Chapter XIII

PERPETUAL QUEST

(1660–1668)

And above all things in navigating
It is necessary to be thoughtful and awake.
The lock is needed to observe
How many hours with a certain wind have been traveled
And calculate at how many miles per hour
have been arbitrated.
And then they will find where they have arrived ...

Goro Dati, *La Spera*, Libro III, "La Carta," (Florence, 1478).

On the heels of the last of the series of competitions or *paragoni* in which his telescopes invariably emerged as the finest then being made, Giuseppe Campani now found himself more fully occupied than ever during the next several years and more. Recently married and experiencing family life since early 1664, not only was he producing lenses and telescopes in increasing numbers, but he also continued fulfilling commissions for silent night clocks with the crank lever escapement. He also was devoting time more and more frequently to making astronomical observations using his own instruments. It was within this period that he also produced a significant publications about his observations, which involved him in correspondence with other astronomers and amateur observers who used his instruments.

Despite the extended range of his activities during this busy period, as his brother Matteo, he tried to set aside time for the development of a nautical clock useful on shipboard for determining the longitude at sea. The words spoken in 1660 by Pierre Guisony, the visiting French physician, about the future prospects of clockwork for navigation had not only intrigued Matteo but had also awakened a determination in Giuseppe's mind to achieve a solution. Finally, he realized that he would be constantly bedeviled by the problem unless he concentrated on the project. Although he knew that great monetary prizes had been offered by several nations, his primary concern was probably not mercenary, such as had been driving Matteo. Giuseppe now found himself in sufficiently comfortable financial circumstances, having received recognition not only for his innovative clocks but also with the success of his lenses and telescopes. The concept of the nautical clock became more and more fascinating as a challenge in invention; it was an invitation to compete that he found it difficult to resist.

In the spring of 1663, when Viviani had come to Rome to question him and Matteo concerning whether they had been in touch with the Dutch government about a nautical clock, Giuseppe had reported that he had not been contacted, although he mentioned that in fact he had been at work on such a project on stolen time for the past year or two. He explained how, after a great many tests with pendulum vibrations, he had been able to reduce the timekeeper to the simplest possible form and finally eliminated use of a pendulum in the project. Although with stationery clocks (on land, not on shipboard), he had managed to reduce the variation to less than "a half minute second", it had not been possible to do so for "timekeepers in motion," that is, for those on shipboard.[716]

Far more knowledgeable about clockmaking than Matteo, Giuseppe kept reviewing in his mind what he knew and what he had learned from other sources about the technical obstacles inherent to the success of such a project. Although the production of such a timekeeper appeared to have defeated everyone who had attempted it, he now put his mind to analyzing all that he knew or what he could conjecture about their efforts. As he studied the project, he increasingly felt confident that a solution existed, although until now it had evaded the efforts of many talented minds as well as his own.

Giuseppe then perused information that was available to him from sources he had obtained, limited as they proved to be, on the present state of navigation on the high seas. There was relatively no major problem in the Mediterranean, where navigation was coastal, as it was in Western and Northwestern Europe, from Gibraltar to the Baltic Sea. It was the need for determination of the longitude through wide expanses of the unknown high seas that provided the greatest deterrent to exploration and discovery in which the several major European powers were competing, and for that reason great monetary prizes had been offered for a solution. While for some time Portuguese sailing ships had been able to explore the contours of the African continent by hugging its coast, winds and currents increased the difficulty of their attempts to sail south by forcing them to sail for weeks on end without seeing land. Points on the high seas and locations and courses now had to be spatial, and a navigator had to locate his position on a grid of imaginary lines that constituted the latitude and the longitude. The Portuguese eventually mastered navigating by latitude by measuring the altitude of stars and the sun by means of astrolabes and cross staffs, but the determination of the longitude while at sea far from a base harbor continued to baffle the seagoing and remained the unsolved problem. No simple method that was sufficiently accurate had

[716] See previous chapter.

been devised to determine the differences in local time between one's location on the high seas and the ship's port, such as Lisbon.

Maps of the period were unreliable and erred greatly in assigning the longitude of places. Consequently, for nations engaged in trade with distant places, such as with the East and West Indies, a means of determining longitude became a matter of considerable national concern. By the late sixteenth century, even larger prizes were being offered as inducements for a solution. In due course, it was the astronomers who ably came to the rescue of the navigators by discovering the satellites of the planet Jupiter and visualizing that their formation formed a clock that could be observed from every vantage point.

When in 1612 Galileo observed an eclipse of one of Jupiter's satellites for the first time, it suggested a solution because such eclipses happened quickly, almost instantaneously, and if a navigator at sea could note the time of its occurrence and compare it with local time when it was predicted to happen at a European reference location, the difference in times—and the longitude—could easily be determined. Thus, tables of predicted eclipses could be compiled for use at sea, and within the year, Galileo had entered into negotiations with the Spanish government to provide Spanish navigators with eclipse tables for the satellites. Also required were telescopes to observe the eclipses. The problem that remained was the provision of telescopes suitable for the purpose. Galileo offered a telescope attached to a helmet for use aboard ships riding at anchor, but it was not a success and negotiations faltered. Within the next century, the initiative of the Spanish Crown was soon to be followed by the French, Dutch, and English governments. When, after his trial, a prize was being offered by the States General of the Netherlands, Galileo again sought the prize, but the Dutch reached the same conclusion as the Spanish, and he received a gold medal for his efforts.[717]

In addition to Guisony's visit, both Matteo and Giuseppe had become interested in learning the sources Galileo may have had and results of experiments he may have attempted. Undoubtedly, they both had been additionally inspired to some degree from knowledge of the contents of the Minutes of the Accademia del Cimento's meeting of August 11, 1662, wherein were described and illustrated Galileo's experiments with the pendulum regulator. Although these Minutes were not published until 1666, knowledge of their content certainly was available in Florence, and a copy may have been acquired from Viviani. It was in the same period that trials were being made at sea for determining longitude with Huygens's pendulum clocks.[718]

[717] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 3, Correspondance 1660-1661, n. 673c, 673d, 485-97: letters of Galileo Galilei (year 1636) on the clock regulated by a pendulum, and his nautical invention to Rael and to the States General.

[718] See previous chapter.

Yet, even thereafter, the subject of such a precision nautical timekeeper continued to have preoccupied many scientific minds. Included among them also were some members of the Medici court, despite the vigilance of the Holy Office that rendered the subject a dangerous one. Unknown to Giuseppe, on October 26, 1655, 13 years after Galileo's death, the sage's last student and most dedicated disciple, Vincenzo Viviani, had cautiously addressed a query to Erasmus Bartholin, the Danish philosopher and mathematician then living in Padua. "I still wish to learn from you," Viviani wrote, "if you should know whether anyone ever discovered a most accurate measurer of time not subordinate to alterations such as are other wheeled clocks or sand clocks, etc., that demonstrate and divide the time into exactly equal hours, minutes, and other parts; other than the invention of Galileo by means of a pendulum about which he researched the means and application of the number of vibrations that are missing from this. I do not believe there can be an instrument that is simpler, nor more exact or more constant, and if you should have occasion to speculate concerning some interesting thought relating to this proposition I beg you to inform me".[719]

Aware of concerns over the possibility of unwelcome Holy Office interest, Viviani apparently had chosen to address Bartholin with his inquiry because the Danish mathematician had recently been traveling extensively in France and Italy before arriving at Padua and presumably would have been well informed of any new scientific developments, news of which might not have as yet reached Florence. Furthermore, it was at Padua, where one could find the university of the maritime Republic of Venice, where Galileo had taught for 18 years and which had become a center for experimental science, that knowledge of such new developments most likely would be known.

Bartholin responded that he had no knowledge of a precision measurer that was not subject to alteration, however, other perhaps than shown in the second edition of Mario Bettini's work *Apiaria universae philosophiae mathematicae*, published in 1648, in which was featured a hydraulic clock devised by the Jesuit science teacher Francesco Eschinardi. Bettini's book undoubtedly was already known at the Medici court, and Viviani would have been aware of that invention, which in fact was not an accurate timekeeper and of which no examples are known to have been constructed.[720]

The fact of the matter was that in the interim since Galileo had concerned himself with pendulum-regulated clockwork, no substantial advancement in horological science was known publicly to have been made in Italy as yet. Coincidentally, however, it was in that same year that Viviani and Bartholin were corresponding, and unknown to them, that the Campani brothers in

[719] BNCF, Gal., vol. 252 c. 8, letter from Viviani to Bartholin, October 26, 1655.

[720] Ibid., vol. 254, c. 35, letter from Bartholin to Viviani on November 12, 1655; Eschinardi, "Appendix Ad Exodium de Tympano"; Enrico Morpurgo, "Il Viviani alla ricerca di un orologio esattissimo", *La Clessidra* IX, no. 8 (August 1956): 11–12.

Rome were in the process of developing their silent night clock with mercury escapement. This development would not become known to Viviani or to the public until the following year, and only just before Christiaan Huygens was to announce his invention of the pendulum-regulated clock, the first mention of which he made early in 1657 in a letter to Van Schooten in Leiden.[721]

It was not until the autumn of 1658 that the Medici court first became aware of the Huygens invention when, in September, Grand Duke Ferdinand II received a gift sent by the King of Poland. It was a pendulum-regulated clock made by Salomon Coster based upon Huygens's invention, delivered by the hand of Tito Livio Burattini, who was in the service of the King of Poland. Coincidentally, a printed work by Huygens on his pendulum clock was received at the court in Florence in the following year.[722]

Galileo's pendulum clockwork, Huygens's patent for his invention of a pendulum-regulated clock, and the question of priority of invention all were to be discussed for the first time in a revealing three-way correspondence that took place among Prince Leopold, Christiaan Huygens, and Ismael Boulliau, Huygens's close friend and a member of the Parisian scientific community.[723]

In March 1659, Prince Leopold had written to Boulliau, "Concerning the Clock regulated by the Pendulum, certainly it is a beautiful Invention, but one must not detract from the glory that is due to our forever admirable Galileo, who, already in one thousand six hundred and thirty six, if I am not mistaken, had proposed this very useful invention to the Lords of the States General of Holland, and I have found a model, although in part dismantled, made by the selfsame Signor Galileo; and three years ago, made one which I hope will succeed in having, when his construction has been completed [*ridotta la sua fabbrica al pulito*], no less facility and precision as that discovered by Christiaan Huygens".[724] This is the first known reference to the survival of the clockwork model that had been attempted by Vincenzo Galilei.

After Boulliau had communicated this information to Huygens, the latter responded that in his view it was possible that Galileo had in fact had the same idea as his own, and that as for the cleverness of the invention, it was of little matter when compared to the great man's other achievements. In responding to Prince Leopold, Boulliau indicated that Huygens did not then claim priority for the invention and that in fact he did not know who was the first to invent it but felt that

[721] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 2, Correspondance 1657-1659, no. 368, page 5: letter to Van Schooten in Leiden on January 12, 1657.

[722] See chapter VI in this book, and Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 2, Correspondance 1657-1659: letter from Boulliau to Huygens on May 9, 1659 (n. 616, pages 403-04) where the Dutch inventor is informed that a copy of his work on the pendulum clock had been sent to Prince Leopold.

[723] Ismael Boulliau (1605–1694) was the author of *Astronomia philolaica* (1645), the first great text on the Copernican theory.

[724] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 2, Correspondance 1657-1659: letter from Prince Leopold to Boulliau, April 1659 (n. 617, page 404).

the invention by Huygens deserved praise for his having developed the same concept as had Galileo. He expressed interest in seeing a drawing of the Galilean model.[725]

Writing again to Boulliau, Leopold apologized for his delay, which had been due partly to illness and partly to his efforts to assemble some of the materials he had promised to provide. Among these that the Prince enclosed was a drawing of the Galilean clock model that had been prepared for him by Viviani.

"Therefore I have enclosed herewith," he noted, "the sketch illustrating the principle of the clock regulated by the pendulum which our always admired Signor Galileo had invented. It is delineated with that same roughness with which the model of the same had been constructed…". He asked Bouilleau to forward the drawing to Huygens, who had asked to see it. In another week, he promised, he would send along the history of the discovery of the pendulum, which he hoped would be of interest. He added, "I also will have made [for you] a drawing of how we have accommodated the Pendulum to our Clocks, and in particular to a very large one that indicates the Hours, and strikes in the piazza of our Palace in which we live".[726]

In his letter Leopold also mentioned that the King of Poland did not believe that Grand Duke Ferdinand II "has taken as his own that invention", the pendulum clock, and that His Majesty had been persuaded by the same Paolo del Buono, who was then in his employ, to have his Polish majesty send the Grand Duke the gift of a pendulum-regulated clock made in Holland according to the Huygens design. He added that this clock from Holland, the one in the piazza in Florence, and "the one constructed some years ago by one of the Generini, all with some diversity, all operate perfectly and consequently in such unity that in the space of eight days one hardly recognizes the difference of two or three minutes before the hour".[727]

This report, prepared by Viviani for Prince Leopold, is the only contemporary record of Galileo's attempts to apply the pendulum to clockwork. Viviani's account of Galileo's last years, of which the report was part, was based upon the summary of the sage's life he had assembled in 1654 for Prince Leopold which had not, however, contained mention of the pendulum clock.[728]

It is probable that during or following the discussions about regulating a clock by means of a pendulum held by Galileo with his son Vincenzo, the latter had made a hasty sketch as a reminder to himself of the details mentioned in the conversations. Otherwise, he might have forgotten during

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[725] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 2, Correspondance 1657-1659: letter from Boulliau to Christiaan Huygens, May 9, 1659 (n. 616, page 404), and letter from Christiaan Huygens to Boulliau, May 14, 1659 (n. 618, page 405).

[726] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 3, Correspondance 1660-1661, n. 655a, pages 467-69, letter from Leopold to Boulliau on August 21, 1658, with enclosure.

[727] Ibid.

[728] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 3, Correspondance 1660-1661, n. 673°, pages 469-70: letter from Prince Leopold de' Medici to Boulliau on October 9, 1659, and n. 673a and appendix, 470-84 from Viviani to Prince Leopold–August 20, 1659.

the 7 years that elapsed between these discussions and Vincenzo's attempts to construct a model. The sketch that Viviani had prepared for Prince Leopold, and which the latter forwarded to Boulliau, was a copy made by or for Viviani of the original sketch that Vincenzo Galilei had made as a reminder, and it was not of the state of the clockwork model as it existed in its unfinished state that had survived after the death of Vincenzo Galilei. That drawing is in fact the one that has come down in history as mistakenly representing Galileo's original clockwork model.[729]

When Prince Leopold again wrote to Boulliau early in October, he enclosed a copy of Viviani's report accompanied by another sketch. This time it was a drawing of the pendulum-regulated tower clock on the Palazzo Vecchio in Florence. This rough sketch probably had been drawn on the Prince's instruction by Johann Philipp Treffler, the court mechanician, who had installed the pendulum regulator on the tower clock then existing. In the same letter Leopold also acknowledged having received from Huygens a copy of the latter's observations of Saturn.[730]

Although he had received Viviani's report and sketch, Boulliau had neglected to forward them to Huygens, and as a consequence the Dutch astronomer remained unaware of the entire story for quite some time. It was not until early January 1660 that Boulliau finally forwarded a copy of the Galilean clockwork model to Huygens and wrote, "I send you the drawing of the pendulum clock begun by Galileo, which was sent to me from Florence. I will send you also the drawing of the clock, which is a public clock, that the Grand Duke had in his old palace of the Medici in the city of Florence".[731] To be noted is Bouilleau's erroneous attribution of the clock drawing. Boulliau retained the two original drawings but had copies made that he forwarded and that in late January Huygens acknowledged having received.[732]

In doing so, the Dutch astronomer noted that the Galilean model incorporated a pendulum as did his own clock, "but not applied in the same manner, because, in the first place, he has substituted a much more complicated invention, instead of using the wheel which is called the crown-wheel. Secondly, he has not suspended the pendulum by a thread or a narrow band, so that the whole of its weight rests upon the spindle upon which it moves; it was doubtless for this reason that his method was not much of a success [...]".[733]

As Prince Leopold had explained to Boulliau in March 1659, he had discovered the unfinished original model made by Vincenzo Galilei and had kept it in his possession. He went on to explain that 3 years previously [i.e., in 1656] an expert at the court had made a clock based upon

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[729] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 3, n. 707, 8-9: letter from Boulliau to Huygens on January 9, 1660 and Vincenzo Galilei's drawing of Galileo's clock with a pendulum.

[730] Ibid., 469–70: letter from Prince Leopold to Boulliau on October 9, 1659, with enclosure; and on January 23 where the drawing is reproduced (n. 712, page 14).

[731] Ibid., n. 707, 8-9: letter from Boulliau to Huygens on January 9, 1660, and on January 23 (n. 712, page 14).

[732] Ibid., 12–14, letter from Huygens to Boulliau on January 22, 1660.

[733] Ibid.

its principle, which he hoped would be successful after it had received its final touches. The "expert" was the court mechanician, Treffler, and from Leopold's account, it is clear that he had not attempted to modify Vincenzo's original Galilean model but had produced an entirely new timepiece based upon its characteristics.[734]

The original Galilean model in the possession of Prince Leopold, meanwhile, had been seen and reported by several contemporary witnesses, including both Matteo and Giuseppe Campani who saw it in May 1659 during their visit to Florence to seek a patent from the Grand Duke for Giuseppe's invention of the crank lever escapement and pendulum regulator. Each of the brothers had published reports of their visit wherein each mentioned having seen the Galilean model.[735]

Just as both Giuseppe and Matteo appear to have been simultaneously inspired by comments made by Pierre de Guisony during his visit in 1660 to Giuseppe's workshop, the French physician and traveler appears to have been equally impressed by what he had observed in the workshop as they were by what he related to them. In a letter to Huygens after his visit, Guisony mentioned that he had been told by someone in Florence that pendulum-regulated clocks were to have been found for some time in that city, and his informant had made a rough sketch for him of the one that Galileo had made. His informant undoubtedly was Viviani.

Guisony then proceeded to inform Huygens, "here [in Rome] I have found a craftsman who not only constructs pendulum-regulated clocks but which furthermore also operate without sound, with the advantage that your clocks have, of being constructed without the loss of time, and a thousand other positive characteristics. He showed me the three clocks that had been commissioned by the Grand Duke of Tuscany, and the one that he is repairing for the King of Spain. He has a brother who is a mathematician with whom we have spoken various times of you. He has begged me to convey his greetings when I write to you, and from the moment that he will have published a treatise on the clocks, without doubt you will not be forgotten. He has two inventions for the construction of silent clocks: one consists of placing a proportional quantity of mercury into an empty drum divided into small compartments, having small openings on the inside, so that the mercury would not move through too quickly from one compartment to another and consequently the cord wound inside the drum and to which the counter weights are attached, unwinds slowly (the counterweights are equivalent to the weight of the mercury), and serves as a balance . . . As to the

[734] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 3, 461–62: letter from Leopold to Boulliau on March 31, 1659.

