon to be published in the *Atti della Fondazione Giorgio Ronchi*.

11. Van Helden, *The Invention of the Telescope*, p. 45–46, with English translation.

12. R. Gualterotti, *Scherzi degli spiriti animali dettati con l'occasione de l'oscurazione de l'anno 1605* (Florence, 1605): "And what is more, a person looking with one eye through the dark barrel of a musket sees better, when looking at something in daylight, than if he had not been looking through that darkness. For the great amount of light in the air near the eye would impede, not help vision, as is shown by our experience that vision passing through that barrel and arriving in the sky sees the stars during the day, which without this tube are not seen, only the air, illuminated by the Sun, [being visible]. And so much better does the act of vision proceed through the darkness than through an illuminated body." Translated by Van Helden, *The Invention of the Telescope*, p. 35. See also p. 9 for a discussion of these tubes.

combining the two lenses. Regrettably we do not have Galileo's written replies on this specific subject and on Gualterotti's lament that his friend was all too ready to credit the Dutch with the invention rather than the Florentines (himself), of whom he proudly asserted that he could not say enough of their astonishing accomplishments. Galileo's obduracy in not recognizing Gualterotti's claim of priority may have been based on his refusal to accept the trustworthiness of his celestial observations with his spyglasses and the veracity of his account of Danti's experiment, which was not reported by anyone else as far as we can gather. He continued to believe that the construction of the telescope was found by chance by a spectacle maker in Holland.[13]

About the same time of the alleged Danti's construction of the two-lens telescopic device in Florence, another combination was tried in England (ca. 1563) by Leonard Digges (ca. 1520–ca. 1559), mathematical practitioner and designer of instruments. He constructed a tubeless magnifier composed of a combination of a concave mirror as an ocular and a convex lens as the objective appropriately positioned. This system simply combined the additive power of two magnifiers, but it cannot be considered the first mention of a reflecting telescope, which strictly speaking has the mirror as the objective. It is significant to note that in the description of the device published in the *Pantometria* (1571) by his son, Thomas (ca. 1546–95), the principal purpose of the instrument was to construct topographical maps of distant city views.[14] A similar construction was described by William Bourne around 1580. These descriptions have laid the basis for the still debated question of whether Elizabethan England had the telescope before Holland and Italy. These telescopes as described, however, were not very practical. If one looked in the mirror with his back to the lens he would see an inverted image; if he placed the mirror at an angle on his chest and bent his head downwards, he would see an upright image. Moreover, the instruments required a lens and mirror with large diameters, both of which were to be specially made, as they were not readily available in spectacle/mirror shops.[15]

There is additional evidence that instruments or gadgets of the more practical two-lens tube variety existed in the late sixteenth century. They were variously named *occhiali* (eyeglasses), perspective glasses, and spyglasses and were designed to extend vision beyond the range of eyeglasses. (The two-lens tube or spyglass (*perspicillum* in Latin) did not receive its name "telescope" (*telescopium*) until April 1611 at a banquet in Rome given in honor of Galileo, who had just been elected to membership in the Lincean

13. See A. Van Helden, "Galileo and the Telescope," in *Novità celesti e crisi del sapere* (Atti del Convegno Internazionale di Studi Galileiani), ed. P. Galluzzi (Florence, 1984), pp. 151–52.

14. Rienitz, "Make Glasses," p. 8–9. See also Dupré, "Galileo, the Telescope," pp. 251–54. According to Dupré (private communication, Nov. 2005) in a reflecting telescope the mirror forms the objective.

15. For a clear and informative description of these efforts in England with pertinent bibliography, see now Dupré, "Galileo, the Telescope," pp. 270–75. Dupré revised the date for the Bourne instrument to 1580 (private communication, Nov. 2005).

Academy.) Descriptions of some of these devices were published by Giambattista della Porta (ca. 1535–1615), Neapolitan dramatist, novelist, and writer with an encyclopedic grasp of many subjects including optics, astronomy/astrology, chiromancy, cryptography, alchemy, art of memory, physiognomy, etc. His writings and career, including his founding of the Academia dei Segreti in Naples (1558–79) and his membership in the prestigious Lincean Academy in Rome, illustrate the rather thin line at this time between scientific experimental inquiry and the pursuit of rather occult disciplines all seeking to unlock the secrets of nature by whatever means. The very title of his most important and popular work, *Magia naturalis* (1558, revised and augmented 1589), which was reprinted many times and translated in various languages, reflects this intermingling of science and magic so common in this period.[16] By his own admission, he divulged "secrets" which he had learned from ancient texts, and by correspondence, observation, and discussion during his travels in Italy, France, and Spain. He also claimed that he had confirmed a number of the described wonders by personal experiment though some of his experiments are described in such a confused manner as to cast doubt on their validity. On the other hand, his works served to popularize scientific and technological concepts developed in the past or in his time, thereby offering a useful guide to what was, known in scientific-technological circles by the early seventeenth century.

It is only in the second edition of the *Magia,* Book XVII, that Della Porta discussed mirrors and lenses, highlighting in the preamble his intended use of mathematical demonstrations of their marvelous properties. He cited as examples the legendary burning mirrors of Archimedes and the long distance capabilities of the mirror supposedly used by Ptolemy III (third century B. C.) at the lighthouse of Pharos (Alexandria, Egypt) to see enemy ships "six hundred miles" away. In fact, he was particularly ecstatic about the capabilities of concave mirrors, because "they surpass others, they are the most marvelous, and the most useful" provided one knows how to establish their focal point (*ponto dell'inversione*).[17] Their magnifying properties can make them useful as burning devices and reading aids, as already described by Seneca, who is specifically cited. They can also

16. On Della Porta's widespread influence in Europe, see W. Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, 1994), pp. 194–233.

17. *Della magia naturale* (Naples, 1611), Book XVII, chap. IV in Ronchi, *Scritti di ottica,* p. 163: "Ma l'operazioni del specchio concavo son quelle che avanzano tutte, e sono le più meravigliose di tutte, e ci servono più di tutte; ma non potrai far cosa niuna con essi perfettamente, se non conosci prima il ponto dell'inversione." This Italian translation made while Porta was still alive and approved by the local church authorities appears to be a faithful rendition of the Latin text according to Ronchi, who published almost all the chapters of this book with a valuable comment elucidating some of Porta's obscure passages about optical devices. In reference to the "point of inversion," I received this informative comment from Mark Smith: "It's true that the *punctum inversionis* is the 'focal point' of the mirror. However, it's worth noting that this point is conceptually rooted in what happens to the *image* at that point. In other words, it's still based on a 'subjective' perspective vis-a-vis the center of sight, rather than on an 'objective' perspective vis-a-vis the projection of light-rays. Hence, even at this turning point in the history of optics, efforts to understand the projection of real images by mirrors and lenses were still conceptually bound by the old Perspectivist analytic norms and their focus on virtual (i. e., psychological) images" (private communication, Nov. 2005).

be combined with various other shapes of mirrors and lenses to achieve special effects as in the case of the awkward but effective combination of a concave mirror and a plane one to enlarge and re-invert letters.[18]

In chapter 10, Della Porta discussed the properties of convex and concave lenses, comparing the magnifying properties of the former to concave mirrors. As burning devices, convex lenses are superior to mirrors but both can equally be combined with candles to provide night illumination capable of allowing reading of letters placed even "twenty paces away." Both types of lenses can, of course, be framed into eyeglasses, which he deemed "most necessary for human beings," claiming that up to now "no one had written about their effectiveness and operation."[19] Since concave lenses provide clarity of vision for distant objects which appear smaller and convex ones magnify near objects but with less clarity, he maintained that they could be combined to provide clear vision for near and far. He added that he had thus satisfied the visual requirements of a number of his friends, though he gave no details about this combination, which he described in his often vague and convoluted language without mentioning a tube. Although this passage has been taken sometimes as a description of a telescope even by Kepler, my view is that it sounds similar to tubeless combinations of these lenses used earlier by others for clear, distant panoramic views or for hunting scenes as in the case of Leo X. A severely myopic individual could probably benefit from this combination as well as one with astigmatism (depending on the positioning of the two lenses), a condition that was not diagnosed at this time.[20]

Surprisingly, Della Porta does not mention this combination at all in his treatise on optics, *De refractione* (1593), which was far less popular than his *Magia* and was apparently not sufficiently appreciated in his own time. Yet it contains the first published theoretical treatment of lenses, for whose utility in giving sight to those who had almost none he expressed unbounded admiration. The author was fully conscious of his originality by stating that such a study was a very difficult enterprise "not yet attempted by anyone" and by excusing himself for not elucidating all the elements of the subject because he had no guide to rely on.[21] In fact, his self-admitted inadequacy in this respect has been confirmed by modern scholars, who have found his geometric analysis of lenses faulty though based on extensive reading of ancient and medieval optical authorities. Like

18. See chap. I, pp. 45–46 for a discussion of this combination.

19. Chap. 10, pp. 179–80: "Molti sono gli effetti della lentecchia di cristallo, né mi par cosa convenevole che le lasciamo a dietro; perché se ne ritrovano concave e convesse, e i medesimi effetti sono quelli de gli occhiali i quali sono molto necessarii all'uso della vita umana, de' quali niuno insin adesso ne ha scritto, né gli effetti, né le cagioni; . . ."

20. Ibid., p. 182, for Ronchi's view about the possible use of this combination for astigmatic eyes.

21. *De refractione*, book VIII, preamble in Ronchi, *Scritti di ottica*, p. 219, Italian trans., p. 218: "Res ardua, mirabilis, utilis, iucunda, nec ab aliquibus adhuc tentata. Utilitatis equidem amplitudinem nequeo satis mirari, quum qui fere lumine orbati sint, eorum ope, etiam ad longissimam distantiam elongent visum, nec eorum causam cognoscunt. . . . Sed lectorum veniam praecamur, si quae minus probata, omissa, et manca in lucem prodeunt, arduum est enim since duce in tenebris per ambages ambulare. Sed rem aggrediamur."

them he regarded the crystalline lens as the principal organ of sight with images forming on its front surface.[22]

Likewise inadequate was his analysis of the causes of presbyopia and myopia. Presbyopia, he argued, was caused by two conditions affecting the elderly. Age causes their pupil to become more relaxed, causing the visual rays to become less concentrated and send "less precise" images to the crystalline lens. In addition, the elderly have a more "dense and impure vitreous humor." Converging, convex lenses serve to concentrate the rays and transmit a "clearer and brighter light" to remedy both natural defects.[23] More vague and confused was his analysis of myopia. He maintained that young people have a constricted pupil so that they need divergent, concave lenses first "somehow" to concentrate and then "somehow" to diverge the images in order to remedy this defect of the pupil.[24]

Clearly we are a long way from the correct explanation of refractive errors and the function of the retina in image formation. While optical historians have noted his failure in arriving at an accurate geometrical analysis of lenses and of their function in the visual system of the eye, they also point to the difficulties of the problem which required considerable mathematical competence apparently not possessed by Della Porta. Others in the sixteenth century may have had the mathematical skill but we have no published record of their providing a correct analysis and understanding of the function of lenses until Kepler, who admitted, however, to having been inspired by Della Porta's writings.

Della Porta's preoccupation with visual remedies is again present in his belated and incomplete treatise, *De telescopio*, the completion of which was delayed by ill health from 1611 onwards and cut short by his death in 1615. The autograph manuscript, which consists of just three folios, was only discovered in 1940 in the library of the Lincean Academy, and was published in 1962. Given its incompleteness, resembling a first draft with many cancellations and corrections, and the author's penchant for vagueness of

22. In his introductions and comments in the footnotes to Della Porta's writings, Ronchi generally takes a negative view of his accomplishments in optics except for his great admiration for the utility of spectacles and his first published attempt to provide an analysis of lenses. For a more balanced view, see D. C. Lindberg, "Optics in Sixteenth-Century Italy," in *Novità celesti e crisi del sapere* (Florence, 1984), pp. 142–48.

23. Ronchi, Scritti di Ottica, p. 237, Italian trans., p. 236, Prop. 14, title: "Senes convexis specillis clarius vident." "Duplex est causa cur senes convexis specillis clarius, et perfectius cernant. Primo quia in senectute relaxatur pupilla . . . ex laxitate igitur pupillae radii liberius vagantur, et rem laxam et minus certam crystallino reddunt: at convexis specillis simulacri radii coeunt, et arctius pyramis colligitur, ut vidimus in praecedenti, unde naturae vitium rependunt congregando specilla convexa simulacra. Altera causa est, quod senibus vitreus humor faeculentior, et impurior redditur, ut in prima propositione huius libri probavimus, intro permeans lux per crystallum clarior, fulgidiorque redditur, et naturae defectus alter ex pituita resarcitur."

24. Ibid., p. 243, Italian trans., p. 242, Prop. 19, title: "Visu debilis concavis specillis acutius vident." "Iuvenes, qui arcta sunt pupilla se vitreo humore, qui in oculo continetur non claro, duo requirerent, et quae similacra dilatarent, ut resarciretur vitium pupillae, et quodammodo unirent, et quod lucem clariorem redderent; duo haec praestat concavum specillum, nam et simulachrum quodammodo unit, ut ex refractionibus intra viri soliditatem apparet, et quodammodo aperiret, ut videmus lineis in adversam partem refugientibus: et lux pertransiens visum multiplicatur."

expression and idiosyncratic Latin syntax, this book presents additional problems of interpretation. Some passages are "wholly undecipherable," according to its editors.[25]

But there is hardly anything new about the telescope in this treatise — the instrument had already been diffused throughout Europe for about five years and its composition was widely known. Della Porta laid great stress on the importance of choosing the best lenses for grinding and polishing with tools used to polish gems in order to ensure better uniform quality. The degree of curvature of the objective lens had to correspond with the length of the tube, whose length was determined by its intended viewing distance. Longer tubes could be subdivided into retractable smaller tubes. The lenses were to be held fixed inside the tubes by means of round rings supported by diaphragms, which allowed smaller apertures to concentrate the light rays and provide sharper vision.[26]

For our purposes it is noteworthy that one of the uses he had in mind for the telescope was as a reading aid. He wrote: *"If you want to see near objects, such as men's faces or read capital letters, you should use smaller lenses and a shorter tube. . . . If you want to read capital letters, you would be satisfied with a tube only a foot long."*[27] It seems that Della Porta had really little cognizance of the telescope as a scientific instrument though he certainly appreciated its value, especially if it could be developed into an instrument capable of truly long distance viewing as supposedly enjoyed by the ancients. But the instruments that were circulating throughout Europe about 1609 could only magnify three times despite exaggerated claims of greater capabilities. Della Porta was not impressed. At the end of August of that year he wrote to Federico Cesi that he had seen such an instrument, which he pronounced a trifle or a hoax, whose composition he had already described in book IX of his *De refractione* (actually he meant to write book XVII of the *Magia*). In the letter he sketched the tube with an accompanying description of its composition, comparing its retractable inner tube to the action of a "trombone" in adjusting the focus to varied individual visual requirements. This is perhaps the earliest such sketch to come to light. A year later, as the news of Galileo's celestial discoveries made with a more powerful telescope reached him, again he wrote to Cesi reiterating his priority in the invention. Four months before his death he wrote to Galileo that he was constructing a telescope "one hundred times" more powerful than the average instrument, but he never realized this impossible dream.[28]

25. The manuscript, formerly owned by Federico Cesi, was found by the librarian of the Academy, G. Gabrieli, who asked V. Ronchi to publish it (G. B. Porta, *De telescopio,* ed. V. Ronchi and M. A. Naldoni (Florence, 1962)). Naldoni transcribed the text and provided an introduction and textual notes. Book V of the manuscript, which contains the treatise, was republished with an Italian translation in Ronchi, *Scritti di ottica,* pp. 243–63.

26. Ibid., pp. 246–49.

27. "At si propinqua velut hominum vultus vel maiuscolas literas leges, angustioribus specillis et contractiore tubo . . . et si maiuscolas literas legere, pedali solo (solo) contenti sumus." Ibid., p. 249; Italian translation, p. 248. The word in parenthesis is repeated in the 1962 edition, p. 156, cited above.

28. Ibid., pp. 145–50.

It is clear that by the end of the sixteenth century knowledge of combinations of lenses with or without a tube, and of combinations of concave mirrors and lenses, was fairly common among instrument and spectacle makers in various parts of Europe. There were reports that spyglasses were available in Holland as early as 1590 and details of their composition were circulated or surmised. Indeed, Lipperhey was denied a patent by the Estates General of Holland in October 1608 because two other Dutch spectacle makers, Sacharias Jansen and Jacob Metius, claimed that they had already constructed the same instrument. Lipperhey, however, remained ahead in the race by developing shortly after a binocular spyglass, which he sold to the Estates General. About the same time, Simon Marius learned to construct one after hearing a description of a Dutch spyglass, which was available for sale at the Frankfurt fair in the autumn of 1608. By the end of the year, the instrument was already used for celestial observations in Holland. In the following year, spyglasses were commonly available in spectacle makers' shops throughout Europe. In August Thomas Harriot (1560–1621) in England had already trained a six-powered one on the moon and made sketches of his observations before Galileo made his first lunar observations in the autumn with his eight-powered spyglass. Earlier that month Galileo claimed that having heard a report of the Dutch spyglass, he proceeded to make his own three-power instrument without having seen one. This might be an exaggeration, as it has been claimed, but it should not be surprising if a 45-year-old professor of mathematics and instrument designer teaching at the University of Padua could duplicate, sight unseen, an instrument already duplicated many times by knowledgeable spectacle makers. It would be surprising if he had been unable to accomplish the feat.[29]

The rapid diffusion of the "invention" attests both to the interest in these instruments, already whetted by ancient reports of far-seeing tubes and mirrors, sometimes illustrated in medieval manuscripts, and the simplicity of their construction. Writing in 1612, Sirtori, who also duplicated the instrument but could not succeed in making a more powerful one, described the race in vivid terms:

> *It was also related that this invention was nothing but two lenses put in a tube. And since Porta had made mention of this business in his 'Magia naturalis', although obscurely, and had spoken of it to many, in my presence, it appeared that this conception was in the minds of many men, so that once they heard about it, any ingenious person began trying to make one, without [the help of] a model. Others, Dutchmen, Frenchmen, Italians from everywhere rushed forward driven by the desire for gain, and there was no one who would not make himself the inventor.*[30]

29. Van Helden, *The Invention of the Telescope*, pp. 16–27, and idem, "Galileo and the Telescope," in *Novità celesti e crisi del sapere* (Atti del Convegno Internazionale di Studi Galileiani), ed. P. Galluzzi (Florence, 1984), pp. 149–55; and E. Sluiter, "The Telescope before Galileo," *Journal for the History of Astronomy* 28 (1997), pp. 223–34.

30. Van Helden, *The Invention of the Telescope*, p. 50.

Even from the necessarily compressed evidence cited above, it is clear that telescopic devices comprised of a combination of lenses within or without tubes had been constructed or at least conceived from antiquity onwards to extend natural vision, but the first known practical applications of these devices seem to date from the late sixteenth century. In essence, the yet to be named instrument was in the minds and hands of many before they realized what they had. But it was only Lipperhey in Holland, the lucky optician, who first brought this first three-power spyglass to the attention of the European world. Its predecessor, the humble and by then all too common pair of spectacles, also was discovered by chance perhaps centuries earlier than the thirteenth century, but it was another lucky optician and a kindly Dominican friar, both residing in Pisa, who made it part of the historical record. Both instruments had many fathers, as we have seen, and were easy to duplicate in kind but not necessarily in quality. It is in this context that Galileo played the initial leading role in transforming a three-power spyglass of limited use into a twenty-plus power scientific instrument capable of searching the outer reaches of the universe, an instrument that deserved a new name, "telescope." He managed to achieve these results mostly by securing the best glass/crystal, by devising more efficient methods of lens grinding and polishing in collaboration with practitioners of the art, and by the use of smaller apertures and diaphragms, all of which have been amply treated by various scholars.[31]

The Camera Obscura

Another powerful impetus for the improvement of lens and mirror technology came from attempts to improve the projection capabilities of the *camera obscura*, which for centuries had been used to project images and observe solar eclipses. In the course of the sixteenth century it was equipped with convex lenses and/or concave mirrors placed over its aperture to project distant images on a screen, glass, or piece of paper suitably placed opposite the aperture. The use of convex lenses permitted a larger aperture and projected more detailed images than those projected without the lenses, but it did not correct the reversal and inversion of the images. One had to use a very thin piece of paper held against the light and retrace the scene on the back of the paper, as Leonardo had suggested earlier when using the *camera obscura* without a lens.

The use of the convex lens in the aperture of the *camera obscura* was apparently first published by Girolamo Cardano (1501–76), a brilliant mathematician and renowned physician practicing in Lombardy but with a European-wide reputation. In his wide-ranging treatise on all sorts of natural phenomena (*De subtilitate*, 1551), he discussed images seen

31. The bibliography is immense on this topic. See Y. Zik, "Galileo and the Telescope: The Status of Theoretical and Practical Knowledge and Techniques of Measurement and Experimentation in the Development of the Instrument," *Nuncius* 14/1 (1999), pp. 31–67, for a good summary of the question and relative bibliography.

through lenses, mirrors and prisms, largely based on the writings of Euclid, Pecham, and especially Witelo. But he is credited with the introduction of a seemingly new element; i.e., the use of a convex lens to project a street scene on a piece of very white paper opposite a hole in a window of a dark chamber, which is only briefly described.[32] It should be noted that the tone of this short passage seems to indicate that such projections were often used for amusement in line with other attempts of the age to use mirrors to reflect street scenes and even happenings inside other people's homes without their being aware. These less serious uses of these projections, which included also the use of prisms, various shapes of mirrors, and magic lanterns, became more common with the later inventions of the telescope and the microscope, themselves objects of wonder, so as to form part of the "cabinets of wonders" that amused and educated European society from the late sixteenth through the eighteenth century.[33]

On the other hand, the more serious use of the *camera obscura* fitted with a convex lens to project outside scenes as an aid for artistic drawing of city views and landscapes was first described with precision and in detail by the Venetian polymath, historian, humanist, and diplomat, Daniele Barbaro (1513–70), who had been trained in philosophy, mathematics, and optics at the University of Padua. In his treatise, *La pratica della perspettiva* (1567), Barbaro gives the following concise but clear explanation, highlighting the quality of the lens and the use of a restricted aperture to provide a sharper image.

> *Next, close all windows and doors of the room, so that there is no light except the light that enters through the lens. Take a piece of paper, and place it opposite the lens and as much removed [from the lens], that you minutely see on the paper all that is outside the house. This happens most distinctly at a certain distance, which you find by approaching or withdrawing the paper with respect to the lens, until you find the convenient place. Here you will see the forms on the paper as they are, and the foreshortenings, and the colors, and the shadows, and the movements, the clouds, the trembling of the water, the flight of the birds and all those things that one can see. For this experience, it is needed that the Sun is clear and bright, because the light of the Sun has great force in extending the visible species, as to your satisfaction you can try by experience. For this experience, you choose*

32. G. Cardano, *De subtilitate*, vol. I, *Libri I–VII*, ed. E. Nenci (Milan, 2004), book IV, "De luce et lumine," pp. 349–424; quotation, p. 389: "Quod si libeat spectare ea quae in via fiunt, Sole splendente in fenestra orbem e vitro collocabis, inde occlusa fenestra videbis imagines per foramen translatas in opposito plano, sed cum obscuris coloribus: subiicies igitur candidissimam chartam eo loco quo imagines vides, et intentam rem mira ratione assequeris. . . ." Nenci has noted (p. 33) that Cardano's interest in optics may also have been prompted by his father, Facio Cardano, who had edited Pecham's *Perspectiva communis* ca. 1482–83. Many passages from book IV were published with an Italian translation and valuable comments on their optical significance by Ronchi, *Scritti di ottica*, pp. 51–59.

33. See B. M. Stafford and F. Terpak, *Devices of Wonder from the World in a Box to Images on a Screen* (Los Angeles, 2001), which was published to comment and illustrate an exhibition with the same title, held at the J. Paul Getty Museum, 2001–02. The book has many illustrations of these "devices of wonder." One recent article by C. E. Letocha, "The Augsburg Art Cabinet in Uppsala," *Ophthalmic Antiques* 92 (July 2005), pp. 9–13, is very informative on this subject and contains recent bibliography.

those lenses which are best, and, if you want to cover the lens as much as to leave a bit of circumference in the middle, and that [part] which is clear is not covered, you will see an even more vivid effect. Then, because you will see on the paper the main lines of things, you can indicate the whole Perspective, which appears in this, with a pencil on the paper, and shadow and color it lightly according to what nature shows you, . . . , until you have finished the drawing.[34]

The problem of the inverted and reversed image projected by the convex lens was solved by placing a plane mirror at a 45-degree angle within the dark chamber in order to reflect an upright image on to a drawing table. This solution was apparently first proposed by another Venetian patrician, Giovanni Battista Benedetti (1530–90), a leading mathematician and natural philosopher whose publications on mechanics seem to have had some influence on Galileo. This arrangement is used at the present time except that it occurs in a specially constructed darkened chamber, whereas in the sixteenth century it consisted of a darkened room in a house.[35]

The use of a concave mirror on the aperture, however, has the advantage that the image projected on the screen is upright and not reversed if certain conditions are observed.[36] Clearly, this use of the concave mirror was of particular interest to painters. One of the first descriptions of this combination was written by the Venetian physician, alchemist, mathematician and designer of mirrors and instruments, Ettore Ausonio (ca. 1520–ca. 1570), in his treatise, *Theorica speculi concavi sphaerici*, about 1560, and published posthumously in 1602 as edited by another instrument and mirror designer, Giovanni Antonio Magini.[37] The same combination was also described in 1573 by Egnazio Danti.[38]

This fascination with the images projected by the *camera obscura* could not fail to attract the attention of Giambattista della Porta. In the second edition of his *Magia*

34. The full passage was translated by Dupré, "Galileo, the Telescope," p. 246. See also *Scritti di ottica*, pp. 65–67 for Ronchi's interpretation of this passage.

35. Hammond, *The camera obscura*, p. 16.

36. See the following description of these conditions by Dupré, "Galileo, the Telescope," p. 245: "To obtain an image projected by a concave mirror . . . the concave mirror is placed inside the camera obscura . . . opposite the aperture, so that an image of the scene outside is focused on the wall or screen that contains the aperture. The advantage of the use of the concave mirror is that the projected image has the same left-right orientation as the scene outside. An image projected in an ordinary camera obscura is top-down inverted and left-right reversed. When projected by a concave mirror on the screen of the aperture, the image will still be inverted, but the left-right reversal will be undone. . . . When the piece of paper, on which the image projected by a concave mirror is traced, is taken from the wall, and turned upside down, left and right will be as in the original scene. Thus, the image projected by a concave mirror might have been particularly useful for a painter, who could take the picture traced after the projected image from the wall and immediately compare it with and finish it after the real scene."

37. S. Dupré, "Mathematical Instruments and the 'Theory of the Concave Spherical Mirror': Galileo's Optics Beyond Art and Science," *Nuncius* 15/2 (2000), pp. 563–72, and idem, "Ausonio's Mirrors and Galileo's Lenses: The Telescope and Sixteenth-Century Practical Optical Knowledge," *Galilaeana: Journal of Galilean Studies* 2 (2005), pp. 145–60, especially pp. 152–70.

38. Dupré, "Mathematical Instruments," p. 574.

he treated four types of the *camera obscura*: without a lens, with a convex lens and an inclined plane mirror to re-reverse the image, with a concave mirror for a larger image, and with a concave mirror to produce an erect image. Not only could the camera be used to project images of outside festivities and spectacles, but he also argued that it would even allow anyone not familiar with the art of drawing to depict the features of a man reflected on a piece of paper.[39]

It is abundantly evident that the sixteenth and seventeenth centuries saw increased practical applications of lenses and mirrors as measuring and projection devices or instruments, whose design and construction depended on mathematics as the foundation. Dupré has aptly stated that "the mathematical core that provided arts like map-making, painting and surveying their disciplinary unity were projection techniques to represent space."[40] In this sense, this period did not recognize a distinction between "art" and "science" because mathematics was the foundation for all the arts needed to represent space and form, known in Italy as arts of the *disegno* (drawing). This overarching concept, contrary to the modern view of separation of the "two cultures," was eloquently expressed by Egnazio Danti in his annotated edition of Euclid's *Optics*.

> *Also, to everyone should it be known to what extent and how perspective enriches Geography, because it alone shows the way to reduce in a plane, oval or circular, or in several other ways, the space of the complete earth, and of the particular provinces . . . And no less help does it offer to Astronomy, because we know with certainty the size of the stars, and the position of the heavens, by which we know that the Moon is lower, and Saturn higher than the Sun, and lower than the fixed stars in the eight sphere. It also shows the distance from one Heaven to another, and from one star to another, and the reason why it happens that the stars appear larger in one place of the Heaven than in another. . . . And leaving aside the advantages and usefulness it offers, to what extent it is necessary to infinite mechanical arts, in particular to Architecture and all the other arts of disegno, . . . I shall only say how I cannot but wonder how it is possible that this science of perspective is so low esteemed by learned men.*[41]

39. Book XVII, chaps. V–VII, in Ronchi, *Scritti di ottica*, pp. 169–75.

40. Dupré, "Mathematical Instruments," p. 552.

41. Ibid., p. 553, quoted and translated by Dupré from Danti's *La prospettiva di Euclide, nella quale si tratta di quelle cose, che per raggi diritti si veggono: e di quelle, che con raggi reflessi nelli specchi appariscono* (Fiorenza, 1573), Proemio. Four years later in his *Le scienze matematiche ridotte in Tavole* . . . (Bologna, 1577), Danti was even more explicit in including a great number of subjects under "practical mathematics" as understood in sixteenth-century Italy, such as arithmetic, geometry, ancient and modern measures, music, gnomonics, "meteroscopia," hydrography, mechanics, geography, architecture, military architecture, painting and sculpture, the measure of motion, and "prospectiva," including sections on plane and curved mirrors. But he left out lenses or combination of lenses and projection of images cast on paper or walls. (I have virtually quoted from a private communication by Tom Settle, Apr. 2005, and from his earlier statement in his article, "Egnazio Danti," p. 35.)

Although the boastful nature of the above statement is obvious and we need not believe that Danti had really calculated "with certainty the size of the stars," an accomplishment probably not entirely fulfilled even today with modern instruments, we should accept the statement as indicative of a program of observation and calculation made by available projection instruments such as astrolabes and astronomical quadrants along with improved compound *occhiali,* later called "telescopes." These instruments had so many practical applications in various fields, including military, such as planning fortifications and calculating the trajectory of cannon balls. It is significant that Galileo's education at the University of Pisa followed this mathematical instruments tradition taught by his professor, Ostilio Ricci, who used as a textbook Alberti's *Ludi matematici* (ca. 1450) with its emphasis on measurements by "sight, depths, heights and distances," and the use of the mirror as a reflecting device.[42] Galileo, in fact, continued his interest in instrument design at the University of Padua, as shown by his invention of the geometric and military compass, which in its final version solved a myriad of mathematical/geometric problems relating to practical applications in mercantile and artisan activities, becoming by 1599 "a universal mechanical calculator."[43]

Although these interdisciplinary applications and methodologies originated in Italy in the fifteenth century, they soon spread to other countries. Bennett has recently summarized this European-wide phenomenon as follows:

> *Those with strong profiles in an account of practical geometry in the fifteenth and sixteenth centuries would include—in a very rough chronological sequence—Florence, Nuremberg, Louvain, Paris, Antwerp and London. To a first approximation Florence might be particularly associated with cartography and perspective, Nuremberg with astronomy, dialling and instrument making, Louvain with surveying and instrument design, London with surveying and navigation. Such characteristics will not stand close scrutiny, but what is well established are shared technologies and common disciplinary identities. . . .*
>
> *Hartmann, who has been mentioned as an astrolabist and perspectivist, is a link with the northern centre of practical geometry in Nuremberg, founded effectively by Regiomontanus, who introduced the mathematical programme to an already thriving centre of technical arts. The same intersection of interests is found here—astronomical practice, instrument making, dialling, cartography. . . . The intersection of geometry, surveying, perspective, cartography and instruments is clear in the work of Hartmann and Durer. Through the travels and personal contacts of Regiomontanus and Durer with Italian geometers, the Florentine*

42. Dupré, "Mathematical Instruments," p. 557.

43. Ibid., p. 562. See also T. B. Settle, "Ostilio Ricci, a Bridge between Alberti and Galileo," in the *Actes, XII^e Congrès International D'Histoire des Sciences,* vol. III B (1968), pp. 121–26, for an eloquent and persuasive statement of this connection.

initiatives were influential here. Regiomontanus knew both Alberti and Toscanelli, and knew of their work on astronomical measurement, which became an enduring feature of practical geometry at Nuremberg, through the observational astronomy of Regiomontanus himself and following him of Walther, Werner and Durer. . . .[44]

Lens Technology

The intense interest exhibited in the whole of Europe during the sixteenth century for a more efficient long-distance visual instrument such as the spyglass and a more practical projection tool such as the *camera obscura* sparked the demand for better quality lenses and mirrors to achieve both objectives. Actually, efforts to improve the quality of lenses arose naturally out of the more than two centuries' experience with spectacle wearing. Documents cited in preceding chapters have shown that artisans and spectacle wearers were aware that the clearest glass and crystal properly ground and polished made the best lenses, and that appropriately fitted frames of choice materials were essential prerequisites for clear and comfortable vision. These concerns were reflected in the various prices charged for eyeglasses and frames, the emphasis on quality expressed by the customers, and the patronizing of certain spectacle makers, sometimes at great distances, for a high-quality product. Experience had taught customers that not all opticians had been created equal! One can also hazard the hypothesis that what was true for individual artisans was also true for leading spectacle-making centers as a whole, such as Florence in the fifteenth century, as well as Venice, Nuremberg, France, and England in the sixteenth century and beyond. These places, obviously, had developed better technology, though in some cases we lack the documents to pinpoint the nature of the improvements. In fact, we know very little about the methods employed to improve the quality of lenses before the end of the sixteenth century. As in the case of frame making, the oral transmission of knowledge was the norm.

Perhaps the earliest and most definite evidence about a crucial step in the advancement of lens technology is provided by the order sent to Florence by Duke Galeazzo Maria Sforza of Milan in 1466, asking for two hundred pairs of spectacles, graded in semi-decades for presbyopia for ages thirty to seventy and two degrees for myopia. With this order we are almost at the threshold of prescription glasses! It will be recalled that these glasses were destined as gifts for a large court and not for prestigious dignitaries whom the duke wished to impress. Then, just two decades later, the Florentine

44. J. Bennett, "Projection and the Ubiquitous Virtue of Geometry in the Renaissance," in *Making Space for Science: Territorial Themes in the Shaping of Knoledge*, ed. C. Smith and J. Agar (London, 1998), p. 29, for the first quoted paragraph and pp. 36–37 for the second. For chronological context, I am adding the following dates: Georg Hartmann (1489–1564); Johannes Regiomontanus (1436–76); Albrecht Dürer (1471–1528); Bernard Walther (1430–1504); Johann Werner (1468–1522). The whole article outlines these European-wide connections.

ambassador, Luigi di Angelo della Stufa, promised to send eyeglasses graded in decades and semi-decades to friars at the Church of the Holy Sepulcher in Jerusalem, clearly an order designed for ordinary people.[45]

Where did this idea that visual acuity declines in five-year intervals after the age of thirty come from? It must have been empirically established because there is no hint of it in the scientific literature of the fifteenth century or earlier. With two similar orders coming from two distant places, so precisely expressed without any reservations or doubts about compliance, we have to conclude that this practice was well established by 1466 at least in Florence. This leads to the conclusion that Florentine *occhialai* had found a way to make convex lenses more precisely ground for semi-decades and even master the more delicate process of making the thin-in-the-middle concave lenses in two strengths for myopes despite the difficulty of producing lenses of this precision as it will be noted below. Surely, this is a sign of progress in lens technology. It would have made no sense to place these precise orders two decades apart without hopes of fulfillment. Therefore, unless documents to the contrary are discovered, we must take them at their word.

We should also add that if Florentine spectacle makers had introduced this more precise method of grinding/polishing lenses, it would not have taken long for knowledge of the process to spread to other spectacle-making centers given the well-documented migration of artisans from one center to the other. We assume that these advances were the result of better hand tools for grinding and polishing lenses because no evidence has been discovered of the use of machines until the time of Leonardo. He is credited with designing the earliest grinding and polishing instruments for lenses and mirrors, which were operated by hand or waterpower.[46] Whether these machines were actually built or whether their drawings came in the hands of lens and mirror makers later in the sixteenth century remains matters of conjecture.[47]

In the closing decades of the sixteenth century we finally have the first publications containing fairly detailed descriptions of the preparation of spectacle lenses, written not by spectacle makers themselves but by writers familiar with their trade. The briefest, and apparently the first, is that provided in 1585 by the Augustinian monk Tommaso Garzoni, who included spectacle makers in his vastly popular encyclopedia of hundreds of occupations practiced in his time. He included them in the chapter on glassmakers, noting that the latter supplied the eye-glasses or blanks (*occhiali*) which were then given appropriate form by those who were "commonly called *occhialari*" so that both trades "stuck together like flowers and grass." After mentioning two "famous" contemporary

45. These orders have been treated in chap. III, pp. 90–93.

46. See S. A. Bedini, "Lens Making for Scientific Instruments in the Seventeenth Century," *Applied Optics* 5/5 (1966), p. 688.

47. See chap. V for more details on Leonardo's mirror-making machines.

occhialari in Venice—*Lorenzo all'occhial grande a San Salvatore and Pietro all'Angiolo a S. Giuliano*—Garzoni proceeded to describe the various iron forms used to grind convex and concave lenses for various ages in decades from 30 to 100 and for cataracts already removed. The curvature (power) of the lenses for each decade was measured on a scale from ½–15 *punti* (points or degrees), presumably "inches" to the foot as understood in Venice.[48]

Garzoni's description is understandably very brief since he discussed hundreds of occupations, but it was sufficient to be understood by other spectacle makers outside Venice, who were familiar with the Venetian measures just as they had knowledge of other systems of weights, measures, and currency particular to each region. Perhaps we may not stray too far from the truth if we assume that this "point/degree system" had originated in Italy, most likely in Florence in the middle of the preceding century, where age-related presbyopic glasses were first mentioned and a measuring unit was needed for determining the curvature of the lenses for each age. If so, Garzoni described a system that had been in place for more than a century although I have never encountered any specific mention of it in the documents. Whatever its origin, spectacle makers would have had to take account of the regional variations in measuring units and undoubtedly would have inserted their individual adjustments as dictated by daily practice. And, of course, this problem persisted until the adoption of the meter as the standard unit of measurement following the Paris Meter Convention of 1875. Perhaps we should not exaggerate the inconveniences posed by the pre-standardized systems of measurements because account books and other evidence of this period show that tradesmen everywhere learned to cope with the many local variations and artisans of the same craft could readily assimilate each other's data.

Almost two generations later, Benito Daza de Valdés, a Spanish Dominican notary of the Inquisition, published in 1623 the application of another measuring unit for grading the surface curvature of the lenses by degrees to correspond to decades from age 30 to 80. It was based on the Spanish medieval linear unit, the *vara*, sometimes known as the Spanish yard, which was about three inches shorter than the English yard, 836 mm

48. T. Garzoni, *La piazza universale di tutte le professioni del mondo*, ed. G. B. Bronzini with P. De Meo and L. Carcereri, I (Florence, 1996), discorso LXIIII, "De' vetrari, o biccherari, occhialari, et finestrari," p. 658: "Ma gli occhialari anch'essi tengono dietro ai vetrari, et convengono insieme, come fa il fiore con l'erba, perché gli occhiali detti latinamente *conspecilla*, . . . hanno la loro origine da'vetrari, ma par ch'acquistino una certa lor forma propria da quelli, che occhialari communemente nominiamo. . . ." "S'adoprano instromenti di ferri, piani, tondi per gli occhiali di cinquanta, e sessant'anni, et che fanno anco di prima vista debile. Et questi istessi fanno anco di trenta, o quaranta lavorati da due bande; gli altri ferri tondi, ma colmi da una banda, et cavi dall'altra, fanno la vista di quaranta, o cinquanta di fuora via dal colmo, et anco vista debole di due punti di fuora via dal colmo, et di dentro via fanno di sessanta, o settant'anni, et anco di vista debile, ma mezzo punto. I ferri da novanta più cavati, et più colmi, di fuora via fanno vista corta di tre punti; et fanno anco di vista di trent'anni, et manco; e di dentro via fanno vista da novant'anni. I ferri da filetto fanno vista corta di sei punti di fuora via, ma di dentro di anni cento; una cazzetta fa di otto punti da vista corta di fuora via, ma di dentro da cataratta, che sia stata cavata. La balla grossa fa di dieci punti in tondo. La balla mezzana fa di dodici punti. La balla picciola fa di quindici punti."

in the metric scale, and equal to 1.1967 diopters. A comparison of Daza's prescribing measurements with the dioptric scale has shown that the former have a higher power especially at the lowest and highest presbyopic levels.[49] The value of the *vara,* however, varied from region to region, including the colonies in the New World, a fact that is not mentioned in the book probably because the author properly insisted on accurate measurement of each patient's vision that would take account of the different values.

This book has become a classic and it has been praised for its originality in that it is the first detailed treatment on the use of eyeglasses in any language, and its recent publication in an English translation is bound to contribute to a growing interest in its many merits.[50] It is really a manual for practitioners, which summarizes current practices as they had evolved over the centuries, some of which we have already encountered and cited from available documents. One would think that such a useful compendium would have become very popular, but the fact that to date only seventeen copies have been discovered, almost all of them in Spanish libraries, suggests that it had limited circulation probably because it discussed procedures already known and practiced by master spectacle makers.[51] For our purposes the book has the additional value that it provides the earliest and fullest description of the state of the art just a few years after our chronological limit.

The book is divided into three parts, called "books." The first part deals with characteristics and properties of the eyes and their refractory conditions; the second, the use of eyeglasses to treat these conditions; the third and longest section is devoted to seven clinical dialogues among a master spectacle maker (*maestro*), a physician knowledgeable about eye diseases, patients, and sometimes medical students. It is this last section that can be considered the most original and useful for our purposes because it shows the process of arriving at solutions for actual problems presented in "consultation" as it were. Instead of the "rounds" in a hospital setting, we have the optical shop where, amidst the friendly banter designed to relieve the monotony of the discourse, Daza treated precise measurements and prescriptions not only for the two most common visual anomalies, myopia and presbyopia, but also for cases where young people have the "vision of old people" (hypermetropia) commonly confused with presbyopia (p. 147); uneven vision where appropriate correction must be made for each eye so that the "weaker" eye does not become "lazy" through lack of use (p. 143); "opposite vision" where one eye is nearsighted and the other farsighted (pp. 148–49); the necessity of adapting gradually to wearing glasses (pp. 140–41); appropriate lens grades after cataract surgery (p. 160);

49. See H. W. Hofstetter, "Optometry of Daza de Valdes (1591–ca. 1636)," *American Journal of Optometry and Physiological Optics* 65/5 (1988), pp. 354–57, and J. S. Pointer, "'Age Markings' on Antique Spectacles and Lenses," *Ophthalmic Antiques* 45 (Oct. 1993), pp. 4–5.

50. B. Daza de Valdés, *The Use of Eyeglasses,* with a commentary by Dr. Manuel Marquez, trans. P. E. Runge (Sarasota, 2004).

51. In Europe, only the British Library has a copy. Ibid., p. 39.

use of printed texts to measure reading distances and appropriate lens power (p. 143); progressive quality of lenses made from plain glass, "mirror crystal" (man-made crystal), and natural rock crystal (pp. 163–65); the advantages of leather over metal frames (p. 134); the color of lenses (all colors were acceptable except yellow and red, with preference given to green (p. 170).

Daza advised against the use of monocles, except for those who can see with only one eye, because they led to uneven vision. By the same token he discouraged the use of single lenses placed over the print, or of hand-held lenses to avoid wearing glasses for vanity reasons because he believed that one should wear glasses on the nose, the natural place for them (p. 168). Above all one should go to master spectacle makers to procure good glasses and not street peddlers (p. 138), cautioning that "eyeglasses are only as good as the man who makes them" (p. 151), and that the "quality of eyeglasses depends so much on the skill of the maker that well-made lenses are better than badly made crystal ones" (p. 152). He even included instructions on ordering glasses in absentia because many people lived at long distances from places like Madrid, Lisbon, and Seville, the leading spectacle making centers in the Spanish peninsula (pp. 115–117, 125). He also devised another scale of measurements for women, who required "more degrees because they do more delicate work and because they have weaker vision" (p. 118).

Not only is this the first complete treatment of the use of spectacles of the age, but it is also the first to express unbounded, even ecstatic, admiration for their utility and appreciation of their necessity for human existence. In the prologue to the second section, Daza praised the ancient custom to honor and even venerate inventors in the arts and sciences, and argued for equal regard for the invention of eyeglasses, which he attributed to heaven. He totally ignored the question of dating the invention or the role that his own Dominican brethren in Pisa and Florence had played in its diffusion. Likewise, he discussed in the last dialogue the composition of the telescope and its uses along with the capabilities of the *camera obscura* without bothering about origins or even mentioning Galileo. On the other hand, he was modest about the role of his own age in that it only promoted and perfected the use of spectacles, in the pursuit of which he offered his book as a contribution. The following passages show his reverence for the subject and served to elevate spectacle making from a mere craft into a profession almost charged with a divine mission, an attitude that has had a great appeal for modern optometrists.

> *If the wise men of antiquity so venerated all these—and many other—inventors of the arts and sciences, then present and future centuries will have even more reason to value the admirable invention of eyeglasses and to praise and esteem those in our century who have perfected this old invention (giving it new hews and a new soul, if this can be said). They have placed it in its rightful position and advanced the use of eyeglasses as much as possible.*

The invention of eyeglasses appears to have come from heaven, from where the eyes also came. So we can say that the "new eyes"—which we receive when we wear eyeglasses —also came from above. To state briefly the virtues of the eyes, the reader should recall that Aristotle reduced all natural gifts to three, all of which are found in the eyes. The first gift is pleasure, the second is virtue, and the third honesty. All of these gifts are also found in eyeglasses. (p. 97).

If any doubts remained about the "divine mission" of spectacle makers and of their close associates, the makers of telescopes and microscopes, they were dispelled about two generations later by the publication of the most comprehensive book on the subject, *L'occhiale all'occhio* (1660), written by the astronomer and designer of lens grinding/polishing machines, Count Carlo Antonio Manzini (1599–1677) of Bologna. Manzini established his own astronomical observatory on the grounds of his estates around Bologna and made his own telescopes, grinding the lenses for them himself.[52] Whereas Daza's book was really a manual for practicing opticians with a limited theoretical scope, Manzini's was both a theoretical and practical compendium of what was known on optics and on the art of spectacle making from the fusion of glass and crystal to the fitting of glasses for various refractive errors and the insertion of precision lenses in telescopes and microscopes.[53] His work was dedicated to St. Lucy, who was appointed by God to be the "advocate of the eyes," as it is shown in numerous paintings representing the saint.

In his preface, Manzini expressed his consternation in seeing the art of spectacle making being passed orally from one generation to the other without written instructions and often in strict secrecy so that much valuable information was lost forever. His book was designed to serve as a guide both in theoretical optics as developed by medieval authorities such as Alhacen, Witelo, Bacon and by writers closer to his age such as Johannes Hevelius (1611–87), Maurolico, Della Porta, Christoph Scheiner (1573–1650), Kepler (1571–1630), Marin Mersenne (1588–1648), and Descartes (1596–1650) among others, and in the actual shop practices followed by leading makers of scientific instruments, some of which he had helped to develop. He revealed that he had learned the first rudiments of hand polishing lenses from a former mirror maker in Venice, Domenico Rambottino, a man without any education (*huomo idiota affatto*) but very skilled in polishing lenses for telescopes, which he supplied throughout Italy and the New World (New Indies) (pp. 238–39). He received additional theoretical and practical instruction

52. Surprisingly, Manzini is little known today. Neither the *Dictionary of Scientific Biography* nor (more surprisingly) the *Encyclopedia Italiana* has an article on him! For a brief biographical sketch, see S. A. Bedini, "An Early Optical Lens-Grinding Lathe," *Technology and Culture* 8/1(1967), p. 76.

53. The full title of this book gives an ample description of what the author planned to deliver: *L'occhiale all'Occhio, Dioptrica Pratica dove si tratta della Luce; della Refrattione de Raggi; dell'Occhio; della Vista; e de gli aiuti, che dare si possono à gli Occhi per vedere quasi l'impossibile. Dove in oltre si spiegano le Regole Pratiche di Fabbricare Occhiali a tutte le Viste, E Cannochiali da osservare i Pianeti, e le Stelle Fisse, da Terra, da Mare, Et altri da ingrandire Migliaia di volte i minimi de gli Oggetti vicini* (Bologna, 1660). And he delivered!

from some celebrated instrument makers of the age such as Francesco Fontana in Naples, who brought the art to such a degree of perfection that he could rightly boast to be the most "sharp-eyed man from the creation of the universe to his time" (Preface). He reserved his highest praise for Eustachio Divini (1610–85) in Rome who rose above all others in the practice of this art, which can now be called "divine" (an allusion to his last name) because of his accomplishments (Preface). Even great princes in Italy and elsewhere, he claimed, have not disdained to use their hands in this art through which men can now scan the skies and the stars and contemplate God's creation. And, he observed, "there are few in the world that would not need the benefits of this art before dying" (Preface). There could hardly be a more enthusiastic and eloquent celebration of the usefulness, dignity, nobility, and even "divine" function of the relatively new profession of optical scientists and practitioners.

The preface also emphasized the practical aspects of the art. Although Manzini distilled optical theory in his chapters on light and refraction for the benefit of those more skilled in mathematics, he advised other readers that these sections could be safely skipped because they were not necessary to become "a perfect master" (*maestro*). They were advised instead to imitate Divini's career, whose portrait graces the frontispiece of his book. Divini, according to Manzini, had relied more on experience, ingenuity, and good judgment than on books to achieve his astounding results in making the best lenses and telescopes in Europe. He was, indeed, credited by his colleagues to be the "first to have perfected the making of telescopes."[54]

Manzini's detailed and extensive description of lens grinding and polishing surpassed by far earlier treatments, including those published by Della Porta in his *Magia naturalis* (1589) and by Giovanni Sirtori in his *Telescopium* (1618). His exposition is based on these and other writings and above all on personal observation and practice as he consorted and worked with top-level masters of the art. It would be impossible to distill in a few sentences the complex steps of this process, which occupies the longest section of the book (pp. 199–263). Moreover, this is a task that should be more properly undertaken by persons who are thoroughly familiar with grinding and polishing of lenses. For our purposes it is sufficient to identify the five stages in the production of lenses: making "templates for the tools for grinding and polishing; producing the sets of tools for

54. Preface: "E se pure si contentasse alcuno, inetto alle astrattioni della materia, le pure Regole pratiche apprendere, lasci da parte i Discorsi della Luce, della Refrattione de Raggi, ed alcuni altri che seguono framischiati, meno materiali, che quelle possono impararsi, senza queste, e necessarii non sono questi per diventare dell'Arte Dioptrica Pratica buono, e pefetto Maestro: quale appunto ti posso proporre da imitare, ò Lettore, di quest'Arte curioso, nella persona, quì sotto effigiata, à cui più l'esperienza, che i libri n'è stata la maestra, e compagni di scuola l'ingegno, e 'l buon giuditio." Under Divini's portrait, Manzini wrote that Divini was "giudicato da scientifiei dell'Arte il primo che sin hora habbia perfettamente praticato il fabricare Occhialloni, e però degno di perpetua memoria. . . ." Strictly speaking the portrait cannot be considered a frontispiece because it is placed in a page right after the preface, preceding the text rather than before the title page.

different focal lengths; the selection of the glass blanks; the grinding process and the polishing process."[55]

The templates were made of metal (copper, steel, pewter, lead, and preferably brass) and were constructed in pairs, "one convex, the other concave, of the same radius of curvature and each set was turned to a different focal length and labeled in feet as a measure of the focal length of the lens to be ground. The pairs in each set were ground against each other to ensure the accuracy of the surfaces of the lenses. . . . The templates were used to form the grinding tools themselves, also made in pairs. Metals were used for these tools, usually iron but preferably brass. The glass blanks were cut into disk shapes from a larger plate of glass, and several of them were fixed with cement to a convex tool or mallet, which was cemented in turn to a post for grinding. All the lenses were then ground at the same time against the tools by hand, using progressively finer sizes of washed emery to bring the lens surface to a semi-polished state. The final polishing was done on "a concave cast iron shell covered with a heavy woolen cloth without its nap, which was pressed into place by working the corresponding convex brass tool on it. The pores of the cloth were then filled with enough *tripoli* (putty powder, calcined tin) to make its surface level."

Manzini advised that grinding and polishing of lenses were accomplished more precisely by hand than by machine. He wrote that he had never seen a lathe or machine capable of doing what the hand could despite the claims of inventors and mathematicians. He even added with a tinge of irony that he had seen one of these mathematicians/inventors, a non-Italian (*Oltremontano*) residing in a leading Italian city, working "many lenses" by hand "with extraordinary diligence and patience."[56] But he was not a Luddite for his text is illustrated with various grinding/polishing machines, including one of his own improved lathes, which was superior to the lathe used by Ippolito Francini

55. The stages, extracted from these early sources, have been described with admirable clarity and detail by D. J. Bryden and D. L. Simms, "Spectacles Improved to Perfection and Approved of by the Royal Society," *Annals of Science* 50 (1993), pp. 7–11. I have used this article as the basic guide and as the source for this and the following quotations. Other detailed descriptions are provided by 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, and R. Willach, "The Development of Lens Grinding and Polishing Techniques in the First Half of the 17th Century," *Bulletin of the Scientific Instrument Society* 68 (2001), pp. 10–15 with several useful illustrations. Solaini, "Storia del cannocchiale," pp. 838–57, provides another detailed description with very instructive illustrations, based primarily on Galileo's writings.

56. Manzini, *L'occhiale all'occhio*, p. 159–60: "Ma quali sono questi Torni, che habbiano proprietà d'imprimere la Colmezza, e la Cavità perfettamente Sferica, ò d'altra figura nel Cristallo senza sospetto d'imperfettione? Io certo, per quanti disegni mi habbia visto andare attorno sù le stampe di hoggidì, non hò conosciuto potermici assicurare, e sia detto con buona pace de loro Inventori, i quali forse no hanno mesio in pratica le loro speculationi, veramente belle, e Matematicamente parlando, bene intese: ma queste sono di quelle cose, nelle quali mescolandosi le materie Fisiche, fanno perdere la Scherma alli Mechanici. Hò visto in una Città delle prime della nostra Italia un Matematico Oltremontano una volta inventore, e publicatore sù le stampe di simil Torni, e Machine varie per questo servitio, lavorare anch'egli molte Lenti à mano senza Torni, ò altre Machine, e starci dietro molto spaccio di tempo, & con istraordinaria diligenza, e patienza: inditio, ch'egli possedeva molto bene quest'Arte, e di quanta acuratezza faccia di bisogno per praticarla; . . ."

(nicknamed *Tordo*), Galileo's skilled lens maker.[57] He stressed, however, the necessity that theory must be informed by practice for the production of excellent lenses following his own example in observing artisans and working with them. This experience had taught him that the final testing of the lenses be done by a person with keen eyesight, operating in a darkened chamber to observe objects at various distances through the lenses with the light being provided by candles, torches, or oil lamps (pp. 252–55). It may be safe to add, however, that Manzini did not discover all the secrets of the trade and that many of these skilled technicians died taking their secrets with them, as he had complained in his preface.

From this marriage of theory and practice, Manzini evolved tables of specific ages requiring appropriate radii of curvature for spectacle lenses. His measurements were based on the foot of Bologna, which was equal to about "five quarters" (*Cinque quarti*) of the ancient Roman foot. The Bolognese foot was composed of twelve "ounces" (*oncie*) (inches?) and each ounce was subdivided into sixty small parts (*particelle*), also called "prime minutes" (*Minuti primi*), as was the practice in astronomy. He distinguished six power degrees of lenses for various ages and for cataracts: 1. 40–50, known as "common vision" (*vista comune*); 2. 50–60; 3. 60–70; 4. 70–80; 5. glasses for a half cataract; 6. glasses for the entire cataract. As it had been established two centuries earlier, he recognized two degrees of myopia — "weak and short vision" (*viste deboli e viste corti*). He cautioned, however, that these measures were averages for there were several "middle" degrees both for presbyopes and myopes and age alone was a very imprecise determining measure. It was necessary to try different models in spectacle shops.[58]

Presumably, this trial and error approach, still practiced for reading glasses at least in general stores and pharmacies at the present time, could result in custom-fitted spectacles by able spectacle makers, but it tended to fatigue the eyes as they were subjected to different focal lengths. Moreover, visual acuity is seldom equal in both eyes, a condition that perhaps could have been observed and remedied on the spot by experienced practitioners. Consequently, customers adopted a number of strategies to overcome these impediments. Some sought to improve their chances for clearer vision by owning several pairs and ordering them from trusted makers even at long distance, as indicated above. Others, as Francesco Maurolico wrote in 1554 at the age of sixty, may have followed his practice of using different spectacles for various distances.[59] It would take the

57. See S. A. Bedini, "Lens Making for Scientific Instruments in the Seventeenth Century," *Applied Optics* 5/5 (1966), pp. 690–91.

58. Manzini, *L'occhiale all'occhio*, pp. 95–105, which contain various tables. The prescription for a person in the 40–50-age range is given as follows: "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" (p. 98).

59. F. Maurolico, *Diaphanorum*, book III, in *Scritti di ottica*, p. 126: "Ego quidem ad longe, prope, propriusve [sic] spectandum legendumque, diversis aliquatenus utor conspiciliis: . . ."

genius of Benjamin Franklin to solve this cumbersome procedure with his development of bifocal lenses nearly two centuries later.

It goes without saying that Manzini reiterated what had been found centuries earlier, that the clearest glass and the purest rock or artificial crystal made the best lenses. The major part of spectacles in Venice and elsewhere, however, were made with glass lenses because they were lighter on the nose and cost less. They were largely imported from Germany, which manufactured round glass blocks "concave on one side and convex on the other."[60] For the rich it was a trade-off between lighter spectacles with glass lenses and heavier spectacles for clearer vision, which could only be achieved through the use of crystal. Rock crystal, in fact, was the material used exclusively by one of the greatest spectacle makers of the age in London, John Marshall (ca. 1659–1723). A member of the Turners' Company, Marshall made wooden rings to hold lenses for spectacles and optical instruments and was used to "turning and grinding." He used brass tools and probably brass templates as well, rather than iron ones, which were easily spoiled during use and caused irregularities in the lenses. His methods produced batches of lenses uniformly ground and polished so that they gradually became the norm for spectacle making in England and elsewhere. About the same time the improved quality of English glass as well as the efforts of other spectacle makers such as John Yarwell (1648–1712), who adopted Marshall's techniques, and Edward Scarlett (1691–1743), who etched focus marks (focal lengths of the lenses in inches as distinguished from age marks) on the frames and attached side pieces to them to rest on the ears, all served to put English produced glasses at the top of the European scale.[61]

Actually, the basic grinding/polishing techniques changed little until the middle of the nineteenth century when power operated machines for grinding and polishing were introduced and resulted in increased production with improved optical quality, which was also enhanced by the development of clearer glass and crystal.[62] Yet, hand processing of lenses was used as late as the middle of the twentieth century for optimal results in special optical projects, and was still practiced only twenty years ago until replaced by computer-controlled machines.[63] The accuracy of the gradation of lenses according

60. Manzini, *L'occhiale all'occhio*, p. 112: "Il Vetro è più leggiero per portare al Naso, & è di minor valore: e però in Venetia, & altrove, per lo più, gran quantità di Occhiali da Naso si lavora di Vetro, non però quello di Murano, ma di Germania, di dove vengono certi Vetri tondi, Cavi da una parte, e Colmi dall'altra, fatti alle Fornaci di que'Paesi. . . ." It will be recalled that the friars of the Monastery of the Paradiso in Florence were already using German glass blanks for lenses two centuries earlier. See chap. V, p. 177.

61. Bryden and Simms, "Spectacles Improved to Perfection," pp. 11–32, and J. S. Pointer, "'Age Markings' on Antique Spectacles and Lenses," *Ophthalmic Antiques* 45 (Oct. 1993), 5–6.

62. Prior to this period, impurities, streaks, and bubbles could not be completely removed, a matter of utmost importance for scientific instruments but not as crucial for spectacles lenses worn close to the eyes. For a concise statement of this question, see G. L'E. Turner, "The Government and the English Optical Glass Industry, 1650–1850," *Annals of Science* 57 (2000), pp. 399–408.