[735] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 18; BNCF, Gal., vol. 279, cc. 5r-14v; Campani, *Proposizione d'orioli giustissimi*: Letter from Matteo Campani to Cardinal Leopold, March, 1670, foll. 5; Campani, *Horologium solo naturae motu*, 9-10.

second invention, concerning the elimination of sound without the mercury and utilizing a pendulum regulator, I will leave the analysis of it to you in your study".[736]

"There is another aspect that I find positive in these clocks," he continued and proceeded to explain the assembly of the revolving dial plate of the night clock and how the hours succeeded each other and were illuminated at night by means of a small oil lamp enclosed within the clock case. He added that Giuseppe was engaged also in developing a type of marvelous sphere demonstrating the movements of the planets that functioned without tension (winding), but since Guisony had been unable to see it, he would not say anything more about it. Although he did not name him, the craftsman he had visited in Rome was Giuseppe Campani and the "mathematician" was his brother, Don Matteo Campani, and it had been Viviani who had sketched the Galilean clock for Guisony.[737]

In another letter to Huygens, written in October, Guisony added a postscript, "At another time I will be able to describe to you a new type of telescope [cannon] or tube for lenses; meanwhile, I beg of you (in case that you should honor me with one of your letters), to remind me to comment about a clock so perfect that by its means one can find the longitude, as you have said".[738] This comment is particularly puzzling, inasmuch as the first trials at sea made of Huygens's marine clocks were not reported until 2 years later, mentioned in the letter from Huygens to Moray in December 1662.[739] The clock Guisony mentioned as having seen appears to have been none other than a timepiece he had seen in Giuseppe's workshop, and that it had been Giuseppe's work in progress, namely, for his nautical clock for determining longitude at sea. It is regrettable that Guisony did not provide a detailed description of the timekeeper he had observed.

Throughout his research relating to the development of a nautical timekeeper, Giuseppe had kept seeking out means that others may not have considered. For the longest period, he had insisted that the solution must lie in the application of the pendulum, but finally his judgment forced him to discard the idea and to seek alternative solutions. With each new aspect he began to explore, he felt confident of overcoming the problem that had preoccupied him for so many years and thus far so unsuccessfully. It was in this manner that more than 3 years passed fairly quickly, during which Giuseppe relished those rare segments of time that he had been able to set aside for his nautical clock project, stolen hours interspersed between fulfillment of commissions from his clients for clocks and telescopes.

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[736] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 3, n. 732, 45–9, *vide* 46: letter from Guisony to Huygens on March 25, 1660.

[737] Ibid.

[738] Ibid., n. 789, 141–44, letter on October 20, 1660.

[739] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 4, n. 1083, 280-81: letter from Christiaan Huygens to Moray, December 22, 1662.

Finally, in late spring 1667, Giuseppe's persistent efforts achieved their culmination with the production of a timekeeper that after much testing appeared to fulfill all requirements. It was with a great sense of satisfaction and triumph that, in July 1667, he sat down to compose a *memoriale* or special report, which he sent to Prince Leopold announcing his success.

Giuseppe urged the Prince to inform the Dutch republic of his invention. "The most glorious will of Your Serene Highness", he wrote, " to promote by every possible means each well-inclined soul gives this humble servant the courage to submit the present memorial. It has been the universal opinion of the intelligent that the most secure and facile manner of taking the longitude on maritime voyages would be with the use of clocks which are the most exact and never subject to error if (as has been said by Father Riccioli in his *Astronomia Riformata*) it is possible to expect such a thing from art".[740]

Giuseppe added that he knew that others have attempted to achieve this goal using clocks with pendulums, "but these must be discarded as a consequence of experience, given that the mechanism of these clocks runs the risk of being stopped by the vehement and unusual agitations of the vessels on which they are to function, and also because of other accidents". Then he added, "Furthermore, those clocks were not perfect, having instead, a great deal of variability and alteration in proportion to the motive power and of the greater or lesser ease with which the wheels rotate according to different variation due to the weather and other factors." He continued:

For a long time, I too have speculated about the invention of a clock having all possible exactness and precision, and finally came to the conclusion that it could never be obtained from the art, if it were not invented in a manner of disposing the wheels and other parts of the clock in such a manner, that they could never alter the motion of the balance [tempo], or spirit as they say, of the clock.

After this [notion] had been thus established in my mind, as an undoubtable and necessary principle, I finally conceived (as God wished) such a mechanism with a disposition of all of the clock's parts that I already had put into work, that succeeded entirely to my satisfaction and is such as I desired.

Given that the clock is now in order, I lack nothing more than the method of taking to myself this glory, and that profit that to an inventor of similar instruments has been promised and that has been offered by all by the Free States of the Netherlands, and by other potentates dominating the ocean and other seas.

Therefore, I address the royal patronage of Your Serene Highness, humbly supplicating you to deign to send this news yourself to Holland and at the same time to procure for me its consequences, while my invention (as it seems fit to reason) proves to be as precise on the sea as it has been demonstrated to be successful on land.[741]

Some time previously, it had occurred to Prince Leopold to utilize his family's contact with Pieter Blaeu of the Dutch publishing family in Amsterdam in order to help present and promote Italian achievements and inventions to the Dutch Republic. Upon being informed of Giuseppe's nautical clock, Prince Leopold immediately realized that Blaeu would prove to be just the contact

[740] BNCF, Gal., vol. 282 - V, Posteriori. 23, Accademia del Cimento. Lettere scientifiche, c. 155. Letter from Giuseppe Campani to Prince Leopold, July 30, 1667.

[741] Ibid.

he needed, one having enough status in the Netherlands to present Giuseppe's invention to the appropriate authorities in the States General.

Pieter Blaeu (1637–1706) was the third generation of the Blaeu family of cartographers, printers, and booksellers. The son of Jan Blaeu, the well-known Dutch publisher and bookseller, Pieter had become a familiar figure at the Medici court, having visited it first in 1660 for the purpose of promoting his father's plan to publish a multi-volume series of engravings of Italian cities. Pieter's mission had been to persuade Grand Duke Ferdinand II, his son Prince Cosimo, and Prince Leopold to provide the illustrations for the volume his father planned that was to be about Tuscany. The result was a magnificent city book of Italy in the North, which may contain contacts between Blaeu and Italian nobility. Pieter continued to remain in contact with Prince Leopold as well as with young Prince Cosimo and the Medici librarian, Antonio Magliabecchi, and he frequently sent them books published by his father's firm. He had sent such a selection to Prince Cosimo in 1667, just prior to the latter's departure for the Netherlands.[742]

His father, Jan Blaeu I, was a great and reputable merchant of the Dutch East India Company who resided in Amsterdam and had traveled extensively in Italy. It was the shop of Jan I that Grand Duke Cosimo III had visited on several occasions on his voyages to Holland in 1667–1669 to admire his collection of rare curiosities and to purchase exotic objects. After the death of Jan Blaeu I in 1673, the business was continued by Pieter and his brothers Jan II and Willem. Like his father and grandfather, Jan II became the official cartographer of the Dutch East India Company.[743]

It was at about this time that Blaeu apparently had decided that he wished to own an Italian night clock and had so hinted to either the Grand Duke or Prince Leopold in a letter written in September 1667. They, in turn, communicated Blaeu's wish to Giuseppe Campani, who apparently produced such a timepiece for Pieter Blaeu during the next month. Among the correspondence known to be missing are several letters, one dated September 1667 from Pieter Blaeu to Prince Leopold or to his nephew Grand Duke Cosimo, another dated October 4, 1667, from Prince Leopold to Giuseppe Campani, and a letter to Prince Leopold from Giuseppe written on October 4, 1667, in which he mentioned having received a reply from Blaeu. Although all these communications are noted in the files, copies cannot be found.[744]

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[742] Pieter Blaeu, *Pieter Blaeu : lettere ai Fiorentini : Antonio Magliabechi, Leopoldo e Cosimo III de' Medici, e altri : 1660-1705*, ed. Alfonso Mirto and Henk Th. van Veen, 2 vols. (Amsterdam: APA-Holland University Press, 1993).

[743] Accounts of the voyage of 1667 are to be found in the diary of Cosimo Priè, companion of Cosimo III on his travels. Cosimo Priè, "Viaggio fatto dal Ser.mo Principe Cosimo Terzo di Toscana di Alemagna e de. Paesi Bassi. Scritto da Cosimo Prie" (1667), Miscellanea Medicea, Viaggi, Archivio di Stato di Firenze; Leo Bagrow and Raleigh Ashlin Skelton, *History of Cartography*, 2nd ed. (New Brunswick, NJ: Transaction Publishers, 2010), 180–83.

[744] Communication from Dr. J. B. Slot, Research Department, Algemeen Rijksarchief, The Hague (September

It is at this point that a critical and unexplained lacuna developed in the papers of Prince Leopold, particularly his correspondence relating to Giuseppe Campani's nautical clock and the arrangements that were being or had been made for its submission to the States General of the Netherlands. Missing also is Giuseppe's further correspondence on the subject containing descriptions of his invention. Surviving later documentation confirms that Prince Leopold in fact had responded favorably to Giuseppe on August 30, 1667, and that he had written also to Pieter Blaeu in Amsterdam at the same time on Giuseppe's behalf. Blaeu then had responded to Prince Leopold on September 9 or September 16, 1667, relating to submitting Giuseppe's clock to the States General, but although noted, this part of the correspondence has not been found.

Nevertheless, it is possible to reconstruct the series of events that had taken place. Immediately after receiving Giuseppe's report of having successfully completed his nautical clock, Prince Leopold communicated with Pieter Blaeu, requesting his cooperation in conveying the news of Giuseppe's invention to the States General. The prince enclosed a copy of Giuseppe's *memoriale* and suggested that Blaeu contact Jan De Witt, informing him that an invention in the field of navigation made by Giuseppe Campani would be of interest and that he might wish to have it be examined by the States General and the Dutch East India Company. In an undated communication, with which he had enclosed a copy of Giuseppe's *memoriale*, Prince Leopold wrote to Pieter Blaeu

> In continuation of the contents of the enclosed letter written to me from Rome by Giuseppe Campani, I believe that you will see the instance that he makes and I propose that his desire to contact the States General be fulfilled because he represents to me to have discovered the precise longitude with one of his new clocks, with which I have a strong desire to cooperate all that I can with all therein that could be of service to the States General and of the above mentioned Giuseppe Campani. I beg you to please him by signifying to those Ministers who would be judging the proposals of the *virtuosi* that come to them to discover their sentiments. And in case that it applies to the experience of the fact, and that there is need to begin negotiations, please inform me to whom the said Campani needs to refer, so that I can write to him concerning it.[745]

Peter Blaeu was absent from home, traveling in Leiden, The Hague, and Rotterdam, when Prince Leopold's letter arrived. Consequently, it was not until September 9, 1667, that he was able to respond, reporting that he had found several of Leopold's letters awaiting him upon his return. "In the first place," he went on, "I must say that I received the letter enclosed from the Sig. Giuseppe Campani, and understanding the intention of that *virtuoso*, which indeed can have the merited and desired success, I will make every possible diligence. Tomorrow I will send his letter together with your own to The Hague to the Grand Pensionary Jan de Witt. He truly has always

18, 1995).

[745] BNCF, Gal., vol. 282 - V, Posteriori. 23, Accademia del Cimento. Lettere scientifiche, c 204. Letter from Leopold to Pieter Blaeu.

demonstrated himself to be indefatigable in every matter that deals with some utility for our Republic".[746]

"Two years ago", he continued, "that same *Sig*. De Witt offered to embark voluntarily upon our war fleet and worked so hard that shortly he became a good sailor, and taught pilots the manner of escaping from the port of Texel almost as if [they were] flying with the winds. On this subject he wrote a short treatise that he had printed for public use. In this year, his brother [Cornelius De Witt] has been on our fleet, and has played a major part in the direction of our enterprise and victory in the Chattam River. I am most certain that the aforesaid *Sig*. Campani can obtain the fame and the profit that the States of Holland have promised to the inventor of such an instrument, in the event that he can demonstrate to the above-mentioned Sig. De Witt, that such a thing [i.e., his invention] is extremely necessary and helpful to the navy. I will let Your Serene Majesty know the response that will be made by the above-named *Sig*. De Witt, as soon as I will have received it, which should be within a few days".[747]

A week later, Blaeu again wrote to Prince Leopold to inform him that, as he had indicated a week ago, he had forwarded the Prince's letter together with the one from Giuseppe Campani to Jan De Witt, Grand Pensionary, and from whom he had received the following reply just on this morning:

> The customary usage is that the Inventors of similar things, or their Plenipotentiaries (or that is, Procurators), are heard by the Commissaries of the State, and if the proposition is found to be of good appearance, then the Dutch East India Company is informed of it—being the one to be interested in the matter—so that such a thing [i.e., invention] will be placed into operation in order to test it. To proceed in good order, however, it will be necessary that *Sig*. Campani constitutes in these parts a Plenipotentiary well instructed about all.
>
> I did not wish to fail to advise Your Highness punctually of this response so that you may wish to inform the above-mentioned *Sig*. Campani in that manner that you consider to be most appropriate.[748]

As the communication specified, Giuseppe was required to designate his "plenipotentiary" to the States General. This would be a diplomatic agent to represent his interests in The Hague and one who had been invested with full power to transact business and act in Campani's absence. He should be capable also to provide any further explanations of the timepiece that might be required. Presumably, Giuseppe appointed such a representative; the most likely selection would have been Pieter Blaeu. Information concerning this action is also missing, together with other correspondence.

Giuseppe wrote to Prince Leopold on October 4, 1667, to thank him for having informed him of the reply the Prince had received from Blaeu concerning the transaction relating to the new clock and stating that he understood and appreciated the urgency with which the matter had been

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[746] Blaeu, *Pieter Blaeu*, 260–61, n. 124: letter from Pieter Blaeu to Leopold, September 9, 1667.
[747] Ibid.
[748] Ibid., 262, n. 125: letter from Pieter Blaeu to Leopold, September 16, 1667.

handled. He hoped that it would be resolved happily, and if so, that it would be the fruit of the singular beneficence of His Lordship.[749]

A week later, Giuseppe was able to inform Prince Leopold that the letter from Holland had arrived while he was out of the city, to which he had just returned within the hour. The present letter could not serve other than to acknowledge receipt of the Prince's communication and to repeat once again his infinite obligation to the Prince who with much affectionate partiality had deigned to protect all his interests. He promised to make haste to respond to particulars requested in the letter from Holland, after more mature consideration.[750]

Giuseppe Campani's letter to Pieter Blaeu dated at some time in October 1667 has not been found. Late in November, Giuseppe wrote once more to Prince Leopold, stating that he had delayed sending a second response because first he wished to clarify one impression "of which I immediately doubted that I had written to Your Excellency in the second letter relating to this affair concerning the new clock. I doubted, I say, that although according to the measure by its own, the 'spirit' of this clock according to measurement by its own means is the natural course of the time, that passes. It does not depend at all on the clock movement, perhaps none the less for receiving the alteration of the unusual mutations of the time, such as from the north wind [*tramontana*] or the *sirocco*, by reason of the major and minor resistance made by the ambient air in which it moves, and by means of which the hour enlarges itself, and now reduces itself, and now increases more and now less. The opportunity to make tests in these extravagant days has clarified, in some manner, this truth, that necessitates me to supplicate Your Highness to deign to sympathize with me considering that the joy or jubilation that within myself I now feel in having overcome all the impediments of the art did not permit me this soon to respond to the vigorous opposition of inexorable Nature, to the defect of which I have not yet found not one manner of remedying. With all of this, I hope to have your indulgence when you will deign to see my above-mentioned Artifice."[751]

Despite the convoluted expressions concerning his difficulties with his nautical clock, Giuseppe managed to resolve them. His formal proposal to the States General, which he had prepared in accordance with the instructions he had received from De Witt, accompanied by his nautical clock or longitude timepiece, were submitted through the various channels from Campani to Prince Leopold to Blaeu to De Witt to the States General, traveling from Rome to Florence to Amsterdam and eventually to The Hague.

[749] BNCF, Gal. vol. 278, c. 72, letter from Giuseppe Campani to Prince Leopold, October 4, 1667.
[750] Ibid., vol. 281, c. 107, letter from Giuseppe Campani to Prince Leopold, October 11, 1667.
[751] BNCF, Gal. vol. 278, c. 92, letter from Giuseppe Campani to Prince Leopold, November 22, 1667.

Its official review, following its safe arrival, was confirmed in the published list entitled "Inventions concerning longitude-finding at sea", offered to official organizations of the Dutch Republic 1651–1740. Therein is listed a proposal of which the inventor is not named, but who certainly must have been Giuseppe Campani:

(Inventor) N. N. (Domicile) buiten de Republiek (Occupation) onbekend
(Year) 1668 (Receiving organization) SG (States General).[752]

The document stated that, in the year 1668, a proposal had been submitted to the States General by an anonymous inventor from outside the Dutch Republic whose occupation was unknown. It was the only proposal recorded for the year 1668; the prior entry had been that for Christiaan Huygens of The Hague, which had been submitted in 1664 to the States General and to the Dutch East India Company. The next proposal to be submitted to the Dutch East India Company was in 1671 by Christiaan Longomontanus, also from outside the Dutch Republic. This entry presents a curious anomaly, for Christiaan Sarensen Longomontanus (also Longberg) was a Danish astronomer, assistant to Tycho Brahe, who died in 1647.[753]

In the files of the States General, it is recorded that the application made by "the anonymous claimant" for the prize of 25,000 guilders was presented to the States General on September 21, 1668. It was studied by the States General's committee responsible for examining [octroying] new inventions. Upon receipt of the report on October 28th, the committee agreed to reply that the anonymous claimant would receive the sum of the prize when he would have proven to the satisfaction of the States General that his system worked.

Despite an extensive search, the original request could not be found among the series of requests received, nor was any other reference to it to be found in the archives of the States General. There was no mention of it either in the archives of the Dutch East India Company, among the resolutions of either the Board of Seventeen Directors, nor in those of the Amsterdam chamber.

[752] [Scientific Editor 2: unfortunately, I could not find among Bedini's papers the documentation about this interesting Dutch part of Giuseppe Campani's story. Writing to the Nationaal Archief in Den Haag, I have received only some general information about possible archival fonds where to further search for these documents: the archivist suggested that one should check the *'resoluties'* of the *Staten-Generaal* for the relevant years. In the *resoluties*, the incoming documents are mentioned, plus the decisions taken. If one finds the reference to an incoming letter/document in the resolutions, one can search, with the help of the date, for the original letter in the *liassen* or the *secrete kas*. The *liassen* and the *secrete kas* are ordered on topic. Perhaps the letters concerning inventions for navigation can be found under the topic *'Oostindische compaignie'*. One should check the resolutions for the year 1668 (and maybe the years around 1668 as well), and also to check the resolutions of the heeren XVII of the VOC (access number 1.04.02). One should also check the inventory number 12509 from the archive of the Staten-Generaal (access number 1.01.02) contains resolutions about *octroys*].