63. A most thorough treatment of lens technology from our period to the middle of last century is provided by F. Twyman, *Prism and Lens Making: A Textbook for Optical Glassworkers*, 2nd ed. (London, 1952). He points out that

to progressive ages in semi-decades and two degrees of myopia already practiced in Florence in the middle of the fifteenth century, therefore, should perhaps be accepted in relative terms. Maybe it should be considered as the best approximation to real needs that could be obtained by experienced artisans of the time. It seems, however, that in time this practice of labeling and separating spectacles by age categories was neglected by some spectacle vendors. In the middle of the sixteenth century Francesco Maurolico complained that most spectacle makers in Italy no longer followed this useful practice for unknown reasons except possible negligence.[64]

Despite various improvements, the optical quality of spectacle lenses during our period left much to be desired in general and there was a great deal of waste in discarding lenses because of imperfections and distortions caused by improper grinding/polishing or impurities in the glass/crystal. It remained very difficult to produce spherical lenses uniformly ground and polished so that clear vision was possible from their center as well as their periphery. At the end of the seventeenth century the Dutch engineer, Cornelius Meyer (1630?–ca. 1700), who worked in Rome for many years, expressed the frustrations of many with the quality of spectacle lenses and proposed improvements, some of which make a lot of sense. He complained that in his time spectacle lenses were made too small so that "the axis of the visual cone, that passed by means of the pupil, did not hit the center of the lens. The visual rays tended to hit the extremity rather than the center of the lens so that vision was constantly altered by this defect of the lenses." He advised that the pupil should see through the center of the lens so that the "species" would travel at "right angle inside the eye." To avoid discarding these small lenses, he suggested that they be combined as in a "cushion" to make bigger lenses so that the centers of these lenses corresponded to the pupils. Furthermore, since the majority of people lacked a straight nose, one must compensate for this by fitting glasses that were "horizontal with the eyes." Naturally, the lenses should be made of pure and fine crystal, taking care that one always used the same side of the lens next to the eye.[65]

"this simple method of hand polishing of prisms and lenses, although long discarded for quantity production, is still in use when work of high class has to be produced in small quantities. . . ." (p. 44). At the meeting of the Optical Society of America in Rochester, N. Y. (October 10–14, 2004), I was surprised to learn that one optical company still used hand grinding and polishing of lenses up to twenty years ago, when computerized machines were adopted.

64. F. Maurolico, *Diaphanorum*, in *Scritti di ottica*, p. 127: "Memini ego olim conspiciliorum fabros tantae fuisse diligentiae, ut notulis infixis aetatem cui accommodanda essent, per annorum numerum declaravent. Quod hodie ut plurimum negligetur."

65. C. J. Meyer, *Nuovi ritrovamenti divisi in due parti con tre tavole in lingua latina, francese, e ollandese* (Rome, 1696), "De gli occhiali": ". . . li fabricatori mancano nella forma, facendo li vetri così piccoli che l'asse del cono visuale, che passa per mezzo della pupilla non batte nel centro del vetro, quale è il più puro per tramandare le specie, mà che neanco li radii visuali, che formano il ditto cono battono tutti due nel vetro, ò al più nell'estremità solamente. . . . Si che le specie non solo de gli oggetti vengono ad alterarsi, & à scontorcersi, mà anco tramandate con iscurcio, & alteratione, è per così dire velatamente dentro l'occhio, si che gli occhi patiscono, come anco perche si viene à mirare quella portione di vetro che suole essere annebiata, & impura, oltre che per quella parte si ripigliano nella pupilla non i raggi retti, e profittevoli, mà gl'offensivi, e stranieri che obliquamente recano le specie: cagioni tutte

While the above listed impediments to optimal lens quality are undeniable, we should not hastily conclude that they were insurmountable at this time or even many centuries earlier. I have already cited expert judgments on the high quality of rock crystal concave/convex lenses in eye-constructs of Egyptian statues of 4,600 ago, and the high quality of rock crystal aspherical Viking lenses, ideal for magnification, of the eleventh/twelfth centuries.[66] And the previously cited pair of Mantuan spectacles of the early seventeenth century was judged to have two "perfectly spherical" biconvex lenses of 34 mm. in diameter, which should have provided clear, straight and peripheral vision for the normal eye requiring an aperture of about 3 mm in daylight.[67] Finally, we should remind ourselves that despite the shortcomings in lens and frame technology noted above, our evidence shows that tens of thousands or perhaps millions of persons all over Europe found spectacles satisfactory in varying degrees. And this conclusion is largely based only on a fraction of the records available in Tuscany alone because, as I have repeatedly noted, documentation for Venice and other parts of Europe for this period is scanty or nonexistent. If some day a systematic search of the Tuscan sources is carried out, and if we are fortunate to find a cache of documents in other areas of Europe, then it is likely that the yearly volume of trade in spectacles cited in this study will have to be doubled or perhaps even tripled. Only then can we reach more accurate conclusions about the diffusion and the popularity of spectacles in our period.

On the Way to the Retinal Image

In the first chapter I discussed medieval optical theory at length, highlighting scholarly consensus that medieval theories of vision had nothing do to with the invention and development of eyeglasses. Spectacles were the product of artisan labor and their improvements followed the same empirical pattern at least until the invention and early

che in vece d'aiutare la vista l'indeboliscano, e progiudicano. Quindi sarei di parere che li vetri de gli occhiali fare si dovessero in modo che la pupilla dell'occhio battesse nel centro del vetro. . . . E perche tal uno potrebbe inferire che servendosi de gli occhiali grandi s'havessero poi da buttare tanti occhiali piccoli già fatti, perciò si dimostra al num. 4. che facendo à gli occhiali piccoli in cuscinetto come alla lettera A. acciò s'allarghino finche il centro delli vetri corrisponda con la pupilla dell'occhio, che saranno ancora servibili. Un altra cosa alla quale devono riflettere quelli che adoprano gli occhiali è che si come la maggior parte delli huomini non hanno il naso rettamente steso, mà torto, così devono mettere l'occhiali che stiano orizontali con gl'occhi, e che à causa del difetto del naso non pendono più verso l'una che l'altra parte." In another chapter, "Del modo di adoprar gli Ochiali," he added: "In oltre deve avvertirsi che gli occhiali siano di Cristallo fino ben lavorato, e pulito, perche quando fussero di Cristallo impuro danneggiarebbono più tosto la vista; si come sarà ancora bene d'avvertire di mettere sempre la medema parte de gli occhiali verso la vista, il si può notare con qualche piccolo segno perche con il voltarsi hora verso l'una, & hora verso l'altra parte può apportare qualche variatione alla vista." The text is keyed with letters and numbers to figures and drawings of lenses illustrating the author's recommendations based on personal experience.

66. See chap. I, pp. 36–40.

67. See Willach, "The Development of Lens Grinding and Polishing Techniques," p. 10, for apertures of human eyes and suitable dimension of lenses. For additional details about the Mantuan pair, see ch. V, pp. 168–69.

development of the telescope and the microscope, which themselves were the inventions of artisans. For three centuries artisans and intellectuals had spectacles on their noses without any precise idea of the function and working of lenses. What is more surprising is the fact that Della Porta's *De refractione* (1593) contained the first theoretical analysis of lenses in a treatise that was far less popular than his *Magia*. As we have seen, he excused himself for not having a sufficient knowledge of the subject and lamented the fact that he had no previous guide to rely on. So at the end of the sixteenth century we have Della Porta's faulty geometrical analysis of lenses and his totally inadequate understanding of the causes of presbyopia and myopia. Since Della Porta was in frequent epistolary and visual contact with colleagues in Italy and some other countries in Europe, we can only conclude that proper geometrical analysis of lenses was widely ignored largely because it posed enormous difficulties as outlined in the first chapter. Even so, it is odd that we do not even have records of false attempts besides those by Della Porta.

Before proceeding to a discussion of the first successful analysis of lenses by Francesco Maurolico, it is instructive to have the following succinct reminder of medieval visual theory derived from Roger Bacon's writings, which "contributed more to the development of the science of *perspectiva* in the West" than those of any other writer. His leading interpreter, David Lindberg, outlines below the major components of Bacon's analysis of the visual process with admirable clarity and precision.

> *We can see the depth of Bacon's commitment to the mathematization of optical phenomena in a third example—Bacon's remarkable supposition (following Alhacen) that the visual apparatus and the very act of vision will submit to geometrical analysis. According to Bacon, all the tunics and humors of the eye (cornea, crystalline lens, aqueous and vitreous humors, and retina) are defined or enclosed by spherical surfaces, the centers of which are situated on a straight line running from the center of the pupil at the front to the opening into the optic nerve at the back. He believed, as Alhacen had taught, that only rays incident on the eye perpendicularly, which enter without refraction, are capable of stimulating the eye's visual power. These perpendicular rays form a cone or pyramid extending from the visual object as base toward an apex (which the rays never actually achieve) at the center of the observer's eye. . . . The rays that make up this visual cone pass without refraction through the cornea and front surface of the crystalline lens (which are concentric, so that a ray perpendicular to the one will be perpendicular to the other); at the rear surface of the crystalline lens, they are refracted in such a way as to be projected through the opening of the optic nerve, which conducts them to its point of union with the other optic nerve (our optic chiasma). There the completion of vision occurs, as the species from the two eyes join to form a single image; that image, in turn, continues to multiply itself into the three chambers of the brain that house the five inner senses defined in Avicenna's* On the Soul. *While*

Bacon's theory contains much more detail, a striking feature throughout is his willingness (following Alkindi, Grosseteste, and especially Alhacen) to extend mathematical analysis to something so apparently unmathematical as human anatomy in his quest to understand the act of vision.[68]

Bacon died ca. 1292 just as eyeglasses were beginning to be used, at least in Italy. He knew and described the use of magnifying lenses but spectacles are not mentioned in his writings. And it was the advent of spectacles that complicated enormously the geometrical analysis of the visual process, which, as we have seen, admitted only one refraction at the back of the double convex crystalline lens, regarded as the principal organ of vision. If one now placed a pair of double convex lenses and later (in the fifteenth century) a pair of double concave lenses before the eyes he would have three refractions—two for the front and rear surfaces of the lenses and one for the rear surface of the crystalline lens. Clearly the age of spectacles demanded a revision of medieval visual theory, which took approximately three centuries to be developed. This long incubation period is indicative of the difficulty of the problem facing mathematicians and optical theorists of the time as they attempted to apply geometrical analysis to spectacle lenses.

One mathematician of great ability, Francesco Maurolico (1494–1575), Benedictine abbot and Professor of Mathematics at the University of Messina, undertook this revision. According to Lindberg "no mathematician of greater acuity applied his intellect to the science of optics between Alhazen and Kepler" than Maurolico. His two treatises, *Photismi de lumine et umbra* (Light on light and shadow) and *Diaphanorum partes . . .* (Transparent bodies) were published together posthumously in 1611, but were written much earlier in precisely dated sections: 1521, 1553, 1554, and 1555.[69] In the first treatise he offered innovative analyses of penumbral shadow and of radiation through small apertures.[70] The second treatise, however, contains his most important contribution to the science of optics at least as far as this study is concerned; namely, his pioneering geometric analysis of radiation through spectacle lenses. This analysis offered new insights

68. D. C. Lindberg and K. Tachau, "The Science of Light and Color, Seeing and Knowing," in the forthcoming volume 12 of the Cambridge History of Science, pp. 19–20 of the computer printout completed by the authors in Oct. 2004, and was kindly sent to me by Lindberg.

69. *Photismi de lumine et umbra ad perspectivam et radiorum incidentiam facientes. Diaphanorum partes seu libri tres* (Naples, 1611). The English translation by H. Crew, *The Photismi de lumine of Maurolycus* (New York, 1940), "is totally unreliable" according to D. Lindberg, "Optics in Sixteenth-Century Italy," in *Novità celesti e crisi del sapere*, supplement issue of the *Annali dell'Istituto e Museo di Storia della Scienza*, (1983/2), p.132, n. 6.

70. These contributions are analyzed by D. Lindberg, "Laying the Foundations of Geometrical Optics: Maurolico, Kepler, and the Medieval Tradition," in D. Lindberg and G. Cantor, *The Discourse of Light from the Middle Ages to the Enlightenment* (Los Angeles, 1985), pp. 33–41. For a slightly different interpretation, see T. Frangenberg, "Perspective Aristotelianism: Three Case-Studies of Cinquecento Visual Theory," *Journal of the Warburg and Courtauld Institutes* 54 (1991), pp. 145–50.

to prevailing visual theory especially with regard to the causes and cures for presbyopia and myopia through the use of eyeglasses.[71]

The third book of the *Diaphanorum*, completed in 1554, deals with the anatomy of the eye, the process of vision, and the use of lenses as aids to the process. At the outset Maurolico humbly admitted that he was not certain how the process of vision occurs. He hoped that combining physics and mathematics with personal experience might yield a better understanding of the process.[72] He was certain, however, that Bacon and Pecham erred in postulating that visual rays entering the front of the crystalline lens (which Maurolico called "pupil") were refracted only at the posterior side of the lens. Since the crystalline lens had a lenticular shape, he argued, it behaved like any double convex lens—visual rays had to be refracted at both surfaces. Still remaining the primary organ of vision, any imperfection affected clarity of vision as Mark Smith has succinctly and accurately described:

> *When the lens is properly shaped, the symmetry between incoming and continuing radiation will be such as to bring the rays emerging from the back of the lens to proper convergence (coincidentia) at the [optic] nerve. When the lens is misshapen, though, the rays will not converge properly. If the lens is too flat, the convergence will occur too late, the result being presbyopia. If, on the other hand, the lens is too sharply curved, the convergence will occur too soon, the result being myopia. Since a double concave lens tends to disperse the rays that pass through it, then placing such a lens in front of a myopic eye will keep the rays from converging prematurely by forcing the incoming ones to strike the lens less obliquely than they otherwise would. A double convex lens, on the other hand, will correct presbyopia by gathering the rays and making them come to convergence sooner than they otherwise would.*[73]

The fact that it took a century after the availability of concave lenses to analyze correctly the function of both types of lenses in the visual process illustrates once more the difficulty of the problem. Maurolico was the first to provide such an analysis, thereby modifying medieval optical theory but not entirely overthrowing it. He still regarded the crystalline lens as the primary seat of image formation and the retina as an organ that nourished the vitreous humor.[74] There is no hint of a retinal image. Yet such a display

71. See Lindberg, "Optics in Sixteenth-Century Italy," pp. 132–41, for a good summary and interpretation of Maurolico's optical theory especially regarding spectacle lenses. See also A. M. Smith, "Ptolemy, Alhazen, and Kepler and the Problem of Optical Images," in *Arabic Sciences and Philosophy* 8 (Cambridge, UK, 1998), pp. 35–38 for a slightly different view.

72. Ronchi, *Scritti di ottica*, p. 117. Ronchi has republished the entire book III of the *Diaphanorum* from the 1611 edition and supplied a facing Italian translation. All the following references to this work are taken from this republication.

73. A. M. Smith, *Alhacen's Theory of Visual Perception* I. Transactions of the American Philosophical Society, 91, parts 4 and 5 (Philadelphia, 2001), p. xci.

74. "Item retina, sive retiformis pellicula ex visorio nervo progrediens, et vitreo alimentum suppetens" in Ronchi, *Scritti di ottica*, p. 105.

of brilliance remained virtually unknown until his nephews published the manuscripts in 1611. Apparently they had a limited circulation before publication, probably because of the author's extreme modesty or simply lack of confidence that he had solved the problem. It seems, however, that Maurolico himself had finally overcome his qualms and had the two manuscripts published in Venice just before his death in 1575, but few copies of this edition have survived.[75]

The fact that Della Porta could write in his *De refractione* (1593) that he was the first to attempt a geometric analysis of spectacle lenses, and that no contemporary scientist ever questioned his statement as far as we can determine, shows that Maurolico's work had a very limited circulation even after its publication in 1575. And if Della Porta, living relatively close to Messina, and being so active in traveling and corresponding with fellow scientists, was unaware of the abbot's writings, is it possible that Kepler in Germany, would have been aware of them and utilized them without giving credit to Maurolico? It is possible that some portions of the manuscripts, especially those pertaining to Maurolico's analysis of lenses, were copied and sent to Germany, but this hypothesis will have to be tested and confirmed.[76] In any case, Kepler's analysis of the visual process was far in advance of any that was produced in the sixteenth century.

Had Maurolico's writings enjoyed wider circulation, they might have given the necessary clues toward a reconsideration of the anatomical structure of the eye. His view that clarity of vision depended on the shape of the crystalline lens, which he called "nature's lens" to distinguish it from "the artificial glass lens," might have led to the inquiry of whether there was another organ within the eye that facilitated or modified the process of vision and image formation.[77] Actually there was a much more suggestive impetus to a revisiting of the anatomical structure of the eye—the model of the *camera obscura*—whose properties were widely known and analyzed during the course of the sixteenth century as we have noted above.

Leonardo da Vinci was particularly fascinated by the *camera obscura* as shown by his approximately 270 diagrams in his notebooks including his incomplete work, *On the Eye* (1508).[78] He used this instrument to investigate various visual phenomena including

75. See V. Ronchi, "Il Keplero conosceva l'ottica del Maurolico?" *Atti della Fondazione Giorgio Ronchi*, 37/2 (1982), pp. 191–93, and "Ancora a proposito dei *Photismi de lumine et umbra* dell'Abate Maurolico," ibid., 37/5–6 (1982), pp. 581–85.

76. Ronchi offered this hypothesis in the articles listed in the preceding note, but he cited no conclusive proof.

77. Ronchi, *Scritti di ottica*, p. 131: "Et quoniam ut iam ratiocinando conclusimus, radiorum visualium per pupillas transmissio non aliter fit, quam per convexa utrimque conspicilia, haud immerito licebit nobis pupillas definiendo, conspicilia naturae: et e contrario vitrea ipsa conspicilia, pupillas artis, commutatis verbis appellare." It should be recalled that Maurolico called the crystalline lens "pupil."

78. This small treatise has been translated twice: "Leonardo da Vinci: of the Eye. An Original New Translation from Codex D," trans. N. Ferrero, *American Journal of Ophthalmology*, ser. 3, 35 (1952), pp. 507–21 (almost complete translation); and D. S. Strong, *Leonardo on the Eye: An English Translation and Critical Commentary of Ms. D in the Bibliothèque Nationale, Paris, with Studies on Leonardo's Methodology and Theories on Optics* (New York and London, 1979), (complete translation).

the inversion and reversal of images; the intensity of light through apertures of various shapes and the consequent interplay of light and shade; and the number of apertures stopping at a maximum of 32. He referred to analogies between the pupil and the apertures and the inversion of images within the eye as in the *camera obscura*.[79] As far as one can ascertain, he never thought of using a combination of lenses and mirrors to right the images, a solution that was adopted later in the century but one that could hardly be considered for the eye. He came to the conclusion that a second intersection had to take place within the crystalline lens so as to correct the initial inversion/reversal of the images at the first intersection as in the *camera obscura*. The images thus corrected would then be transmitted by the optic nerve to the common sense, the brain. In this system the crystalline lens lost its privileged position as the seat of vision, serving only as a refractive lenticular device. Yet Leonardo could not make up his mind whether the visual power resided at the front surfaces of the eye or at the opening of the optic nerve in the back.[80] On the face of it, it is surprising that with his intimate familiarity with the *camera obscura* Leonardo did not realize that the concave-shaped and reddish white retina functioned as a screen capable of righting the images in the same manner as a concave mirror in the *camera*. It is noteworthy, at least parenthetically, that his analogy of the eye as an optical device like the *camera*, was also shared by a contemporary Sienese cleric, Bartolomeo Benvoglienti, a friend of Lorenzo the Magnificent. Like Leonardo, Benvoglienti believed that the eye "was a physical optical instrument like a lens or a mirror." In this context, he discussed the use of lenses for both myopes and presbyopes to match the ocular properties of the eye for the correction of defective vision.[81]

One should add that Leonardo's views on optics were founded on a limited access to ancient and medieval sources, some of which he was not capable of comprehending fully because of his scanty knowledge of Latin. Moreover, being a self-educated man, he lacked some of the fundamental knowledge, including a thorough grounding in mathematics, which was the foundation of optical science and allied disciplines. On the other hand, it is known that he was closely associated with friar Luca Pacioli, an able math-

79. See K. Veltman, "Leonardo and the Camera Obscura," in *Studi vinciani in memoria di Nando di Toni* (Brescia, 1986), pp. 81–92, for a complete reference guide to Leonardo's manuscripts on this topic. In addition to Strong's commentary, I have found the following writings particularly useful in assessing Leonardo's visual theory: B. S. Eastwood, "Alhazen, Leonardo, and Late-Medieval Speculation on the Inversion of Images in the Eye," *Annals of Science* 43 (1986), pp. 413–46; D. C. Lindberg, *Theories of Vision from Al-Kindi to Kepler* (Chicago and London, 1976), pp. 154–68; M. Kemp, "Leonardo and the Visual Pyramid," *Journal of the Warburg and Courtauld Institutes* 40 (1977), pp. 128–49; J. S. Ackerman, "Leonardo's Eye," ibid., 41 (1978), pp. 108–46, republished with two postscripts in his *Distance Points: Essays in Theory and Renaissance Art and Architecture* (Cambridge, MA, 1991), pp. 97–150.

80. Eastwood, "Alhazen, Leonardo," p. 444.

81. See A. A. Crombie, *Styles of Scientific Thinking in the European Tradition: The History of Argument and Explanation Especially in the Mathematical and Biomedical Sciences and Arts* II (London, 1994), pp. 1488–90, which contain extensive excerpts with English translations of Benvoglienti's brief treatise, *De luce et visibili paradoxon* (Florence, 1481–82). For additional analysis of this work, see now P. Potestà, *Gli occhi, il sole, la luce: metafore sulla visione tra scienza e arte dall'antichità greca al '400* (Florence, 2002), pp. 131–44.

ematician with a more practical than theoretical interest, and he would not have lacked other consultants in sixteenth-century Italy. Nevertheless, leading scholars have found it difficult to untangle his scattered notes so as to ascertain Leonardo's comprehension of the visual process. It is clear that Leonardo himself vacillated in his conclusions causing a degree of confusion, which has left some leading commentators confused as well. This in itself points again to the difficulty of understanding the mechanics of the visual process when a man of such intelligence, prone to investigate and experiment, was not capable of going beyond the erroneous tenets of medieval visual theory.

It seems also that Leonardo did not have a full understanding of refractive errors as well, although he wore eyeglasses to correct his presbyopia and he mentioned them several times in his notebooks as I have noted in the preceding chapter.[82] But he never mentioned myopia and he "failed to detect changes of the pupil with accommodation." His description of the functioning of spectacles lacks basic understanding of their properties, certainly well below the level of clarity and accuracy attained by Maurolico in the middle of the century.[83] The following quotation from Codex D (1508) is illustrative of his later views. It has this heading: "Whether the images of the objects are perceived by the sense of vision upon the surface of the eye or whether they pass into it."

> *The glasses of the spectacles show us how the images of the objects stop at the surface of these glasses, and from this surface they go, bending, to the surface of the eye, from which surface the eye can see the images of these objects. And this is proved to be possible because this surface is the common boundary between the air and the eye, dividing the albugineous humour from the air. If we maintain that the images of the objects stop definitely at the surface of the spectacles, one could say that through the aged man's spectacles the image appears much larger than the real object, and if it were not for the interposition of the said glass between the eye and the object, the object would appear in its natural size. Therefore, it is evident that the ray of the image of any object which is caught by the interposition of transparent bodies, will imprint itself on their surface, and from here goes out a new ray which leads to the eye the image of said object.*[84]

It is evident that Leonardo understood the operation of spectacles with convex lenses as one causing magnification of the visible objects not as corrective devices to provide a proper convergence of the incoming rays to compensate for a misshapen (too flat) crystalline lens. This was the dominant view up to the time of Maurolico. It was probably

82. Chap. V, pp. 193–94.

83. See K. D. Keele, "Leonardo da Vinci on Vision," in *Proceedings of the Royal Society of Medicine* 48 (1955), p. 387, where Keele concluded: "There can be no doubt that Leonardo appreciated the relation between light and the size of the pupil. . . . But his own keen vision failed to detect the changes of the pupil with accommodation. . . . Leonardo had to wear glasses in his later years, and this may account for the fact that with regard to errors of refraction he makes no mention of myopia, but describes his own presbyopia at some length."

84. "Leonardo da Vinci: Of the Eye," p. 508.

the result of viewing convex lenses simply as enlarging devices harking back to the origin of spectacles, which consisted of two magnifying lenses with centrally connected handles. These rivet spectacles made it easier to superimpose the two lenses so as to provide greater magnification if held at a suitable distance from the visible object. Even Kepler at first thought "that presbyopia was corrected by magnification."[85]

Nevertheless, despite the suggestive and seemingly pervasive influence of the *camera obscura*, and the ever-increasing frequency of human dissections by professors of anatomy and by artists, the anatomy of the eye retained the essential features described by Galen (129–ca. 199 A. D.) up to almost the end of the sixteenth century, 1400 years later! Galen's view that the crystalline lens, located in the center of the eye, was the seat of vision remained unchallenged except for a few hints by some anatomists in the intervening centuries that perhaps the retina had some role in the visual process. In other words, anatomists saw what they expected to see according to the prevailing theory of vision when they dissected cadavers.[86]

One of the most explicit hints about the role of the retina was dropped, so to speak, by Andreas Vesalius (1514–64), the celebrated Belgian anatomist, and sometime professor of surgery and anatomy at the University of Padua, the leading medical school in the sixteenth century. In his *De humani corporis fabrica* (On the fabric of the human body, 1543) and in a later revised and augmented edition (1555), Vesalius corrected a good number of Galen's anatomical observations, which were based on the dissection of animals. Vesalius performed his own dissections of cadavers rather than relying on the labor of his assistants, all of which resulted in the production of the best anatomical text of the age, with illustrations prepared by artists in Titian's circle in Venice and keyed to the text, which in itself was a printing feat. His hands-on approach allowed him to gain firsthand knowledge of the anatomy of the eye, resulting in more detailed and accurate drawings of the structure of the eye than had been previously achieved.[87]

Despite his direct observations, Vesalius still placed the crystalline lens at the center of the eye, which functioned as a magnifying convex lens. He questioned, however, Galen's view that it was the seat of vision. Admitting that he really did not possess sufficient knowledge of the process of vision, a subject he planned to treat at a later date in a separate work (never published), he dropped the hint that "many consider this tunic [the retina] to be the chief organ of sight."[88] Who were these "many" (anatomists?) who

85. See Smith, "Ptolemy, Alhazen, and Kepler," p. 35.

86. See Lindberg, *Theories of Vision*, pp. 168–72, for a summary of anatomical knowledge up to Vesalius.

87. Ibid., p. 173. For a biographical sketch of Vesalius, see I. V. O'Neill, "Vesalius, Andreas," in the *Encyclopedia of the Renaissance*, vol. 6 (New York, 1999), pp. 252–53.

88. Quoted by Lindberg, *Theories of Vision*, p. 173. In describing the crystalline humor as a lens, Vesalius used the Latin term, "specillum," which Lindberg translates as "a looking glass." At this time "specillum" designated a lens, whereas "speculum" would denote a looking glass or mirror. On this interpretation, see also Crombie, *Styles of Scientific Thinking in the European Tradition* II, p. 1118 and note 10, p. 1490: "He [Vesalius] described the

held such a view and why did they refrain from disseminating it through publications? It remains a mystery. One can venture the hypothesis that this alternative view was perhaps discussed in conversations and in private correspondence among colleagues, but it was not to be printed particularly because it was difficult to prove unless anatomists could see the actual operation of the eye by practicing vivisection. To make such a switch from a theory that had held sway among the best minds of the past for more than a millennium would have subjected the proponents to ridicule and perhaps vilification. Even at the present time most of us can cite examples of novel or radical theories and procedures in medicine and other fields, which originally were rejected with contempt and ridicule, and were later accepted and became the norm.

The fact that barely a generation after Vesalius' death another anatomist and a mathematician explicitly stated that the retina was the sensitive organ of vision tends to support the above hypothesis. At least since Vesalius the idea of a retinal image was in the air, so to speak, and must have been discussed informally by anatomists. Chronologically the first to publish it was Felix Platter (1536–1614), professor of medicine at the University of Basel. In his treatise, *De corporis humani structura et usu* (1583) he announced that the retina was the primary organ of vision and the crystalline lens was simply "the eye glass of the visual nerve," which collected and magnified the incoming images and transmitted them to the "retiform nerve" [the retina]. In brief, what Vesalius had hinted about the role of the retina, Platter stated as a definite proposition. He offered no proof, however, and like Vesalius did not consider the question of the inverted images, even though he had used the analogy of the *camera obscura*.[89]

Two years later Giovanni Battista Benedetti (1530–90), Venetian patrician, mathematician, and philosopher, who also wrote treatises on mechanics and music, arrived at the same conclusion, apparently independently. In two brief letters of 1585, he described his "geometrical comparison of the eye with a camera obscura in which the images of external things were projected through the pupil onto the retina."[90] His *camera* did not contain lenses or mirrors to right the images, but he took for granted that through various refractions within the eye, images arrived at the retina un-inverted. But this concept was expressed in such confused and convoluted language as to give the impression that he "fudged" the issue because he did not know how to solve the problem. It seems that these letters constituted a mere diversion from his more substantial mathematical and scientific studies. In essence, then, this first attempt to solve the inversion of images within the eye by a geometric ray analysis failed.[91]

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crystallinus as magnifying like eyeglasses (*specilla*) and its shape, flattened front and back, as 'like a lentil (*ad lentis similitudinem*)'. . . ."

89. See Crombie, *Styles of Scientific Thinking* II, p. 1119, and Lindberg, *Theories of Vision*, pp. 175–77.

90. Crombie, *Styles of Scientific Thinking* II, pp. 1122–24.

91. In addition to Crombie, see T. Frangenberg, "Il 'De Visu' di Giovanni Battista Benedetti," in *Cultura, scienze e tecniche nella Venezia del Cinquecento: Atti del Convegno internazionale di studio Giovanni Battista Benedetti e il suo tempo*

It remained for the genius of Johannes Kepler (1571–1630) to apply correct geometric analysis using the tools already developed by Alhacen almost 600 years earlier, commented upon and refined by perspectivist theorists following his methodology. In his modestly titled treatise, *Ad Vitellionem paralipomena* ("Emendations to Witelo," 1604), Kepler adopted Platter's view of the eye being a *camera obscura*, and regarded the crystalline lens, whose posterior surface he deemed hyperbolic in shape, not as a sensitive organ but only as a focusing device for transmitting images to the screen of the *camera*, the retina. In this connection, he analyzed the refocusing function of eyeglasses, which corrected the anomalies of a misshapen eyeball. In an excessively elongated one "the rays projected through the crystalline lens will be brought to focus too early, and the result will be nearsightedness. If the eyeball is unnaturally compressed, . . . the rays will be brought to focus too late, the result being farsightedness."[92] The use of concave and convex lenses of appropriate curvature will solve either condition by providing a proper refocusing of images on the retina.