[753] Idem

The absence of these documents may be attributable, however, to the fact that a large number of the Company's records relating to its administration in Europe at this time were reported to have been accidentally destroyed, according to the official report.[754]

All that survives are the following records in the files of the States General. On September 21st it was recorded:

At the meeting [held this date] has been read the request of a certain person who is outside the territory of this State who claims to have found the East and West [method for determining longitude at sea] and consequently requests that the premium offered for this will be paid to him when he has shown to the satisfaction [contentment] of Their High and Mighty the course to East and West with certainty. On this has been deliberated and decided that this letter will be given in hands of the Gentlemen Van Gent and the other members of the Committee of Their High and Mighty to the octroys [examiners] of new inventions to hear the arguments of the one submitting the request and to report on this.

Four days later, on September 25th, the response of the designated Committee was received, in which it was stated:

The report of the gentlemen Van Gent and the other members of the committee of Their High and Mighty for the examiners [Octroys] of new inventions has been heard. Following the resolution of the 21st of this month, having investigated and examined the request of a certain person who is outside the territory of this State, and who pretends [claims] to have found the East and West and because of this requests that the premium offered for this will be paid to him when he will have shown with certainty the course of the mentioned East and West to the satisfaction of Their High and Mighty. On this has been deliberated and decided that this person will enjoy the premium of 25,000 guilders assigned for this by Their High and Mighty when this will be firmly proven in practice that he has indeed found the gradus longitudinis or East and West.[755]

Written in ink on the margin of each page of the document is the phrase "East and West." The fact that Giuseppe Campani, who was identified in the records as "a certain person who is outside this State," had succeeded in submitting his timekeeper to the States General and in having it tested became a matter of official record. Lack of further documentation suggests the possibility that it may not have entirely fulfilled the requirements for the great prize, or that for some reason the tests could not be completed. Or Giuseppe's nautical clock may have been found to be successful and worthy of the prize.

Nothing more is known of the disposition made of it by the States General of the Netherlands, since the required additional documentation in the files of the States General Gemeen Rijksarchief of The Hague is missing and appears to have been destroyed. Equally frustrating is that also missing are the records of the Dutch East India Company for the period when testing Campani's nautical clock at sea. No explanation is provided for the absence of both of these records. Nor has further correspondence on the subject between Giuseppe and Cardinal Leopold and/or Pieter Bleau been found in the Medici archives or in the papers of Pieter Bleau in

[754] Ibid.
[755] Ibid.

Amsterdam. By this time, Cardinal Leopold had moved to Rome to assume his new role in the Church hierarchy, during an interval when presumably he had become completely preoccupied with the responsibilities of his new office. Undoubtedly, Giuseppe kept copies of the correspondence and related papers, disposition of which will be mentioned later.[756]

Surely Giuseppe had been greatly disappointed by the lack of success of his nautical clock, particularly after it appeared to have achieved approval up to the final stages of testing. Was he informed of the final decision and was it favorable or not? After the expenditure of so much effort and excited anticipation, so many hours that had been devoted to perfecting it, and such great hopes that had been raised, only now to be totally wasted! Yet, in retrospect, the very thought that Giuseppe Campani's invention of a nautical timepiece for determining the longitude at sea had been sent to Holland and there reviewed by the commissioners and tested at sea may have been enough to console the mind of the energetic clockmaker from the Umbrian hills. He must have sadly returned to work, however, where at the same time he found welcoming him was a huge pile up of commissions for lenses and telescopes waiting to be fulfilled in addition to an occasional request for one of his clocks with crank lever escapement, all evidence of the success he had achieved in several dimensions. The practically minded Giuseppe finally forcefully put the dream of the nautical clock out of his mind and turned once more to satisfying his clients. He may have planned to return to the project at a future time, and once again to seek a solution to the invention of a timekeeper for determining the longitude at sea, but there is no evidence that he did so.

An acknowledgment of achievement must be granted to Giuseppe Campani for his nautical clock project, even though it apparently did not win the offered prize. There had been no other to his time, nor for a while thereafter, who had successfully submitted a nautical timekeeper completed to operative state to the States General, where it passed preliminary trials and then was taken to sea for testing by the Dutch East India Company. This achievement appears to have been totally overlooked and forgotten even by his Medici sponsors and contemporary and later historians and has remained unknown until presented in these pages. Once again, one might mention *Sic transit gloria mundi*.

[756] Maria Vittoria Campani, Giuseppe Campani's daughter, had a chest containing her father's papers. See chapter XXIV in this book.

Chapter XIV

VENTURES WITH TIME

(1672–1678)

> [...] *when it comes to the aggrandizement and favor of the Prince, not only the aforesaid stimulate the ingenuity of the invention, but foreigners still compete to present theirs to them: as does now the* Signor *Campani addressing these of his to the Majesty of the Most Christian King Louis XIV, whose magnificence and greatness not least of the resplendent arms in that which can serve to the advancement of the Sciences and noble Arts.*
>
> *Giornale de' letterati* [757]

The years 1666-1677 proved to be a critical period for Matteo Campani, as he repeatedly endeavored to achieve recognition and acknowledgment. Between 1668 and 1678, he produced five books in the form of brief tracts. Ostensibly for the purpose of promoting himself as a *virtuoso* and his own horological inventions, which indeed were achievements deserving of praise, they were in fact to claim as his own some of the achievements of his brothers. As a consequence, his action brought about a final fatal rupture with Giuseppe in particular. It was an action to be viewed with sadness, for throughout so many years Matteo had unselfishly supported his brothers' activities, guiding and protecting Giuseppe in particular to the achievement of fame. That in his brother's fame now there was no place for him, rankled and eventually led to uncontrolled resentment and foolish action.

In 1672, four years after the appearance of his little pseudonymous publication on "The Most Accurate Clock", Matteo produced another short tract, entitled "A New Clock free from every danger of error and inaccuracy in memory of the first Galilean investigation and quasi-discoverer, to the Most Invincible and Most Christian King of the French, Louis XIV, given to him by Matteo Campani degli Alimeni, inventor". Whereas the first work had appeared under Matteo's pseudonym, the second was published under his own name. It subsequently was included and published in Angelo Fabroni's collection of "previously unpublished letters of illustrious men".[758]

[757] Gardair, *Giornale de' letterati de Rome*, 250, ftn. 9.

[758] Matteo Campani, "Novum horologium ab omni erroris, & inaequalitis periculo liberum ad mentem Galilaei primi indagatoris & quasi Indicis [...]," in *Lettere inedite di uomini illustri per servire d'appendice all'opera intitolata Vitæ Italorum doctrina excellentium*, by Angelo Fabroni, vol. 1, 2 vols. (In Firenze: Alla stamperia di Francesco Moücke, 1773), which was intended to supplement Fabroni's work *Vitae Italorum doctrina excellentium*, 20 vols. (Pisa: Genesius, 1778). Two manuscript copies of this letter, one copied in Italian in Viviani's hand and the other in Latin by an unidentified copier, are contained in a collection of Viviani's manuscripts relating to horology in the Biblioteca

The Latin text, addressed to the French monarch, was in the form of an open letter relating to the same subject matter. The text of the letter deserves being quoted in full for several reasons. It was less than modest in tone and began with these words:

Although I would have kept silent, and not even mentioned the natural quality of the genius that I perceive in myself, I would easily have believed that there was no one, not only in this city, but in all of Italy, who does not know that I have for many years applied myself to the investigation of the nature of every aspect of new mechanical devices. From my early youth I have taken delight in these studies and my interest in them has grown with the passing years. I do not think to be mine the habit to express so much in writing or in speech, as it is in modestly and silently listening to others in considering my success in that field and my literary and mechanical accomplishments.

Alexander VII, of happy memory, in the year 1655, just at the beginning of his pontificate, was my mentor, and he suggested that I attach a pendulum to the ordinary and common clocks having small, toothed wheels. This suggestion was evidently inspired by a new clock [the mercury night clock] that I had invented and presented to His Holiness. This timekeeper, as well as other inventions of mine, included the the restored Archimedean sphere. However, when the illustrious Masters Caramuel and Virgilio Spada, who perhaps had not heard of those things that His Holiness had suggested to me, had spoken with me about the application of a pendulum of this type to common clocks, it immediately occurred to me that the works of the pendulum could become affixed, so that clocks could divide the days and hours into their parts in a completely equal manner; but whether this could be done had been doubted by most savants up to this time.

Four years later, on May 5, 1659, when I betook myself from Rome to Florence, I met a friend at Radicofani by the name of Monanno Monanni from whom, however, although he is unskilled in this art, I learned that the beginning had been made at Florence by the command of the Most Serene Great Ruler of Etruria [Grand Duke Ferdinand II] of constructing common clocks according to the form derived from the old mechanism of Galileo. After hearing these things, this information immediately suggested to me that the whole matter regarding the work and plan that the clock would be corrected only to that point when pendulums are attached.

Hence, I attached a pendulum ball [pendulum bob] to my portable clock [neck watch], and when because of my long-standing esteem I had presented it, correctly set up with its pendulum, to His Most Serene Highness Ferdinand II, he most kindly ordered that be shown to me a certain clock of his own, of greater size, to which he had ordered a similar pendulum to be attached, namely, the invention derived at once from an ancient, rusty, and by no means completed mechanism that Galileo's son had already constructed, dating from the year 1649, and at the same time, from certain writings of the same Galileo, and [from] letters concerning the use of the pendulum, written to Hollanders, all of whom are outstanding in several periods. The Cardinal, the Most Serene Prince Gian Carlo de' Medici, brother of the Grand Duke, has very kindly seen to it that copies be made for me.

Therefore, Galileo's mechanism having been attentively considered, and the rules thoroughly discussed and pondered (which are handed down in this manuscript), I began to think about the many kinds of clocks and the various ways of attaching a pendulum to them; but when, shortly thereafter, there came into my hands a little book by the learned Christiaan Huygens of The Hague, published in the year 1658, in which he describes a manner of making a similar clock with a pendulum, there grew in me the spirit and desire of inventing a new method, by means of which clocks would be so constructed with a pendulum that either, moved always by an equal force, vibrated by independent oscillations, the pendulum would run down equal arcs; or it would be so moved by a clock, that it would be in no way whatsoever moved but left alone with its own principle of movement, which it has from nature, it would forever make its own vibrations, neither begun nor increased, by external force; which idea I certainly took from a letter of Galileo written to Laurens Reael, on June 5, 1637, in which I read these things, among others: "From this accurate and stable principle I trace the structure of my chronometer, in which I employ not a weight hanging from a thread, but a pendulum made of a solid and heavy material, which would be brass or copper, and which pendulum was in the form of a sector of a circle of 12 or 15 grades, and of which the semi-diameter was 2 or 3 palms; and when it would be the greater, it could be assisted with less of an increase. This sector was larger in the radius of its center, going less towards the extreme ends, which I made end in a blade-like line to avoid whenever possible the impediment of air, which is the only thing that holds it back. This is perforated in the center

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Nazionale Centrale.

[with an opening] through which passes a small iron in the form of that ones on which lever-scale revolve. This iron terminates underneath in an angle, and on top has two bronze supports, in order to limit the wear caused by the continuous movement of the pendulum. Once the pendulum (when it is well-balanced) is put in motion by the means of lifting it by many degrees from the perpendicular state, it will reciprocate the oscillation from both sides for a great number of vibrations, before it is stops. In order to make it operate continuously, depending on the need, it may be necessary to assist it, from time to time, by means of a forceful impulse, amplifying its oscillations."

Also, in the same letter [to Laurens Reael], Galileo teaches, where the good use of wheels has been agreed upon (as it is in the clocks), the tedium of numbering the vibrations of the pendulum can be avoided, and the first and second minutes can be noted, from which came the hours and the days, and not only the greater part of passing time.

"But it is superfluous to explain this to you, who [in the Netherlands] have capable and ingenious men in the art of making clocks, and other admirable mechanisms, because they themselves, upon this new basis of knowing that the pendulum moves equally in large or in small oscillations, they will be able to discover more subtle consequences than anything I can imagine. And because the fallacy of clocks consists principally of which there is no one who has been able to make the regulator of the clock, which we call the *tempo*, so precise that its vibrations are equal, in my pendulum clock–which is very simple and not subject to alterations–one can find the means of maintaining the measure of time always equal".

Upon these precedents, in the year 1667, the invention of an Archimedean sphere, mentioned above, gave me the idea of producing a clock actually enclosed within a glass container, by which I easily brought it about that the instruments would be free of interference by the various actions and changes of the surrounding air, since it would be certain that for the measuring of time, as they call them, the movement would be changed not a little, on account of a different degree of humidity or dryness. Moreover, about the same time, I also found a new method by which the pendulums would be moved through equal arcs for equal time periods; and this by means of a small weight set up within the mechanism of the clock, and suspended from a pulley attached to the axle of a wheel contiguously moving another wheel, by which the pendulum is moved.

At last, in 1668, after the publication of my book, under the title *L'Oriolo* [...] in order to remove all difficulties and every minute problem, I finally invented what seemed to be as difficult as it was desirable in this field. I invented, as I said, a very safe and very specific method, mentioned above, of measuring time by clocks by means of simple and unadorned pendulums, moved by no external force, but by its own proper and natural movement, or a vibrated pressure; which discovery I exposed secretly to Grand Duke Ferdinand II, the very wise Eminent Highness praised above, and with his advice also to the very learned and beloved D. Francesco Redi and D. Vincenzo Viviani by whom (lest I conceal anything) it was accepted not without some approval, modestly speaking.

I wanted, most sincerely, to refer to all these things: 1st, so that the great Galileo would be strictly maintained in the possession of his prior invention, and so that any others, who could beyond all doubt, come into the knowledge of that letter, would be kept from unjust usurpation, and finally, so that his invention and praise would be held intact for him as his own thing.[759]

In this work, Matteo proceeded to describe how in the course of the invention of their self-winding sphere, which he identified as "an Archimedean sphere", he and his brothers had devised a mechanism operated by clockwork that was sealed within a glass enclosure. This appears to have provided the inspiration for Matteo's later ambitious project, to invent a "nautical clock," which preoccupied him for the next several years.

In this incredible litany of misrepresentation, Matteo mentioned for the first time his claim that, in 1655, 2 years before Huygens had achieved his invention of the pendulum-regulated clock, none other than Pope Alexander VII had suggested to him that he should apply the pendulum to

[759] Campani, "Novum horologium."

clocks. No mention of such a meeting or discussion was made in his earlier writings, and if such a momentous event had taken place, the vain Matteo would not have failed to mention it. After reflection, Matteo added, he had succeeded in following the Pontiff's suggestions and developed a means of regulating clocks in such a manner that the divisions of the hours were perfectly equal. He then explained how he had been inspired by Galileo's efforts to accomplish the same.

Matteo's account of his visit to Florence and the subjects of the observations he made in the granducal museum appear to have been factually correct. It had been Giuseppe, however, who had accidentally discovered the pendulum's function as a regulator, then attached a pendulum to his neck watch, not Matteo. It was evident that Matteo was aware of Galileo's achievements with the pendulum and experiments in timekeeping and it had been assumed his informer had been Viviani, Galileo's last pupil, who was collecting the sage's papers at that time. Herein is provided the particularly revealing explanation that it had been Cardinal Gian Carlo de' Medici who had made it possible for Matteo to gain access to the papers of Galileo, the content of which would not become publicly known until much later.

Matteo submitted the manuscript of this new work to a printer in Bologna on May 9, 1672, and 6 weeks later, on July 12, 1672, he was once again in Bologna, anxious to obtain copies of the publication just as soon as it emerged from the press. Upon returning to Rome, he personally delivered a copy of the tract to Bishop Cesár d'Estrées, Duc de Loan, the French ambassador at Rome, with the request that it was to be forwarded to Paris to the French monarch.

It is amusing to trace the route of Matteo's slim publication from Rome to Paris and thereafter. On the day after having received the copy, d'Estrées, who had just been named a cardinal 2 months earlier, sent a letter that dealt with various matters of diplomacy to Jean Baptiste Colbert, French minister of finance. He included a report on the progress being made by the lens makers Giuseppe Campani and Eustachio Divini in producing lenses that Colbert had commissioned for the Paris observatory. He also enclosed Matteo's publication, and then d'Estrées added, "Yesterday someone named Campani, brother of the one who works with telescopes, brought me a letter he had written to His Majesty about the design of a new clock, by means of which he pretends to be able to recognize the meridians. Many fine spirits have made tentative useless attempts to do this; I do not know whether he is more optimistic or more capable than the others; but in any case, I thought I should make you aware of what he is proposing. Let me know, if you please, how I should respond to him, and whether you judge it appropriate to have some craftsman work with his machine. You are to determine, Sire, whether, in order better to keep the secret, it would not be more appropriate to send us a French artisan of whose loyalty one can be more assured than one would be with one of the Italians".[760]

Upon receiving Matteo's publication, Minister Colbert presented it to His Majesty, who in turn gave it over for review to the court architect, Claude Perrault. The latter, presumably because the subject matter was horological, gave it to Christiaan Huygens, a fellow member of the Académie Royale des Sciences who was then in Paris.[761]

Huygens appears to have been the first in France actually to have read Matteo's work. In a letter to his brother Lodewijk Huygens, the astronomer mentioned that he had received from Perrault a work that the brother of [Giuseppe] Campani had sent to the King, the title of which was "New Invention of Very Accurate Clocks". He noted that in fact it did not describe the writer's own invention, "as well as I can determine, this appears to be some new type of discourse because the best I am able to judge, the author does not explain anything about his own invention, but he puts it into an anagram, and he says that it would have been just as easy to send the same clock, but that he has not dared to entrust it to any artisan, for fear that he will steal his secret".[762]

It was not until the ensuing summer that Huygens finally was able to take the time to read Matteo's book and prepare a review of it, which he submitted to the Académie Royale by which it was published in the form of a letter. "The author of this work", Huygens wrote, "promises a new horological invention that appears to be something extraordinary; in addition to knowing about the invention of pendulum clocks and of the precision that has been achieved by this means, he claims to have found something that regulates the movement of clocks with even greater precision. He excuses himself for not having sent the King a clock made in this new fashion, because he has not found a clockmaker to whom he can confide his secret, which may seem strange furthermore, since it is known that he has a brother, who according to what is said, is a perfect master of this craft. Inasmuch as he does not explain at all as to what is his invention, and that it seems at the same time that he has not put it into execution, it is impossible to reach any judgment concerning its value, nor as to whether it would serve better for determining longitude than do clocks that are with pendulums. He claims that his clocks are less subject than those of others to the agitation of the sea;

[760] Jean Baptiste Colbert (1619–1683) was a French statesman and minister of Louis XIV with considerable merit in economics and politics. He founded the Académie Royale des Arts et Metiers and the Observatoire de Paris. Georges Bernard Depping and Guillaume Depping, *Correspondance administrative sous le règne de Louis XIV: entre le cabinet du roi, les secrétaires d'Etat, le chancelier de France et les intendants et gouverneurs des provinces, les présidents, procureurs et avocats généraux des parlements et autres cours de justice, le gouverneur de la Bastille, les évêques, les corps municipaux, etc.. Tome IV et dernier*, vol. 4. Travaux publics, affaires religieuses, protestants, sciences, lettres et arts, pièces diverses (Paris: Imprimerie nationale [puis] impériale, 1855), 584: letter from d'Estrées to Colbert on July 13, 1672.

[761] A. G. Keller, "Claude Perrault," ed. Charles Coulston Gillispie, *Dictionary of Scientific Biography* (New York: Scribner, 1974).

[762] Huygens, Oeuvres Complètes de Christiaan Huygens, vol. 7, 212–14, no. 1903: letter from Christiaan Huygens to Lodewijk Huygens on August 5, 1672.

because when it is a matter of precision, one finds that pendulum clocks have enough of it for this purpose. As for the rest of it, the difference that he says there is between the clocks of his invention and ordinary ones, as far as it concerns the order of the movements, and although here he proceeds contrary to what one is accustomed, it is not new, because we have seen the same thing in the pendulum clock that M. Perrault made that operates by means of the water of a fountain, in which the pendulum receives the movement directly from the water, and communicates it immediately to all the wheels of the clock".[763]

Inasmuch as originally Matteo had dedicated the invention of his nautical clock to Prince Cardinal Leopold, as well as his earlier publication describing it in 1668, one is led to wonder why then did he have his work reprinted twice, 4 and 5 years later, and each time dedicated instead to the King of France? Until now the Medici princes, in particular the Grand Duke and Prince Cardinal Leopold, had shown themselves to be favorably inclined toward the priest from Rome and appeared to be supportive of his proposals. The explanation may be found in one or another of several factors. First of all may have been the questionable degree of success or apparent failure of Matteo's invention. Its success apparently was in fact much in question, as indicated in an article that appeared in the *Giornale de' Letterati*, which "described a new precision clock for navigation, communicated already many years ago by its Author to the Most Serene Prince Cardinal Leopold de' Medici, and by the latter much applauded, although the said Most Serene Highness believed that it was impossible to avoid some little inaccuracies completely, which appeared to be caused by storm; however, it is hoped that when it will have been reduced to perfection with the Table of Meridians that Sig. Gio. Domenico Cassini in the Royal Academy of Paris has compiled, the afore mentioned clock will be able to greatly facilitate navigation". The implication is that although the Medici prince had applauded the invention at first, it had proven to be impossible to make it operable.[764]

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[763] Ibid., 214, report by Huygens to the Académie Royale des Sciences in August 1672. Claude Perrault (1613–1688), described as architect, a naturalist, and a literary man, was commissioned by Minister Colbert to translate Vitruvius from the Latin, and he also published several writings on physics and the natural sciences. He attained eminence in the profession of architecture and constructed the facade of the Louvre. He was the inventor of a pendulum-controlled hydraulic clock, which he described in a memoir he presented to the Académie prior to 1669 and of which he had sent a drawing to Huygens. He also designed frictionless machines and a pulley system for rotating the mirror of a reflecting telescope. His brother, Charles Perrault, was assistant to Minister Colbert, and the Campani publication would have been referred to him for review as a work of science. At some time before his death in 1668, Perrault had presented a description and illustration of his hydraulic pendulum clock to Huygens and provided a descriptive memoir with a detailed plate to the Académie Royale. In it he proposed that it operated with water as the driving force, with a toothed wheel shown in the rear being turned by the arm on a knife-edge bar of the pendulum crutch. A striking mechanism was later added. As described and shown in the drawing, the clock could not have operated. Gallon, *Machines et inventions approuvées par l'Academie royale des sciences*, 39–40; Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 6, 506-12, n. 1769: letter from Claude Perrault to Christiaan Huygens re hydraulic pendulum clock, October 28, 1669.

[764] "Raguagli del P. Francesco Eschinardi della Compagnia di Giesù dati a un amico in Parigi; sopra alcuni pensieri sperimentali proposti nell'Academia Fisicomatematica di Roma," *Giornale de' Letterati* 1680, no. 4 (1680):

It may be that practical considerations had arisen that led Matteo to seek another patron, namely, because the patronage of the Medici princes had come to an end. Cardinal Prince Gian Carlo, who had favored him some years earlier, had died in 1663. Prince Leopold, who also had favored him, had been elected cardinal 4 years later, in December 1667. His election inevitably changed his priorities, at least for the time being, from the academic to the religious. The Prince had removed his residence temporarily to Rome, although not permanently. Then, 2 years later, in late May 1670, Grand Duke Ferdinand II had died, and the combination of these events effectively reduced or eliminated the patronage that Matteo had enjoyed at the Medici court.

At the same time, he was aware of the great favor his brother Giuseppe now was enjoying at the French court. After Gian Domenico Cassini had been called to Paris in 1669 by the French king and his minister Colbert, his use of Giuseppe Campani's lenses and telescopes had brought Matteo's brother to much favorable royal attention. It was in this period that the superiority of Giuseppe's work had become widely acknowledged and was eagerly being sought by the French monarch in preference to instruments made by others. There is every reason to believe that Matteo, while desperately seeking new patronage and recognition for his work, now foresaw an opportunity to derive royal support on the basis of his family name. Apparently, he anticipated no problem with having two patrons for his work at the same time.

In the following year (1673), Matteo's horological work was reprinted in Rome by the same printer. It appeared with a revised title, however, "Proposal for Clocks of the Greatest Accuracy. Inasmuch as their Measurer necessarily must move in equal periods, and uniformly under whatever intemperance of the air, and even though within the same clocks there is unequal power. An Invention Useful to Navigators for Determining the Longitude, and also to Geographers, and to Astronomers. Dedicated to the Sacred Majesty of the Most Christian King Louis XIV. By the Inventor Matteo Campani de Gli Alimeni, Priest of Spoleto Pastor of the Parrochial Church of San Tommaso Apostolo in the Rione of Parione of Rome".[765]

In his little tract published in 1672 and now reprinted a year later, Matteo had proposed to enclose the clock escapement and pendulum in a vacuum sealed within a glass bell-shaped container. As indicated in his illustration, the clock weights were at the left of this glass enclosure with the dial plate and the wheelwork was at the right. The axis of the main wheel passed through the bell and at another place through the cover, suggesting that the vacuum would have been less than perfect.

Again dedicated to the French monarch with another extensive paean of praise for His Catholic Majesty, the tract was illustrated with an intriguing drawing of Matteo's invention of his

54.; Gardair, *Giornale de' letterati de Rome*, 129.

[765] Campani, *Proposizione d'orioli giustissimi,* 19.

Horologium Nauticum or "nautical clock" in which every part of the invention was illustrated and labeled.

[Figure]

Nonetheless, despite the subsequent lack of success of his timekeeper, to Matteo belongs the credit for having realized a problem and proposed a solution. Of interest is his suspension, which is not based upon the Cardan system but appears to be an innovation. A ring [ball and joint] supports the entire weight of the clock with its hand or index. The ring is positioned on the hand, and during the ship's motion, it slides gently upon its smooth superficies and presumably maintains the clock in the position desired. Furthermore, if the pitching and rolling of the vessel should transmit to the clock a pendulum damaging to its function, there was a system of compensation within the bell that was raised in such a manner as to neutralize the motion not desired. It is to be noted further that the pendulum, this time free in the same manner that Huygens had applied it, was to be suspended by two threads. Certain axes did not have the usual pivots and instead had a cone turning in a cavity. Some axes of the wheels did not terminate in a pivot but with a pin lever insinuated into a cushioned cavity. Possibly the axes had a cavity at the base and the point in high. It is a system that was used with great success by the watchmaker Roskopf 200 years later.[766]

Matteo Campani appears to have been the first to have conceived of the use of a pneumatic vacuum and sealed glass enclosure to isolate the clock's pendulum from variations of atmospheric pressure in order to maintain its maximum accuracy. This proved not to have been such an outlandish proposal, for the concept of a clock functioning within a vacuum was again suggested several times early in the next century. In 1705, the Reverend William Derham experimented with the use of an air pump he had borrowed from Francis Hawksbee to observe the effect of a vacuum on a spring-driven clock having a seconds hand and a half-seconds pendulum and compared its going with that of a month clock having a seconds pendulum. Derham found that *in vacuo* the pendulum arc was 0.3 inches longer than in air, and that the clock sealed *in vacuo* lost 2 seconds per hour. Derham submitted the results of his experiments to the Royal Society in a paper that was published in the *Philosophical Transactions*.[767]

Soon thereafter the proposal to enclose a clock in a vacuum also was developed and described in 1714 by an English scholar, Jeremy Thacker of Beverly in Yorkshire. He was one of a group of writers known as "Longitudinarians" who published pamphlets describing proposed means of determining longitude. Thacker claimed that there were only two solutions, one was by means of

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[766] G. F. Roskopf was a Swiss watchmaker who in the late 1860s invented the first reliable inexpensive watch with the pin lever.

[767] W. Derham, "Experiments About the Motion of Pendulums in Vaccuo, By the Reverend Mr. W. Derham, F.R.S.," *Philosophical Transactions of the Royal Society of London* 24, no. for the years 1704-1705 (December 1704): 1785–1791, no. 194.

astronomy, which as yet had not been sufficiently advanced, and the other was by perfecting clockwork. He described his timekeeper as a spring-driven clock having a seconds hand, suspended on gimbals with a leaden weight below, and kept in a vacuum enclosed within a bell jar. Rods were provided that terminated in keys for winding and activating an auxiliary spring for maintaining power during the winding. He wrote that it was suggested to him by an Italian mathematician active in London and who also was interested in the problems of the longitude. Thacker appears to have been the first to use the word "chronometer" for marine timekeeper.[768]

In the same year, Dorotheo Alimari, a Venetian mathematician, proposed a portable instrument, "in the Nature of a Clock . . . from which the author shows that the Longitude of the Place may be easily discov'd." In a later edition of her work, she described the method of finding the longitude "by a most perfect clock, which, for months on end, shows time accurately to the second".[769]

Early in July 1673, two months later,Matteo forwarded to Viviani "a copy of my studies on the nautical clock, which I send to you with my usual trust in you". He wrote:

I had put this study aside for a long time owing to that other painstakingly crazy research of mine [the mechanism he had engineered to demonstrate perpetual motion], which may prove to be just impossible. Yet I believe it to be possible due to that new principle of the perpetual levers I have discovered.

In my vain experiments with these levers, I have happened to witness a strange thing. Much to my surprise, I noticed that the machine carrying the levers was deprived contrary to their weights. That is, if we picture the machine's diameter to be NOP, the weights of levers N and P, instead of making the machine bend toward P, make it first go up and then come down toward N. Of course, the disposition and the size of the wheels are crucial; if all the wheels were of the same size, it would remain in perfect balance. This should not be so, given that the weight of lever N is closer to O (which is the center) whereas the weight of lever P is further away from the said center. I then find it impossible that one cannot come up with some recondite combination and disposition of levers and wheels that falls outside of this balance.

I thus have come to ask you to enlighten me with your learning, so as to dispel my errors and keep me from wasting further time on it. In your next letter you can also tell me which issues of the journal you are seeking; I will manage to get them for you. Please do not hesitate to ask me for other favors, so that in fulfilling them I may show you I am being your most humble and devout servant.[770]

[Figure]

[768] Jeremy Thacker, *The Longitudes Examin'd: Beginning with a Short Epistle to the Longitudinarians, and Ending with a Description of a Smart, Pretty Machine of My Own, Which I Am (Almost) Sure Will Do for the Longitude, and Procure Me the Twenty Thousand Pounds* (London: Printed for J. Roberts, at the Oxford-Arms in Warwick-Lane, 1714).

[769] Doroteo Alimari, *The New Method Propos'd by Signr. Dorotheo Alimari, Professor of Mathematicks at Venice, to Discover the Longitude: To Which Are Added Proper Figures of Some Instruments Which He Hath Invented for That Purpose with a Plain Description of Them : Humbly Presented to the Right Honourable the Lords, and Others, Appointed by Act of Parliament Commissioners, for Examining and Judging of Proposals for Finding the Longitude* (London: Printed for J. Roberts, 1714). This was followed by an edition in Latin published in the following year, Doroteo Alimari, *Dorothei Alimari, mathematici veneti, Longitudinis aut terra aut mari investigandae methodus.: Adjectis insuper demonstrationibus, & instrumentorum iconismis.* (Londini: Sumptibus bibliopolarum in vico dicto the Strand, 1715).

[770] BNCF, Gal., vol. 255, c. 244: letter from Matteo Campani to Vincenzo Viviani on July 1, 1673.

More than a year after Matteo had delivered a copy of his tract to the French ambassador in Rome to be forwarded to the French king, he wrote again to Cardinal Leopold de' Medici. He conveyed renewed assurances of his servitude and wished him a happy and long life. He explained that with the assured encouragement of His Lordship, he hoped to complete the work that he had begun many years earlier. Because of the Prince's past kindliness to him, he now was encouraged to petition him to give his attention to the enclosed writings and to inform him of his reactions concerning their content. Matteo noted with some pride that he had been commanded by "Cardinal de tries" [d'Estrées] to publish an account of his "exact clock", and reported that already he had sent the title page and preface to the printer. This was an obvious attempt to restore his association with the Medici court at the same time that he was seeking the support of a new patron overseas.[771]

On December 29th 1673, a week after having addressed Cardinal Leopold, Matteo wrote to Viviani, conveying best wishes for a happy New Year and auguring prosperity in years to come. He asked for any new instructions he might have for him because, until now, due to various mishaps and misfortunes experienced on his own part, he probably appeared to have been an inactive and negligent servant. Since it was due only to Divine mercy that he had remained still alive and healthy; he asked the favor of Viviani to let him know whether he wished to have him send the *Avvisi* of the Letterati and from which period; he promised to do so soon. The inveterate self-promoter could not forego bragging about his new French contacts, as he went on, "I wish to add that I have been requested by the Cardinal d' Estrées to write down and clarify my invention of the 'precision clock' [*l'oriuolo giusto*]. The preceding Saturday I had sent the title page and the preface to the reader of His Reverend Eminence Cardinal de' Medici at the Roman Academy in Rome. I would like to have you read it also and let me have your thoughts concerning that proposition".[772]

Subsequent to the development of his nautical clock in a vacuum, Matteo next ventured to experiment with other horological principles, being inspired by the continuing success of his brothers in their various endeavors. Apparently, it was at this time that Matteo began to reveal evidence of experiencing delusions. The first to report on it was Stefano Gradi (1613–1683), Dalmatian, an important philologist and poet then living in Rome.[773]

Gradi communicated with Viviani on several occasions late in 1675 concerning Matteo's claimed invention of a lathe for polishing telescope lenses, which he named the *circinus sphaericus*. After discussing Matteo's proposal in detail, as Matteo had related it to him, Gradi added that

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[771] Ibid., vol. 279, c. 167 and 168-173: letter from Matteo Campani to Prince Leopold on December 22, 1673 with a manuscript copy of the preface of the new edition of his *Novum Horologium* dedicated to Luis XIV.

[772] Ibid., vol. 256, c. 25a–26b: letter from Matteo Campani to Viviani on December 29, 1673.

[773] Montanari, "Stefano Gradi."

colleagues with whom he had discussed it had different opinions, and so now turned to Viviani for his evaluation.

Viviani responded that he did not understand how Matteo's invention functioned. Then Gradi explained that the mentioned "circle" was an instrument similar to the compass, just as the compass rotated upon a plane surface making a circle having its same circumference, this circumference created a sphere rotating on a solid body or through the rotation that the solid body makes around the circle's circumference while the circle remains motionless. He noted that in the past Viviani had made some calculations based upon geometry for Matteo, upon which the *circinus* appeared to be based. In the final analysis, Gradi concluded that he was correct and that his friend, and also Matteo, were wrong.[774]

Two years later, Matteo forwarded a copy of his book *L'Oriuolo Giusto* to Viviani with a note: "Your great benevolence induces me to dare to bother you by sending you this little work of mine. I am sure you will find many a pitiful flaw in it. Yet it would have been ungrateful on my part not to send it to you. I also would like to send a copy to the Most Illustrious Marquis Vitellio, Captain of the Guards of His Most Serene Highness, and another one to Doctor Redi. I owe a great debt of gratitude to both of them. Nevertheless, I am prevented from sending them copies of this work of mine for fear of bothering them, and because of my little acquaintance with them, far less than I have with you." The reference to the captain of the ducal guards and to the Grand Duke's physician may have been related to the occasion during which Matteo became ill in Florence. The Grand Duke had arranged for him to recuperate in Pisa, during which time presumably Matteo had been attended by Francesco Redi, the Grand Duke's physician.[775]

It was in this year, 1677, that Matteo published a tract in which he described the *circinus sphaericus*, claiming that it was he who was the true inventor of the lens grinding and polishing lathe attributed to his brother Giuseppe Campani. It was entitled "Method for Turning and Polishing Lenses for Telescopes With the Spherical Compass," which he had discussed 2 years previously with Gradi. He also produced a broadside on the subject.[776]

This was undoubtedly the most outrageous of Matteo's unsupported claims, for at no time in his career had there been any evidence whatsoever that he had been engaged in the grinding and polishing of telescopic lenses, an activity for which his brother Giuseppe had received wide acclaim for his achievements in that field. It is inconceivable that Matteo could have expected the French king, his Minister Colbert, and others engaged in the field of astronomical optics to have believed

[774] BNCF, Gal., vol. 256, cc. 73–75: letters from Gradi to Viviani on October 26, 1675; cc 76-77, November 8, 1675; c. 80, November 30, 1675.

[775] BNCF, Gal., vol. 256, c. 152, July 31, 1677.

[776] Matteo Campani, *Modo di tornire e polire le lenti per I telescopi col compasso sferico, Trattato dell'Opuscolo di Matteo Campani* (Roma: Ignazio de Lazari, 1677). No copies of the broadside have been found.

him. It was in just that period that they had been actively engaged in commissioning Giuseppe to produce lenses and telescopes for them. There can be no doubt that Matteo's mind had become seriously disturbed by this time and that he had begun living on delusions of his own creation.