Kepler recognized the problem that these images, already reversed and inverted on the anterior surface of the crystalline lens, reached the retina in the same form. Unlike Benedetti, he did not use unclear and confused language to hide his struggle to solve this problem. He concluded at first that it was a problem for natural philosophers, who today could be classified as physiologists and psychologists. He never reached a definite conclusion on this matter, which had bedeviled his predecessors, except that he mentioned "spirits" residing in the soul or brain cavities, which had the capacity to perceive the images in the proper form.[93] In essence, once he had established the operation of the eye as an optical system governed by physical laws, he concluded that his job was done. What governed the interpretation of the images after they reached the retina was somebody else's business. Perhaps it is this "unfinished business," in addition to Kepler's adoption and extension of Alhacen's ray analysis, that has led Lindberg to regard Kepler as "the culminating figure in the perspectivist tradition" rather than as a revolutionary theorist, though he admits that the implications of his visual theory based on the retinal

(Venice, 1987), pp. 271–82. Both authors agree on the obscurity of Benedetti's language and the failure of his geometric analysis.

92. Smith, "Ptolemy, Alhazen, and Kepler," p. 41.

93. Kepler expressed his thoughts on this matter in the following passage from his *Paralipomena* as quoted by Crombie, *Styles of Scientific Thinking* II, p. 1136: "I say that vision occurs when the image (*idolum*) of the whole hemisphere of the world which is in front of the eye, and a little more, is formed on the reddish white concave surface of the retina (*retina*). I leave it to natural philosophers (*phisici*) to discuss the way in which this image or picture (*pictura*) is put together by the spiritual principles of vision residing in the retina and in the nerves, and whether it is made to appear before the soul or tribunal of the faculty of vision by a spirit within the cerebral cavities, or the faculty of vision, like a magistrate sent by the soul, goes out from the council chamber of the brain to meet this image in the optic nerves and retina, as it were descending to a lower court. For the equipment of opticians does not take them beyond this opaque surface which first presents itself in the eye." On Kepler's visual theory, see also J. Hirschberg, *The History of Ophthalmology*, vol. II, *The Middle Ages; the Sixteenth and Seventeenth Centuries*, trans. F. C. Blodi (Bonn, 1985), pp. 293–99.

image were revolutionary as his views were developed and commented upon by others during the seventeenth century.[94] Some other historians of optics such as Mark Smith and Alistair Crombie hold the opposite view. Smith states categorically that "Kepler's account of retinal imaging represented not a continuation, but a repudiation of the medieval optical tradition."[95]

In fact, judging from the following succinct description of the visual process as understood at the present time by leading researchers, one can argue (perhaps with some exaggeration) that there would be little in it that would surprise Kepler:

> *When a person looks at something, light reflected from the object passes through the cornea (a transparent sheath across the front of the eye) and a fluid known as the aqueous humor, on through the pupil of the iris and into the lens, which is normally clear and is shaped and oriented something like the lens of a camera. From there the light travels through the gel-like vitreous body to the retina, the part of the eye that converts light into electrical signals that are transmitted to the brain for interpretation.*
>
> *In order for the image to come into focus, the light must be bent so that the rays converge at the fovea, the center of the retina. The nearer something is to the eye, the more the light must be bent if the object is to be seen clearly. The cornea, aqueous humor and vitreous body each have a fixed refractive power, or ability to bend light, but the lens can accommodate: it can sharpen the curvature of its front and back surfaces, thereby increasing its focusing power.*[96]

Kepler could argue that these "electrical signals," obviously not "invented" in his time, would take the place of his "spirits," but he would have to investigate the accommodating power of the lens, which he had not previously considered. He would certainly be surprised to learn, however (as I was), that as late as 1988 the above quoted experts could

94. Lindberg, *Theories of Vision*, p. 207–08: According to Lindberg, Kepler's "theory of vision was not anticipated by medieval scholars; nor did he formulate his theory out of reaction to, or as a repudiation of, the medieval achievement. Rather, Kepler presented a new solution (but not a new kind of solution) to a medieval problem, defined some six hundred years earlier by Alhazen. By taking the medieval tradition seriously, by accepting its most basic assumptions but insisting upon more rigor and consistency than the medieval perspectivists themselves had been able to achieve, he was able to perfect it." For additional discussion of Kepler's visual theory, see chap. I, p. 30.

95. See Smith, "What is the History of Medieval Optics Really About?" in *Proceedings of the American Philosophical Society* 148/2 (2004), pp. 180–94: "To adopt his [Kepler's] theory of retinal imaging with all its entailments meant jettisoning the Alhacenian model of light and sight. In the long run, of course, that is precisely what happened, and by the end of the seventeenth century the science of optics had been radically transformed in accordance. . . . Visual images had been replaced by optical images, some real, some virtual. The center of sight had been replaced by focal points . . ." (Quotations, p. 194). This view is fully supported by Crombie, *Styles of Scientific Thinking*, II, p. 1108, and G. Simon, *Archéologie de la vision: L'optique, le corps, la peinture* (Paris, 2003), pp. 203–41.

96. See the excellent article by J. F. Koretz and G. H. Handelman, "How the Human Eye Focuses," *Scientific American* (July 1988), pp. 92–99, quotation on p. 92. The still tentative understanding of the visual process is also revealed by this summary of the authors' findings, which appears right after the title: "As people age, their ability to focus on nearby objects gradually declines. Several *probable* [my emphasis] causes have been identified, including changes in the eye's geometry and biochemistry."

not supply definitive answers to two basic questions: "How does the healthy young eye focus on a nearby object?" and "Why does near vision fade?" The answer to the first question has long been incomplete, and the answer to the second remains a matter of conjecture.[97] The fact that modern investigators cannot answer these questions precisely, despite mathematical modeling and computer-aided photography, only increases our respect for Kepler's achievement.

Kepler expanded and deepened his new formulation of visual theory in his *Dioptrice* (1611), again using the *camera obscura* as a model. Apparently he never lost his fascination for this vision aid. Ten years before his death, he was using a portable black tent, totally dark except for one small hole to which he attached a convex lens, separated at a distance from a concave lens, a sort of telescopic aid to paint a scene. He explained that he wanted to draw not as a painter but as a mathematician.[98]

It was the mathematicians who followed closely and expanded the lines of inquiry Kepler had pioneered. The medical professions as a whole were slow in appreciating the new ocular physiology and its applications to visual problems. Even some professors of medicine still continued to believe that the crystalline lens was the principal seat of vision.[99] According to Hirschberg, Herman Boerhaave (1688–1738), professor of medicine at the University of Leiden, "was the first university professor who taught the correct concept of vision and Kepler's explanation of myopia and hyperopia" in 1708.[100] The least impact was registered among the barber surgeons, whose practice centered on taking out cataracts and applying the usual centuries-old poultices and lotions to treat various eye diseases. Within this group there was little understanding of refractive errors and of the real function of spectacles, which led to viewing them at best as a necessary evil. Obviously, we cannot gauge with any degree of accuracy how common this view

97. Ibid., p. 92. The authors continue as follows: "By means of photographic studies of the lens of the eye and mathematical modeling, we have recently gained new insight into both problems. We have shown that several processes conspire to progressively limit one's ability to focus on close objects; other processes counteract the decline for a while, but these ultimately fail—typically in the fifth decade of life." In brief, the authors of this study gained new insights but still had to remain within the realm of probabilities. They concluded (p. 99) that "perhaps someday investigators will learn enough to reverse or prevent the natural, age-related decline of near vision. For now, however, the need for reading glasses is—like death and taxes—inevitable."

98. The English diplomat, Henry Wotton, who visited Kepler in Linz in 1620, provided an eyewitness account of this episode. His report is quoted by Crombie, *Styles of Scientific Thinking*, vol. II, p. 1141. It is now believed, however, that Kepler actually used a telescope with three lenses to right the image inside the *camera*. A drawing of such an instrument is preserved in Kepler's manuscripts in the Academy of Sciences Archives in St. Petersburg, Russia. See F. Camerota, "The 'Perspective Glass' from the pictorial metaphor to the Invention of the Telescope," in *When Glass Matters: Studies in the History of Science and Art from Graeco-Roman Antiquity to Early Modern Era*, ed. M. Beretta (Florence, 2004), 342–43, and fig. 5 for a photograph of the drawing.

99. See Crombie, *Styles of Scientific Thinking*, II, p. 1142, and Hirschberg, *The History of Ophthalmology*, II, pp. 299–300: "It is remarkable that Kepler's discoveries did not find an enthusiastic response among physicians, surgeons and ophthalmologists. . . . But the physicians and surgeons did not want to take any notice. Perhaps they were not able to. It was perhaps not to be expected from the uneducated barber surgeons who in general practiced ophthalmology."

100. Hirschberg, *The History of Ophthalmology*, II, p. 300.

5. Master of Heiligenkreuz (possibly Bohemian). *Death of the Virgin*, ca. 1400. Tempera and oil with gold on wood; 66 x 53.3 cm. © The Cleveland Museum of Art, Gift of the Friends of the Cleveland Museum of Art in memory of John Long Severance 1936.496.

was within this group because, typically, they did not write books. Two practitioners, however, wrote books, which demonstrated medical thinking about the value of glasses shortly before the age of Kepler.

The Spanish physician Cristóbal Méndez (ca. 1500–1560), who studied medicine at the University of Salamanca (1524–26) and practiced both in Spain and Mexico (1528–45), published a book in 1553 on corporal physical exercises, which included exercises for the eyes.[101] It is considered one of the first medical books of the early modern period to treat the value of physical exercises for every part of the body. According to Méndez,

101. The full title is: *Libro del exercicio corporal y de sus provechos, por el qual cada uno podra entender que exercicio le sea necessario para conservar su salud* (Seville, 1553). A modern edition with the title, *Libro del ejercicio corporal y sus provechos*, was published by E. Álvarez del Palacio (León, 1996). See pp. 23–34 for a biographical sketch of Méndez and pp. 292–96 for his comments on exercises for the eyes: "Del exercicio de los ojos, con otras cosas que al proposito se traen." A complete English edition with a facsimile reproduction of the book was published with this title: *Book of Bodily Exercise*, trans. F. Guerra, ed. F. G. Kilgour (New Haven, 1960), pp. 29–30. For an analysis of this book with special reference to vision and use of eyeglasses, see A. González-Cano, "Eye Gymnastics and a Negative Opinion on Eyeglasses in the 'Libro del exercicio' by the Spanish Renaissance Physician Cristóbal Mendez," in *Atti della Fondazione Giorgio Ronchi* LIX/4 (2004), pp. 559–65.

the eyes must be fatigued to improve their performance just as other bodily exercises preserve and improve various bodily functions. Thus it is good for the eyes to look at very small and intricately detailed objects and read small letters so that this extra effort will force tears to flow and clear the eyes of impurities. At the same time, this exercise will serve to keep the sense of sight constantly trained. This is surely a "no pain, no gain" approach. The use of eyeglasses, therefore, should be avoided as much as possible because they facilitate the process of vision and thus negate the value of forcing the eyes to work unaided. Furthermore, they tend to impede the natural flow of impurities and vapors out of the eyes, reflecting them back to the source. Nevertheless, he accepted their use for myopes and presbyopes who could not function without them, but cautioned that continuous wearing of glasses will not serve to preserve visual acuity. The following quotations show his ambivalence about the use of spectacles:

> *. . . You should also rub and clean your eyes because in that friction there is always some heat due to movement that is beneficial. This is why I am not apt to praise gentlemen who use spectacles continually because they are shortsighted; the eyes covered in this way do not have any exercise, and I am sure they have more superfluities which cause them harm. . . .*
>
> *Besides the eyes not dissipating something produced by lack of exercise (because the spectacles prevent it), many superfluities and vapors of the body cannot come out through the eyes which have those doors in front of them. I am convinced that they remain inside and collect within the exterior layers of the eyes, causing great harm without any doubt. This is clear because we always have to clean spectacles due to the superfluities which deposit on them. This is why I advise not wearing them continually but using them once in a while when you cannot see very well, ...*
>
> *If nothing else can be done, and spectacles have to be worn because the sight is very weak, my advice would be to take them off for a while during the day and clean the eyes, or even wash them with some water of the herb called eyebright or chilidonia. . . .*
>
> *Furthermore, I do not agree completely with the habit of wearing glasses for study because without doubt there is no better exercise than reading and studying without them. It is said that the realgar or sulphide of arsenic in the frame may produce some inconvenience and reduce the sight. I do not mean to say that we should study without them, but that sometimes we should study without them in order to exercise the eyes. . . . I mean to say that for those who are in the habit of studying or reading or writing with spectacles because they do not see well, or to preserve sight, it would be good to study without them once in a while so the eyes may have some exercise and follow the practice mentioned above after doing such exercise. . . .*
>
> *I even dare to say that if it were possible that no spectacles existed it would be a good thing, because their constant use (as I stated) produces great harm to the eyes*[102]

102. Mendez, *Book of Bodily Exercise*, second treatise, chap. 2, pp. 29–30.

Except for the last statement, probably exaggerated deliberately to underline his concern, Mendez' position on the use of eyeglasses was one of ambivalence rather than total negation of their value. His belief in the harmful effects of continuous wearing of glasses, which was consistent with his advocacy of eye-exercises as a means of getting rid of the harmful "crutch," had a kind of logic beyond it although his insistence on forcing and fatiguing the eyes would be totally unacceptable in current practice. It is not likely, however, that his precepts had wide circulation because of the rarity of the book. Only three copies are known to exist—two in Spain and one at Yale's Medical Library.[103] It is odd that both books by two Spaniards, Mendez and Daza de Valdés, were relatively rare for different reasons.

Much more diffused, on the other hand, were the negative views on the use of spectacles held by Mendez' younger contemporary, George Bartisch (1535–1606), self-described "oculist, stone cutter, and surgeon," as expressed in his book, *Ophthalmodouleia, That is the Service of the Eye* (Dresden, 1583). Bartisch had no formal education and learned his "profession" as an apprentice to a barber surgeon since the age of 13. The book is considered to be the first systematic treatise on ocular diseases and ophthalmic surgery and is amply illustrated with anatomical plates skillfully prepared by the author himself. But ophthalmologists are divided on the contributions of the book. Some have pointed out that it is full of superstitious beliefs and inferior to the contributions in ophthalmology already made by the Indians, the Egyptians, the Greeks, and the Arabs.[104] Herbal remedies, so frequently promoted by the author, had a very ancient origin and it is difficult to discern exactly what was really new about Bartisch's own remedies. But such judgments are outside our field of expertise or as Kepler would probably say, "they are somebody else's business."

The "third part" of the book begins on p. 31 showing a portrait of an elderly man wearing glasses while reading a book as a pair of goggles lie on the table touching his left arm. The long title of this part reads as follows and establishes the tone of the whole section: "The decrease, faintness, weakness, dimming, and cloudiness of vision is indicated and describe [sic] in the third part. Also how one may protect and abstain from lenses and eye glasses. Further how one should escape and refrain from lenses and eye glasses." He believed that the chief cause of weak vision was old age, but contributing factors were harmful foods (such as garlic, onions, crustaceous animals, beans, peas, etc.), fluid in the brain, sadness and stress, living in damp quarters, looking at length into

103. Ibid., p. x.

104. See Hirschberg, *History of Ophthalmology*, II, pp. 340–41, for an evaluation of various comments by ophthalmologists. He added his own comment: "Bartisch is deeply steeped in the superstition of his time. It is embarrassing that this complete system of superstition which does not occur in the *Ebers Papyrus*, nor in the ophthalmology of the Indians, the Greeks and the Arabs, now occurs for the first time during the modern era which is influenced by Christianity" (p. 340). See also D. L. Blanchard, "Superstitions of George Bartisch," *Survey of Ophthalmology* 50/5 (2005), pp. 490–94.

fires, sunlight, mirrors, wandering in the snow for a long time, reading fine script, excessive bloodletting, and too much drinking. As remedies, he advised drinking appropriate potions, purges, taking special pills, use of eye powders, head washes, and wearing various charms around the neck including one containing "the tongue of a male fox" for men and the tongue of a female fox for women. Some of these concoctions had to be consumed either in the "waning" or "waxing" of the moon (pp. 31–36). Even more strange is his belief that witchcraft, magic, evil spirits, and the devil can severely damage the eyes and play havoc with vision. Once again eyewashes and potions are employed as remedies (chap. 13, pp. 231–36). One can protect his eyes and preserve vision by avoiding pokes and blows against the eyes, practicing a good diet, wearing such noble jewels around the neck as turquoise and ophthalmite, as well as dried out hearts and eyes of horned owls (p. 238).

There is no better way to illustrate the author's abysmal ignorance of lenses and spectacles than to use his own words:

> *One finds many people who have beautiful, clear, and very pure eyes. No deficiency or affliction is to be seen or recognized except when they want to see or recognize something especially when it is a thin, subtile, small, and clear thing. Then they can not recognize it. It is then that they put on and use spectacles and eye glasses. Then they think it appears much larger to them than otherwise. One finds people in a number of places who become accustomed to that and think it is very good for their vision even in their youth. By this they think they keep their vision fresh. Be that as it may. It is not a good habit. It is much better and more beneficial that one not require spectacles and may do without them. It is natural, to be sure, that a person should see and recognize something better when he had nothing in front of his eyes than when he has something in front of his eyes, however subtile, clear, or thin it may be. It is much better for a person to preserve two eyes than one should have four.*
>
> *When however it happens that some people say they see better through spectacles and eye glasses, better than otherwise, consider this more as a habit, than as an affliction or deficiency of the eyes. Yet I do not want to be against this, some people may be somewhat polluted in the crystallin humor of the eye. The sun light can not light its way so well through that into the head as when they look through glass. The hindering humor may be a cloudy vitreous. Their vision is hindered by that also. On account of this it happens that people do not see so well if these humors are polluted unless they use a glass before the eyes. . . . (p. 36)*

To be sure, the belief in the deleterious effects of spectacle wearing was common at this time and persisted in the following centuries (even up to the present!), especially as it was noted that the use of spectacles required progressively stronger lenses (particularly for myopia) and thus provided deterioration rather than improvement of unaided vision.[105] And Bartisch could not have known of the first analyses of lenses published by Della Porta and Maurolico at the time of the completion of his book. But he lived in a country that was a large exporter of spectacles and by the time of his death, two years after the publication of Kepler's *Paralipomena,* he could have consulted with people sufficiently knowledgeable about the process of vision and the function of eyeglasses. An unlettered artisan like him could have sought out competent advice just as other unlettered artisans, such as Leonardo and his fellow artists, had consulted with various experts. Yet there seems to be no published evidence that he ever changed his mind about spectacles.[106] In other words, millions of bespectacled Europeans by this time were laboring under a grand illusion except for Bartisch!

History was to prove that it was not a grand illusion, but the wave of the future. Spectacle making had spun a large industry and another class of mostly unlettered but skilled artisans, who not only improved the quality of lenses for spectacles, but also invented the two instruments (telescopes and microscopes), which revealed for the first time hitherto invisible objects on earth and in the heavens. The Scientific Revolution could hardly be imagined without these vision aids. These advances in lens technology were the product of artisans working magic with their hands without the benefit of any knowledge of mathematics or optical theory. University professors like Galileo learned from them. Descartes recognized this fact in the opening lines of his *La dioptrique* ("Dioptrics," 1637) by stating: "The whole conduct of our life depends on our senses, among which vision being the noblest and most universal, there can be no doubt that inventions serving to increase its power are the most useful there can possibly be." Pointing to the telescope as the best example of these inventions, he lamented that "to the shame of our sciences this invention, so useful and so admirable, was found first only by experiment and chance" by someone without mathematical knowledge.[107] And so

105. See J. R. Levene, *Clinical Refraction and Visual Science* (London, Boston, 1977), p. 41.

106. Hirschberg, *History of Ophthalmology,* vol. 2, p. 329, considered this part "the weakest chapter of the book. The stubbornness of the uneducated craftsman becomes quite obvious." But he also gives this balanced assessment of Bartisch's contributions, p. 341: "We have to concede that Bartisch was a victim of the superstition of his time and the poor education of his trade. We have to admit that he was a brave, honest and ambitious man, a good observer and an excellent and courageous surgeon. He had a better gift to draw than to describe. He was the original designer of several instruments and invented some operations; he wrote the first handbook of ophthalmology in German. The book was esteemed highly even 100 years later. Who could claim this nowadays about his own contributions? . . ."

107. Crombie, *Styles of Scientific Thinking,* II, pp. 1145–46. The full quotation, too long to be included here, can be found in R. Descartes, *Discourse on Method, Optics, Geometry, and Meteorology,* trans. P. J. Olscamp (Indianapolis, 1965), "Optics," pp. 65–66. Here (p. 66) Descartes added an interesting comment about the skill of unlettered artisans in this field: "And inasmuch as the execution of the things of which I shall speak must depend on the skill of artisans, who ordinarily have not studied, I shall attempt to make myself intelligible to everyone, and to omit nothing, nor to assume anything that might have been learned in the other sciences." I have preferred to follow Crombie's translation in the first quotation.

this is yet another celebration of the practitioners of this art, declared "divine" by Daza de Valdés and Manzini. Unlike Bartisch, Daza believed that eyeglasses were truly a gift from God, just like the eyes themselves, and that one could see better with four than two eyes. In line with this tradition, then, today's far more educated and mathematically sophisticated opticians can feel justly proud that they are practicing a "divine" calling!

APPENDIX I

SPECTACLE MAKERS ACTIVE IN FLORENCE (1413–1562)

The following list contains the names of artisans who are definitely identified as *occhialai*. Their names are immediately followed by the sources of the information, mostly archival documents, which frequently disclose the location of their shops. Lorenz Böninger and Richard Goldthwaite discovered most of the names. To the total of 48 we should add four friars making spectacles in two monasteries as listed in Appendix II.

1. 1413, 28 Oct. Piero di Iacopo, *fa ochiali*, ASF, *Prestanze 2904, San Giovanni*, 187^{r}; listed in 1427 as Piero di Iacopo *"che fa li occhiali, nel popolo di S. Pier Maggiore,"* ASF, *Catasto 1427*, 59, 819^{r};[1] in 1428 as Pierus Iacopi *degli occhiali*, ASF, NA 15101, 121^{v}; and in 1429 as Piero olim Iacobi Ciardi, *qui facit oclearios, qui dictus "Piero degli ochiali,"* pp. S. Petri Maioris, ASF, NA 7388, 110^{r}, 292^{r}.
2. 1445, 21 Feb. Giovanni di Iacopo da Brucanese, *che fa gl'occhiali in borgho San Lorenzo.*[2]
3. 1447. Lionardo di Tommaso, *fa gl'ochiali*, ASF, *Catasto 654, Santo Spirito, Drago*, 411^{r}; listed in 1458 as *forzerinarius* [strong-box maker], *pop. S. Ambrosi de Florentia*, ASF, NA 6204, 245^{v}.[3]
4. 1454, 20 May. Maestro della Dona, ASF, *Corporazioni religiose soppresse dal Governo francese, 78 (Badia Fiorentina)*, F. 314, fol. 574: Francesco Caccini to Bartolomeo Cederni in Venice. This letter also mentions an unnamed *altro maestro.*
5. 1456, 10 Jan. Bonaiuto di Giovanni, *qui facit ochialos*, ASF, NA 13279, 648^{r}; 1464, "Buonaiuto di Giovanni fa gli ochiali del Popolo di Santo Filice in Piaza," Neri di Bicci, *Le ricordanze*, p. 227);[4] 1469, August. Bonaiuto Iohannis, *fa gli ochiali*, ASF, *Mercanzia* 305, 40^{r}; also active in Dec. 1471, ibid., 309, 158^{r}. Listed in 1471 as *ossarius* in *Mercanzia* 310, 125^{r} and on 4 Dec. 1472 in *Mercanzia*

1. This entry continues as follows: "Fo bottega d'occhiali ed òvi tra masserizie e merchatantia in tutto il valsente di f. 4. Tengo la bottegha da Pazino di messer Palla per f.10 l'anno di pigione; de la quale ne rapigiono una parte a Franceschо di Benedetto merciaio per f. 7." I am indebted to M. L. Grossi for this reference and transcription. The effective rent of f. 3 paid by Piero compares with the combined rent of f. 6 paid by two spectacle makers listed in the Census of 1562 (P. Battara, "Botteghe e pigioni nella Firenze del '500. Un censimeno industriale e commerciale all'epoca del granducato mediceo," *Archivio storico italiano* XCV (1937), p. 16.

2. He acted as a "mezzano" (intermediary or broker) in the sale of a manuscript—S. Gregorio, *Omelie sui Vangeli:* "Funne mezzano Giovanni di Iacopo da Brucanese che fa gl'occhiali in borgho San Lorenzo." (*I manoscritti datati della Biblioteca Riccardiana di Firenze,* vol. II, MSS. 1001–1400, ed. T. De Robertis and R. Miriello (Florence, 1999), No. 47, pp. 27–28. For unexplained reasons, the Index of this volume lists him as Giovanni di Antonio da Brucanese.

3. This later record of 10 Jan. 1458 reveals that on this date Leonardo and Simone Iacobi "ossarius" nominated as arbiter the Prior of San Marco to resolve their "questio et controversia de et super arte degli ochiali tempore quo idem Simon stetit in apotecha dicti Leonardi." In essence this record shows that a strongbox maker and a bone smith cooperated in making spectacles probably along with other products.

4. Neri di Bicci, *Le ricordanze (10 marzo 1453–24 aprile 1475)*, ed. B. Santi (Pisa, 1976), No. 445, p. 227, 29 May 1464. He is listed as a witness in a notarial act.

7229, 167r. Again listed in 1472, *fa gli ochiali*, in *Mercanzia* 1472, 349v–350r.

6. 1465. Piero di Chralione [?], *fa gl'ochiali*, ASF, *Corporazioni religiose soppresse dal governo francesce, San Salvatore di Camaldoli*, 87, 56, 157r.
7. 1465. Antonio di Iacopo, *merciaio, fa gli ochiali*, ibid., 57, 182r.
8. 1465, 4 Dec. Lorenzo di Francesco, *fa gli ochiali*, ASF, *Mercanzia* 1441, 216v–217r; also listed in 1475 as Laurentius Francisci, *facit ochiaros, Mercanzia* 315, 3r, and in 1476, 31 May, as Laurentius olimi Francisci, *ochialarius*, ASF, NA 14717, 167v.
9. 1465, 9 Dec. Matteo di Giovanni, *fa gli ochiali*, ASF, *Mercanzia* 1442, 8r-v.
10. 1466, Jan. 11. Laurentius olim Francisci Iacobi, *fa gli ochiali*, populi S. Ambrosii, ASF, NA 3307, 104r-v; also listed in 1475, 10 Feb., as *merciarius sive magister occhialiu*, pop. S. Petri Maioris, ibid., 7306, 180v;[5] in the Catasto of 1480, *fa gli ochiali*, in the quarter of Santo Spirito, ASF, *Monte, Copie del Catasto, Ferza* 997, 393r, and in 1481, 5 Jan., as *ochialarius*, ASF, NA 20257, unpaginated.
11. 1466, 21 Jan. Pierus Chechonis, *magister oclearius*, Soprastanti alle Stinche 94, 9v. Listed also as *ochialarius* in 1478, ASF, NA 6082, 42r.
12. 1474. Leonardus Iacobi, *ochialarius*, pp. S. Fridiani, ASF, NA 6081, 98r-v.
13. 1478. Bertus Luce Berti, *merciarius sive oclearius*, pp. S. Fridiani, ASF, NA 7649, 171v.
14. 1478. Guglielmus Antonii Guglielmi, *ochialarius*, pp. S. Felicis in Platea, ASF, NA 6082, 62r.
15. 1478, 30 Oct. Giovanni di Piero, *fa gli ochiali*, Firenze, Archivio dell'Ospedale degli Innocenti, *Estranei*, No. 237, 163s.
16. 1478. Iacobus olim Iohannis Pierozi, *fa gli ochiali*, pop. Sancti Laurentii, ASF, NA 15037, fol. 317r.

5. This is a contract to rent a "bottegha" "super angulo de Pecoris" by Lorenzo from Guidaccio Pecori for five years at 5 florins "de sigillo ad annum."

17–18. 1480. Luca di Berto di Iacopo and Giovannandrea di Francesco, bottega, ASF, Catasto 1000, Drago, 319r, pop. S. Maria Nipotecosa.[6]

19–21. 1480. Bernardo and Niccolò di Giovanni Mini, ibid., 1020, *Chiavi*, 293r; and Bartolomeo di Carlo di Giovanni, ibid., 313r. All three in pop. S. Maria Nipotecosa.

22. 1480. Stagio di Piero di Martino Martini, ibid., 1024, *Vaio*, 285r, Borgo San Lorenzo.
23. 1480. Giovanni d'Antonio, ibid., canto dei Pecori.
24. 1480. Carlo di Bartolo di Buongiovanni, ibid., 1020, *Chiavi*, 329r, Corso degli Adimari.
25. 1480. Lionardo di Tommaso di Lionardo, ibid., 1000 Drago, 303r, Corso degli Adimari: *ha un garzone di 13 anni di nome di Piero Braccesi.*
26. 1483, 20 Aug. Magistro Smeraldo di Biagio Dideo, borgho San Michele, *insignarli l'arte del fari gl'occhiali*, Archivio dell'Ospedale degli Innocenti, *Serie XII, Ricordanze 2, 36v.*[7]

6. The names of the spectacle makers listed in the Catasto of 1480 were kindly furnished to me by Marialuisa Bianchi from her dissertation, "Le botteghe a Firenze dal catasto del 1480," Facoltà di Lettere e Filosofia, Università degli Studi di Firenze, relatore Elio Conti (Florence, 1984). Bianchi listed the spectacle making shops as whole units, but some of the shops employed more than one spectacle maker and perhaps several helpers, who are rarely mentioned in the sources. I am listing above the names of spectacle makers as listed in each shop. I have not included, however, the name of Lorenzo di Francesco di Iacopo who is listed under 1466 so as to avoid counting him twice.

7. This famous foundling hospital customarily placed the children as apprentices in various artisan shops. This is the only case found to date registering the placement of a boy as an apprentice to learn the trade of spectacle maker. The entry reads as follows: "1483. Richordo questo dì 20 agosto noi abbiam posto Giovanni, nostro fanciullo, cho magistro Smeraldo di Biagio Dideo, sta a chasa in borgho San Michele tralle dua parte et debbelo tenere in chasa sua et darli le spese, el chalzere et vestire, et allo tolto per anni cinque che cominciando detto dì; et oltre alle dette chose gli debbe dare in detto tempo per suo salaro fiorini tre larghi d'oro et promette insignarli l'arte del fari gl'occhiali. . . ." The entry also records that on 28 Oct. 1484 the boy had left the shop, his whereabouts unknown, but Smeraldo believed that he had gone to Rome. See now T. Takahashi, *Il Rinascimento dei*

27. 1488. Iohannes Bartolomei Chirichi, alias el Palla, *ochialarius,* ASF, NA 5242, 57^{r}.
28. 1488. Angelus Bartolomei Chirici, *ochiaio,* pp. S. Laurentii, ASF, NA 9872, 178^{v}.
29. 1489, 17 Dec. Santi di . . . *ossaio che fa gl'ochiali nel chorso de gl'Adimali.*[8]
30. 1490, 16 Oct. Franciscus Smeraldi Blasii, *ochialarius,* populi S. Nicholai ultra Arnum, ASF, NA 7646, 127^{v}–128^{r}.
31. 1491. Iohannes olim Bonaiuti, *ochialarius,* pp. S. Felicis in Platea, ASF, NA 6088, 69^{r}.
32. 1491. Iohannes Bartholomei, *fa gli ochiali,* ASF, NA 9873, 83^{r}.
33. 1492. Lorenzo di Smeraldo, *ochialaio,* nella via de' Servi, ASF, Mercanzia 21, 23^{r}.
34. 1492. Pasquino di Michele Buontempi, *ochialaio,* in Borgo San Lorenzo, ASF, ibid., 21, 32^{v}.
35. 1492. Benedetto d'Antonio, *ochialaio,* nella via de' Servi, ibid. 21, 5^{v}.
36. 1500, 12 March. Romulus Cipriani Bartolomei, *ochialarus contra archepiscopatum,* ASF, *Arti, Medici e Speziali* 10, 42^{v}.
37. 1501. Iacobus Antonius Iohannes, *ochialarius,* ASF, NA 5248, 26^{v}.
38. 1503, 2 Jan. Petrus Lodovici Papi di Solongo [?], *ochialarius,* in borgho via Servorum, ASF, *Arti, Medici e Speziali* 10, 60^{v}.[9]
39. 1505, 27 July. Matteo di Bartolomeo di Niccolò, *ochialaio* da Staggia, ASF, NA 635, 171^{r}–173^{r}.
40. 1521. Piero di Matteo, *ochiolaio,* ASF, *Carte Strozziane,* 5th ser., 102, *Entrata e uscita di Lorenzo e Filippo Strozzi, propri,* 50^{v}.
41. 1525, [March–April]. El Zuccha, *occhialaio, ha tre garzoni e un factore,* S. Giovanni, [area of Via Adimari], BNF, *Nuove accessioni 987, descrizione della città di Firenze* (unpaginated).
42. 1525. Bartholomeo, *fa gli ochiali, ha dua figliuoli e dua garzoni e un factore,* S. Giovanni, area of Borgo San Lorenzo, ibid.
43. 1525. Pasquino di Philippo, *occhialaio, ha tre figliuoli, un garzone e un factore,* Borgo San Lorenzo, ibid.
44. 1525. Francesco di Piero, *fa gli ochiali, dirimpetto al fornaio della macciana, ha dua figliuoli, fanno amendua il merciaio presso a suo padre,* S. Spirito, near S. Niccolò, ibid.[10]
45. 1525. Sanno, *fa gli ochiali, al canto le Laude,* S. Spirito, near Santa Chiara, ibid.
46. 1525. Francesco, *fa gli ochiali, ha un figliuolo e un garzone e un factore,* S. Giovanni, via dei Servi, ibid.
47. 1562. Antonio di Benedetto detto il Boncio, *ochialaio,* ASF, *Decima Granducale* 3784, 73^{r}, No. 213, Santa Croce, near Piazza de' Signori [?].[11]
48. 1562. Marco di Domenico di Marco, *ochialaio,* ibid., 83^{r}, No. 336, Santa Croce, canto del diamante.[12]

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trovatelli. Il brefotrofio, la città e le campagne nella Toscana del XV secolo (Rome, 2003), p. 138, for a quotation of the last portion of this document. I am indebted to Maria Fubini for this reference.

8. "Santi di (. . .) ossaio che fa gl'ochiali nel chorso de gl'Adimali de' avere f. uno d'oro larghi sono per ochiali dati per infino al tempo che do[n] Greghorio todesco era priore [1477–86] in questo monestero e per qualunque altra chosa avesse dato d'accordo per insino adì 17 dicembre 1489 in questo a c. 185 spese diverse debino dare . . . f.1 16 s. d." (C. Chiarelli, *Le attività artistiche e il patrimonio librario della Certosa di Firenze (dalle origini alla metà del XVI secolo),* vol. II (Salzburg, 1984), p. 385. This bone smith, whose patronymic was not given in the entry, was included in this list because clearly he was functioning as a spectacle maker for several years, and not just as a seller, as some of his other colleagues might have been.

9. Nos. 33 and 35 were listed by Taddei, *L'arte del vetro,* p. 64 but dated 1499 Florentine style; actually they are dated 1500 and 1503 respectively, modern style.

10. In this case it would seem that the father made the glasses, which were then sold by his two sons who act as storekeepers in the premises and sell glasses as well as other merchandise.

11. This entry reads as follows: "Compagnia detta ma casa contigua alla porta che nel terreno si fa l'ochialaio; contigua alla porta era un'altra detta compagnia tiene al metà [?] Antonio di Benedetto, detto il Boncio, ochialaio. . . ."

12. This entry reads: "Iacopo di Piero Primadori [?] una madia a uso di ochialai sul canto del diamante contigua a una bottega delle monache di San Gaggio tiene a pigione Marco di Domenico di Marco, ochialaio. . . ." Cf. Taddei, *L'arte del vetro,* p.64, who cites

Perhaps we should not add to the above list the following two bone smiths / merchants (*ossai*) so far identified, who prepared the bones for the spectacle frames and might have inserted the lenses ground by them or supplied by glass workers. They also acted as vendors and exporters of spectacles in large quantities, supplying a lower cost market, but they cannot be definitely identified as *occhialai* on the basis of available evidence.

this document and the preceding one from the *Decima Granducale* without giving the names of the spectacle makers. Both Marco di Domenico and Antonio di Benedetto are also listed in *I Fiorentini nel 1562. Descritione delle bocche della città et stato di Fiorenza fatta l'anno 1562*, ed. S. Meloni Trkulja (Florence, 1991), (facsimile ed. of ASF, *Miscellanea Medicea 224*), 4ᵛ, and 41ʳ, 53ᵛ, respectively. In this list, however, Marco di Domenico is listed in the quarter of Santo Spirito.

OSSAI (BONE SMITHS / SPECTACLE VENDORS)

1482–84. Giovanni di Piero e compagni, *ossai*, Pisa, Archivio di Stato, *Archivio Salviati*, ser. II, 23: ledger of Alamanno di Averardo Salviati, 1482–91, fol. 12.

1484, March–April. Taddeo di Tomaxo, *hossaio* e compagni, ASF, *Corporazioni religiose soppresse dal governo francese* 79, No. 208, fol. 1s. (Lorenzo di Smeraldo, listed in preceding list as *ochialaio*, was also involved in this transaction.)

APPENDIX II

FRIARS AS SPECTACLE MAKERS IN FLORENCE

The following four friars in two monasteries have been identified as *occhialai*, of whom one (friar Daniele) was active for only a couple of months in 1440 according to available records, whereas the other three operated a rather busy spectacle making shop for at least twenty-five years.

1440, March–April. Florence, Friar Daniele, ASF, Ospedale di S. Giovanni detto di Bonifazio, *Entrata e Uscita*, Reg. 282, fols. 2^{r-v}.[1]

1452–77. Florence, ASF, Monastero di S. Brigida detto del Paradiso, *Entrata e uscita*, F. 148: Friars Antonio, Martino, and Tomaso, 1452–61; F. 149: Friars Tomaso, Martino, and Antonio, 1462–66; F. 147: Friar Tomaso, 1467, 1469, 1474; F. 152: Friar Tomaso, 1477.[2]

A most recent chance discovery of a summary account of eyeglasses sold by the friars at S. Brigida monastery, reproduced in the following table, offers a convenient, graphic view of a rather active rhythm of spectacle making in this monastery.[3] From

1. The three entries about the sale of eyeglasses in 1440 follow: fol. 2^r, 10 Mar. 1440, "Da un paio d'ochiali vendé frate Daliello [sic] a dì 10 di marzo, soldi quindici . . . s.15"; fol. 2^v, "Da frate Daniello a dì 24 di marzo, soldi ventinove, sono d'ochiali disse avera venduti . . . £1 s.9"; ibid., "Da frate Daniello a dì 9 d'aprile, soldi ventisette, d'ochiali lui vendé . . . £1 s.7." After 1440 neither friar Daniele nor spectacles are mentioned in subsequent registers, which leads one to suspect that the friar had died or had been transferred and no other spectacle maker worked at this monastery on Via San Gallo, now used as an office building for the police. This hospital for men and women was founded in 1377 next to the Augustinian convent of San Luca with funds donated by the mercenary captain, Bonifazio Lupi, originally from Parma but long at the service of Florence. For a brief history of the hospital and its works of art, see A. M. Zandri, C. A. Luchinat, and S. Francolini, *Lo spedale di messer Bonifazio* (Florence, 1989). This book, however, makes no mention of friar Daniele or spectacle making at the hospital. I am indebted to L. Böninger for this reference.

2. These documents pertaining to eyeglass production have now been published by their discoverer, Alessandro Guidotti: "Produzione di occhiali (lenti, montature, custodie) nella Firenze del '400: i documenti del monastero di S. Brigida al Paradiso, Parte I: 1452–1474," *Atti della 'Fondazione Giorgio Ronchi'*, LVIII/5 (2003), pp. 689–700. Earlier I had microfilmed and transcribed a good portion of them.

3. ASF, Monastero di San Luca, 76, *debitori e creditori A, 1439–1351* of the Monastero del Paradiso, fol. 94, "Ochiali venduti pe' frati del nostro monastero." Goldthwaite found this ledger in 2000 as he was inspecting an account book of the monastery of San Luca. The reason that such an account seems out of place is that in 1734 Pope Clement XII issued a bull bestowing the patrimony of the St. Brigida monastery to the Conservatory for the Poor in the hospital of Bonifazio, which became the depository of the possessions of other monasteries such as those of San Luca. In this mingling of patrimonies it is possible that particular accounts may have been mixed in the books of other monasteries, which seems to be the case here. It is a mere coincidence, therefore, that some accounts of the two monasteries making spectacles as listed above should have been combined three centuries later. On the history of these institutions, see G. Bacarelli, "Storia del monastero di Santa Maria e Brigida al Paradiso: 1392–1776," in *Il 'Paradiso' in Pian di Ripoli: Studi e ricerche su un antico monastero*, ed. M. Gregori and G. Rocchi (Florence, 1985), pp. 18–29, and A. M. Zandri et al., *Lo spedale di messer Bonifazio* (Florence, 1989), pp. 13–160. These publications, however, make no mention of spectacle making in any of the monasteries.

mid-September 1454 to the beginning of January 1460, the friars collected the sum of £257 s.5 d.10. If we add the sum of £141 s.8 d.4, carried from a previous eyeglass account for the years 1452–54 in the same book "B," we have the grand total of £398 s.14 d.2 that was collected during the eight-year period. My own check of the complete entries in the *entrata* book "B," to which the table refers, has established the accuracy of the abbreviated entries in the table except for three omissions totaling £7 s.10 d.6, which increase the total to £264 s.16. d.4.[4] Subtracting three entries in the table dealing only with spectacle cases in the amount of £16 s.4,[5] we are left with a net total of £248 s.12, collected exclusively from the sale of eyeglasses. In the following table, the "×" after some entries signifies that no additional information was recorded by the scribe. The table has been reproduced here as it was found except for the initial comments in the heading.

4. ASF, Monastero di S. Brigida ditto del Paradiso, N. 148, *Entrata e uscita della Badessa segnato B*, fol. 15^v, 1454, 27 Sept.: "Da ochiali vendè frate Martino a dì 27, grossi dodici, monta . . . £3 s.6;" ibid., 1454, 21–25 Oct.: "Da un paio d'ochiali si venderono, soldi undici, di frate Tomaso . . . s.11"; and "Da oghiali si venderono in due volte, lire tre, s. tredici, denari sei. . . . £3 s.13 d.6" (Guidotti, "Produzione di occhiali," p. 692).

5. The three entries are those of 1457, 28 Nov. 1459, 30 Mar., and 22 Sept., each in the amount of £5 s.8. (Guidotti, "Produzione di occhiali," p. 694).

ASF, Monastero di San Luca, 76: debitori e creditori A, 1439–1451 of the Monastero del Paradiso fol. 94: account in name of "Ochiali venduti pe' frati del nostro monasterio" description: the account consists only of credit entries; there are no debit entries, and therefore obviously the account is not balanced and closed. (× = no information given)

Date	Money received from	Lb.	s.	d.	cross-ref. to entrata B bianca, a carta:
1454 X	opening entry: transferred from libro di fitti e pigionali A(?) nero,c.76	141	8	4	
sett 12	frate Tomaso	2	9	6	15
sett 25	da ochiali	9	16	6	15
ott 20	Antonio Parenti di frate Tomaso	10	4		15
ott 25	frate Martino	5	1		15
nov 12	fra Tomaso		18		15
X X	si vendero	8	5		15
dic X	frate Antonio	5	1		16
1455 gen 28	da ochiali	5	14		16
feb 8	da ochiali	3	10		16
gen X	ochiali	1	2		16
giu 19	frate Martino	21			17
lug 6	da ochiali si venderono	16	18	6	17
nov 21	frate Martino	15	12		18
X X	frate Martino	11	10		18
X X	frate Tomaso	6	10		19
1456 gen X	ochiali	2	8		19
gen 24	frate Tomaso da ochiali lui lavoro'	21	12		24
1457 mag 8	ochiali	2	8		25
sett 2	fra Martino	10	16		27
nov 28	fra Martino	5	8		30
1458 feb 28	fra Tomaso d'ochiali fece vendere	22	15		32
apr 23	frate Martino d'ochiali vende'	5	8		33
1459 mar 30	frate Martino	5	8		41
X 31	frate Tomaso	1	9	4	41
apr 5	d'ochiali	1	2		41
apr 11	da ochiali	2	15		41
mag 30	frate Martino	5	8		42
lug 1	frate Martino	5	8		43
sett 22	frate Martino	5	8		45
X 23	frate Antonio	5	8		45
X X	vende' frate Zanobi a Mantova di quegli d'Antonio merciaio alla insegna delle campane	16			46
nov 5	da ochiali	5	8		49
X 15	frate Antonio	1	15		49
nov 22	frate Tomaso	2	2		49
1460 gen 3	frate Martino	5	8		50
	TOTAL	398	14	2	

APPENDIX III

SPECTACLES IN ART

One of the more pleasant aspects of doing research in the early history of eyeglasses is the necessity of consulting works of art for additional or confirming evidence not provided by written or archeological sources. Indeed, before the discovery of a great number of the archival documents presented in the preceding pages, artistic representations of spectacles offered the most accessible and revealing sources, especially useful for the identification of spectacle frames, which are particularly important for collectors of antique visual aids. Historically minded ophthalmologists and opticians, many of whom are collectors, have long been attracted to works of art in pursuing their passion for the first examples of a particular style of frame and other identification characteristics to be used in dating, etc.

The most extensive catalogue embodying a massive list of works of art representing spectacles from the earliest times through the eighteenth century was published by ophthalmologist Richard Greeff and colleagues as part of an exhibition held in Amsterdam during the thirteenth international congress of ophthalmology in 1929.[1] The catalogue lists not only works of art in public collections but also originals and copies held by private persons including the authors of individual sections of the catalogue, all of whom are collectors of original visual aids.[2] Regrettably, it lacks illustrations. A great number of illustrations, however, can be found in the most comprehensive photographic record published in 1978–1980 by W. Poulet.[3] It contains photographs of works of art from the invention of eyeglasses through the nineteenth century, most of which are accompanied by enlarged details of the various spectacles, a boon to collectors. Both publications have long been out of print and are virtually unobtainable even in the antiquarian market. A reprinting of both would, even without updating the contents, be immensely useful for the history of eyeglasses and other visual aids.

Some of the contents of these now rare publications are often duplicated and sometimes augmented by additional images illustrating most general surveys

1. R. Greeff et al., *Katalog einer Bilderausstellung zur Geschichte der Brille* (Amsterdam, 1929). The German text was followed, beginning on p. 189, by an English translation that is somewhat faulty. The first sentence of the Introduction by Greeff highlighted the importance of works of art: "If we want to occupy ourselves with the history of the [sic] spectacles we cannot do without the works on representative art" (p. 189).

2. The extensive private collection of the famed retina surgeon, H. J. M Weve, one of the section authors, was deposited on loan around 1950 in the Utrecht University Museum. See D. Fleishman, "University Museum Utrecht—The Weve Collection," *Ophthalmic Antiques* 94 (Jan. 2006), pp. 8–9.

3. W. Poulet, *Atlas on the History of Spectacles*, trans. F. C. Blodi, 2 vols. (Bonn-Bad Godesberg, 1978–1980). Vol. 2 is more useful for our purposes. Its Introduction makes clear the primary purpose of the publication: "These works of art allow us to date various kinds of visual aids provided we know who was the artist." It is largely based on the world-famous private collection and museum formed in Paris by P. Marly, optician and designer of fashion spectacles. The Marly collection was acquired around 2002 by the Essilor Company, which deposited it on permanent loan in the Musée de la Luneterie at Morez in the High Jura region of France, long a leading center for spectacle making. The museum was officially inaugurated in May 2003. See R. J. S. MacGregor, "Viseum Inauguration," *Ophthalmic Antiques* 85 (Oct. 2003), pp. 1–2.

of the history of spectacles. These surveys are generally written by ophthalmologists / opticians who are once again interested in collecting rather than in breaking new ground based on archival documents. It can hardly be expected of them, of course, to master the indispensable paleographic skills and spend months and years in archives while continuing their optical practices. One notable exception was the remarkable career of Giuseppe Albertotti, who somehow was able to take time from his professorship of ophthalmology at the University of Padua to uncover original sources, especially pictorial.[4] On the whole, then, the historical sections of these surveys, which are often connected with exhibitions of eyeglasses and other visual aids, repeat myths and errors of past publications. Occasionally archival or art historians provide some brief treatments primarily based on their respective disciplines, but their brevity limits their scope. This has been the pattern especially in the last thirty or so years during which a significant number of these surveys have appeared, attesting to the popularity of the genre but adding hardly anything new. It seems, in fact, that many feel qualified to treat this currently popular subject and simply copy from one another sometimes without changing the words![5]

Surprisingly art historians have generally neglected artistic representations of eyeglasses, being content to leave this field to others who are less qualified in exploring the deeper meaning of vision aids as intended or imagined by Renaissance artists. To my knowledge there is no single monograph focusing on this subject written by an art historian. Consequently we must struggle unaided in trying to understand the following apparent anomalies in Italian regional artistic representations of spectacles.

Let us begin with the intriguing fact that despite Venice's apparent secondary role in relation to Florence in the production of spectacles before the sixteenth century, the Venetian region as a whole outranks its rival as the home of the earliest and most numerous representations of eyeglasses in art. Some other Italian regions such as the Marches and Umbria are also prolific in this sphere. So far I have noted only three such representations in paintings by Florentine artists during the Quattrocento. Domenico Ghirlandaio painted *St. Jerome in his Study* (1480) with glasses

4. In the course of this study I have cited most of his numerous publications and I need not repeat them here.

5. I list here some of the more significant publications containing many illustrations with comments where I deem appropriate, omitting several popular publications with no discernable scholarly contributions. Madame A. Heymann, *Lunettes et lorgnettes de jadis* (Paris, 1911): one of the best surveys, frequently cited, with some original illustrations; P. Marly, *Spectacles and Spyglasses*, texts by J-C Margolin and P. Biérent , rev. ed. and trans. B. Tulett (Ligugé, Poitiers, 1988): the essay by Margolin, "Towards a Historical Semeiology of Spectacles," pp. 17–82, is a masterpiece; *La lente: Storia, scienza, curiosità attraverso la collezione Fritz Rathschüler* (Genoa, 1988): one of the better annotated exhibition catalogues, based on the Rathschüler collection, now part of the Luxottica Museum at Agordo (Belluno); *Bel Vedere: The Spectacles of the Luxottica Museum*, 2 vols., ed. M. Del Vecchio (Treviso, 1999): beautifully illustrated and published in four languages, it contains a historical section by G. Guadalupi, who listed no references and was not aware of the Florentine evidence published in 1976 and cited in other earlier catalogues; *The Telescopes of the Luxottica Museum*, ed. M. Del Vecchio (Milan, 1995): the historical text by G. Guadalupi again contains nothing new and lacks references; *Occhiali da vedere: Arte, scienza e costume attraverso gli occhiali*, ed. M. Miniati and W. Winkler (Florence, 1985); *Sette Secoli a cavallo del naso*, ed. G. Bologna (Milan, 1991); *Il Museo dell'occhiale: Pieve di Cadore* (Milan, 1990): contains one of the best essays ("Gli occhiali: un'avventura veneziana," pp. 12–14) by M. F. Tiepolo, former Director of the State Archives of Venice, with full treatment of Venetian early documents, which is balanced by G. Bologna's essay, "Gli occhiali fra scienza, storia e costume alla corte milanese degli Sforza," pp. 18–19; J. W. Rosenthal, *Spectacles and Other Vision Aids: A History and Guide to Collecting* (San Francisco, 1996), with some striking and useful illustrations; *A Spectacle of Spectacles: Exhibition Catalogue*, edited W. Winkler (Leipzig, 1988), based on the vast collection in the Optical Museum of the Carl-Zeiss-Stiftung, Jena, and beautifully illustrated; and F. Rossi, *Eine Geschichte der Sehhilfen die Brille* (Leipzig, 1989), with many stunning illustrations and strong on German sources judiciously chosen by the author, former Director of the Zeiss Museum in Jena. An on-line catalogue of illustrations is now being developed by David A. Fleishman, a retired ophthalmologist, at this website: www.antiquespectacles.com.

dangling from his desk in the Church of Ognissanti, and a portrait of an unidentified bishop wearing glasses (1482–85) in the Sassetti Chapel of St. Trinità. And Piero di Cosimo depicted a bespectacled St. Anthony in the act of writing (*The Visitation with St. Nicholas and St. Anthony Abbot*, ca. 1490). Three pictures in a city crawling with spectacle makers!

Why were Florentine painters so unmindful of a commonly used vision aid, one that must have been a habitual complement of their work past the age of forty, while their colleagues in other regions of Italy and Europe acted otherwise? As far as I can ascertain, art historians have never posed this question, which again reveals their lack of interest in the subject. It remains for us to suggest a tentative answer. From the time of Masaccio and for the rest of the fifteenth century many Florentine painters were more concerned, in some cases obsessively so, with perspectival representation of nature and the human form. This was the new "modern" way to look at reality without crowding the canvas with a plethora of distracting objects or symbols. One is reminded of the criticism of Flemish painters attributed to Michelangelo—too many symbols distracted the viewer from the central theme of the painting.

It is significant that of the Florentine painters Ghirlandaio was most influenced by the Flemish style as shown in his detailed naturalistic compositions and depictions of landscapes. And Piero di Cosimo was too eclectic and idiosyncratic in his interests to adhere to any particular style, but he was admired for his skills by his colleagues and later by Vasari, who explicitly mentioned the bespectacled St. Anthony in the above painting.[6] Artists in other regions of Italy and Europe, long interested in scenes of everyday life and depictions of familiar tools and gadgets, adopted the main aspects of the Florentine mathematical approach to art only late in the fifteenth century. Among art historians only Maginnis has commented generally on this aspect of Italian Renaissance art in this period but without focusing on Florentine art and without supplying an answer.[7]

A century earlier, the Emilian artist Tomaso da Modena and his colleagues did have an interest in objects of daily life and showed them in their paintings, as I have noted in the first chapter. Tomaso, in fact, established the genre of representing eyeglasses and the two other vision aids—magnifying lenses and concave mirrors—in his frescoes at the Dominican monastery of St. Niccolò at Treviso. The three Dominicans he painted using these aids were past their forties and thus he began the trend of representing such persons of advanced age with the use of vision aids in the pursuit of their common scholarly interests. Henceforth, the scholarly St. Jerome, particularly venerated by the Dominicans, was most often represented in his study wearing or having spectacles near at hand. At times this anachronistic symbolism was carried over even when the saint was represented as a penitent beating his chest with a rock so that gradually St Jerome was thought to be the inventor of spectacles as well as a patron of scholars.

Anachronism was the most frequent and pervasive element in artistic representations of eyeglasses, so frequent in fact, as to be useless in listing it as a separate theme. Since this vision aid was associated

6. G. Vasari, *Le vite de' più eccellenti pittori, scultori e architetti nelle redazioni del 1550 e 1568*, ed. R. Bettarini, commented by P. Barocchi, vol. IV, pp. 620, 700–01, who recorded that this painting was executed for the chapel of Gino Capponi in Santo Spirito in Florence.

7. H. B. J. Maginnis, *The World of the Early Sienese Painter*, p. 111, n. 80: "One of the most fascinating aspects of central Italian art of the Renaissance, an aspect that largely passes without comment, is painters' unwillingness to portray new technologies. I refer not merely to the fact that eyeglasses seem to have been depicted first more than a half century after their invention. Images of clocks and cannons, both in use by the mid-fourteenth century, are nonexistent for a very long period thereafter."

initially with old age, the elderly, scholarly, and at times saintly figures of earlier centuries, including Virgil and saints like Peter, Paul, and Joseph, were often bespectacled. Even baby Jesus was shown dangling (not wearing!) a pair. Clearly glasses were meant to convey not only old age but also *gravitas,* wisdom, intellectuality, and scholarship. They became the normal equipment, along with magnifying lenses and concave mirrors, of scholars' studies during the Renaissance.[8] This prestige factor persisted over the centuries to our own time. In my youth, I can recall persons wearing spectacles with plain glass lenses in order to be judged intelligent and intellectual!

The above characteristics of Renaissance art with respect to vision aids will be illustrated in the following list of artistic spectacle representations, which consists of a selection of a greater number known to me. I have made an effort to include a significant number of lesser-known works alongside some widely reproduced pictures, whose inclusion was made necessary for various reasons. The list is designed to provide additional evidence to accompany the archival and archeological documentation presented in the preceding text. In order to provide some kind of order in the presentation, I have divided the works of art into thirteen artistic themes explored by artists in which eyeglasses were clearly meant to have a role in the representations. One could add additional themes and works of art, and some representations could be listed under more than one theme. Upon further reflection I could change the number of themes and representative illustrations, but there comes a time when one must stop reflecting and take action. As far as I can gather, this thematic approach has never been used before and certainly not to this extent.

Art historians, of course, would be more knowledgeable and sophisticated in their interpretation of these artistic representations, but until they decide to take an interest in the subject, they can perhaps forgive this reluctant intrusion into their field. My purpose is purely illustrative and is not intended as an exercise in art history, which would require perusal and citation of a vast bibliography about artists and their productions, clearly outside the scope of this presentation and the qualifications of the presenter. Perhaps the shortcomings of this effort may spur art historians to take action and produce, hopefully on a cooperative basis, a truly comprehensive survey of the subject. It could result in a multivolume reference work with an abundant selection of color reproductions, which only a leading optical firm or a bank could finance. These publications are commonly produced in European countries, especially in Italy.

8. See D. Thornton, *The Scholar in His Study: Ownership and Experience in Renaissance Italy* (New Haven and London, 1997), who mentions convex mirrors as reading aids; actually they had to be concave because the former distort the image whereas the latter magnify it if placed in focus.

THEMES

1. TRADES AND OCCUPATIONS

It is appropriate to begin this selection of bespectacled persons with those exercising various trades and professions. Even from this short list one can see the necessity of not only intellectuals but also of various artisans from alchemists to castrators of cats to use glasses for their work. This list adds pictorial evidence to the written record, which demolishes the myth that only wealthy people and ecclesiastics could afford the price of spectacles. The tens of thousands of eyeglasses produced and sold throughout Europe in any given year, as documented in the preceding narrative, can only be explained by a mass demand for vision aids.

OSTADE, ADRIAEN VAN (1610–85).
An Alchemist, 1661. National Gallery, London. A pair of glasses rests on a stool.

IDEM.
Eyeglass Peddlar, probably 1646, etching, National Gallery of Art, Rosenwald Collection, Washington, D. C. (Fig. 1).

1. Ostade, Adriaen van, *Eyeglass Peddlar*, probably 1646, etching. National Gallery of Art, Rosenwald Collection, Washington.

STRADANUS, JOANNES (also known as STRAET, JAN van der, 1523–1605).
The Alchemists, 1570. Studiolo of Francesco I, Palazzo Vecchio, Florence.

IDEM.
Printing Shop, in *Nova Reperta* (New Discoveries), (Antwerp, ca. 1590), pl. 4, by Adriaen Collaert and Theodore Galle, series of nineteen prints designed by Stradanus.

IDEM.
Sculptura in Aes (Engraving in Copper), *Nova Reperta*, pl. 19.

IDEM.
Spectacle Vendor's Shop (1582), *Nova Reperta*, pl. 15.

CORNELISZ VAN OOSTSANEN, JACOB, also called JACOB CORNELISZ VAN AMSTERDAM (ca. 1472–77–1533).
Spectacle Maker's Shop, ca. 1515. St. Catherine's Convent Museum, Utrecht, The Netherlands. An elderly man is trying spectacles from an open box containing several pairs, being assisted by the vendor, a woman.

FEI, ALESSANDRO (1543–92).
Goldsmith's Shop. Palazzo Vecchio, Florence. Bespectacled goldsmith holds glasses to his eyes as he inspects a gilded pitcher.

FLORIGERIO, SEBASTIANO (also FLORIGORIO), ca. 1500–1543.
The Castrator of Cats, Museo Civico, Treviso (Fig. 2).

VAN LEYDEN, LUCAS VAN (ca. 1494–1533).
Old man drawing (1520?). British Museum, London.

BENING, ALEXANDER (1469–1519).
Scribe Writing, the Author Presenting His Book. Miniature attributed to A. Bening, late 15th century, National Gallery of Art, Rosenwald Collection, Washington, D. C.

2. Florigerio, Sebastiano, *Castrator of Cats.* Painting, detail, 16th century. Museo Civico, Treviso.

MIÉLOT, JEAN, 15th Century.
Le Miroir de la Salvation humaine, ca. 1450. Bibliothèque Nationale, Paris, Ms. fr. 6275, fol. 1. Miniature showing a Dominican friar seated before a lectern as he writes on a large sheet of paper. A pair of straight handle rivet spectacles rests on his desk. The miniature was executed in Jean Le Tavernier's shop.

PORTIIS, JOHANNES ROCCHUS DE (1389–1462).
Sermones, ca. 1450, Ms. MA 493, fol. 9^{r}, Civica Biblioteca Angelo Mai, Bergamo. A miniature by an anonymous Lombard artist depicts a scribe in the act of sharpening his pen. A pair of round bridge spectacles hangs on the front board of his desk.

ANONYMOUS, Middle of the 14th Century.
Initial office of the dead, psalter used in the Diocese of Angoulême, Ms. 140, Bibliothèque of Besançon. Miniature showing four clerics or choir singers singing the office text placed on a lectern. The eldest of the group wears rivet spectacles. If this date is correct, this miniature is a contemporary of Tomaso da Modena's fresco of 1352 at Treviso.