In 1677, Matteo ventured into publication once more and for the final time, with a work entitled "A Clock Which by Natural Motion Alone Indicates Regularly Equal Divisions of Time".[777] He prefaced the work with an incredible explanation of how, in his earlier years, he had given much active study to scientific problems. "But my calling, the sacred office that I hold, the care of souls, in which I have been engaged these last twenty-seven years, have kept me from the manual effort required to conduct these experiments. I therefore looked to my home for assistance. My two younger brothers have at my prompting devoted themselves to clockmaking. It was they who carried out the experimental work in connection with my theories. At my desire they published their discoveries as their own, winning thus for themselves and for our family a good reputation, as well as conferring a great blessing upon all who appreciate the place that time measurement plays in the proper arrangement of one's activity".[778]

Then Matteo went on to describe how he had invented the silent night clock and how, after experimenting with quicksilver and finding it to be inadequate, he "turned to the careful construction of a mechanism, which among other interesting things, seemed to be a reconstruction of an ancient device of Archimedes". Through the good offices of Cardinal Farnese, he said he had then presented it to the Pontiff, who "graciously accepted it and praised the talents and the craftsmen who had lent a hand in making it. But, in addition, His Holiness suggested that I use the vibrations for controlling the time". He quoted the Pontiff's own words, "With this practical invention of yours, and with a properly applied pendulum, you could build a most beautiful and most precise sphere (which, to facilitate the maker's task, could be built following the hypothesis of Copernicus). And since Galileo, relying upon the new scientific rule that he had discovered, said that the pendulum is an infallible time meter—that those men expert in making clocks could discover the most beautiful consequences and wonderful and useful machines".[779]

Matteo proceeded to relate that there was much that he had learned from Galileo, citing conversations he had held at various times with Virgilio Spada, Bishop Caramuel, and Stefano Gradi, prefect of the Vatican Library. It was Gradi, he stated, who had discussed the usefulness of his mechanism for determining longitude and for guiding the course of ocean voyagers. He proceeded to report how Pope Alexander VII, being unable to sleep at night, had asked him to build

[777] Campani, *Horologium solo naturae motu*, 2 illus.
[778] Ibid., 5-6.
[779] Ibid., 7-8.

for him a silent night clock, and then Matteo explained in great detail how the first silent night clock was developed.[780]

Next Matteo described how he devised a timekeeper utilizing twin pendulums. Each of the two pendulums terminated in what he described as a small globule. In due course, he realized that a mechanism suitable for carrying this into execution must be devised, by means of which mechanism, in the space of the time required by the first globule to complete its first group of 15 vibrations—15, he had decided, was the most convenient number—the second globule was prepared to succeed it in the same task of giving off the 15 similar vibrations of the second group. When these had been completed, the vibrations of the first globule would begin again. "Here, then", he went on, "is the solution of the enigma I long ago proposed with these letters:

aaaaaa bb c d ee G iiiiiiii lll m nnn pppp rrrr sss t uuuuu.

If you were to fit them all into the correct order, you obtain the following sentence

Bina Galilei pendula pura proprio vibrata nisu vicissim [Galileo's pair of pendulums set vibrating in turns by their pressure]".[781]

Matteo then proceeded to describe each part and its function in greater detail, adding, "Meanwhile, in the figure adjoining, we have had a sketch made showing what concerns the natural movement of the pendulums".[782]

Matteo next described his nautical clock, as "a clock of an entirely new—and unless the deceptive blandishments of affection deceive me—of marvelous mechanism, enclosed within a glass globe or small jar. The exquisite control of its fine equal motion is derived from weights balanced within it which by turns in continuous succession set in motion a pair of levers. These levers rest immediately upon a wheel; by the circular motion if the wheel *perhaps* the first and second minutes of the hour are indicated".[783]

In an Appendix that Matteo added to this work, he described "his" *circinus sphaericus*, a mechanism that he claimed was his method for grinding and polishing lenses for telescopes. "There is no need to multiply instances", he wrote. "If small things may be compared to great, I too, who am not well versed in the heaven of mathematics, some time ago invented a method of grinding and polishing glass lenses for use in telescopes. The method does not use plates or salvers [*patines and scutellae*; probably "molds"]. It seemed incredible to savants, especially to Clarissimus Huygens, whom I informed of it. In a letter to me from The Hague, 6 October 1664, he says, 'Let us pass over

[780] Ibid., 8-9.
[781] Ibid., 9-15.
[782] Ibid., 17.
[783] Ibid., 17-18.

this and consider your brother's marvelous device, by means of which he claims to make perfect lenses without spherically hollowed molds (my brother is mentioned because of my having ascribed to him, from a motive of brotherly affection, this and all my other discoveries. But now truth should have precedence over affection). This is so far beyond my comprehension that I almost pronounced it impossible. And so I would like for you to tell me candidly once more; for a certain amount of suspicion exists that your reason for publishing it is to delude others who are doing the same research.' Thus far, the words of Christiaan Huygens".[784]

Matteo continued, "The lens-grinding method that I propose also to publish on the occasion of publishing the little work that I am now engaged in writing, these results derived from my long studies during which I made every effort to consult to the extent of my power, the interests of the scientific world and the general benefit of mankind and to see to it, as far as I can, that nothing that is likely to profit our age may be concealed for long." This was followed by a detailed description of the *circinus sphaericus*.[785]

Note must be taken that, so many years after the events he described therein, Matteo now took for himself the credit for virtually all of the achievements of his brothers Pier Tommaso and Giuseppe, to whom he had contributed advice at the beginning with the mercury night clock. The estrangement between Matteo Campani and Giuseppe, in particular, had become final. Matteo claimed that it was as a result of his prompting that his brothers had chosen the craft of clockmaking, and that none of their work was original but what they had only carried out of his theories. It was because it was his wish, he claimed, that they published their discoveries as being their own. There is question also about the veracity of his claim of having had a discussion with Pope Alexander VII, because no previous mention had been made of it.

Nonetheless, despite this plagiarism, it is to be admitted that Matteo pioneered at least two horological firsts. One was the proposal for a clock sealed in vacuum. The second one was the operating with two pendulums, credit for which he described. Many years later, in 1735, the eminent French clockmaker Jean Baptiste Dutertre produced an invention that echoed Matteo's clock. It was a marine clock utilizing double pendulums geared together for maritime use. He proposed that the shifting of the ship would have effects equal although opposite on the two pendulums.[786]

Matteo's clock with two pendulums also was acknowledged a half century later by the Benedictine Dom Jacques Allexandre in his *Traité Général des Horologes*. He described the clock with two pendulums that Matteo Campani—whom he described as "This author a great artist"—

[784] Ibid., 18-25.
[785] Ibid.
[786] Gallon, *Machines et inventions approuvées par l'Academie royale des sciences*, vol. 5, 79–80 and plate.

believed would remedy the irregularity such as occurred in the vibrations of the pendulum caused by "alterations of air that affected the precision of clocks". He mentioned also a clock designed by Matteo consisting of three weights, two of which formed perpetual levers by means of which the third was balanced.[787]

A review of substantial length of Matteo's book that appeared in the *Journal des Sçavans* for January 7, 1678, stated:

This work merits to be held in the first range among those which were reported from the Italian journals, as much for the grand reputation of its author, who seemed in some manner to be French, because it was dedicated to the French monarch, whose magnificence is no less brilliant in his protection that he gives to *virtuosi* same within as outside of the Kingdom, than the value with which he subdued all his enemies, and braved the forces of all of Europe.

One finds therein two particular inventions. The first is a clock divided into two stages, one for the movements of the wheels and the other for the pendulum. The treatment only of this last, after listing the motifs in this work, the manner and the progress with which it finally terminates in the famous night clock, in the first year of the pontificate of Alexander VII. The irregularities derived from the alterations of the air in which are the vibrations of a pendulum, is, as one knows, that which hinders the precision of these types of clocks as well as the inequalities of these vibrations.

In his work, the author goes on to write that neither of the above-mentioned methods was sufficient to liberate the clock satisfactorily from any error […]. Thus, it was for the same reason, therefore, that the knowledgeable Grand Duke had not brought the same fine principle to the attention of the same Vincenzo Galilei, and to other intelligent persons […].

In his work, he proposes to make a clock for navigation that functions in a vacuum within a glass container, in order to avoid atmospheric variation, and also for the negative effect of the dust upon the lubrication. The movement is suspended in equilibrium and counter-weighted in order to preserve the same position while at sea, as the pendulum is suspended by means of two threads. Although at first it does not seem to be an invention researched thoroughly with great scientific rigor, it does appear to have been studied under the historical technological profile.[788]

At approximately the same time, the *Horologium* was reviewed also in the *Philosophical Transactions.* At a meeting of the Royal Society, Robert Hooke produced the book by Matteo Campani, of which he gave the following account. "This writer", he wrote, "who was rector of a parochial church, and seemed from some passages in his book to be brother of that CAMPANI, who made glasses [lenses] in Rome, endeavored to make himself the author of two inventions, which long before had been published and shown to the Society by one of their members. The first, a clock of two pendulums, rectifying one another, was shown by Mr. Hooke, January 2, 1666/67, as appeared from the *Journal*, and from the testimony of many, who could not have forgotten it. The second, *sphaericus*, for making of glasses [lenses], was the same with that published by Mr. Hooke in his *Micrographia*, in 1664; who did not doubt but that this pretended inventor was aware of it, since otherwise he would not have endeavored to anti-date it so much as he had by making it prior to October 6, 1664, citing a letter of Monsieur HUYGENS for his voucher, though the words

[787] Jacques Alexandre, *Traité général des horloges [...]* (Paris: Chez Hippolyte-Louis Guerin, 1734), 321–22.

[788] "Matthaei Campani de Alimenis ... Horologium solo naturae motu ...," *Journal des sçavans* 5, no. Du lundy 7 fevrier 1678 (1678): 45–50.

quoted by him assert no such thing. But upon a perusal of the book it was plain, that CAMPANI could be the author of neither of these inventions, since he seemed not to understand either mathematics nor mechanics enough to know, whether the things were true, when done; and therefore it was very improbable that he was the inventor of either. Nor did he at all explain how either of the inventions may be performed either mathematically or mechanically, as any one upon perusal would easily find".[789]

An unsigned manuscript found among Viviani's papers entitled "Report on Campani's Little Book" concerning Matteo's book, appears to have been compiled by Viviani. It noted that, on January 24, 1674, Matteo had presented his nautical clock to the recently appointed Grand Duke Cosimo III. It went on to say, "concerning the polemic with Huygens that he brought to the author, the author remedies the irregularity of air by means of the invention of sealing the clock in a glass as I had reference to in the *Giornale* of the year 1669; and if M. Huygens had mended at the beginning to the first end of those vibrations with the cycloid that I described in the *Giornale* of 1670, he pretends to have provided for both ends. A similar mechanism was referred to by me in the *Giornale*(ies) of 1670 on the occasion of the publication in England in 1667 of the *Micrografia* of M. Hooke. (Incredibly) it was esteemed most highly as almost impossible by M. Huygens, as was apparent from his letter of 4 October 1664 written from The Hague to Rome to the present author, who had given part of this his invention to working lenses without forms".[790]

As previously noted, the death of Pope Alexander VII in 1667 had substantial impact upon the lives of all three Campani brothers. The Pontiff had been a frequent patron of both Pier Tommaso and Giuseppe, and Matteo also claimed to have conversed with him on scientific matters. His successor, Giulio Rospigliosi, was a member of an eminent family of Pistoia, subjects of the Grand Duke of Tuscany. Upon his election to the papacy on June 20, 1667, he assumed the name of Clement IX. He too proved to be a beneficent patron of the Campani brothers, but unfortunately his reign was to be too brief. He was devout, patient in the conduct of affairs, and expert in avoiding problems. Described as the paragon of discretion, nothing appears to have occurred during his reign to disturb the papacy's image. More than any other of all the pontiffs of his period, he appears to have been the one most interested in the sciences.[791]

The year 1668 marked the beginning of a period of renewed competition between the Campani clockmaking brothers, each of whom was engaged in producing another major invention. While Matteo published as Antimo Tempera his *L'Oriuolo Giusto*, and Giuseppe was working at

[789] Robert Hooke, *Philosophical Transactions*, pp. 469–470; Birch, *History of the Royal Society of London*, vol. 3, 382: January 31, 1678.

[790] BNCF, Gal. vol. 315, cc. 1061–1064, "*Relazione sul libretto del Campani*" (possibly by Viviani).

[791] "Clement IX," *The Catholic Encyclopedia* (New York: Appleton, 1907).

his new projector-clock, Pier Tommaso invented a new automaton. For the past several years, Pier Tommaso had been seeking and experimenting with ideas for development into new and exciting forms of timepieces with which to intrigue his wealthy patrons. There was no variation to speak of in the clockwork movements of his silent night clocks with his modified crank lever escapement except for the addition of striking and alarm mechanisms in some instances, so that the major variation to which he could resort was in elaboration of the clock cases by means of various devices. Accordingly, he then considered the possibility of adding features generally foreign to the time-telling function but which could be powered by the clock movement. After contemplating various forms of visible movement, they led him to begin experimenting with clockwork-operated automata, similar to one he had made a decade earlier for the newly elected Pontiff.

The first of the timepieces that Pier Tommaso had been commissioned to make for Pope Alexander VII, as already noted, had been the macabre clock of which no contemporary description is known to exist. Presumably it had been commissioned by the Pontiff through Gian Lorenzo Bernini, who had produced other elements reflecting the recently elected pontiff's morbid preoccupation with death at this time. It is known that the grim clock survived Alexander's death and passed into the hands of his successor, Pope Clement IX. In the course of the years, the Clock of Death, as it was to become identified, formed part of the furnishings of the Quirinal, the papal summer palace on Monte Cavallo. After the unification of the Italian states, and the confiscation of papal properties by the new Italian government, the palace became the residence of the King of Italy, and after the second World War, of the President of the Italian Republic. It has not been possible to determine whether the timepiece survives to the present time in the presidential surroundings.

The second timepiece that Pier Tommaso made for Pope Alexander VII, and which had received much public notice, was the elaborate clock presented to Queen Christina of Sweden by the Pope upon her formal arrival in Rome in October 1655. The only surviving description is to be found among the announcements in the gossipy pages of the *Avvisi* of October 23 and November 13, 1655. Therein it was described as being "extremely curious and bizarre" because when it struck the hours "it had the most beautiful effects, and various figures appeared." Pier Tommaso was paid the impressive sum of 1,500 *doppie* for this "admirable artifice" that became the conversation piece of all of Rome.[792]

It was at about this time that Pier Tommaso obtained or was offered employment as a clockmaker in the Apostolic Palace in Rome; perhaps it was because of having executed these and likely other papal commissions that he was so favored. After Pier Tommaso and his brothers had

[792] *Avvisi*, Rome (October 23 and November 13, 1655): see chapter 2 of this book.

produced their silent night clock with mercury escapement for Pope Alexander VII in 1656, Pier Tommaso continued to be employed in the Apostolic Palace for a time, meanwhile continuing to produce complicated clocks with automata for his wealthy clientele in a shop of his own. After Giuseppe had patented his silent clock with crank lever escapement, Pier Tommaso developed another version of the crank lever escapement based upon the same principle that apparently did not violate Giuseppe's patent and that Pier Tommaso featured thereafter in the next several decades in the silent night clocks that he produced.

Intent upon attracting his clientele by means of noteworthy timepieces, Pier Tommaso next perfected a novelty timepiece featuring a small statue that activated a fan and moved the air about. The fan's size was such that it could scarcely freshen even its immediate vicinity by its motion, but nevertheless it provided another interesting conversation piece for the papal court. On May 30, 1668, Pope Clement IX awarded Pier Tommaso a letter patent for the invention of the clock "in which a statue moves a small fan and by means of which the air is agitated". The text of the patent read as follows:

Having His Holiness of Our Holy Father Clement IX with his apostolic letters in the form of Briefs expedited under date of last 30 May, conceded ability and privilege to Pier Tommaso Campani of Spoleto a clockmaker in this ancient City of Rome to make for ten years from the date of this Brief, clocks with statues, and with instruments that move a fan, or separate instruments, that with their motion agitate the air, invented by means of his ingenuity, with the privilege that during the said period of ten years, no clockmaker or vendor of clocks nor any other person of any state, quality, or grade or condition can make this type of timepiece with a statue or instrument moving the small fan, to the grave prejudice and loss of Pier Tommaso.[793]

The text of the edict continued with the standard verbiage adopted by the Vatican for prior papal letter patents, providing the same safeguards for the inventor and penalties for those who violated them. The edict was dated May 30, 1668, in the first year of the pontificate of Clement IX and was signed by I. G. Slusius. Added to it was a supplementary note:

On July 4, 1668, the above-inscribed Brief of His Holiness was presented and shown to the full Apostolic Camera, and on the third day of September of the same year 1668, by decree of the Camera, by order of the Most Illustrious and Reverend Lord Alessandro Colonna, cleric president of the said Camera, and the judge happily elected by the same Camera to execute the business, and on the citation of the Most Illustrious and Reverend Lordship, Giacomo Fantuzzi [*Elephantutius*], General Commissary of His Holiness and the same Cancelleria Camera, it was admitted and registered in the book of the signatures of His Holiness, kept in my office, on page 120.

Francesco Antinori, notary of the Camera.

[793] Clement IX, "Letter patent to Pier Tommaso Campani for the invention of the clock 'in which a statue moves a small fan and by means of which the air is agitated'" (Roma, May 30, 1668), vol. 27, fol. 456, Miscellanea, Armadio IV: Bandi, Archivio Segreto Vaticano.

Printed at the bottom of the edict was noted Pier Tommaso's domicile, "He lives in the Trastevere near Ponte Sisto and maintains his shop in the [Via del] Pellegrino at the end opposite the Cancelleria".[794]

Presumably this timepiece that Pier Tommaso had constructed in order to obtain his patent remained in the Pontiff's possession. Several months later in the same year, Clement IX commissioned Pier Tommaso to make another such clock for him. An entry in an anonymous manuscript diary for the year 1668, subsequently published, noted: "Our Holy Father has presented as a gift to Don Tommaso [Rospigliosi] a noble and bizarre clock representing a statuette, which in addition to its other curiosity, moves the air with a fan in her hand. Invented by Pier Tommaso Fontana [sic, Campani], clockmaker, to whom His Holiness has conceded a privilege which for ten years specifies that only he can produce such work".[795]

Tommaso Rospigliosi was one of the Pontiff's nephews, the son of Camillo Rospigliosi. Upon assuming the papal throne, Clement IX had immediately established positions for three of his nephews. He nominated Camillo to be general in charge of the pontifical army, Tommaso as custodian of Castel Sant'Angelo, and his nephew Vincenzo as captain general of the prisons.

It is probable that, in addition to featuring a statuette activating a fan, the Rospigliosi timepiece was also a silent night clock of the type for which the Campani brothers had become famous. An unsigned clock with statuette apparently in this style made in the same period was formerly in the collection of the Abate Manfredo Settala of Milan and is now privately owned.[796]

Few records have been found relating to Pier Tommaso's activities after his separation from Giuseppe. In 1668, he commissioned the local carpenter Agostino Petrucci to undertake a great quantity of cabinet work inside his shop in Via del Pellegrino, including providing cabinets with glass doors, tables, replacement of doors, etc.[797]

Thereafter, almost the only references to Pier Tommaso Campani and his work that survive are to be found in church records, and occasionally in his surviving signed silent night clocks, in the inscriptions of which are occasionally to be found dates of production and shop addresses. As

[794] Ibid.