STROZZI, ZANOBI (1412–68).
Antiphonarium, 15th century, Ms. Edili 149, fol. 62^{v}, Biblioteca Medicea Laurenziana. A sizable group of clerics and choir singers sing as they read a choral text on a lectern positioned high over a desk. At the rear of the group, far from the text, one of them (myope or hyperope?) reads with a pair of spectacles (Fig. 3).

BRUEGHEL, PIETER THE ELDER (1525/30–1569).
The Painter and the Connoisseur (mid-1560s), drawing. Graphische Sammlung Albertina, Vienna. The connoisseur observes the work of art with glasses while clutching his money pouch—an apparently negative image.

3. Strozzi, Zanobi, *Antiphonarium*, 15th century Ms. Edili 149, fol. 62v. Biblioteca Medicea Laurenziana.

MAES, NICHOLAES (1634–93).
The bookkeeper (1656). Art Museum, St. Louis, Missouri. Bespectacled woman making entries on a ledger page. One of the relatively few women portrayed with glasses.

REYMERSWAELE, MARINUS VAN (ca. 1493–1567).
Tax Collectors, ca. 1540. Hermitage Museum, St. Petersburg, Russia. One of the collectors wears glasses as he writes in the ledger (Fig. 4).

4. Reymerswaele, Marinus van, *Tax Collectors,* ca. 1540. Hermitage Museum, St. Petersburg, Russia.

BRUNSCHWIG, HIERONYMUS (ca. 1450–ca. 1512).
Surgeon treats abdominal wound, Das Buch der Cirurgia (Strassburg, 1497), woodcut, fol. LXXVIII^r. One of the students or onlookers observes procedure with one lens of a pair of spectacles held to his left eye.

HEMESSEN, JAN VAN (active 1519–56).
The Village Surgeon, ca. 1550. Museo del Prado, Madrid. The surgeon, wearing a round bridge pair of spectacles, performs surgery on the forehead of a patient.

CORT, CORNELIS (1533–78).
Art Academy, 1578, engraving. A bespectacled artist is hoisting a statue while another designs next to a pair of glasses resting on his table. Reproduced in *Occhiali da vedere* (Florence, 1985), p. 39.

DELAUNE, ETIENNE (1518–83).
Silversmith Workshop, engraving, Augsburg 1576. One of the workers wears glasses. Reproduced in J. Cherry's *Goldsmiths* (Toronto, 1992), p. 27.

2. DEATH, ASSUMPTION, AND CORONATION OF THE VIRGIN

The "Death," (also called the "Dormition") of Mary, has inspired many artistic representations. Typically Mary lies on her deathbed, surrounded by attending apostles, one of whom reads a book (of psalms?) using spectacles. There is no need to repeat this description in each case unless there are significant variations.

While reading glasses in representing the death of Mary fit the narrative, their inclusion in the "Assumption" is less compelling and it is altogether difficult to understand in the case of the "Coronation." The latter took place in Heaven where one presumes there is no need to wear spectacles. Perhaps such considerations explain why these depictions are far less frequent than the representations of the "Death."

UNKNOWN ARTIST.
Death of Mary, 1370–72. In Winged Altarpiece of the "Schloss Tirol," (Tyrol Castle), Tiroler Landesmuseum Ferdinandeum, Innsbruck, Austria.

UNKNOWN ARTIST, 11th Century.
Dormition of the Virgin. Miniature in an anonymous 11th century manuscript in which one of the apostles reads a book with a pair of glasses added three centuries later! Neuberg Monastery, Vienna. This most unusual image was published by A. Manguel, *A History of Reading* (New York, 1996), p. 295.

MASTER OF HEILIGENKREUZ (possibly Bohemian).
Death of the Virgin, ca. 1400. Cleveland Museum of Art (Fig. 5).

SWABIAN MASTER.
Death, 15th century, Castle Museum of Donauschingen, Germany.

UNIDENTIFIED ARTIST, GERMAN
(Nuremberg, last quarter of the 15th century). Formerly attributed to: WORKSCHOP OF MICHAEL WOLGEMUTH, GERMAN, 1434–1519. *Dormition of the Virgin, with an Epitaph,* about 1493. Oil on panel, Museum of Fine Arts, Boston. Gift of the children of Mrs. Samuel Dennis Warren in memory of their mother, 03.610. Photograph © 2006 Museum of Fine Arts, Boston (Fig. 6).

PACHER, MICHAEL (active 1462–98).
Death. Altarpiece (ca. 1481) in St. Wolfgang Church, Salzkhammergut, Austria. Weeping apostles with rivet glasses.

UNKNOWN ARTIST.
Dormition. Miniature in *Breviary of Martin of Aragon,* 15th century, Catalonia, Spain. Bibliothèque Nationale, Ms. Roth 2529, fol. 369, Paris.

MAESTRO DE LA SISLA (active latter half of 15th century?).
Death, ca. 1500. Prado Museum, Madrid. Here one of the attending apostles placed the lenses of his rivet spectacles close to a book to be used as magnifiers.

SCHONGAUER, MARTIN (ca. 1430–91).
Death, ca. 1475. Engraving, British Museum, London.

LOTTO, LORENZO (ca. 1480– 1556).
Assumption, ca.1511–12. Pinacoteca di Brera, Milan. Apostle on extreme right observes the Ascension holding glasses before his eyes for distance viewing, indicating a hyperopic condition because of his advanced age.

IDEM.
Another *Assumption* (1527), Church of Santa Maria Assunta in Celessa di Caprino Bergamasco. The

5. Master of Heiligenkreuz (possibly Bohemian). *Death of the Virgin*, ca. 1400. Tempera and oil with gold on wood; 66 x 53.3 cm. © The Cleveland Museum of Art, Gift of the Friends of the Cleveland Museum of Art in memory of John Long Severance 1936.496.

incredulous Thomas with glasses on his nose is bending over a table, probably reflecting on this miracle and trying to reconcile faith with reason.

PROVOST, JAN (1465–1529).
Coronation of the Virgin, Hermitage Museum, St. Petersburg, Russia. An elderly man at right seems ready to wear glasses in order to read a scroll held by a young woman.

6. Unidentified Artist, German (Nuremberg), last quarter of the 15th century. Formerly attributed to Workshop of Michel Wolgemut, German, 1434–1519. *Dormition of the Virgin, with an Epitaph,* about 1493, oil on panel. Museum of Fine Arts, Boston. Gift of the children of Mrs. Samuel Dennis Warren in memory of their mother, 03.610. Photograph © 2006 Museum of Fine Arts, Boston.

3. ADORATION OF THE MAGI, HOLY FAMILY.

The theme of the "Holy Family" is one of the most common in Renaissance art, and in my view, one of the most sentimental. Typically Mary is nursing or holding Baby Jesus while bespectacled Joseph suspends his reading to respond to the baby's need for attention. Such a representation brings the "Holy Family" to the level of the ordinary family. What could be more familiar than a baby's reaching out for his father from his mother's lap? Joos van Cleve and his workshop issued several variants of this representation, some without spectacles. On the other hand, the use of eyeglasses in connection with the "Adoration of the Magi" is not easily explainable.

BRUEGHEL, PETER THE ELDER
(active 1551–d. 1569).
Adoration, 1564. National Gallery, London. A spectator on extreme right wears glasses.

FERRARI, DEFENDENTE (active 1501–35),
School of Piedmont.
Holy Family with Angels, early 16th century Walters Art Museum, Baltimore. As Baby Jesus reaches to embrace St. Joseph's face, the latter interrupts his reading to respond while holding his reading spectacles in his right hand—a most delightful composition (Fig. 7).

7. Ferrari, Defendente, *Holy Family with Angels*, early 16th century. Walters Art Museum, Baltimore.

CARRACCI, ANNIBALE (1560–1609).
Holy Family. Biblioteca Marucelliana, Stampe XIX, 66, Florence. St. Joseph is holding glasses in his left hand while the index finger of his right hand holds a book open at appropriate pages as if his reading has been interrupted by baby Jesus' need for attention.

CLEVE, JOOS VAN (ca. 1485–1540/41).
The Holy Family, ca. 1512–13. Metropolitan Museum of Art, New York. Mary is nursing Baby Jesus while beardless Joseph interrupts his reading and holds glasses in his right hand to observe the tender scene.

CLEVE, JOOS VAN, WORKSHOP.
Holy Family, ca. 1515. Metropolitan Museum of Art, New York. Depicts Virgin breast-feeding baby Jesus while bespectacled Joseph continues his reading.

4. ST. BERNARDINO (1380–1444)

This saint is almost always depicted with a spectacle case dangling from his belt, but never with a pair on his nose or in his hands. One could probably say that without his dangling case, St. Bernardino would be "out of uniform." It is surprising that no artist was ever tempted to depart from this tradition and, as far as I know, no art historian has ever investigated this matter, perhaps because it does not appear to be of momentous significance. In the following list, therefore, all portraits have the ubiquitous dangling case and no additional references to it will be made unless significant variants occur.

NICCOLÒ DI LIBERATORE DA FOLIGNO, (called L'ALUNNO, ca. 1430–1502).
Madonna on Throne with Baby Jesus and Saints (1471?). Triptych, Pinacoteca Comunale, Gualdo Tadino (Perugia).

IDEM.
Gonfalone della Fraternita di S. Antonio Abate, ca. 1468. Pinacoteca Comunale, Deruta (Perugia).

UNKNOWN LOMBARD PAINTER (Maestro dei Santi Cosma e Damiano di Como).
Saints Louis of Toulouse and Bernardino da Siena, ca. 1520. Pinacoteca del Castello Sforzesco, Milan.

PIETRO DI GIOVANNI D'AMBROGIO (1409/10–1449).
St. Bernardino da Siena, ca. 1444, detail. Pinacoteca Nazionale, Siena. Presumably the only extant portrait made during Bernardino's lifetime (Fig. 8).

IDEM.
St. Bernardino, 1448. Museo Comunale, Lucignano (Siena).

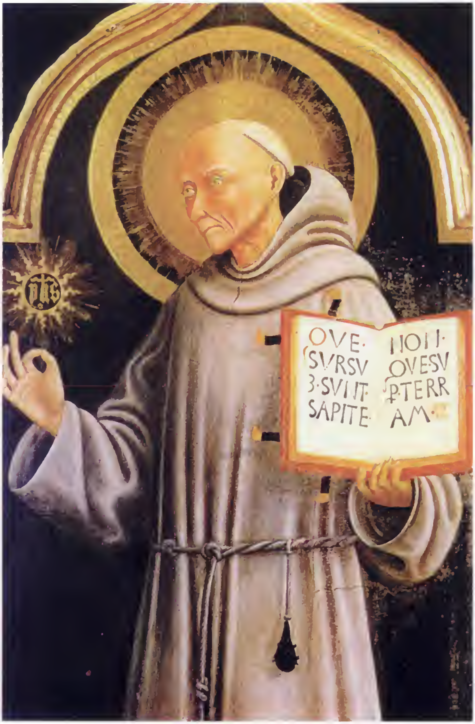
FIGUERA, JOAN (active 1455–ca. 1479) and RAPHAEL THOMAS (no dates available).
Altarpiece of San Bernardino, Pinacoteca Nazionale, Cagliari.

PAUL KOLER (Venetian gold-silversmith? No dates available).
St. Bernardino. Silver altarpiece in the cathedral of Krk, in the Adriatic island of Krk, Croatia. St. Bernardino depicted with an ornate spectacle case hanging from his belt on extreme right side of lower second row of saints.

MATTEO DI GIOVANNI (ca. 1430–1495).
Madonna with the Child, Saints Anthony of Padua and Bernardino, and Angels, 1460. Museo dell'Opera del Duomo, Siena.

LANDI, NEROCCIO DI BARTOLOMEO (1447–1500).
Madonna with the Child, Saints Michael and Bernardino, 1476. Pinacoteca Nazionale, Siena.

GIULIANO PRESUTTI (active 1490–1554).
Madonna with the Child and Saints, 1510. Polyptych in Church of St. Francis in Monte San Pietrangeli (Ascoli Piceno). Upper portion has portrait of S. Bernardino.



8. Pietro di Giovanni d'Ambrogio, *San Bernardino da Siena*, ca. 1444, detail. Pinacoteca Nazionale, Siena. (***Su concessione del Ministero per i Beni e le attività Culturali***).

5. ST. JEROME (ca. 341–420)

If painters neglected to draw a pair of spectacles on St. Bernardino's nose, confining themselves to the depiction of his hanging spectacle cases, no such qualms restrained them from depicting Jerome with glasses perched either on his nose or deposited nearby for ready use. In fact, eyeglasses became so closely associated with the activities of his daily life, whether in his desert cave but more often in his study, that through the seventeenth century he was believed to be their inventor! This tradition, of course, arose out of the fact that Jerome complained of poor vision in his later years as well as his widespread fame as a scholar, translator of the bible from the Hebrew and the Greek to the Latin (the *Vulgate* edition), and author of numerous biblical commentaries. Artists, however, seem not to have been cognizant of the fact that Jerome's supposed use of spectacles was anachronistic. Equally anachronistic was his representation as a cardinal. Occasionally, however, painters left out the eyeglasses and substituted the reading concave mirror as the vision aid used by the saint as demonstrated by the first two artists in this selection, deliberately placed at the head of the list. The concave mirror and the magnifying lens were widely used as vision aids in the ancient world as it has been noted in the first chapter. For unknown reasons it seems that artists did not show Jerome using a magnifying lens, which would have immensely aided his reported poor vision. The fact that artists emphasized the anachronistic use of spectacles over the other two aids may signify that they were not aware of these chronological distinctions, at least not during our period.

BARISINI, TOMASO (TOMASO DA MODENA, ca. 1325/6–ca. 1379).
St. Jerome in His Study, ca. 1352. Column fresco in Church of S. Niccolò, Treviso. No spectacles are shown, but a concave reading mirror encased in a leather horn [?] is depicted on a bookshelf, perhaps at the right angle for focusing and enlargement of letters. This is perhaps the first such depiction in the history of Western painting.

COLANTONIO, NICCOLÓ (ca. 1420–d. after 1460).
St. Jerome in His Study, ca. 1445. Museo Nazionale di Capodimonte, Naples. His spectacle case is hanging from a bookshelf while his concave reading mirror rests nearby on top of his desk (Fig. 9).

PIRAMO, REGINALDO DA MONOPOLI (active from end of 15th century to 1529).
Madonna on throne with Baby Jesus between St. Jerome and St. Benedict, triptych. Church of Monteoliveto, Naples. Jerome has spectacle case hanging from his shelf.

GIOVANNI ANGELO D'ANTONIO (documented 1443–76).
St. Jerome, early 1460s. Pinacoteca di Brera, Milan, (on deposit from the Museo Poldi Pezzoli, Milan). Formerly part of the upper portion of a double-storied Polyptych.

NICCOLÒ DI LIBERATORE DA FOLIGNO (called ALUNNO, ca. 1430–1502).
Madonna with Baby Jesus and Saints. Polyptych, Galleria D'Arte Antica, Palazzo Barberini, Rome. Jerome with glasses reading a book.

COLLANTES, FRANCISCO (1599–1656).
St. Jerome. National Museum, Copenhagen. Penitent Jerome has spectacles resting on a closed book in front of him.

COECKE VAN AELST, PIETER (1502–50).
St. Jerome Meditating on Death, ca. 1530. Walters Art Museum, Baltimore (Fig. 10).

9. Colantonio, Niccolò, *St. Jerome in His Study*, ca. 1445. Museo Nazionale di Capodimonte, Naples.

BERMEJO, BARTOLOMÉ (active 1474–after 1498).
Pietà of Canon Luis Desplá, 1490. Cathedral Museum, Barcelona. Bespectacled Jerome in the left background reads the bible? (Fig. 11).

SPADA, LIONELLO (1576–1622).
St Jerome (ca. 1610). Galleria Nazionale di Arte Antica, Palazzo Barberini, Rome. Bespectacled Jerome in the act of writing.

CARRACCI, ANNIBALE (1560–1609).
St. Jerome. Galleria Doria Pamphilj, Rome. A pair of glasses is resting across the edge of the saint's inkwell.

IDEM?
St. Jerome. Galleria Doria Pamphilj, Rome. Jerome's spectacles rest on an open book.

LOMI, AURELIO (1556–1622).
St. Jerome, 1595. Chapel in the Camposanto

10. Coecke van Aelst, Pieter, *St. Jerome Meditating on Death*, ca. 1530. Walters Art Museum, Baltimore.

Monumentale, Pisa. The saint as a penitent in a grotto-studio, books and glasses resting on rock shelves.

GIROLAMO DI GIOVANNI DA CAMERINO (active 1450–73).
Crucifixion and Saints Sebastian, Peter, Laurence, and Jerome. Pinacoteca di Brera, Milan, on deposit from the Museo Poldi Pezzoli. Polyptych, formerly in the Church of St. Augustine, Gualdo Tadino (Perugia).

ANSELMI, MICHELANGELO (1491–1554).
Saints Jerome and Catherine of Alexandria. Pinacoteca di Brera, Milan. Jerome's reading has been interrupted and he holds his eyeglasses in his right hand as he looks at Catherine.

BELLINI, GENTILE (1429?–1507).
Penitent St. Jerome, 15th century. Spectacle case dangling from his belt. Collection of sacred art, portal of the organ of the cathedral, Trogir, Croatia.

BRACCESCO, CARLO (d. 1514?).
The Four Doctors of the Church. Ca d'Oro Museum, Venice. Jerome on the extreme right wears glasses as he reads a book.

GHIRLANDAIO, DOMENICO (1449–94).
St. Jerome in His Study, 1480. Church of Ognissanti, Florence. His eyeglasses hang from the right side of his lectern.

GIOVENONE, GEROLAMO (1490–1555).
St. Jerome (ca. 1521). Museo Francesco Borgogna, Vercelli. The saint in the act of praying as his spectacles rest on a book in the foreground. The picture forms the right panel of a triptych with the holy family in the center and another saint on the left.

GIOVANNI ANGELO D'ANTONIO (documented 1443–76).
St. Jerome, early 1460s. Pinacoteca di Brera, Milan. Bespectacled Jerome reads a book.

ANTONELLO DA MESSINA (ca. 1430–79).
St. Jerome in His Study, ca. 1475. National Gallery, London. Spectacle case hangs from his bookcase.

JOOS VAN CLEVE, FLEMISH (ca. 1485–1540/41).
St. Jerome in his Study, 1528. Princeton University Art Museum. Eyeglasses on his table are hardly visible in contrast to his spectacle case, which is in plain sight as it juts out of the shelf in his lectern.

IDEM.
St. Jerome in his Cell, ca. 1510–30. Muzeul National de Arta al Romaniei, Bucharest. Spectacle case is jutting out of lower shelf of lectern, but no spectacles are visible.

VOUET, SIMON (1590–1649).
St. Jerome and the Angel, ca. 1625. National Gallery of Art, Washington, D. C. The saint's writing is interrupted by the appearance of an angel. Jerome's spectacles are hardly visible as they lie on his desk.

11. Bermejo, Bartolomé, *Pietà of Canon Luis Desplá,* 1490, detail. Cathedral Museum, Barcelona.

6. OTHER SAINTS AND BIBLICAL FIGURES

Even from the following short selection, one can appreciate the significant number of saints associated with spectacles. If we add the additional names listed under separate sections, we can easily come to the conclusion that the history of eyeglasses is immeasurably enriched by the depiction of bespectacled saints. For some saints, like St. Matthew, the former Roman tax collector, and St. Luke, believed by tradition to have been a physician and a painter and credited with having painted the first portrait of the Virgin, this connection is natural and logical. For others, there seems to be no other explanation other than advanced age. In one case at least, Crivelli's *St. Peter conversing with St. Paul,* it is difficult to understand the motive for depicting glasses on St. Peter, the fisherman, and denying them to St. Paul, the intellectual.

BARTOLI, ANDREA DEI (d. after 1368).
Philosophers Confronting St. Catherine, ca. 1367. Chapel of St. Catherine of Alexandria (Egypt), also burial chapel of Cardinal Alborñoz (d. 1367), Lower Church of St. Francis, Assisi. One of the philosophers holds a pair of rivet spectacles on his nose while another uses a magnifying lens to read an open book. This is the second oldest picture of a bespectacled person after that executed by Tomaso da Modena in 1352 (Figs. 12–13).

12–13. Bartoli, Andrea dei, *Philosophers Confronting St. Catherine,* ca. 1367. Chapel of St. Catherine of Alexandria, Lower Church of St. Francis, Assisi (Archivio fotografico Sacro Convento, Assisi).

DE LITIO, ANDREA (active ca. 1430–ca. 1480).
St. Anthony Abbot, fresco (ca. 1480) in the choir of the canons in the Cathedral of Atri (Teramo). The saint wears glasses.

URBANI, LUDOVICO (active 1460–93).
Saints Sebastian, Catherine, John the Baptist, and Romuald. Church of Saints Teresa and Antonio,

Metelica (Macerata). Romuald (950–1027), founder of the Camaldolese Benedictines, reads a book with spectacles.

NICCOLÓ DI LIBERATORE DA FOLIGNO (L'ALUNNO, ca. 1430–1502).
Saints Peter, John the Baptist, Benedict, and Blaise. Polyptych, Church of Santa Maria di Piazza Alta, Sarnano (Macerata). St. Blaise, 4th century bishop, patron saint of wool carders, stonemasons, shepherds, etc., wears glasses while reading a book.

IDEM.
Coronation of the Virgin, 1466. Polyptych of Montelpare. The first row of saints in the predella has images of three bespectacled evangelists: Philip, James, and Matthew. Vatican City, Pinacoteca Vaticana.

UNKNOWN PAINTER.
St. Mark Evangelist and the prophet *Hosea*, early 15th century(?). Rusconi Chapel, Duomo, Parma. Both wear glasses (Figs. 14–15).

UNKNOWN EMILIAN PAINTER, 17th Century.
Evangelist. Galleria Doria Pamphilj, N. Q. 43, Rome. Unidentified, bespectacled Evangelist reading a book.

SOEST, KONRAD VON (ca. 1370–after 1422).
Apostle, 1403. Wildunger altarpiece in Cathedral, Bad Wildungen. Unidentified apostle reading a book while holding spectacles to his eyes.

MEISTER VON MONDSEE, Late 15th Century.
St. Augustine in His Study. Österreichishen Galerie, Vienna.

UNKOWN FRENCH MINIATURIST.
St. Matthew. Book of Hours, 15th century, Cod. 445, Biblioteca Trivulziana, Milan. Matthew holds spectacles before his eyes while reading a book held open by an angel.

VAN EYCK, BARTHÉLEMY
(active ca. 1440–ca. 1469).
St. Matthew. "Unfinished Hours" for Rome Use, Ms. M. 338, fol. 17r, Pierpont Morgan Library, New York City. Another version of the preceding one (Fig. 16).

UNKNOWN FLEMISH ARTIST.
St. Matthew, ca. 1500. St. Agnes Church, Cawston, Norfolk, UK. Rood screen with depiction of St. Matthew holding glasses before his eyes as he reads a book.

CARAVAGGIO (MICHELANGELO MERISI, 1571–1610).
Calling of St. Matthew (1599–1600). Contarelli Chapel in the Church of S. Luigi dei Francesi, Rome. Matthew is counting coins on a table in pursuance of his profession as a tax collector just before Jesus interrupts and "calls" him to be his disciple. A colleague on his right holds spectacles to his eyes as he observes the counting.

CRIVELLI, CARLO (ca. 1430–94).
St. Peter (with glasses) conversing with St. Paul, ca. 1490. Gallerie dell'Academia, Venice. It is interesting that Peter rather than Paul, the intellectual, wears spectacles.

UNIDENTIFIED PIEDMONTESE PAINTER
(end of 15th—beginning of 16th century).
Apostle. Church of Saints Nazario and Celso, Quinto Vercellese (Vercelli). This unidentified apostle holds eyeglasses before his eyes as he reads a book.

14–15. Unknown Painter, *St. Mark Evangelist and the Prophet Hosea*, early 15th century(?). Rusconi Chapel, Duomo, Parma.

16. Van Eyck, Barthélemy, *St. Matthew*, "Unfinished Hours" for Rome Use, Ms. M. 358, fol. 17^r, Provence, France, ca. 1440–1450. "Gift: J. P. Morgan (1867–1943)." The Pierpont Morgan Library, New York.

UNIDENTIFIED LOMBARD PAINTER.
Habakkuk, ca. 1456. Church of Santa Maria and San Siro at Sale (Alessandria). The prophet holds glasses before his eyes as he reads (Fig. 17).

BELLINI, GENTILE (ca. 1429–1507).
St. Vincent Ferrer, 1464. Basilica of Saints John and Paul, Venice. Polyptych of St. Vincent Ferrer (+1419), Spanish Dominican saint, shown with dangling spectacle case.

UNKNOWN ARTIST, NETHERLANDISH.
Esdras Renewing the Law, From the *Book of Hours for Sarum use and Gallican Psalter with Canticles (Pembroke Hours),* fol. 109^v, ca. 1465–70), Philadelphia Museum of Art, the Philip S. Collins Collection, gift of Mrs. Philip S. Collins in memory of her husband, 1945 (Fig. 18).

ZURBARÁN, FRANCISCO DE (1598–1664).
St. Peter Nolasco and Image of the Virgin, 1630. Art Museum, Cincinnati. Spectator on extreme right observes the scene with spectacles.

HEEMSKERCK, MARTEN VAN (1498–1574).
St. Luke painting the Virgin and Child, 1532. Frans Halsmuseum, Haarlem.

MASTER OF THE HOLY BLOOD, BRUGES.
St. Luke Painting the Virgin and Child, ca. 1520. Courtesy of the Fogg Art Museum, Harvard University Art Museums, The John Witt Randall Fund, 1910.6. Interesting use of the convex mirror (Fig. 19).

GIOVANNI DI PAOLO (ca. 1399–82).
St. Jerome Appears to St. Augustine, ca. 1465. Staatliche Museum, Berlin. Augustine's eyeglasses rest on his desk.

17. Unidentified Lombard Painter, *Habakkuk,* ca. 1456 *(Su gentile concessione da parte del Rettore del Santuario di Santa Maria e San Siro in Sale, provincia di Alessandria, arciprete Alessandro Cipriani).*

PIERO DI COSIMO (1462–1521).
The Visitation with Saint Nicholas and Saint Anthony Abbot, ca. 1490. National Gallery of Art, Samuel H. Kress Collection, Washington. Bespectacled St. Anthony in the act of writing. As an item of additional interest, this is the third Florentine painting known to me which portrays eyeglasses after the two by Domenico Ghirlandaio (Fig. 20).

ANOMYMOUS PIEDMONTESE PAINTER
(end of 15th – early 16th century).
Apostle (bespectacled and unidentified). Church of

18. Unknown artist, Netherlandish, *Esdras Renewing the Law,* from the *Book of Hours for Sarum use and Gallican Psalter with Canticles (Pembroke Hours),* fol. 109v, ca. 1465–70. Philadelphia Museum of Art, the Phillip S. Collins Collection, gift of Mrs. Philip S. Collins in memory of her husband, 1945.

19. Master of the Holy Blood, Bruges, *St. Luke Painting the Virgin and Child,* ca. 1520. Courtesy of the Fogg Art Museum, Harvard University Art Museums, The John Witt Randall Fund, 1910.6.

the Saints Nazario and Celso, Chapel of the Apostles, Quinto Vercellese (Vercelli).

SCHOOL OF ALTICHIERO ALTICHIERI (JACOPO AVANZI, 1320–95).
Doctor of the Church, (ca. 1370). Vault of the Chapel of San Giacomo, Basilica of Sant'Antonio, Padua. An unidentified Doctor of the Church wears glasses.

THE MASTER OF THE SAINT BARTHOLOMEW ALTARPIECE (active ca. 1470–1510).
Saints Peter and Dorothy. National Gallery, London. St. Peter holds spectacles in his left hand while he gives a

20. Piero di Cosimo, *The Visitation with Saint Nicholas and Saint Anthony Abbot*, ca. 1490. National Gallery of Art, Samuel H. Kress Collection, Washington.

quizzical glance, variously interpreted, at St. Dorothy. The lenses reflect panes on a window.

DE SALIBA, ANTONIO (1467–1535) OR PIETRO RUZZOLONE (doc. 1484–1526).
Saint (unidentified). Polyptych of the Coronation of the Virgin, *Madre Vecchia* Church, Castelbuono (Palermo), detail. The saint wears a bridge type pair of glasses as he reads a book. The frescos have been attributed alternatively to both artists (Fig. 21).

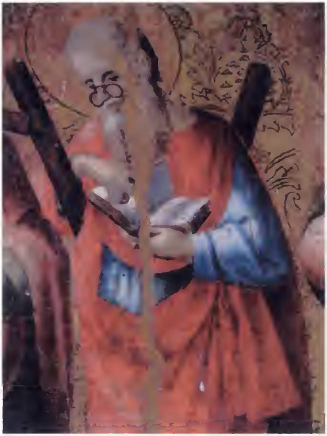
BLOEMAERT, ABRAHAM (1566–1651).
The Four Evangelists, ca. 1612–15. Princeton University Art Museum. A pair of spectacles rests on a bowl within easy reach of the Evangelists, who are reading and writing around a common table.

DANTI, GIROLAMO (1547–80).
The Baptism of the Centurion, fresco, ca. 1574. Sacristy, St. Peter's Basilica, Perugia. This fresco shows St. Paul baptizing the centurion, the act being witnessed by a group of persons. One of these on the extreme left observes the scene wearing glasses.

ALFANI, ORAZIO (1510–83).
St. Peter Cures a Crippled Man. St. Peter's Basilica, Perugia. A man wearing round bridge spectacles, standing on the right of the saint, is observing the miracle.

HORENBOUT, GERARD (1460s–1540/41).
The Family of Saint Anne. Poortakker Triptych, Museum voor Schone Kunsten, Ghent. In the central panel a man reads a book while holding glasses to his eyes with his right hand.

WESTPHALIAN MASTER, 15th Century.
The Relatives of St. Anne, end of the 15th century Church of St. Servatus, Maastricht, The Netherlands.



21. De Saliba, Antonio or Pietro Ruzzolone, *Saint* (unidentified), early 16th century. Polyptych of the Coronation of the Virgin, *Madre Vecchia* Church, Castelbuono, provincia di Palermo, detail.

On the extreme right there is Zebedee (the father of Jesus' disciples James and John), reading a sheet of writing while holding rivet glasses to his eyes with his right hand. On the extreme left there is Alphaeus who holds in his lap his baby son, James, later one of the twelve apostles. Most interesting is the fact that baby James holds a pair of rivet spectacles in his right hand while a sheet of writing covers the upper part of his body. This is indeed a rare picture of a baby holding a pair of spectacles in his hand (Figs. 22–25).