[795] [Scientific Editor 2: Silvio Bedini sent a letter to the Biblioteca Apostolica Vaticana on the 3rd of October 1990 asking for a reproduction of the pages of the Manuscript Barb. Lat. 6450 where one could read of the gift from "Papa Clemente IX di un ‹‹bizzarro Orologio … Inventione di Pier Tomaso Fontana››". The 3rd of October 1990, from the Biblioteca Apostolica Vaticana, one answered that such information could not be found in the abovementioned manuscript. So far, I was not able to identify from what source Bedini drew this quotation. I found these letters among Silvio Bedini's personal papers].

[796] Privately owned in Milan. In modern times, a silent night clock of the traditional type made by Pier Tommaso Campani, possibly for the Pontiff of the Rospigliosi family, was owned by a member of the same family and was repaired by the Rome clockmaker Orlando Zijno in circa 1965.

[797] ASR, Campani, Pier Tommaso, "Conto del Sig. Tommaso Campana con Agostino Petrucci falegname" (September 17, 1668), Notai e Cancellieri del Tribunale Civile dell'Auditor Camerae (1625-1871), Sezione XLII - Ufficio I e II, vol. 244, cc. 543–544.

derived from records in the archives of the Vicariato di Roma, Pier Tommaso moved from one parish to another at least five times. From the parish of San Lorenzo in Damaso in 1664, in the next year he was to be found in the parish of San Salvatore in Onda, then in San Giovanni della Malva in 1670, returning once more to San Giovanni della Malva in 1683, where he remained until at least 1705, which may have been the year of his death. Records exist of more than 20 silent night clocks made by Pier Tommaso after 1664, of which some 15 have survived in whole or in part to the present time.[798]

[798] Pier Tommaso Campani moved five times: ASR, Curia del Cardinale e Vicario, Off. 31, Pinus Landus, c. 248 (June 6, 1669); c. 74 (September 10, 1669); c. 190 (January 30, 1670); cc. 733–734 (November 26, 1671).

Chapter XV

MAGICAL SHADOWS

(1668–1670)

> *From this new invention of showing the hour at a distance various comforts can be derved that which are not possible with ordinary clocks: such as not hearing in the room the sound of the moving wheels, and neither the smoke generated by the lamp that is necessary for seeing the hour of the night ...*
>
> "Nuova Mostra d'Horologio del Signor Giuseppe Campani," *Giornale de Letterati* (Rome), p. 56 (1669).

Giuseppe undoubtedly was greatly disappointed by the lack of success of his nautical clock and particularly the absence of acknowledgment after so much excited anticipation. So many hours spent and so many hopes raised, now totally wasted! Yet the very thought that his invention had been received in the Netherlands and been reviewed by the commissioners provided sufficient satisfaction to the energetic clockmaker from the Umbrian hills to enable him to move on to other endeavors. After this interim, he found facing him commissions for lenses and telescopes that had mounted up and were waiting to be fulfilled, in addition to an occasional request for one of his silent clocks with crank lever escapement. The practically minded Giuseppe put the dream of the nautical clock out of his mind and turned to satisfy his waiting clients. Undoubtedly he promised himself to find time in the future to return to the project of developing a timekeeper for determining longitude at sea.

As Giuseppe resumed his working schedule, innovative ideas came to mind from time to time for potential new uses or new dimensions or aspects for his timepieces, as well as those that may have been suggested by others. Being deeply involved in the lucrative production of lenses and telescopes for wealthy patrons in Rome and Florence, it was inevitable that at some point his mind contemplated the possibility of a marriage of his clocks and lenses. Whatever or whomever had provided the inspiration, it led him at this time to review the functions and limitations of the night clock as well as the possibilities of combining his two occupations—clockmaking and lens-making—to achieve yet another dimension hitherto never attempted.

It was inevitable that in the course of time Giuseppe Campani would become intrigued by the potential for innovative means of time measurement other than night clocks, which led him to explore sources for novelty forms. Such an opportunity came with a commission emanating from one of his Vatican contacts or directly from Johann Paul Schor, the talented Austrian-born sculptor and architect frequently employed by the Vatican. The project was to provide the clockwork mechanism for a celestial globe, whose upper part was pierced with openings to represent six-pointed stars, the images of which would be projected on the ceiling by illumination from within.

The globe is made of copper, its upper *calotta* (or spherical section) is made double to enable the heat and smoke to escape. The clockwork contained within activates a band perforated with the hour numerals that revolve around the center of the globe. The hour numerals appear in sequence through an opening at the front of the globe. The illuminated globe is upheld by the left hand of a figure of Chronos, or Father Time. The figure is life-sized, carved, and gilded overall and is shown standing upon a rocky promontory, holding a scythe in his right hand. The rock base and scythe are finished in silver. The total height of the clock, including sculpture and globe, is 182 cm.[799]

The sculptured figure is attributed to Johann Paul Schor, a sculptor born in Innsbruck, the son of the court painter of Emperors Maximilian III and Leopold V. Having migrated to Rome around 1640, from 1656 until his death, Schor was frequently employed by the Vatican. It was reported that in his studio his staff was constantly confronted with the entire range of sculptured work, from the design of medals to the production of large statuary for public buildings. Schor was praised by Bernini as a great decorator and a man of unlimited imagination and invention. Popularly known as "Giovanni Paolo Tedesco", he became Rome's leading decorative sculptor of his time.[800]

The fact that Schor was employed at the Vatican from the beginning of the reign of Pope Alexander VII suggests the possibility that the clockwork globe had been commissioned by either that Pontiff or his successor Clement IX, or possibly by one of the papal Chigi nephews. Furthermore, the clockwork may have been commissioned by the Vatican not from Campani, but from Schor, who then had negotiated with Campani to produce it according to his specifications.

Enclosed within the copper globe is Campani's clockwork movement with modified crank lever escapement, regulated by means of a pendulum oscillating below the globe. The movement is signed in the usual manner, "*Joseph Campanus Inventor Romae*." The globe's outer surface features the 12 zodiacal constellations painted against a blue sky. Motivated by the clockwork, the perforated hour numerals appear in sequence upon a gilt brass band revolving counterclockwise

[799] The total height of the clock with figure is 182 cm (6 feet). The figure is in gilt while the rock base and scythe are finished in silver. [Scientific Editor 2: At the time when Bedini wrote this book, the clock was owned by Dott. Giancarlo Del Vecchio in Milan, and formerly in the collection of Alberto Di Castro. Illustrated in Lizzani, *Il mobile romano*, 159; Antonio Simoni, "Orologi notturni veramente eccezionali," *La Clessidra*, no. Special issue (April 1967): 43; Brusa, "Italian Night Clocks". None of these descriptions provide additional details, indicating that the writers had not seen or examined the clock itself].

[800] Pearl M. Ehrlich, "Giovanni Paolo Schor" (Columbia University, 1975); Giulia Fusconi, "Disegni decorativi di Johann Paul Schor," *Bollettino d'arte* 6, no. 33–34 (1985): 159–80; Walker and Hammond, *Life and Arts in the Baroque Palaces of Rome*, 8–12.

around the globe's midriff. The current hour and quarters are revealed when illuminated by means of a *lucerna* enclosed within the globe, through an opening at the front of the globe's surface.

Neither the revolving band with the perforated hour numerals, nor the figure of Chronos supporting a timepiece, are original concepts with this timepiece, for they have been achieved several times in other European clockworks. Likewise, timepieces featuring a revolving band bearing the hour numerals were popular for a time with seventeenth century French and German clockmakers; a notable example was made by Georg Seydell in about 1640. However, the production of such a feature on a timepiece of such a much larger scale as the one by Campani is unusual.[801]

Traditionally, the image of Father Time, known in Greek mythology as Chronos (in Latin as Saturnus and in English as Saturn), such as the figure featured in the supporting sculpture of the Campani clock, generally has been accepted as that of a benign figure. Further investigation into its origins, however, reveals a stormy historical tradition in Greek mythology. Chronos was part of a group of beings called Titans that existed prior to the Greek gods. Chronos was one of the multitude of children of Gaia (Earth) who had been fathered by Uranus (Heaven). Having become very fearful of the children he had conceived, Uranus kept them confined inside of Gaia, much to her discomfort and displeasure (one can imagine!). For her protection from Uranus, whom she feared, she surreptitiously gave a sickle to her son Chronos, who was the wily, youngest, and most terrible of the children of Uranus and who hated his progenitor. When Uranus next approached Gaia for lovemaking, Chronos appeared upon the scene and cut off his father's testicles, and he became the ruler of the universe until he was in turn overthrown by his own son, Zeus. The blood spilled from Uranus' wound formed itself into creatures such as the Giants and the Furies. His genitals were thrown into the sea and eventually produced Aphrodite. So much for mythology.[802]

It is not known whether it was as a consequence of the modest success of the illuminated projected stars and hours from the celestial globe or whether it was derived from his recollections of the invention of the magic lantern, but at about this time, Giuseppe Campani proceeded to explore its possibilities further. The development of the magic lantern had been undertaken two decades earlier at the Collegio Romano by Athanasius Kircher. It was a project that had resulted in the

[801] Ernst von Bassermann-Jordan, *The Book of Old Clocks and Watches*, 4th ed., fully revised by Hans von Bertele (New York: Crown Publishers, 1964), 197.

[802] Apollodore d'Athènes, *Apollodorou tou Athènaiou Bibliothèkè = Bibliothèque d'Apollodore l'Athénien*, trans. E. Clavier, 2 vols. (Paris: de l'imprimerie de Delance et Lesueur, 1805), Chronos; Hésiode, *Théogonie ; Le bouclier d'Héraclès ; Les travaux et les jours*, ed. Charles-Marie Leconte de Lisle and Yves Germain (Clermont-Ferrand: Éd. Paleo, 2007); Homer, *The Illiad of Homer*, ed. Maynard Mack, trans. Alexander Pope (London: Methuen & Co., 1967), chants XIV and XV.

publication of his work *Ars Magna Lucis et Umbrae* (*The Great Science of Light and Dark*) in 1645.[803]

The precise date when Kircher had made his first official presentation of his new invention the magic lantern is not known, but it had been held on an evening between 1644 and 1645. A score or more guests had been invited, including Kircher's fellow members of the Collegio Romano's faculty and a selected number of the young Roman nobility who were students at the Collegio. On the evening designated, they all stood about in front of the Collegio's main entrance in the large Piazza del Collegio Romano, impatiently waiting until, at exactly the appointed hour, carriages with mounted escort arrived and discharged several distinguished monsignors in flowing purple robes.

The guests were admitted to an upper hall of the Collegio, where they assembled to welcome Cardinal Francesco Barberini. It was he who had been responsible for bringing Kircher to Rome two decades earlier, and he had come this evening to observe which of his arts this so-called "Master of a Hundred Arts" was about to reveal. Following ceremonial greetings and salutations among those gathered, Kircher waited until everyone was seated. Then, after all the candles and lamps in the chamber had been extinguished, he slipped behind a curtained partition that concealed his projector. It is not known whether Matteo Campani was among the audience of this first public demonstration, but it is probable that he did attend with his Jesuit friends associated with the Collegio or later learned details of the event. At first the audience sitting in the absolute darkness saw nothing, until finally, as their eyes gradually became accustomed to the darkness, they observed a faint light that was beginning to appear upon the white surface of a screen mounted in front of the first row of seats. Then, the flames in Kircher's lantern began to burn more brightly and, as he adjusted his projector, the content of his first glass slide could be distinguished as it gradually assumed the form of a recognizable image. The incredulous older ecclesiastics murmured prayerful ejaculations while the young men exclaimed excitedly at the sight. Each succeeding slide increased the wonder of the audience as Kircher, a born showman, went through his selection of art subjects one by one. Included were figures of animals and even images of the devil. Kircher slyly had included the latter in order to taunt those in the audience who suspected him of dabbling in necromancy, and in fact some among the spectators became almost convinced that indeed he had

[803] Athanasius Kircher, *Ars magna lucis et umbrae, in X. libros digesta. Quibus admirandae lucis & umbrae in mundo, atque adeò universa natura, vires effectusque uti nova, ita varia novorum reconditiorumque speciminum exhibitione, ad varios mortalium usus, panduntur* (Amstelodami: apud Joannem Janssonium à Waesberge & haeredes Elizaei Weyerstraet, 1671); Athanasius Kircher, *Vita admodum Reverendi P. Athanasii Kircheri*, ed. Hieronymus Ambrosius Langenmantel (Ausgustae Vindelicorum: Typis Utschneiderianis, 1684); Simon Henry Gage and Henry Phelps Gage, *Optic Projection: Principles, Installation, and Use of the Magic Lantern, Projection Microscope, Reflection Lantern Moving Picture Machine, Fully Illustrated with Plates and with over 400 Text-Figures* (Ithaca, N.Y.: Comstock Publishing Company, 1914), 675–80.

resorted to black magic to produce his effects. Although at the conclusion of the performance many congratulated him, others pointedly remained dubious. [804]

There was no mention of projection lanterns in the first edition of the *Ars Magna Lucis et Umbrae* published in 1646. Kircher noted in his work that many others had been drawn to the invention of the magic lantern after he had "merely outlined the subject", and that they had applied their minds to refining it. He described one of them, the Danish entrepreneur Thomas Rasmussen Walgensten. "First among these was a Dane, Thomas Walgensten", he wrote, "not a little known as a mathematician, who, recalling my invention, produced a better form of the lantern which I had described. These he sold, with great profit to himself, to many of the prominent people of Italy. He sold so many that by now the magic lantern is nearly commonplace in Rome. Kircher credited Walgensten as being the first popularizer of the projector and the first "road show" showman. "However", he added, "there is none among all these lanterns which differs from the lantern described by us".[805]

Despite the apparently ineradicable tradition that Kircher was the inventor of the magic lantern, which has persisted through the centuries, other authorities claim the invention for Walgensten. Kircher's claim is based upon the second edition of his book *Ars Magna Lucis et Umbrae* published in 1671–the illustrations appeared for the first time in this edition. These may have been replacements for Kircher's own drawings and probably had been printed before Kircher had an opportunity to see them. In them was featured a lantern with a light source, translucent slides, and a lens, mistakenly shown arranged with the lens between the light source and the slide so that the illustrations published did not reflect his concept. It is obvious that the mistake made by the artist had not been reviewed by the author before the printing and consequently remained uncorrected. The French inventor and man of science Milliet de Chasles noted that it had been Walgensten who had introduced the magic lantern in France at Lyons some years after it had been invented by Kircher.[806]

The role of Walgensten in the development and popularization of the magic lantern deserves further study. Preserved in Rome at Monte Porzio Catone, as part of the Osservatorio Astronomico di Roma, for example, is an unexplained object lens of long focus, inscribed on the border of the glass "*Tomaso Valghestenio fece in Venetia anno 1668-5 Splis. Diametro 25 palmi Romani*". The

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[804] Martin Quigley, *Magic Shadows: The Story of the Origin of Motion Pictures* (Washington: Georgetown University Press, 1948), 9–10.

[805] Kircher, *Ars magna lucis et umbrae*, 768.

[806] Ibid., 768-770 ; Claude-François Milliet Dechales, *Cursus seu mundus mathematicus* (Lugduni: Apud Anissonios, 1690).

collection also contains four of Kircher *tavole sciateriche* surviving from the *Museo Kircheriano* in Rome.[807]

During the next several decades, as the magic lantern grew in popularity, it quickly became commonly available in Rome and elsewhere. Although Pier Tommaso did not avail himself of this diversion, Giuseppe saw the opportunity to combine his two occupations. He finally arrived at a solution—a timepiece that projected the image of the clock dial by means of a lens and indicated the current hour upon an opposite wall or ceiling! In about 1664 or shortly thereafter, he developed an adaptation of the principle of projection from the new invention with his silent night clock equipped with crank lever escapement. It was a simple matter for him to modify his standard silent night clock by the addition of a lens inserted in front of a transparent dial, using the illumination customarily provided by a small *lucerna* or oil lamp contained inside the clock case. It is not known at what point Giuseppe first undertook this project, but by late 1667 or early 1668, he had produced several successful examples.

Among the earliest, if not the first, of his projection clocks was one commissioned by Cardinal Antonio Barberini, papal nuncio to the French court, several years before Campani had obtained a papal patent for this invention. The timepiece for the papal nuncio most likely was taken to France in the luggage of none other than the celebrated architect and sculptor Gian Lorenzo Bernini, who had been invited to Paris by the Cardinal. On April 25, 1665, Bernini left Italy for the first and only time in his life. Then age 66, Bernini was acknowledged to be the most famous artist in Europe in his time, and his visit had come about as the consequence of negotiations that had been conducted personally between the young French king and Pope Alexander VII.[808]

Minister Colbert, Superintendent of the King's Buildings, had failed to find a French architect he considered to be sufficiently competent to complete the remaining work on the palace of the Louvre, and he also had discarded plans submitted by other Italian architects. Thereupon, the King had requested the newly elected Pope Clement IX to permit his own architect, Bernini, to visit Paris. He had in fact personally written an invitation to Bernini, who was one of four Italian architects whose plans were being considered.

Several years earlier, Cardinal Antonio Barberini, who had taken refuge in Paris after the death of his uncle, Pope Urban VIII, had commissioned several sculptural works from Bernini and had invited him to come to France. As arrangements were being finalized, the King sent Paul Freart,

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[807] Kircher, *Ars magna lucis et umbrae*; W. A. Wagenaar, "The True Inventor of the Magic Lantern: Kircher, Walgenstein or Huygens?," *Janus : Archives Internationales Pour L'histoire de La Médecine et Pour La Géographie Médicale* 66, no. 1–3 (1979): 194–207; Giuseppe Monaco, "Quattro tavole sciateriche su ardesia di Kircher," in *Enciclopedismo in Roma barocca*, ed. Maristella Casciati, Maria Grazia Ianniello, and Maria Vitale (Roma: Marsilio, 1986), 348–54.

[808] Cecil Gould, *Bernini in France: An Episode in Seventeenth-Century History* (Princeton, N.J.: Princeton University Press, 1982), 1–28, 94.

Seigneur de Chantelou, to accompany Bernini. He was to serve as the guest's equerry and interpreter, and Freart also was instructed to maintain a daily diary documenting Bernini's stay in France.[809]

Arriving in Paris early in April 1665, Bernini, his son, and Freart were accommodated as house guests in the Cardinal's palace. During the course of Bernini's stay, the subject of an Italian night clock housed in an ebony case occurred and reoccurred again and again in Chantelou's diary and in several accounts of Bernini's visit.

The Cardinal already was fully familiar with Giuseppe Campani and his innovative timepieces because, in his earlier position as the Vatican's *camerlengo*, it was he who had issued the papal patent for Giuseppe's crank lever escapement. From time to time in the ensuing years, the Cardinal had purchased some of Giuseppe's clocks and telescopes for his own use. Although it was not until several years later, in 1668, that Campani received a papal patent for his projection night clock, as previously noted, he already had produced several of them.