22, 23, 24, 25. Westphalian Master, *The Relatives of St. Anne,* end of the 15th century, Church of St. Servatus, Maastricht, The Netherlands. Four details: 1. Zebedee reading with spectacles; 2. Alphaeus holding baby James on his lap while the latter holds a pair of rivet glasses; 3. Detail of glasses held by Zebedee; 4. Detail of glasses held by baby James.

7. EVENTS IN THE LIFE OF CHRIST

Certain events in the life of Christ seem to cry out for the use of spectacles, which artists depicted with abandon—always anachronistically. The delicate surgery involved in the *Circumcision*, obviously, could be better carried out with the use of a vision aid of some kind—a magnifying lens would have been appropriate to the time, but artists judged that the "surgeon" needed both hands free as they saw spectacles everywhere in their own age.

Jesus Among the Doctors, on the other hand, posed a different visual problem. Here we have a twelve-year-old boy disputing articles of theology and Judaic law with a group of "doctors" at the Temple. The facial expressions of the learned men range from surprise and grudging admiration for the knowledge displayed by the precocious boy to skepticism and outright rejection. Yet, at least one of them is sent to the books, so to speak, and hence to the necessary crutch—reading glasses. What could be more natural to the scene?

The *Adulteress* scene involved reading a message, which Jesus had scratched on the ground as he was about to enunciate his famous pronouncement: "Let him who is without sin among you be the first to throw a stone." Among the Pharisee spectators, one who stood at a distance from the written letters is depicted with spectacles, trying to read the message, whose contents remain unknown to this day. On the other hand, *The Tribute Money* required clear eyesight to keep records and count coins when paying taxes, necessary requirements in modern times as well. Peter was at the age where a pair of spectacles could help in these tasks, not to mention Matthew, the former Roman tax collector.

MAZZOLINO, LUDOVICO (ca. 1480–ca. 1528).
Circumcision, ca. 1520. Isola S. Giorgio Maggiore, Collezione Vittorio Cini, Venice. A spectator on the extreme right reads a book while holding a pair of eyeglasses to his eyes.

IDEM.
Circumcision, 1526. Galleria degli Uffizi, Florence.

GLOCKENDEN, NIKOLAUS (1515–34).
Circumcision, 1507, Ms. U. 6. 7, fol.13, miniature, Biblioteca Estense, Modena (Fig. 26).

CARDI, LODOVICO (called IL CIGOLI, 1559–1613).
Circumcision. Church of St. Francis, Prato.

RIBERA, JUSEPE DE (LO SPAGNOLETTO, 1591–1652).
Christ Among the Doctors. Galleria Nazionale d'Arte Antica, Rome. No spectacles, but one of the doctors on the extreme right uses a magnifying lens.

STOMER, MATTHIAS (ca. 1600–1650).
Christ Among the Doctors, ca. 1630. Courtesy of Loyola University Museum of Art, Martin D'Arcy Collection, Chicago, Illinois. A bespectacled doctor reads a book (Fig. 27).

PRETI, MATTIA (1613–99).
Jesus Among the Doctors, 1640–45. Musée des Beaux-Arts, Nîmes. A bespectacled doctor on the extreme left.

IDEM.
The Tribute Money, ca. 1675. Museo di Capodimonte, Naples. In this and in the following "Tribute" at the Brera, one of the apostles wears glasses as the coins of the taxes are counted.

IDEM.
Peter Pays the Tribute. Pinacoteca di Brera, Milan.

26. Glockenden, Nikolaus, *Circumcision,* 1507. Ms. U.6.7, fol. 13, miniature. Biblioteca Estense, Modena.

IDEM.
Resurrection of Lazarus. Galleria di Arte Antica, Rome. One of the spectators observes the scene with spectacles from a distance.

MAZZOLINO, LUDOVICO (ca. 1480–ca. 1528).
The Adulteress Before Christ, early 16th century. Strossmayer's Gallery of Ancient Masters, Croatian Academy of Sciences and Arts, Zagreb. A scribe or Pharisee holds spectacles on his nose to read the message Christ had written on the pavement (Figs. 28–29).

BONIFACIO DE' PITATI (CALLED BONIFACIO VERONESE, 1487–1553), AND HIS WORKSHOP.
Christ and the Adulteress. Pinacoteca di Brera, Milan. One of the old men on the extreme left is getting ready to use his eyeglasses to read Christ's writing on the ground.

27. Stomer, Matthias, *Christ Among the Doctors*, ca. 1630. Courtesy of Loyola University Museum of Art, Martin D'Arcy Collection, Chicago, Illinois.

28, 29. Mazzolino, Ludovico, *The Adulteress Before Christ,* early 16th century. Strossmayer's Gallery of Ancient Masters, Croatian Academy of Sciences and Arts, Zagreb.

VALENTIN DE BOULOGNE (LE VALENTINE, 1591–1632).
Christ and the Adulteress, 1620s. J. Paul Getty Museum, Los Angeles.

PRETI, MATTIA (1613–99).
Christ and the Adulteress. Kunsthaus, Zürich.

NETHERLANDISH ARTIST, 16th Century.
Christ and the Woman Taken in Adultery, ca. 1500/1599. Tapestry, National Gallery, Widener Collection, Washington, D. C. (Fig. 30).

PIAZZA, PAOLO (FRIAR COSMO DA CASTELFRANCO, 1557–1621).
Cena in Emmaus, ca. 1590. Sacristy, Duomo, Castelfranco Veneto, Treviso. In this dining scene, full of details of kitchen life, there is in the extreme right foreground the figure of a large man wearing a white apron sitting on a Savonarola-type chair. He is drawn

30. Netherlandish Artist, 16th century, *Christ and the Woman Taken in Adultery*, ca. 1500/1599, tapestry. National Gallery of Art, Widener Collection, Washington.

31. Piazza, Paolo, *Supper at Emmaus*, ca. 1590. Sacristy, Duomo, Castelfranco Veneto (Treviso).

in profile with a pair of spectacles perched on his left ear. He seems to be the chef observing the kitchen help at work (Fig. 31).

CANAVESIO, GIOVANNI (fl. 1450–1500).
Pact of Judas, 1492. Church of Notre-Dame-des-Fontaines, La Brigue, France. One of the priests watches the proceedings holding a pair of rivet spectacles to his eyes while Judas reaches for the 30 pieces of silver. This fresco is part of the Passion Cycle painted by this artist-priest, who seems to use his art to vent his anti-Semitic sentiments.

GIORDANO, LUCA (1634–1705).
Ecce homo. Pinacoteca di Brera, Milan.

VAN DER STRAET, JAN (JOANNES STRADANUS, 1523–1605).
Crucifixion, 1581. Museo di Casa Vasari, Arezzo. Man in left background wears eyeglasses for distance, probably hyperopic or myopic depending on his age, which is difficult to gauge. This use of spectacles seems to be a rare depiction for a Crucifixion.

8. PORTRAITS

Although already a tradition in the ancient Egyptian and Roman world, portraiture became very popular during the Italian Renaissance with its emphasis on individual achievement and its memorializing of wealth and power in a predominantly merchant society. Seventeenth-century Holland with its rich burghers created the same conditions, which resulted in abundant portraiture and celebration of wealth as disclosed in the attention to the details of everyday life shown in artistic productions. The following selection deals only with portraits and self-portraits containing spectacles either worn, held in hand, or deposited nearby for ready use. Comments will be included only in those cases revealing interesting poses or variations. One general observation, however, is in order at the outset. The prominent depiction of spectacles in the self-portraits may be interpreted as another sign of the higher social status of the artist by the late sixteenth century. He is no longer just another artisan working with his hands, but an intellectual worker, a "fine artist" as we say today, the intellectual equal of the humanists, even aspiring to noble rank.

32. Bening, Simon, *Self-Portrait*, 1558. Victoria and Albert Images/ Victoria and Albert Museum, London.

BENING, SIMON (1483–1561).
Self-Portrait, 1558. Victoria and Albert Museum, London.
This leading book illuminator represented himself at his easel near a window as if his work on a drawing of the Virgin and Child shown in front of him was interrupted. Having removed his glasses, which he holds in his left hand, he was ready to self-pose for the portrait (Fig. 32).

DOLCI, CARLO (1616–87).
Self-portrait at Age 58, 1674. Galleria degli Uffizi, Vasari Corridor, Florence. Painter holds portrait of himself wearing glasses.

GUMPP, JOHANNES (1626–after 1646).
Double Self-Portrait at the Mirror, 1646. Galleria degli Uffizi, Florence. No spectacles, but interesting use of the mirror for a double self-portrait.

GIORDANO, LUCA (1634–1705).
Self-Portrait, (late 1670s–ca. 1688). Staatsgaleire, Stuttgart. Giordano wears spectacles (pince-nez) with large lenses, probably showing influence of the fashion in Naples and later in Spain where he worked for ten years. Unusually, this artist's numerous self-portraits flaunted rather than masked his weak sight with the use of this type of spectacle frame.

IDEM.
Homage to Velázquez, ca. 1672. National Gallery, London. Although the title of this painting has long been disputed, considering the fact that it does not really show Velázquez at his worktable, there is no dispute about Giordano's self-portrait at the lower right of the painting, where he represented himself with his pince-nez and a Spanish collar.

IDEM.
Self-Portrait, ca. 1692. Pio Monte della Misericordia, Naples. This time Giordano represented himself bespectacled with his pince-nez and adorned with a wig, collar, and a jabot, all emblems of the aristocracy (Fig. 33).

THERBUSCH, ANNA DOROTHEA (1721–82).
Self-Portrait, 1776–77. Gemäldegalerie, Berlin. The artist has a monocle over her right eye, which is attached to a leather or metal strap. The strap is attached to the underside of her hat. The lens is convex, which allowed closer work while her unaided eye permitted distance viewing. On the other hand, a myope using this contraption with a negative lens could have used the monocle for distance and the unaided eye for close work. This is a rather rare image, but there might have been earlier, unrecorded vision aids of the type. For this reason, I have included this self-portrait even though its date falls outside of our period of interest.

EYCK, JAN VAN (ca. 1395–1441).
The Madonna with Canon van der Paele, 1436. Groeningemuseum, Bruges. Though this painting is well known and often reproduced, it is included here because it shows the portrait of the donor, Van der Paele (ca. 1370–1443), who has removed his reading glasses as he apparently meditates on what he has read, and prays to the Virgin. This painting has sometimes been credited with the first depiction of spectacles with concave lenses. Further examination by competent opticians on both sides of the Atlantic has established that the lenses are convex.

RAPHAEL (RAFFAELLO SANZIO, 1483–1520).
Leo X with Cardinals Giulio de' Medici and Luigi de' Rossi, 1518. Galleria degli Uffizi, Florence. Leo holds a biconcave lens monocle in his left hand.

CHIMENTI, JACOPO DA EMPOLI (1554–1640).
Leo X. Casa Buonarotti, Florence. Portrait of Leo X looking through a monocular lens held in his right hand.

33. Giordano, Luca, *Self-Portrait,* ca. 1692. Pio Monte della Misericordia, Naples.

ANONYMOUS, 17th Century.
Portrait of Ambrosio de Morales. Reproduced in Madame Alfred Heymann, *Lunettes et lorgnettes de jadis* (Paris, 1911), p. 26. This portrait of Morales (1513–91), Spanish historian, shows him with a pair of spectacles resting over his right ear. Apparently this was a fairly common practice at this time—the glasses were always at hand, ready to wear and obviated the inconvenience of misplacement. Yet few paintings document this practice, perhaps because it was too common.

ANONYMOUS.
Portrait of Francesco Caetani, Duke of Sermoneta, 1660–62, Palazzo Caetani, Rome. Caetani (1594–1683), Governor of Milan and Viceroy of Sicily for the Spanish crown, is represented with the chain of the Order of the Golden Fleece, wearing spectacles with rather large concave lenses. What seem to be wires attached to the spectacles, and partially covered by his hair, may find their resting place over the ears. This is another interesting example of a nobleman following the Spanish tradition of displaying rather than hiding the use of spectacles with large lenses in order to indicate high social status (Fig. 34).

34. Anonymous, *Portrait of Francesco Caetani, Duke of Sermoneta*, 1660–62. Palazzo Caetani, Rome.

GALIZIA, FEDE (1578–1630).
Portrait of Paolo Morigia, 1596. Pinacoteca Ambrosiana, Milan. The portrait of this Jesuit historian at the age of 72 was painted by the artist when she was only 18 years old, as revealed in the writing at the top of the painting. Morigia is depicted as his writing was interrupted and holds his spectacles in his left hand. The clearly convex lenses reflect objects in the room.

VASARI, GIORGIO (1511–74).
Presumed Fresco Portrait of Miniato Pitti, 1544? Sacristy Corridor in the Olivetan Monastery, Naples. Pitti was a Florentine Olivetan monk, a cosmographer, and a friend of Vasari. He is shown holding his eyeglasses in his left hand.

COSTA, LORENZO (ca.1460–1535).
Group Portrait of the Bentivoglio family, 1493. © Museo Thyssen-Bornemisza, Madrid.This unusual group portrait of ten people, assembled around a central figure holding a musical score, depicts a private concert given in the residence of the Bentivoglio, rulers of Bologna. This is one of the earliest group portraits in Italian art and probably the first to show a member of the group (lower right) wearing a pair of spectacles. The members of the group, which include singers and the painter himself (lower left), were identified at the top portion of the painting (Figs. 35–36).

GHIRLANDAIO, DOMENICO (ca. 1448–94).
Funeral of St. Francis, ca. 1485. Sassetti Chapel, Church of Santa Trinità, Florence. In essence this is another group portrait. In this case, leading Florentine citizens, one of whom is an unidentified bishop wearing eyeglasses perched on his nostrils as he reads a book, are depicted attending the funeral.

MORANDINI, FRANCESCO DETTO "IL POPPI" (1544–97).
Portrait of Don Vincenzo Borghini at age 55. Staatliche Kunsthalle, Karlsruhe. Borghini (1515–80), court humanist of Duke Francesco de' Medici, suggested the iconography for the Duke's *Studiolo* (1570–75). His spectacles lie on a table in front of him.

BELLI, GIUSEPPE (second half of 16th century).
Portrait of Gaspare de Albertis (1547). Accademia Carrara, Bergamo. This musical composer (ca. 1480–1560/65) holds two framed lenses attached to a long handle to be held before the eyes for distance viewing.

DAVID, H.
Portrait of Girolamo Capivaccio (Capodivacca), Doctor of Medicine in Padua. Engraving by David in *Jacobi Philippi Tomasini Patavini illustrium virorum elogia . . .* (Padua, 1630). Museo Civico, Padua. He wears glasses with attached strings wound around his ears, a common practice in the seventeenth century.

35–36. Costa, Lorenzo, *Group Portrait of the Bentivoglio Family,* 1493. © Museo Thyssen-Bornemisza, Madrid.

37. Greco, El (Domenikos Theotokopoulos), *Portrait of a Cardinal, probably Cardinal Don Fernando Niño de Guevara* (1541–1609), ca. 1600. The Metropolitan Museum of Art, H. O. Havemeyer Collection, Bequest of Mrs. H. O. Havemeyer, 1929 (29.100.5). Photograph © 1992 The Metropolitan Museum of Art.

GRECO, EL (DOMENIKOS THEOTOCOPOULOS, 1541–1614).
Portrait of a Cardinal, probably Cardinal Don Fernando Niño de Guevara (1541–1609), ca. 1600. The Metropolitan Museum of Art, H. O. Havemeyer Collection, Bequest of Mrs. H. O. Havemeyer, 1929. (29.100.5). Photograph © 1992 The Metropolitan Museum of Art. He wears spectacles with strings around his ears (Fig. 37).

39. Vermeyen, Jan Cornelicz, *Portrait of Felipe de Guevara*, 1531. Gift of Asbjorn R. Lunde. Sterling and Francine Clark Art Institute, Williamstown, Massachusetts.

38. Anonymous, *Portrait of Michele Savonarola*, 1455. Biblioteca dell'Archiginnasio, Bologna.

ANONYMOUS.
Portrait of Michele Savonarola, 1455. Biblioteca dell'Archiginnasio, Bologna. The illustrious doctor and medical writer, grandfather of the preacher-reformer Girolamo Savonarola, is shown wearing glasses while reading a book (Fig. 38).

VERMEYEN, JAN CORNELICZ (ca. 1500–ca. 1559). *Portrait of Felipe de Guevara*, 1531. Clark Art Institute, Williamstown, MA (Fig. 39).

LOTTO, LORENZO (ca. 1480–1556).
Portrait (1527) of Bishop Toma Nigris (ca. 1450–after 1531). Franciscan Monastery, Poljud (Split), Croatia. The bishop is kneeling in prayer as a pair of

bridge-type eyeglasses rests on his desk in front of him. From the reflected light one can judge that the lenses were convex.

VELÁZQUEZ, DIEGO DE SILVA Y (1599–1660).
Portrait of Francisco Gómez de Quevedo y Villega, 1631–35. Instituto de Valencia de Don Juan, Madrid. This portrait of Francisco de Quevedo (1580–1645) shows this influential Spanish humanist, poet, and satirist in noble attire, which includes the cross of a member of the Order of Santiago. His spectacles with large lenses denote his high social rank as a secretary to King Philip IV. Noteworthy for our purpose is the fact that his name gave rise to a new term for eyeglasses in Spanish, *quevedos,* which is used to this day alongside the old term, *anteojos.*

BOULANGER, JEAN (1606–80).
Unidentified Portrait of a Young Man. Palazzo Ducale Estense, Sassuolo (Modena). Part of a cycle of frescoes by Boulanger, one of which shows a young man standing on a balcony next to a child, holding a pair of spectacles to his eyes with his right hand to look at a distant person or object in the courtyard below. Formerly the palace was used by the Military Academy of Modena, but it has been up for sale since March 1999.

RIBERA, JUSEPE DE (LO SPAGNOLETTO, 1591–1652).
Portrait of a Knight of Santiago, 1630–38. Arthur H. Meadows Collection, Meadows Museum, Southern Methodist University, Dallas, Texas. 77.02 This knight, still not identified, is depicted with all the symbols of the nobility with a high military rank from the collar of the Order of Santiago (reserved only for the Spanish nobility) to the baton of Captain General of the Spanish army held in his right hand, and the sword on which his left hand rests. His leather under vest seems ready to be covered with the steel armor of the fighting knight. His spectacles with large lenses, however, perched on his nose without strings around his ears, render the portrait somewhat incongruous. For this reason, portraits of knights wearing glasses are relatively rare in this period because they seem to detract from the martial spirit of the sitter. We have seen earlier in the text that the Sforza court in Milan was crawling with Florentine eyeglasses, but we have never discovered a portrait of Duke Francesco Sforza (a former mercenary captain) or of his son, Galeazzo Maria, wearing glasses. The message in the fifteenth century seems to have been that armor and spectacles do not mix! (Fig. 40).

MASSYS, QUENTIN (1465/66–1530).
Portrait of a Canon, ca. 1520–25. Collections of the Prince of Liechtenstein, Vaduz. Half bust with spectacles in his right hand.

40. Ribera, Jusepe de, *Portrait of a Knight of Santiago,* 1630–38. Arthur H. Meadows Collection, Meadows Museum, Southern Methodist University, Dallas, Texas. 77.02

9. ARCHEOLOGICAL FINDS, ARCHIVAL DOCUMENTS, RELICS

As it has been noted repeatedly in the text, archeologists have provided us with a wealth of information particularly relevant to the manufacture of spectacle frames. This information is constantly growing as more digs unearth additional evidence. Archival documents, on the other hand, have revealed much hitherto unknown optical information, and have documented the widespread diffusion of eyeglasses throughout Europe and the surprisingly low cost of ordinary spectacles produced in great quantities. Relics of saints have provided additional specimens, some of which are in perfect condition, but, regrettably, they cannot be examined directly owing to their sacred character. I have made an effort to include in this section a representative selection of this ever-growing body of evidence.

ARCHEOLOGICAL FINDS — THE NETHERLANDS

RIVET SPECTACLES, 15th Century.
The first five specimens listed below are fully described and illustrated in color on a single page by Paul Aangenendt, "Rivet Spectacles in the Netherlands," *Ophthalmic Antiques,* No. 79 (April 2002), pp. 4–5. Some of the specimens have been restored by the Municipal Archaeological Service at Bergen op Zoom under the direction of Marco Vermunt. Photographs were provided by P. J. K. Louwman, while English translations and other photographs were supplied by Carla Aangenendt, Paul's sister, both optometrists and collectors of antique spectacles, residing at Eindhoven, the Netherlands (Fig. 41).

I. VLISSINGEN.
Complete pair of spectacles with lenses, dated second quarter of the 15th century, found in 1972 in a garbage pit at a dig at Castle Aldegonde.

II. WINDESHEIM/ZWOLLE.
A horn framed pair found in 1986 in an excavated garbage pit under the foundations of an Augustinian monastery (destroyed in 1572), four miles south of Zwolle.

III. HAARLEM.
Two willow-wood handles of a rivet pair, excavated at the castle "Huis ter Kleef," in 1990–94. Thickness of the willow-wood is ca. 3mm.

IV. HAARLEM (same site).
Fragment of a bone rim of another pair. Its thickness is ca. 2mm.

V. BERGEN OP ZOOM.
A complete pair of bone spectacles of early 15th century, found in 2001 at a dig in the vicinity of the main church (*Grote Kerk*) in Bergen op Zoom. This pair has the unique feature that the two straight handles resemble two "faces in silhouette," the only such pair found to date. The convex lenses, however, have largely deteriorated.

VI. MIDDELBURG.
Complete pair of bone spectacles with lenses (ca. late 15th century) found in a trash pit at Souburg Castle.

ARCHEOLOGICAL FINDS, ENGLAND, 15TH CENTURY

I. MUSEUM OF LONDON.
Partial bone spectacle frame without lenses found in the 1974–75 excavations at Trig Lane, Blackfriars, City of London. The surviving incomplete rims were intended to accommodate a convex lens of ca. 30mm. Complete frames of this type are estimated to weigh 5g without the lenses (Fig. 42).

41. *Rivet Spectacles in the Netherlands,* 15th century. Photographs of archeological finds, Documentation/Archive, assembled by Paul Aangenendt, Eindhoven, The Netherlands.

42. *Partial Bone Spectacle Frame,* mid-15th century, found in excavations at Trig Lane, Blackfriars, City of London. Museum of London.

II. MUSEUM OF LONDON.
Another partial bone spectacle frame without lenses found in 1994 on the foreshore of the Thames River at Swan Stairs, City of London.

III. MUSEUM OF LONDON.
Suggested construction of bone frames from the metacarpal bones of bulls. More recent research, however, suggests that the frame material might have been antler. This remains an open question (Fig. 43).

Archeological Find, Italy, 15th Century

FLORENCE, SOPRINTENDENZA ARCHEOLOGICA PER LA TOSCANA.
Rivet bone/antler or ivory spectacle frame with curved handles without lenses, found in 1982 in a well (8.3 meters deep) in Via dei Castellani at the rear of Palazzo Vecchio. In a provisional analysis Italian archeologists concluded that the frame was made of horn, but the breaks and protrusions meant to be secured with wire after the insertion of the lenses suggest bone/antler and less likely, ivory, especially in view of the large number of bone objects present in the dig. Horn frames were made in one piece without protrusions and the lenses were inserted by the application of heat to the frames. A wooden frame is another possibility, but after five centuries the intermittent flow of water from the Arno and a nearby stream, the extreme humidity, and the heavy debris dumped into the well, all would have heavily damaged the frame, which survived in near-perfect condition. The frame is 68mm in length and the diameter of the rims is 33mm (Figs. 44–45).

Archival/museum Evidence Italy, France, Austria, Germany

MANTUA, ARCHIVIO DI STATO, CIMELI 151, Possibly mid-17th Century.
Perfectly preserved pair of spectacles with lenses intact found in 1986 in a register of notarial acts, dated 1518, of the Mantuan notary, Santino Fozia, active for forty years after 1510. The frame consists of a single 3mm band of material, probably leather or less likely whalebone, surrounding two biconvex spherical lenses held in place by two thin brass wires attached at the base of a round bridge. The lenses have a power of + 1.50 each, a total of ca. 3 diopters. The diameter of the rims is ca. 37mm, that of the lenses, 34mm. The total weight is 8 g, far less than the lightest modern specimens made with titanium frames and acrylic lenses, which weigh 14 g. The shape of the frame suggests that the pair belonged to a person who consulted the acts in the early or middle 17th century (Fig. 46).

43. *Suggested Construction of Bone Spectacle Frames from Metacarpal Bones of Bulls,* 15th century. Museum of London.

44–45. *Rivet Bone/Antler or Ivory Spectacle Frame,* late 15th century, found in Florence. Soprintendenza Archeologica per la Toscana, Florence.

46. *Round Bridge Spectacle Leather (?) Frame with Lenses,* probably middle of the 17th century. Archivio di Stato, Cimeli 151, Mantua.

47–48. *Round Bridge Spectacle Leather Frame with Lenses,* early 17th century. Archivio di Stato, Perugia.

PERUGIA, ARCHIVIO DI STATO.
Another pair of ca. early 17th century was discovered more recently among the notarial acts of Giovanni Cristoforo Petrogalli, active in Perugia from 1537 to 1583. This pair is similar in construction to the Mantuan pair and measures 8.5 cm. in length. The power of the glass lenses is ca. 3 diopters. The lenses have different diameters—one of 3.35 cm and the other of 3.55 cm. The frame seems to be made of leather (Figs. 47–48).[9]

SPECTACLES WITH CASE, FRANCE, ca. 1550–75.
Vienna, Kunsthistorisches Museum, Kunstkammer. Beautiful rivet gold-framed pair with curved handles and lenses intact, 8.4 cm in length. Both the frame and the case are richly enameled with arabesque designs, clearly a cooperative effort of spectacle makers and goldsmiths. Once again this pair, which can be considered a work of art, shows a high degree of collaboration in the trades, and it reveals the degree of sophistication achieved by the spectacle-making industry in France by the middle of the sixteenth century.

PARIS.
Letter of Duke Francesco Sforza of Milan to his ambassador in Florence, Nicodemo Tranchedini, Milan, 21 Oct. 1462 (Fig. 49), in which he ordered three dozen pairs of eyeglasses from Florence, including one dozen with concave lenses for myopes (Paris, Bibliothèque Nationale, *Fonds Italien,* Cod. 1595, fol. 291, reel 1762). To date this letter constitutes the first definite evidence of the existence of concave lenses in this period and the first unequivocal statement of Florence's leadership in the manufacture of high quality spectacles. (See chap. III, pp. 82–88.)

9. I am indebted to Dr. Gherardo Villani of Spoleto for the above information that forms part of a more extensive analysis, too technical to be included in a general survey. He also supplied the photographs.

MILAN.

Letter of Duke Galeazzo Maria Sforza of Milan to his ambassador in Florence, N. Tranchedini, Milan, 13 June 1466 (Fig. 50), in which he ordered two hundred pairs of spectacles for progressive degrees of presbyopia varying from ages 30 to 70, and two degrees of myopia ("medium" and "distant") for the young (Milan, Archivio di Stato, Archivio Ducale Sforzesco, *Potenze Estere-Firenze*, cart. 270, reel 501). This is the first documentary evidence of such ordering of glasses by age category, including the earliest identification of two degrees of myopia. This massive order itself is a record. (See chap. III, pp. 90–92.)

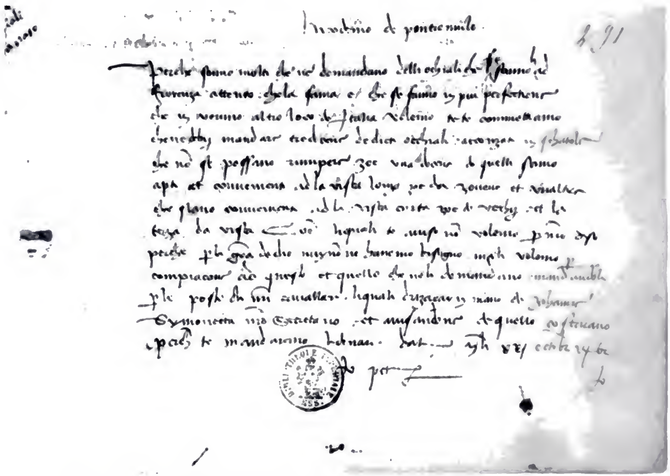
EISANACH, GERMANY.

Five leather-framed spectacles of the humanist Willibald Pirckheimer, 1520–30, Wartburg-Stiftung, Eisanach (Fig. 51).

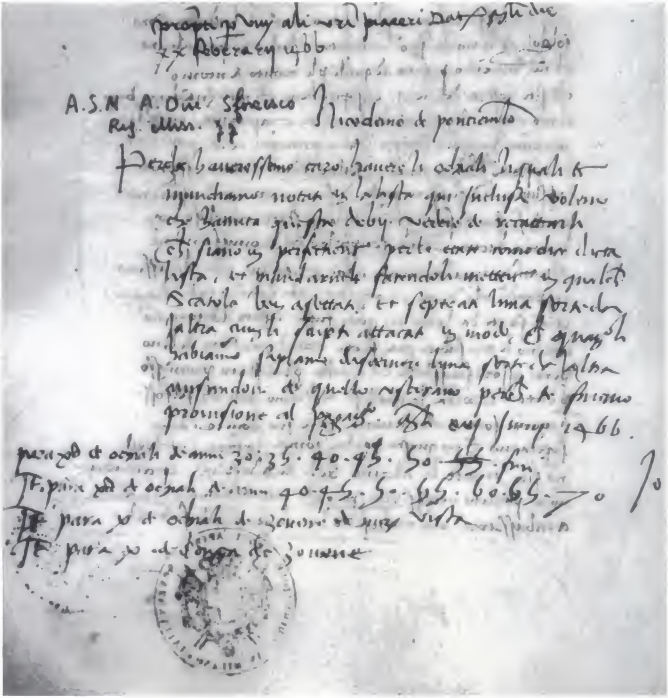
Relics

SAINT PHILIP NERI (1515–95).

Two pairs in a reliquary of Chiesa Nuova (Rome), both with convex lenses of ca. 3.5 diopters. One pair appears to have a leather frame, while the other seems to be framed in dark horn. A third pair, housed in the *Palazzo Massimo* (Rome), could not be seen because the palace is open to the public only on March 16th (Fig. 52).



49. *Letter of Duke Francesco Sforza of Milan to his Ambassador in Florence, Nicodemo Tranchedini*, Milan, 21 Oct. 1462. *Fonds Italien*, Cod. 1595, fol. 291, reel 1762, Bibliothèque Nationale, Paris.



50. *Letter of Duke Galeazzo Maria Sforza of Milan to Tranchedini,* Milan, 13 June 1466. Archivio Ducale Sforzesco, *Potenze Estere–Firenze,* cart. 270, reel 501, Archivio di Stato, Milan.

51. *Five Leather-Framed Spectacles of Willibald Pirckheimer,* 1520–30. Wartburg-Stiftung, Eisanach, Germany.