During the visit of his Italian guests, the Cardinal endeavored to find various means to entertain them. As reported in Chantelou's diary for April 1665, following a dinner with the distinguished Italian sculptor at the Cardinal's residence, "His Eminence had arranged to have shown to Bernini, before we sat down at the table, a clock for the night, in which, by means of a lamp which illuminated the dial, one was enabled to see what hour it was at any hour of the night. There was in this clock a painting by Carlo Maratta, of small figures of one foot [sic] in height, that the Cavalier highly praised".[810]

On another occasion, Chantelou's diary reported, "In the meantime *M. le Nonce* had arrived, and my brother came a little later, and at the same time Cardinal Antonio had sent for his 'clock for the night,' in which was a painting by Carlo Maratta, before presenting it to His Majesty, when His Majesty was to come to the home of the Cavalier. *M. Le Nonce* was unable to remain and his having departed, we went to dine".[811]

On Monday, September 7th, while Bernini was again dining with the Cardinal, he is reported to have admired a night clock, "which was then a sensational novelty. It contained a lamp and featured a painting by Carlo Maratta. As a consequence of Bernini's praise, the next day the Cardinal sent the clock to the Palais Mazarin so that it could be presented to the King when next he came to sit. At the presentation on the following day, Bernini made the observation that Maratta

[809] Paul Fréart de Chantelou, *Journal du voyage du cavalier Bernin en France*, ed. Ludovic Lalanne (Paris: Gazette des beaux-arts, 1885), 4–5.

[810] Ibid., 144, shows Bernini the clock.

[811] Ibid., 146.

was one of the best painters in Rome, to which the king responded that he himself should have begun to look at pictures earlier, but that he had been doing so only for the past several years".[812]

In an entry made in his diary 2 days later, Chantelou next reported, "After dinner, on the 3 hours, the King arrived, the Marquis Francois de Neufville having already arrived some time previously, then M. Saint-Aignan and Magalotti, who was there to present to His Majesty the clock of Cardinal Antonio Barberini on behalf of His Eminence. The King considered it, the Cavalier [Bernini] told him that the painting that His Majesty was seeing was by one of the finest painters in Rome. The King observed it for some time, then he said that 'he had known that he had been at the Academy'. He replied to His Majesty that he had expressed his sentiment on the manner of instructing the young men. . . .".[813]

Chantelou later referred to the clock in yet another entry in his diary. "In this time Perdigeon", he wrote, "whom His Majesty had sent to inquire, arrived to determine what ornamentation could be added to this clock that had been presented to him by Cardinal Antonio, which, except for the painting, was only of ebony. After looking at the hour, His Majesty said that it was necessary that he and the Marechal de Villeroi must leave immediately, having two affairs in his Council that obligated him, and he departed, saying to the Cavalier [Bernini] that he would see him the following day at the same hour".[814]

The clock case of black ebony apparently was stark and too simple for the King's taste and required adornment, which Perdigeon presumably was expected to recommend and provide. It is known that after the clock had been so formally presented to His Majesty, decorations were added to the clock case. Although no descriptions of the decorations survive, it is probable that antique gilt bronzes were applied to its exterior. The movement of the clock would have been signed "*Joseph Campanus Inventor Romae*".

It has been suggested by art authorities that the dial painting of the clock that the Cardinal presented to the King was in fact one that featured a miniature painting by Carlo Maratta depicting the allegory of the boatload of the Four Seasons being piloted by Father Time along the river Styx meanwhile a *putto* that is flying overhead displayed a riband bearing the words *"TV DORMIS ET TEMPVS TVVM NAVIGAT"*.

Confirmation that the clock presented by Barberini to the King featured a miniature painting depicting this subject by Maratta, is based upon two factors. The composition of the painting by Maratta was later engraved by Picart in about 1696 prior to his departure from France to Flanders.

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812 Gould, *Bernini in France*, 94, Bernini praised clock sent to Paris.
813 Fréart de Chantelou, *Journal du voyage du cavalier Bernin en France*, 149.
814 Ibid., 172.

The subject matter in the miniature painting by Maratta enjoyed some success, for it was duplicated by Maratta again in dial paintings of at least two other Campani silent night clocks.[815]

Interestingly enough, the clock Cardinal Barberini presented to King Louis XIV appears to have itself become the subject of depiction in an engraving drawn by Giovanni Augusto Corvino and engraved upon copper by Johann Jakob Schübler. The engraving was one in a series of drawings entitled *Synopsis Architecturae Civilis Eclecticae . . .* published by Jeremias Wolff of Augsburg in 1724. The series depicted uses made of furnishings. The title of the particular engraving, translated from the German, states that it was a "Projection Night Clock in the Bedroom of King Louis XIV", and almost certainly it purports to represent a projection night clock by Giuseppe Campani.[816]

Two versions of the engraving were produced, both of which depicted the King's bedroom and its antechamber. In one version, a mantel clock housed in a large case of the elaborate Boulle style is shown positioned upon a decorative pedestal in the foreground of the antechamber. The clock is projecting an image of the clock dial onto the wall inside the royal bedroom; in the other version, the image of the clock dial appears projected onto the floor at the entrance to the bedchamber. Apparently, the artist had not been provided with a sufficiently detailed description of the clock case in question and was unaware that it was in fact in the form of an Italian night clock. Presumably the artist concluded that inasmuch as the scene to be depicted took place in the royal French bedroom, it would have been a timepiece in a clock case of Boulle marquetry, a style that was popular in France during the reign of the Sun King.

FIGURE

The several years between 1664 and 1668 constituted one of the busiest periods in Giuseppe Campani's career. Early in 1664, he had married Theopista Caterina Santori of Albano Laziale, and established a household; then, in July, came the publication of his *Ragguaglio,* which brought him much public notice. Meanwhile, he had been constantly occupied producing lenses and telescopes for a whole range of new clients preoccupied with astronomical observations. His first child, Giulia Francesca, was born in December 1664, and a son, Carlo Francesco, was born in the spring of

[815] The engraving by Picart of 1696 of the painting attributed to Maratta is in the Cabinet of Engravings and Printing, Amsterdam. Angela Negro, "‹‹Ruit hora››: sulle decorazioni figurate di orologi a Roma in età barocca", in *Le ore dell'Imperatore: la pendola Urania del Museo Napoleonico : studi, incontri, restauro*, ed. Fabio Benedettucci, Interventi d'arte sull'arte (Roma: Gangemi editore, 2015), 90. Although the descriptions provided in the account of Bernini's visit are not sufficiently detailed to indicate the name of the maker of the clock, no other timepiece being produced in that period qualifies for the description that it was "a night clock in which, by means of a lamp that illuminates the dial, one can see what the hour is during the entire night".

[816] Johann Jacob Schübler, *Johann Jacob Schüblers seines vorhabenden Wercks, Welche neue architectonische Castra Doloris ansehnliche Capellen [...]* (Augsburg: Verlegt von Jeremias Wolff, Kunsthandlern in Augpurg, 1724), plate 4.

1667.[817] Despite the cares for his growing household, Giuseppe yet found time to invent and make his projection night clocks and to apply for a papal patent. This also was the year marking the death of one of his major patrons, Pope Alexander VII.

During the same period, as time permitted, Giuseppe was actively making and recording astronomical observations of his own. Together with Gian Domenico Cassini and other distinguished personages gathered on occasion at Montecitorio to test telescopes, they observed the shadows of the satellites of Jupiter with one of Giuseppe's instruments.[818]

In Florence, meanwhile, changes had taken place at the Medici court. On December 12, 1667, 9 months after the last recorded meeting of the Accademia del Cimento, Prince Leopold de' Medici had been created a cardinal by Pope Clement IX. This selection generally was recognized as a political action and almost as a family matter. Despite Leopold's expressed libertarian views, the Pontiff was determined that there should be a Medici cardinal in the Curia. Leopold was the obvious successor to his brother Cardinal Gain Carlo de' Medici, who recently had passed away. Although Leopold accepted the appointment with some degree of pleasure, expecting he would enjoy the consequent pomp attending it, it was not until the following March that he made his way to Rome. He was greatly enthusiastic about the Eternal City, its wealth of art treasures, and its aristocratic society, and he remained there until June 1668 before returning to Florence. Although the Accademia had ceased to function, Leopold continued his correspondence with his scientific friends abroad, particularly astronomers. He was to make only one more visit to Rome, at the end of 1669, to attend the conclave that elected the successor to Clement IX.

Upon his arrival in Rome for the first time, Cardinal Leopold had taken up residence in the family Villa Medici, and during the next several months he managed to see much of the city and its historic features. In late May or early June 1667, the Cardinal paid a visit to the shop of Giuseppe Campani, with whose work he was familiar but now wished to meet him. During the past few years, when Leopold and his brothers had commissioned Giuseppe's clocks and telescopes, the Medici court's negotiations with Campani had been undertaken for the most part through the Grand Duke's minister in Rome, Count Torquato Montauti. Giuseppe had, however, visited the Medici court in Florence a few years previously.[819]

Cardinal Leopold's personal visit to Campani's shop was an unusual event, and as the Cardinal was looking about inside the shop and marveling at examples of his handiwork, he became particularly intrigued when he saw the project that Giuseppe had under construction. It was an

[817] Libri dei Battesimi di San Lorenzo in Damaso year 1664, f. 266r, December 18, and year 1667, f. 331v, April 15, "Archivio Storico del Vicariato di Roma", Archivio storico diocesano di Roma.

[818] Bedini, *Science and Instruments in Seventeenth-Century Italy*, 399.

[819] Torquato Montauti, "Letter from Count Torquato Montauti to Prince Leopold on June 25, 1667" (1667), Mediceo del Principato, vol. 5539, letter 89, Archivio di Stato di Firenze.

example of his new invention of the projection silent night clock, and the Cardinal immediately commissioned one to be made for himself. Its delivery was to be delayed, however, for a reason beyond Giuseppe's control. So intrigued had the Pontiff, Pope Clement IX, become with this new invention that Giuseppe had presented to him a short time earlier with his application for a papal patent, that the Pontiff requested the next one to be made for himself, which he planned to send as a gift to Shah Suleiman I in Ispahan.

Considering the order of priority among his patrons, Giuseppe had no choice but to accede to the pontiff's wishes, and upon completing it, he surrendered to him the clock he had originally intended for Cardinal Leopold. Then he set to work at once constructing another for Cardinal Leopold.

In August, 2 months after his return from Rome, Cardinal Leopold received a report from Abate Ottavio Falconieri, concerning various state matters. He also informed the Cardinal on the status of his commission to Campani for the projection night clock. "The clock begun by [G.] Campani for your use", he reported, "was desired by the Pope to send as a gift to the King of Persia, and therefore he is presently at work on another for you that, according to what he told me will be completed in the month of September".[820]

Giuseppe's invention of the projection night clock attracted local public notice and also was featured several months later in the *Giornale de' Letterati* in an account entitled "New Demonstration of Clock of Signor Giuseppe Campani". The report had been extracted from *Giornale XIII di Francia* for publication in the Italian newspaper. Therein also was described the magic lantern as an invention attributed to a Danish gentleman named Thomas Walgensten who had visited Rome some years previously. The account then went on:

This [invention by Campani] is an instrument of proportions substantially larger than the ordinary Lantern, in which in the part in front is inserted a tube containing two glass lenses, and in the posterior part there is a concave mirror to increase the illumination between them [. . .] Near the insertion of the tube there is a fissure through which one pulls a sheet of glass painted with various figures, which in passing before the opening [mouth] of the tube because of the light increased by the concave mirror is refracted by the two lenses [. . .].

Signor Giuseppe Campani, a person of great merit for the fabrication of his telescopes, and other instruments, has transferred this invention [of the magic lantern] to a clock, which, when placed in one place projects the hour upon the wall of another, represented with great distinction and clarity, and to the great delight and marvel of those who are not familiar with his artifice. From this new invention of showing the time at a distance, it is possible to retrieve various comforts that are not possible with ordinary clocks; such as not being able to hear in the room the noise of the clock's moving wheels, and without the smoke generated by the lamp, which is necessary in order to see the time at night; in addition to the curiosity of being able on occasion to project on a wall of a tower without knowing whence it came. To the care of a bishop, on the occasion that he was departing for Oriental countries, was consigned one of these clocks so esteemed for its novelty, and charm and was thus worthy of being presented to the King of Persia.[821]

[820] Ottavio Falconieri, "Letters from Ottavio Falconieri to Cardinal Leopold in August 1668" (August 1668), Carteggio di Artisti, filza X, c. 209r, 212, Archivio di Stato di Firenze.

[821] "Nuova mostra d'horologio del Signor Giuseppe Campani," *Il Giornale de Letterati, per tutto l'anno 1669*

The traveling bishop who was to deliver the clock to the Shah of Persia has not been identified, but the nationality of the original source of the announcement, *Giornale XIII di Francia*, suggests that he was a member of the French clergy.

Giuseppe's projection night clock also was mentioned in *Centuriae opticae*, a work by Eschinardi that appeared in 1668, the year in which Giuseppe had obtained a papal patent for his invention. In a section discussing the various applications of the magic lantern, Eschinardi noted "Giuseppe Campani [shortly after the first introduction of the magic lantern] discovered the useful art of reproducing a small clock in strong enlargement for use in the night time".[822]

It was by means of a papal Brief dated September 20, 1668 (but printed one year later), that Giuseppe had been granted another impressive privilege, or letter patent, in which his invention was described as "*catoptrico-dioptrico* to enable the time to be seen at night". The letter patent specified:

Having Our Holy Father Clement IX with his Apostolic letters in the form of Briefs, expedited under September 20, 1668, conceding the below described privilege to Giuseppe Campani for having from his own ingenuity invented that which could be said to be Catoptric Dioptric, by means of which one can see the hour of the night in a plane opposite to or in front of or within the same room in which the clock is situated, or which can in another separate one, or even in the public square at a distance, and the largeness of the horary characters […].

Then followed the customary standard text of papal patents of this period, appearing first in Latin and then in Italian:

And since it is our wish to provide that altogether, wholly, omnipotent, is put into execution, it is offered as much as is contained in the foregoing Brief, and to the damage that the aforesaid inventor of the said clock could receive from not observing [the instructions of] this brief during the ten-year period. Hence it is that the order expressed by word of mouth, and by the authority of our office of the *Camerlengo* [Privy Chamberlain] and in execution of the pre-inserted Brief, and in every other better means, with the present public Edict prohibiting and expressly commanding for the duration of ten years—No Clockmaker, artisan, or professional [professor] of whatever art, nor any other sort of person of whatever state, grade, condition, in Rome, as well as in any other city, Country [world, *terra*], place [region] of the Ecclesiastical State immediately [at once] or mediately, subject of the Holy See, can make the above-mentioned clocks of the same type as above described, even on the pretext of wishing to add, to diminish or change any part, nor keep them displayed for sale meanwhile, without the express license or permission of the selfsame inventor Giuseppe, under the penalties contained in our Brief, that is, of the loss of the selfsame clock, of 500 gold *scudi* of the Chamber one third of which is to be applied to the Apostolic Chamber, another [third] to the above-named Giuseppe, and the third part to the accuser, whose identity is to be kept secret, and known only to the Judge. Everyone is warned to not contravene to the present Edict because we will proceed against the transgressors with every rigor irremediably [without pardon], and in order that no one can claim ignorance of the present Edict of the Apostolic Brief, we wish, and decree, that it be posted in the usual public places, usual in Rome and also in other cities of the Ecclesiastical State, that being thus affixed, and published in

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(Tinassi), 1669, 55–56.

[822] Francesco Eschinardi, *Centuriae opticae pars altera: seu, Dialogi optici pars tertia in qua definitiones, seu explicatio terminorum : problemata reliqua, quae desiderantur in prima parte ad complendam centuriam ...* (Romae: TypisNicolai Angeli Tinassij, 1668), 222.

places, constraining everyone as if personally intimate. Given in Rome in the Most Reverend Apostolic Chamber, on this day 7 September 1669. [Signature][823]

In this instance, the patent did not include the inventor's address or that of his shop, although in other papal letter patents it had been customary to include the recipient's address and place of business. For more than a decade now, Giuseppe had maintained his own establishment and was no longer sharing space in his brother's rectory.

Giuseppe managed to complete the projection timepiece for Cardinal Prince Leopold within the time frame he had specified, writing to the Cardinal on October 3, 1668, to inform him that on that date he had consigned to Monanni, the Master of the Post in Rome, "a night clock similar to the one that the Prince had seen just prior to his departure from Rome. It was completed with the greatest solicitude possible and it is presented to Your Highness well prepared [packed]. I was not able to send it before this time, as had been my desire", he went on, "because Our Signor [the Pope] had wished to have the first one to send as a gift to the King of Persia, as he has done, and for this reason I have been constrained to make a second one, which is the one above-mentioned. I hope Your Highness will accept this small donation as a mark of my debt".[824]

In the interim, Giuseppe had received several other requests for his projection silent night clock, including one ordered by Cardinal Flavio Chigi, and he proceeded to execute each request in the order it was received. He waited patiently, meanwhile, for some expression of satisfaction or pleasure from Cardinal Leopold, but while the time passed month after month, none was forthcoming. It was not until some 10 months later that Campani ventured somewhat timidly to bring the matter to the attention of Ottavio Falconieri, the Medici representative in Rome, who in turn mentioned it to Prince Leopold.

The Cardinal was greatly embarrassed by his oversight and instructed Falconieri to make proper amends. Following his instructions, as Falconieri subsequently reported back to him, "This morning I communicated to Campani the benign will of Your Highness to repay him for his gift of a night clock, although up to the present time numerous cares have kept Your Highness from remembering to make him enjoy its effects. Given that I have found no reluctance whatever in Campani to receiving money, in the same time I gave him the forty *doppie* that Monanni had given me in payment. I mentioned also, however, the kind thought of Your Highness in ordering me to give him a neck chain [necklace] as a gift. He has shown how greatly he appreciates this kindness to

[823] "Papal letter patent" (September 7, 1669), Bandi, vol. 28, Archivio di Stato di Roma.
[824] BNCF, Gal., vol. 278, c. 211, letter from Giuseppe Campani to Prince Leopold on October 3, 1668.

him that Your Highness had decided to do, and I have no doubt that he will demonstrate it in more detail by means of a letter to Your Highness".[825]

At the time of Cardinal visit to Rome in 1667, Matteo—undoubtedly with Giuseppe's permission—had placed one of the new timepieces on display in his rectory and invited friends and distinguished associates to come to see and admire the invention.[826] However, one year later, Matteo had managed to become badly enmeshed in the matter of Giuseppe's invention of projection clocks. He finally confided his concerns to Abbot Giovanni Filippo Marucelli or to Vincenzo Viviani, with whom he had developed a friendship. Writing from Spoleto on October 24, 1668, he informed this Florentine courtier that as a consequence of "domestic vexations" he had been experiencing, he had been unable to pursue the discourse they had undertaken "on the subject of that artifice" of which the latter was aware. Presumably this related to one of Matteo's vacuum clock.[827]

As previously noted, a month later, on November 10th, Matteo wrote again to the Florentine courtier concerning Giuseppe's accusation that Matteo had claimed having invented the projection night clock—"a night clock with a magic lantern".[828] Matteo mentioned that in the course of a conversation he had held with Cardinal Prince Leopold in either Rome or Florence, he had asked the latter whether he had ever heard of a proposal to illuminate the public clock of the Palazzo Vecchio in Florence at night by means of a magic lantern. Leopold responded, Matteo said, that he had in fact learned of such a project from none other than Matteo's brother, Giuseppe. Matteo told the Florentine courtier that he then informed the Cardinal that Giuseppe in fact had invented it before he himself had done so.