52. *St. Philip Neri's Spectacles,* mid-16th century. Reliquary, Chiesa Nuova, Rome.

SAINT JOSEPH CALASANCTIUS
(JOSÉ DE CALASANZ, 1557–1648).
Chapel of relics in Church of San Pantaleone and San Giuseppe Calasanzio: one pair of spectacles with a reconstructed bridge, and half of a pair (rim with lens and attached part of a round bridge), plus a magnifying lens with a long handle. (See chap. V, p. 172.)

10. SCULPTURES

Sculpted eyeglasses are relatively rare in the medieval/Renaissance period. Surely this rarity is not due to a lack of interest on the part of sculptors. Since art historians seem to ignore this aspect as well, one is left with hazarding a hunch that it was much more difficult to sculpt spectacles on the noses of stone or marble statues than for painters to accomplish this feat with their brushes. Wood, on the other hand, lends itself more easily to this task and this explains the relative frequency of wood sculptures adorned with spectacles. Misericords, especially, show a number of examples of bespectacled persons. As it may be known, this was a type of wood sculpture involving projections or brackets protruding from the underside of the hinged seats of choir stalls, against which the standing clerics could lean during lengthy services.

53. Unknown Sculptors, *Funeral Monument of Salvino degli Armati*, ca. 19th century. Chapel of the Orlandini del Beccuto family, Church of Santa Maria Maggiore, Florence.

The subjects of these projections varied from religious to secular themes, some of the latter rather crude or bizarre, placed there (apparently) to relieve the monotony of the proceedings—hence, the name misericords from the Latin *misericordia*, mercy![10]

It may be instructive, however, to open this section with a false funeral monument erected over the course of the nineteenth century to honor the memory of the alleged inventor of eyeglasses, the Florentine Salvino degli Armati. It is reproduced here as a reminder of the intense rivalry among cities such as Pisa, Venice, and Florence for the origin of the invention. (See pp. 16–18 for an extended discussion of this hoax.)

UNKNOWN SCULPTORS, 19th Century.
Funeral Monument of Salvino degli Armati. Chapel of the Orlandini del Beccuto family, Church of Santa Maria Maggiore, Florence. This is a grotesque monument composed of various marble parts from different centuries (Fig. 53).

LONDON, WESTMINSTER ABBEY, HENRY VII CHAPEL, ca. 1500.
Two stone (?) statues: 1. St. Matthew with glasses reading a book; 2. Philosopher (not identified) with spectacles reading a roll. In both cases the frames seem to be made of leather. (*St. Matthew*, Fig. 54).

SILOE, GIL DE (active ca. 1468–d. 1500).
Self-portrait alabaster statue (1468) attached to the lower part of the funeral monument of the Infante Don Alfonso of Castile in the Cartusian Monastery of Miraflores (Burgos). The artist portrayed himself wearing a pair of spectacles resting on his nostrils.

54. Unknown Sculptor, *Stone (?) Statue of St. Matthew with Glasses*, ca. 1500. Westminster Abbey, Henry VII Chapel. Courtesy of the Dean and Chapter of Westminster.

IDEM.
Another self-portrait statue of Siloe in the wood altarpiece of the Chapel of Santa Ana, Cathedral of Burgos. Here the artist represented himself in the act of writing or drawing, wearing the same type of spectacles as in the Cartusian monastery.

VERONA, PALAZZO CANOSSA (1530–37).
Series of sculpted rivet spectacles with curved handles serving as decoration in the frieze of the entablature

10. For a succinct, illustrated survey of these sculptures, see P. Aangenendt, "Stalles avec représentations optiques," in *The Profane Arts/Les arts profanes*, VIII/2 (1999), pp. 24–44.

of the courtyard, presumably the work of the original architect, Michele Sammicheli (1484–1559) (Fig. 55).

BERNINI, PIETRO (1562–1629).
Church of Santa Maria Maggiore, Rome.

1. Sacristy, marble relief of the Virgin's *Assumption,* 1607–10. Figure in lower left wears horn or leather spectacles.
2. Pauline Chapel, marble relief of *Coronation of Clement VIII,* 1611. In the extreme right top panel a person, partly hidden by a horn or trumpet player, wears same type of glasses.

PIANTA, FRANCESCO JR. (1630?–92).
Pair of spectacles sculptured in wood resting on a book, also sculpted in wood, in Library of Scuola Grande di San Rocco, Venice.

CHOIR STALLS: SPECTACLES CARVED IN MISERICORDS.
Saint-Claude Cathedral (Jura), France, 1449–1465. Eyeglasses in leather frames (?).
Saint Catherine Cathedral, Hoogstraten, Belgium, 1531–48. Spectacle vendor.
Church of St. Nicholas, Kalkar (Westphalia), Germany, 1505–08. Praying man with glasses (Fig. 56).
Collegiate Church, Feuchtwangen (Bavaria), Germany, ca. 1490. Monk reading a book with horn or leather spectacles.
St. Martin's Church, Bolsward, The Netherlands, end of 15th century. Man holding big pair of rivet spectacles.

55. Sammicheli, Michele (?), *Sculpted Rivet Spectacles,* 1530–37. Palazzo Canossa, Verona.

56. *Praying Man with Glasses,* 1505–08. Misericord, Church of St. Nicholas, Kalkar (Westphalia), Germany.

11. THE SENSES — VISION

It is well known that artistic representations of the five senses were common during the Renaissance, especially with some artists like David Teniers the Younger. Eyeglasses were the most frequently used attributes of the sense of sight, soon to be joined by scientific instruments such as telescopes, sextants, and astrolabes. Other objects often associated with sight were mirrors, keenly sighted animals like eagles and cats, sunlight, and the art works themselves showing artists practicing their craft. It seems that artists vied with their colleagues in providing the most original depictions to the point that some of the representations verge on the bizarre.[11]

RIBERA, JUSEPE DE (LO SPAGNOLETTO, 1591–1652).
Sight, ca. 1616. Franz Mayer Museum, Mexico City. Shows a man holding a telescope with both hands (apparently first time the telescope appeared in a painting), looking at us across a table on which rest a pair of spectacles and a framed flat [?] mirror.

MUTTONI, PIETRO (also known as PIETRO DELLA VECCHIA) (1603–78).
Sight (1650–60), unnamed private collection, Milan. Caricature showing three deformed persons — an elderly woman wearing glasses looking at herself in a mirror and drawing the attention to her reflected image to a young boy while a third person observes the strange scene. This seems artistic imagination run amuck in depicting the sense of sight.

SAENREDAM, JAN, ENGRAVER (1565–1607) and GOLTZIUS, HENDRICK, DESIGNER (1558–1617).
Allegory of Sight and the Art of Painting, ca. 1600. Graphische Sammlung Albertina, Vienna. This engraving encompasses most of the attributes accompanying artistic representation of sight in all its aspects — a bespectacled painter at his easel painting a semi-nude Venus (personification of the sense of vision) as she regards herself in the mirror; animals with keen vision such as a cat and a flying eagle, all illuminated by the sun, source of light and vision.

COQUES, GONZALES (1618–84).
Sight, Koninklijk Museum voor Schone Kunsten, Antwerp. A bespectacled sculptor works at his statue, combining the senses of sight and touch.

MITELLI, GIUSEPPE MARIA (1634–1718).
Sight, ca. 1699, Engraving. Civica Raccolta Bertarelli, Castello Sforzesco, Milan. The half figure of a bespectacled old man, wearing a cap labeled with the word *vedere* (to see) is surrounded by numerous drawings of eyes and pupils.

AUBRY, ABRAHAM, ENGRAVER (after 1682), and BOSSE, ABRAHAM, DESIGNER (1602–76).
Sight, engraving, Museum für Angenwandte Kunst, Vienna. Two young women regard themselves in a mirror while another is at a window looking at a distant object through a telescope. At the bottom of the composition there is a deformed face wearing a pair of spectacles, labeled *visus, la veue.*

KITTENSTEYN, CORNELIS VAN, ENGRAVER (1600 – after 1650), HALS, DIRCK, DESIGNER (1591–1656).
Sight, 1623, Graphische Sammlung Albertina, Vienna. A richly attired young woman seated in a garden is admired by a young man holding a telescope and by another man wearing glasses.

11. A thorough survey of this theme with an abundance of striking illustrations is provided by the exhibition catalogue *I cinque sensi nell'arte: immagini del sentire,* ed. S. Ferino-Pagden (Martellago, Venice, 1996).

57. Aelst, Pieter Van, *Sight in Honores*, tapestry, 1526–27. Royal Palace, La Granja de San Ildefonso, Segovia. © Patrimonio Nacional.

58. Aelst, Pieter Van, *Temperance in Honores*, tapestry, 1526–27. Royal Palace, La Granja de San Ildefonso, Segovia. © Patrimonio Nacional.

59. David Teniers the Younger, *Sight*, ca. 1640. Gemäldegalerie der Akademie der bildenden Künste, Vienna.

DAVID TENIERS THE YOUNGER (1610–90).
Sight, ca. 1640, Gemäldegalerie der Akademie der bildenden Künste, Vienna. A young draughtsman seated at his drawing table is observed on his right side by an old bearded man holding one lens of his spectacles to his left eye (Fig. 59).

AELST, PIETER VAN (ca. 1450–ca. 1533).
Honores (Honors), (nine tapestries commissioned by Emperor Charles V in 1520–21, delivered in 1526 –27), now on display in the palace of La Granja de San Ildefonso, near Segovia, © Patrimonio Nacional. Five of the panels are devoted to the senses. The sense of sight is represented by a horse with rivet spectacles above the eyes, repeated as decoration on its bridle and harness with alternation of rivet and round bridge spectacles. There was nothing unusual about horses and their riders wearing glasses at this time, as we have noted in the text. In the nineteenth century nearsighted horses were fitted with concave spectacles (*Sight*, Fig. 57).

Temperantia (Temperance), regarded at this time as the leading cardinal virtue, forms the subject of one of the above nine tapestries. This virtue is represented by a woman who holds a clock in her left hand and a pair of rivet spectacles in her right hand. These attributes signified promptitude and reliability (the clock), and perspicacity (the eyeglasses) (Fig. 58).

12. SATIRE, CARICATURE, DEVIOUS DEVICES

The ungainly appearance of early spectacles made them an easy target for caricature. Except for the more expensive pairs, their deficiencies in insuring clear vision made them a convenient vehicle for ridicule and deceitfulness. They could produce blurred images that distorted reality, which was better realized through unaided eyes with objects at the proper focus. Artists used spectacles frequently in their compositions to illustrate their usefulness for various visual conditions but also to symbolize their deceitfulness. Eyeglasses became the favorite equipment of demons, who used them to sharpen their wits to ensnare men to sin and perdition. This obsession with devils, already present in the medieval period, was further developed in the Renaissance, especially among Dutch painters. What could be more appropriate than adopting the new technology, eyeglasses, to the evil purposes of the master deceivers? In essence, a device invented by men to better their lives and read the word of God was turned against them by evil spirits, who could certainly procure the best lenses! There is the ironic fact, however, that millions of people in Europe and elsewhere could not be productive without this "deceitful" device, demons notwithstanding.[12]

SIGNORELLI, LUCA (1441–1523).
Group of Four Devils, drawing. Purchased as the gift of the Fellows, 1965.15, The Pierpont Morgan Library, New York. The devil on the extreme left of the group holds a large pair of spectacles to his eyes with his left hand, looking into the distance. Searching for his next victim? (Fig. 60).

MANETTI, RUTILIO (1571–1639).
Temptation of St. Anthony, ca. 1630. Church of St. Augustine, Siena. The saint is tempted by the devil, who wears spectacles.

BRUEGEL, PIETER THE ELDER (1525/30–1569).
The Temptation of Saint Anthony, ca. 1556, drawing. Ashmolen Museum, Oxford. While the hermit, St. Anthony, prays at the foot of a tree by the bank of a river, he seems oblivious to the wild scene going on at his back, which is designed to distract him from his devotions and the virtuous life. Demons cavort and play tricks, a town burns in the background, and a huge monstrous human head is mired in the river. The head has an interesting detail for our purposes —its huge nose is pierced by a round bridge pair of eyeglasses in the manner that some young people today pierce their noses with a ring or other piece of jewelry. Did Bruegel have an obsession about spectacles? He depicted them so frequently and mostly in a derogatory sense.

VOS, MARTEN DE (1532–1603).
The Temptation of St. Anthony, 1591–94. Koninklijk Museum voor Schone Kunsten, Antwerp. In the usually confused mayhem accompanying this common depiction, here we have a multitude of devils, some drawn as swine, who virtually surround the poor hermit. One of these devils in human form wears glasses and brandishes a snake in his right hand ready to strike the saint.

UNKNOWN (ILLUMINATOR).
Theodas with the Book of Magic and the Devil, 1469, miniature, No. 83.MR.179, fol. 280 (Ms. Ludwig XV 9). The J. Paul Getty Museum, Los Angeles. Miniature

12. This topic has been treated extensively and perceptively with many illustrations by Margolin, "Towards a Historical Semeiology of Spectacles," pp. 17–82, and in his two articles: "Des lunettes et des hommes ou la satire des mal-voyants au XVI[e] siècle," *Annales: Économies, Sociétes, Civilizations*, 30 (1975), pp. 375–93), and "L'histoire des lunettes à nez," *L'histoire*, 21 (1980), pp. 14–21.

60. Signorelli, Luca, *Group of Four Devils*, 15th century(?), drawing. Purchased as the gift of the Fellows, 1965.15, The Pierpont Morgan Library, New York.

showing a bespectacled cleric holding a devil at bay by confronting him with an open book, presumably a sacred text (Fig. 61).

BRUEGEL, PIETER THE ELDER.
The Ass at School, 1556, drawing. Staatliche Museen zu Berlin, Kupferstichkabinett. The donkey participates through a window in a lesson given to schoolchildren, many of them in grotesque poses. On the window-sill, next to the donkey, rests a pair of round bridge spectacles. At the bottom another hand has written: "Although the ass goes to school in order to learn, if it is an ass, it will not return [as] a horse."[13]

HEYDEN, PIETER VAN (active ca. 1551–72)
after BRUEGEL, PIETER THE ELDER.
The Merchant Robbed by Monkeys, 1562, engraving. Rijksmuseum, Amsterdam. A sleeping itinerant merchant's goods are rummaged by a group of monkeys, who handle the various wares such as gloves, necklaces, and musical instruments, but also items potentially symbolizing folly in contemporary parlance: eyeglasses, mirrors, flutes, and Jew's harps. The coarser depictions in this engraving are too gross to be mentioned.

IDEM.
The Festival of Fools, ca. 1510–70, engraving. The Metropolitan Museum of Art, the Elisha Whittelsey Fund, 1969 (69.598), New York. Humorous depiction of a large group of fools bowling while also dancing and playing tricks, etc. One fool on the extreme right has a pair of spectacles sticking out of his cap while he holds another pair high in the air with his right hand. Next to him sits another who plays the Jew's harp. The connection of these two objects with

61. Unknown (Illuminator), *Theodas with the Book of Magic and the Devil,* 1469. Miniature, No. 83.MR.179, fol. 280 (Ms. Ludwig XV 9). The J. Paul Getty Museum, Los Angeles.

deceit and fraud is made clear in the bottom inscription, which reads in part: "Some sell Jew's harps and the others spectacles/ With which they deceive many nitwits.[14] (Fig. 62).

BOSCH, HIERONYMUS (ca. 1450–1516).
The Magician, 1475–80. Musée Municipal, Saint-Germain-en-Laye. As the magician performs his tricks, a spectator (an accomplice?) at the back of the

13. Quoted in *Pieter Bruegel the Elder: Drawings and Prints,* ed. N. M. Orenstein (New Haven and London, 2001), p. 142.

14. Ibid., p. 252.

62. Heyden, Pieter van, after Pieter Bruegel the Elder, *The Festival of Fools*. Engraving, ca. 1510–70. The Metropolitan Museum of Art, The Elisha Whittelsey Collection, The Elisha Whittelsey Fund, 1969 (69.598), New York.

group of participants looks innocently up to the sky with a pair of metal (?) framed spectacles, while with his right hand he snatches the purse of an elderly spectator in front of him. The eyeglasses seem to have no useful visual function; rather they symbolize their deceitful nature or purpose.

TERBRUGGHEN, HENDRICK (1588–1629).
The Gamblers, 1623. The Minneapolis Institute of Arts, The William Hood Dunwoody Fund. Two young men seem intent on enticing a bespectacled older man into a game of dice, apparently loaded or otherwise altered. In this instance, however, the spectacles appear to be used as a device to prevent fraud—whether they succeeded or not, is left intentionally ambiguous by the artist (Fig. 63).

SAFTLEVEN, HERMAN II (1609–85).
Deceiver, 1647, etching, vol. 9, D.2, British Museum, London. Depicts an itinerant peddler carrying a basket of goods, including spectacles clearly displayed above the others. The prominence given to the spectacles and the label "deceiver" chosen by the artist are meant to emphasize the deceitfulness associated with these peddlers and their wares, especially eyeglasses. This is a common view of the age.

DUSART, CORNELIS (1660–1704).
The Cupping, 1695, etching. Metropolitan Museum of Art, New York. A comic scene of the act of cupping performed by a bespectacled woman wearing glasses and an inverted funnel over her head, symbolizing emptiness inside it.

UNKNOWN GERMAN ARTIST.
Martin Luther and a Nun (Katharina von Bora?) Exposing Themselves, ca. 1535. Germanisches National-Museum, Nuremberg. Hand-colored trick woodcut showing the two figures—a nun and Luther. Luther wears glasses, holds a book in his right hand, and lifts his robe with his left hand. Clearly a piece of anti-Lutheran propaganda.

UNKNOWN ARTIST.
Pope Leo X Playing Cards, 1519, woodcut. Medical Historical Library, Collection Otto Hallauer, University of Bern. The triple mitered pope holds a pair of rivet spectacles to his eyes as he observes or participates in a card game played

63. Terbrugghen, Hendrick, *The Gamblers,* 1623. The Minneapolis Institute of Arts, The William Hood Dunwoody Fund.

64. Unknown Artist, *Fox with Spectacles,* 16th century. Miniature, Cod. DCCLVIII, fol. 107^{v}. Biblioteca Capitolare, Verona.

65. Workshop of Lorenzo and Agostino Rubini, *Bespectacled Mask,* ca. 1473. Sala dell'Oroscopo, Palazzo Barbaran da Porto, Vicenza.

by a group of courtiers—a piece of anti-Catholic propaganda.[15]

UNKNOWN ARTIST, 16th Century.
Fox with Spectacles, miniature. Cod. DCCLVIII, fol. 107^{v}. Biblioteca Capitolare, Verona. A bespectacled fox in the dress of a physician checks a flask of urine—apparently a caricature at the expense of the medical profession (Fig. 64).

WORKSHOP OF LORENZO [+1574] and AGOSTINO RUBINI, ca. 1570s.
Bespectacled Mask, ca. 1473, Sala dell'Oroscopo, Palazzo Barbaran da Porto, Vicenza, designed by Andrea Palladio (1508–80). This grotesque head with big spectacles forms part of the stucco decoration, which framed the paintings on the ceiling of this chamber (Fig. 65).

15. The woodcut is reproduced in W. Poulet, *Atlas of the History of Spectacles,* vol. 2, trans. F. C. Blodi (Bonn-Bad Godesberg, 1980), pp. 302–03. Here the pope is described as playing soccer, apparently a mistranslation.

13. MISCELLANEOUS DEPICTIONS

This last section contains depictions that defy exact classification and stand by themselves. The three frescoes by Tomaso da Modena have been published many times, especially the supposed portrait of Cardinal Hugh of St. Cher, but they can hardly be excluded from a history of early spectacles because of their importance in illustrating the use of vision aids in their three forms—magnifying lenses and concave mirrors (known and used since antiquity), and the "new" invention, spectacles. The other entries are self-explanatory. They reveal various aspects of the use of eyeglasses such as teaching the alphabet and arithmetic and making spectacles without lenses. The inclusion of the portraits of Francesco and Galeazzo Maria Sforza and their castle in Milan, where many of the Florentine imported eyeglasses were worn, can be seen as an appropriate coda to this study in view of their role in eliciting interest in an old subject.

BARISINI, TOMASO DA MODENA (1325/26–79). *Cardinal Hugh of St. Cher,* 1352. Chapter House, Dominican monastery of San Nicolò, Treviso. The cardinal is the first person known so far who wears (anachronistically) the first type of eyeglasses, the rivet model (Fig. 66).

66. Barisini, Tomaso da Modena, *Cardinal Hugh of St. Cher,* 1352. Chapter House, Dominican monastery of San Nicolò, Treviso.

67. Idem, *Cardinal Nicholas de Fréauville,* 1352. Chapter House, Dominican monastery of San Nicoló, Treviso.

68. Idem, *Pietro Isnardo da Chiampo of Vicenza*, 1352. Chapter House, Dominican monastery of San Nicolò, Treviso.

IDEM.
Cardinal Nicholas de Fréauville, 1352. Chapter House, Dominican monastery of San Nicolò, Treviso. The cardinal is reading with a magnifying lens (Fig. 67).

IDEM.
Pietro Isnardo da Chiampo of Vicenza, 1352. Chapter House, Dominican monastery of San Nicolò, Treviso. This prominent Dominican preacher is represented with a concave reading mirror on his shelf above his desk (Fig. 68).

AMMENHAUSEN, KUNRAT VON, 14th Century.
The Book of Chess, late 14th century, fol. 109^r, No. 307, miniature. National Library of Russia, St. Petersburg. This miniature shows a seated monk playing a game of dice with a man standing in front of him. The monk wears a pair of rivet spectacles with very dark lenses, which may signify that he was blind. Regrettably, the meaning of this miniature escapes me.

MENABUOI, GIUSTO DE' (active ca. 1349–90).
Miracle of the Tower, 1382, fresco. Chapel of the Beatified Luca Belludi, Basilica of St. Anthony, Padua. St. James Major frees a prisoner from a tower at the foot of which there is a pair of rivet spectacles. Were the glasses dropped by the fleeing prisoner? (Fig. 69).

UNKNOWN FLEMISH ARTIST, 16th Century.
The Triumph of Fame, ca. 1502–04, wool and silk tapestry. Metropolitan Museum of Art, New York. Inspired by Petrarch's *Triumphs*, this representation of *Fame* shows a man reading at a lectern wearing a pair of round bridge spectacles.

UNKNOWN AUTHOR.
Libro di aritmetica in dialetto calabrese (Arithmetic book in calabrese dialect), 15th cent., drawing, Cod. ASHB 956, Biblioteca Medicea Laurenziana, Florence. What seems to be a female teacher sitting high on a podium instructs a pupil seated below in arithmetic calculations. High on the left side of her podium hangs a pair of rivet glasses (Fig. 70).

UNKNOWN AUTHOR.
Book of Hours, 15th century, miniature. Acquisti e Doni 147, fol. 40^v, Biblioteca Medicea Laurenziana, Florence. In the midst of this richly ornate miniature there is the figure of a cleric reading a book with rivet spectacles.

69. Menabuoi, Giusto de', *Miracle of the Tower*, 1382. Chapel of the Beatified Luca Belludi, Basilica of St. Anthony, Padua.

70. Unknown Author, ***Libro di aritmetica in dialetto calabrese***
(Arithmetic book in calabrese dialect). Drawing, 15th century, Cod. ASHB 956.
Biblioteca Medicea Laurenziana, Florence.

UNKNOWN AUTHOR.
Le Vieux Tristan, 15th century, color drawing. MS 443D, fol. 1^{r}, National Library of Wales, Aberystwyth, United Kingdom. The drawing shows a man writing at a desk wearing round bridge eyeglasses (Fig. 71).

UNKNOWN AUTHOR OR COMPILER,
16th Century.
Mores Italiae, Venice, 1575, MS 457, fol. $88^{r.}$ Image No. 1051888, Beinecke Rare Book and Manuscript Library, Yale University. This water-color drawing shows a friar of the monastery of St. Michael in Bosco outside the

71. Unknown Author, *Le Vieux Tristan*, 15th century, MS 443D, fol. 1r. By permission of Llyfrgell Genedlaethol Cymru, The National Library of Wales.

walls of Bologna taking a stroll wearing round bridge glasses. Presumably he was myopic. This Olivetan monastery was suppressed in 1797 (Fig. 72).

GHERARDO DI GIOVANNI DI MINIATO (1445–97) and MONTE DI GIOVANNI DI MINIATO (1448–1532/33).
Lisbon Bible, miniature, vol. VI, Monumental title-page. Arquivos Nacionais da Torre do Tombo, Lisbon. An unidentified man peering from the edge of the title page wears a pair of round bridge spectacles.

UNKNOWN DUTCH MASTER, 17th Century.
Two Antiquarians. Medical Historical Library, Otto Hallauer Collection, University of Bern. One of the antiquarians reads with a pair of round bridge spectacles while the other writes with the aid of a magnifying lens held close to his left eye. A revealing depiction of how people preferred to cope with their particular vision problems.[16]

16. Reproduced in Poulet, *Atlas on the History of Spectacles*, vol. 2, p. 38.

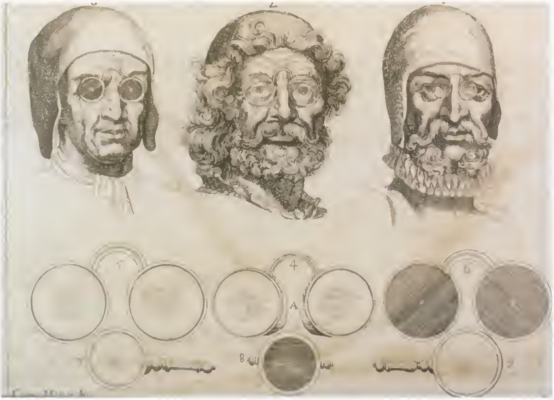
72. Unknown Author, *Mores Italiae,* (Venice, 1575). MS 457, fol. 88^r, "A friar of St. Michael in Bosco outside the walls of Bologna, wearing glasses." Beinecke Rare Book and Manuscript Library, Yale University.

73. Vasari, Giorgio, *Man Reading a Book at a Window.* Fresco, *trompe l'oeil,* 1548, Sala del camino. Museo di Casa Vasari, Arezzo.

74. Host von Rombech, Johann, *Congestorium artificiose memorie* (Venice, 1533), ch. 8, p. 36ᵛ. Beinecke Rare Book and Manuscript Library, Yale University.

MURILLO, BARTOLOMÉ ESTEBAN (1617–82).
Four Figures on a Step, ca. 1655–60. Kimbell Art Museum, Fort Worth, Texas. Of the four figures only the elder woman wears a pair of large spectacles, signifying high social status in Spain, while looking in the distance with an inquisitive stare. The younger woman has lifted her veil and her inviting manner may suggest a scene of procurement. But this is speculation—the real meaning of the painting remains a mystery.

VASARI, GIORGIO (1511–74).
Man Reading a Book at a Window, fresco, *trompe l'oeil,* 1548. Sala del camino, Museo di Casa Vasari, Arezzo. In this illusionistic representation a man is seen reading a book with his arms resting on the windowsill, on which are depicted a spectacle case and a pair of rivet eyeglasses (Fig. 73).



75. Meijer, Cornelis, *Nuovi Ritrovamenti*, 1689. Ch. 5, *Degli Occhiali (On Spectacles)*.

ANGUISSOLA, SOFONISBA (ca. 1532—1626).
Old Lady Learning the Alphabet, Mocked by a young girl, drawing. Gabinetto dei Disegni e delle Stampe degli Uffizi, Florence. While the old lady studies the letters intensively with her round bridge eyeglasses, the young girl points to her with derision as she looks out to a presumed spectator.

HOST VON ROMBECH, JOHANN (fl. 1485–1532).
Congestorium artificiose memorie (Venice, 1533).
Ch. 8, p. 36^{v}, Beinecke Rare Book and Manuscript Library, Yale University. This page has a memory chart with pictures of various objects to teach the alphabet to children, in which one of the objects under the rubric *biblioteca* is a pair of rivet spectacles. The first edition of this book was published in 1490, which highlights the fact that by this earlier date children were thought to recognize glasses, commonly associated with libraries (Fig. 74).

TERBRUGGHEN, HENDRICK (1588–1629).
Old man writing by candlelight, ca. 1627, Smith College Museum of Art, Northampton, Mass. The lenses in the round bridge glasses that he wears must have been excellent to allow him to write by the light of a single candle.

REMBRANDT HARMENSZ VAN RIJN (1606–69) AND WORKSHOP.
An Old Lady with a Book, 1637. Andrew W. Mellon Collection, National Gallery of Art, Washington, D. C. The lady is portrayed opening the latches in the book with her left hand as she holds a pair of round bridge glasses in her right hand with the

apparent intention of opening and reading pages in the book.

MEIJER, CORNELIS (ca. 1620–ca. 1701).
Nuovi Ritrovamenti (Rome, 1689), chap. 5, *Degli Occhiali [On spectacles).* Discusses proper use of eyeglasses with illustrations keyed to the text by letters and numbers. In the absence of glass lenses, he proposed constructing a pair of spectacles using tinplate or a thin piece of brass, or even a piece of black colored paper in which a hole in the middle corresponded exactly to the position of the pupil. This is, of course, a demonstration of pinhole vision (Fig. 75).

BONSIGNORI, FRANCESCO (ca. 1455–1519).
Portrait of Francesco Sforza, ca. 1490, attributed to Bonsignori, probably a copy of a lost original by Andrea Mantegna, painted later than the date shown, 1455. National Gallery of Art, Washington, D. C., Widener Collection (Fig. 76).

POLLAIOLO, PIERO DEL (ca. 1441–ca. 1496).
Portrait of Galeazzo Maria Sforza, 1471. Galleria degli Uffizi, Florence (Fig. 77).

Sforza Castle, Milan, 1966? Aerial view (Fig. 78).

76. Bonsignori, Francesco, *Portrait of Francesco Sforza,* ca. 1490, attributed to Bonsignori (ca. 1455–1519). Probably a copy of a lost portrait by Andrea Mantegna painted later than the date shown, 1455. National Gallery of Art, Washington, D. C., Widener Collection.

77. Pollaiolo, Piero del, *Portrait of Galeazzo Maria Sforza,* 1471. Galleria degli Uffizi, Florence. Su concessione del Ministero dei Beni e le Attività Culturali.

78. *Sforza Castle,* Milan, 1966(?), aerial view. Duke G. M. Sforza resided in this castle when he ordered the 200 pairs of Florentine spectacles.

79. Pisa, Church of St. Catherine of Alexandria, Egypt, with adjacent Dominican monastery where earliest spectacles were made ca. 1286.

HOW SPECTACLE FRAMES WERE MADE IN THE 14TH CENTURY

The process of making spectacle frames from cattle horns is shown by horner Roland F. Cadle and videotaped by Charles E. Letocha in 1997. See pages 159–161 for a complete description of horn frame making in a Florentine carnival song of the early sixteenth century.

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