To Matteo's apparent surprise and concern, as he reported in the letter, Giuseppe subsequently concluded that Matteo was attempting to make others believe that he and not Giuseppe was the inventor of the magic lantern clock. Now, in order to prove to him otherwise, Matteo was appealing to the authority of the Cardinal Leopold. Matteo wrote:

> Your innate congenial kindnesses and cordiality lead me to confide a misfortune of mine and the less than good fortune that I have had with my brothers; while I have worked as hard as I was able for their esteem and reputation (as all the world knows), these persons assumed the contrary. It is for such a matter that I beg you to reflect on everything that was proposed by Your Excellency concerning the *creche* that could be constructed with the magic lantern on that evening that you and other cavaliers [gentlemen] were in my house to see that magic lantern [clock] of my brother Giuseppe. I want you to recall what you can of what I had replied concerning this interesting idea, my having then said that such a *creche* could easily be made if designed to operate like a clock and with the same ingenuity and prodigality. Of what I then said to you and

[825] Ottavio Falconieri, "Memorandum from Ottavio Falconieri to Prince Leopold" (August 17, 1669), Carteggio di Artisti, filza X, c. 209, Archivio di Stato di Firenze.

[826] BNCF, Gal., vol. 284, cc. 21-22, letter from Matteo Campani to Marucelli or Viviani (?) on November 10, 1668 from Rome.

[827] BNCF, Gal., vol. 284, cc. 20r-v, letter from Matteo Campani without address but believed to be to Cardinal Leopold through Maruccelli (the Grand Duke's secretary) on October 24, 1668.

[828] See Chapter 12.

your brother the Abbot [Francesco Marucelli?], I do not recall where, or which then (although many times we have talked together of other matters).

No further mention at all was made other than when I was interrogated the last time by His Serene Highness, and he repeated it to me. I responded whether anything had been said by you concerning a certain proposal relating to illumination of the public clock [of the Palazzo Vecchio] at night by means of the magic lantern. His Excellency answered that he had heard of it from my brother, and I recall that I remarked further to His Serene Highness that therefore he too believed also that it had been thought by him before I did, inasmuch as he had not told me anything about it.

Now this misfortune has brought me the gravest vexation, and against all reason he [Giuseppe] thought that I had attempted to rob him of the invention, and he brought as irrefutable evidence the authority of the Cardinal. I have no doubt that my brother is in error in this particular opinion as in many other matters, but meanwhile the rupture between us that was born principally from this continues still.

However, if within the limits of the truth, and if it does not appear differently to Your Illustrious Excellency, in order to remove right from the beginning the false opinion of this man, do me the favor of writing a letter to me concerning this particular, responsive to this narrative of mine, of the truth of the fact of what passed between Your Most Illustrious Excellency and me, and also of what I said to Your Serene Excellency. I would receive it with many particular thanks and possibly it could put to right the fantasy of my said brother which has been altered out of moderation. For the love of God, please condone the length of this letter.[829]

It readily became obvious that it was at this time that the rupture between Matteo and Giuseppe had gone beyond repair and become permanent, fueled by Giuseppe's awareness that Matteo was claiming some of his inventions for himself. There is ample evidence that, in fact, Matteo thereafter continued to do so. Until fairly recently, Matteo had been unremittingly extremely supportive of Giuseppe, in particular, from the time of his arrival in Rome, acting as his entrepreneur in the development and promotion of his horological inventions, then of his lenses and telescopes, and frequently also as his agent in commissions he received for his work. Until now, Matteo unquestionably again and again had used every opportunity to support and promote his brother's work.

The break was caused by more than the matter of the projection night clock, however, and the authorship of the proposed applications of the magic lantern for illuminating public clocks. With each year, Giuseppe's fame had been increasing, not only at home but also abroad, while Matteo continued to valiantly strive to achieve some recognition for himself by means of his own usually unsuccessful inventions and his publications concerning them. One after another, his projects proved to be less than successful. His clock with twin pendulums remained unfulfilled, and there is doubt whether a successful example ever was constructed and completed. His nautical clock had resulted in an operating but non-functional clockwork as well as a publication, and it never fulfilled the dream for it that he had maintained.

Giuseppe's projection day-and-night clocks were not produced in any great number, possibly because of their cost, but most probably because hereafter he intended to concentrate his

[829] BNCF, Gal. vol. 284, cc. 21-22, letter from Matteo Campani to Giovan Filippo Marucelli (?) on November 10, 1668 from Rome.

energies and direct his priorities to lenses and telescopes. Of the few projection silent night clocks of which there is record is the one he had submitted to the Pontiff for which he had been granted a patent, one that Pope Clement IX sent to the Shah of Persia, and those he had made for Cardinal Leopold de' Medici, for Cardinal Barberini, for Don Fernando de Valenzuela, for the Landgrave Karl of Hesse, and other clients not identified. He also produced a day-and-night clock, which may have been a projection night clock, for the Grand Duke and another projection night clock for Cardinal Flavio Chigi.

The clock for Cardinal Chigi, which survives, is housed in a massive case made of oak veneered with ebony and having impressive serpentine columns. The movement is attached behind the clock door in the same manner as in other clocks by this maker. The clock's decorations utilize gilt bronze Corinthian capitals and bases, gilt copper decorations, and gilt bronze trimming around the lower opening. The door supporting the dial plate is made of fruitwood, painted in a dark shade of red, as is the interior of the clock case. Centered on the door is a wooden dial plate featuring a painting of a marine scene with spandrels painted with floral arrangements. The large gilt bronze chapter ring for daytime time-telling features perforated hour numerals and has a single index or hand.

As in all of Giuseppe's projection silent night clocks, in the space within the chapter ring, underneath the numeral XII appears a round opening in which is inserted a duplex lens contained in a brass frame. This mystery dial consists of two transparent glass disks, on one of which is a fixed index or hand, while the other, contained in a geared frame, is painted with the hours, and revolves activated by the clock movement.[830]

Giuseppe made another of his projection night clocks for the Spanish court, either for the Spanish Queen Regent Mariana, widow of King Felipe IV, or for Don Fernando de Valenzuela, her court favorite and prime minister. In all probability, it was made for the Queen, who presented it as a gift to her minister. It is described in the inventory compiled in 1699 of the property of Don Valenzuela's widow as "Another clock of transparency, that had to hold a spy glass necessary . . . of silver, that served to enlarge letters on the wall, with pendulum, made by the same craftsman [Giuseppe Campani] with its case of ebonized pearwood".[831]

Another projection day-and-night clock by Giuseppe Campani in a museum in Genoa is known, as well as two that survive now as relics, the movement of one which is incomplete and lacking a case, and another in the same state but retaining part of the original dial plate and support. The latter came to light in 1997 in a shop in Massachusetts specializing in the sale of clock dials. The surviving parts are only the chapter ring and hand and the incomplete movement with its

[830] Formerly in the collection of the writer, obtained in London in 1956; presently privately owned.
[831] Montañés, "Los relojes de don Fernando de Valenzuela : una notable colección, reunida en el s. XVII": 12.

mystery dial.[832]An identical movement signed by Giuseppe Campani in the collection of the Musée de l'Horlogerie in Geneva, Switzerland, lacks its dial plate and clock case. [833]

One of the most unusual of Giuseppe's projection night clocks was the one he made for the Landgrave Karl of Hesse in 1699. It was described on the Landgrave's invoice following a listing for a camera obscura as "another [clock] for the night" for the price of 1-1/2 *doppien*. The equipment was contained within a footed silver housing shaped in the form of a building with doors that opened at both ends, having a tiled roof and a large chimney for emission of the heat and smoke.

A telescopic tube with a lens cover projects from one end, while a transparent dial is visible from the opposite one. The cover on the tube may be removed to bring out the movement, which can be pulled forth. The original clock movement that operated the index or hand in front of the dial is missing and has been replaced with a later one. The present dial is a later imitation. At present, the clock case is soldered together, and restoration attempted in subsequent years has eliminated some of the original elements so that it is difficult to determine exactly how it operated.[834]

Another of his patrons for whom Giuseppe had made one of his projection night clocks was Grand Duke Ferdinand II, who had learned of the invention when his brother Leopold had described it to him after his visit to Giuseppe's shop. This timepiece has not survived, but undoubtedly it provided the inspiration for the illumination of the new public clock on the tower of Florence's Palazzo Vecchio.[835]

The Palazzo's tower clock movement had been made in Augsburg by the German tower clockmaker Georg Lederle and had been installed in 1667. Pleased with the new public clock, the Grand Duke then considered ways in which it could be made even more useful for the public. His recent acquisition of Campani's projection silent night clock led him to contemplate the possibility

[832] Silvio A. Bedini, *The Pulse of Time: Galileo Galilei*, *the Determination of Longitude*, *and the Pendulum Clock* (Leo S. Olschki, Florence), pp. 72–73 (1991).

[833] It is inventoried in the collection as "*Pendule-veilleuse No. 1123. Pendule-veilleuse à cadran lumineus (incomplete). Fusée pour corde à boyau. Mouvement signé Joseph Campanus inventor Romae. Epoque 1677, pays Rome, Dimensions 0 132 Haut 197. Provenance Don de M. César Schepers Florence*". The surviving clock movement is described as follows: *Elle porte deux glaces concentriques et superposées; sure l'une d'elles, fixée à la partie superérieure du mouvement, sont peinte les heures en noir; la seconde, sertìe dans une roue actionnée par le mouvement et entièrement peinte en noir, sauf une partie restée transparente et formant index, se déplace devant la premiere. Cette pièce ingénieuse est signée Joseph Campanus inventeur Rome 1677.* Courtesy of J. L. Sturm, Musée de l'Horlogerie de Geneva (July 29, 1998); Ml. C., "À propos des cadrans lumineux," *Journal suisse d'horlogerie et de bijouterie* 46, no. 1 (1921): 26–27.

[834] Johann Balthasar Klaute, *Diarium Italicum, Oder Beschreibung derjenigen Reyse, Welche Der Durchläuchtigste Fürst und Herr, Herr Carl, Landgraff zu Hessen ...* (Cassel: Harmes, 1722), 159; Ludolf von Mackensen, *Die Naturwissenschaftlich-technische Sammlung: Geschichte, Bedeutung und Ausstellung in der Kassler Orangerie* (Kassel: G. Wenderoth, 1991); Karsten Gaulke and Bjoern Schirmeier, *Optica: optische Instrumente am Hof der Landgrafen von Hessen-Kassel* (Petersberg: Michael Imhof Verlag, 2011), 110–11, Inventory n. APK U 42, and Inventory n. APK U 66; Gisela Bungarten and Museumslandschaft Hessen Kassel, eds., *Groß gedacht! Groß gemacht? Landgraf Carl in Hessen und Europa*, Kataloge der Museumslandschaft Hessen Kassel, Bd. 65 (Petersberg: Michael Imhof Verlag, 2018), n. VIII.14, pages 360-63.

[835] Bedini, *The Pulse of Time*, 73-75.

of adding illumination to the new palace clock. This would not be a simple matter, he realized, for the clock dial could not be lighted from within because of the nature of the clockwork and dial plate, the construction around it, and the considerable distance that existed between the clock dial on the tower and the nearest opposite building.

There appears to have been little if any comment about the project in the Medici court's correspondence until a year later. The subject of illuminating public clocks by means of projecting artificial light was discussed in the already noted letter from Matteo to Marucelli or Viviani, dated October 24, 1668. In the summer of 1669 or possibly earlier, Cardinal Leopold communicated with Giuseppe proposing nocturnal illumination of the public clock on the Palazzo Vecchio. Before responding to the Cardinal, Giuseppe gave serious consideration to the project and its problems. After acknowledging receipt of payment for a silent night clock he had recently completed for the Medici palace, he went on:

> As for the clock of the Campanile, I consider it to be most difficult, because the great distance [from the dial plate to the nearest base to which a light source could be attached] requires a lens of extremely large size, in order that the dial will appear sufficiently illuminated and so that it will overcome the difficulties. I have, however, appreciated the order of Your Highness, and desire to serve you in all ways to which I can extend my powers, and which is not impossible to do.[836]

Subsequent correspondence about the matter has not been found nor have any descriptions of details of the means by which the illumination was achieved. Although Giuseppe's first response to the proposal had been negative, undoubtedly he dutifully traveled to Florence to review the conditions on the site, discussed the project with Prince Leopold, and sought the advice and cooperation of Viviani, the court mathematician. The materials and labor required would have been provided from the contemporary Fabbrica di Palazzo Vecchio.

It may be speculated that it soon became apparent to all involved that there was no possibility of illuminating the clock dial from the front or from the sides without construction of permanent ugly projections which would be deleterious to the appearance of the tower. Illumination, therefore, would have to come from some point directly in front or at one side of the clock. The buildings on the opposite side of the Piazza della Signoria were situated at too great a distance for an effective magnification of illumination. The only choice remaining was to utilize the flat roof of the Loggia dei Lanzi located at the right of the Gallerie degli Uffizi, and at right angles to it. Its spacious roof provided an ample clear area for erecting a small permanent housing required to contain a light source and lens, perhaps somewhat like the structure for the projection night clock he had made for the Landgrave. Basically, the structure would have the general appearance of a large version of a magic lantern.

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[836] BNCF, Gal., vol. 278, c. 272: letter from Giuseppe Campani to Cardinal Leopold on August 20, 1669.

A problem remaining to be resolved was the production of a light source of sufficient size. In Campani's time, this could be achieved only by multiple candle power or oil lamps. The obvious solution was a large bank of oil lamps contained in an iron framework situated in front of a parabolic mirror and behind a large lens at the front of the structure. This feature may have projected from a tube which could be extended or retracted and adjusted to achieve the correct focus and direction. One or more attendants would be required during the night to keep the oil lamps fed and the illumination properly directed. No record has been found of Giuseppe's solution but that he successfully completed the project is verified by several contemporary accounts stating that, prior to the end of the year 1669, the tower clock was illuminated at night for the first time.[837]

The concept of illuminating a clock dial situated on the face of a public building was not new. A drawing of such was illustrated in Mario Bettini's *Apiaria*, published in 1641, and was described as a "method for knowing the time at night". It consisted of a light source, in this instance a candle, installed on the wall of a facing building behind a large lens and directed to the clock face on the building some distance away. It is not certain whether it had been executed successfully, and it may only have been a concept awaiting execution. Giuseppe was undoubtedly aware of the prospect proposed in Bettini's publication, but probably it would not have been applicable for his needs.[838]

FIGURE

A most unusual projection timepiece produced by Giuseppe Campani survives in a unique example that he appears to have made for an incumbent Pontiff, either Pope Alexander VII or possibly for Pope Clement IX. It is a day-and-night clock in an unusual version of his projection night clock. For many years, the timepiece had been featured in the Apostolic Palace, housed in the Camera della Falda of the Sala dei Paramenti. This was the dressing chamber in which each reigning pontiff dressed in his formal robes in preparation to participate in the ceremony of the Mass in the basilica of Saint Peter and for other public appearances. During the past several decades, this remarkable timepiece has been relegated to storage in the Vatican's Servizio della Floreria. Originally, the Floreria was the unit in the Apostolic Palace responsible for the maintenance and provision of flowers for religious functions. In time, it became the repository for the Palace's retired or discarded furnishings. With the passage of time and changes of administration, there was need for storage of damaged or unused but nevertheless valuable furniture

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[837] Bedini, *The Pulse of Time*, 73-75.

[838] Mario Bettini, *Apiaria universæ philosophiæ mathematicæ, in quibus paradoxa, et nova pleraque machinamenta ad usus eximios traducta, et facillimis demonstrationibus confirmata. Opus non modo philosophis mathematicis, sed & physicis, anatomicis, militaribus viris, machinariæ, musicæ, poëticæ, agrariæ, architecturæ, mercaturæ professoribus, &c., vtilissimum ... Accessit ad finem secundi tomi Euclides applicatus, et conditus ex Apiarijs, indicatis usibus eximijs præcipuarum propositionum in prioribus sex libris Euclideorum Elementorum*, vol. 1 (Bononiæ: Typis I.B. Ferronij, 1650), pt. Apiarium sextum, in quo dioptrica arcana, 27.

and furnishings. At the present time, this installation is replete with discarded great picture frames, carpets, armchairs, and other items of furniture and furnishings replaced by more modern items and no longer in use in the Apostolic Palace. The Floreria formerly was maintained under the Borgia Apartments on the ground floor of the new palace built by Sixtus IV, now the Library of Pius IV. Its faded manuscript inventories are replete with a fascinating miscellany of entries of sacred objects, mixed together with mundane furniture and miscellany.

During the course of the past several centuries, the Campani day-and-night clock stored therein appears to have suffered from considerable vandalism to the clock case, which originally had been of substantial proportions. It is now modified to a sturdy rectangular ebony case, part of which was reassembled primarily with what originally had consisted of the clock's door and frame and other elements salvaged from the original case.[839]

The clock's principal feature is a large dial plate of copper having an overall painting of a turbulent seascape; this may have been painted at a later date over the original dial painting, which most likely featured a sacred subject or scene and may have been damaged. A opening placed at the upper center of the dial plate with a decorative painted frame serves as a window through which the passing 24 hours are visible, two at a time, painted against a white and black background upon a large copper disk. The outer periphery of the disk is divided into 24 panels for the hours, each containing the hour numeral and a delicately miniature painting of a scene from the life of Christ in the New Testament, each bearing an appropriate legend identifying the scene. A comparison of the extremely fine quality of these miniature paintings with the outer dial painting of the sea confirms the conclusion that the latter is in a later style in another hand.

Centered near the base of the door of the original clock case is a large round glazed opening through which still may be observed the passing scenes from the life of Christ, painted upon a transparent glass disk, divided with markings for the minutes. These scenes were originally illuminated by means of a small lamp or *lucerna* attached to the inside of the back wall of the case opposite the paintings, and it probably had been equipped also with a lens to enlarge or project these images. The paintings on the glass plate have suffered considerable damage but nonetheless reveal evidence of their high quality.

The present modified clock case measures 32-1/2 inches (82.5 cm) in height, 21 inches (53 cm) in width, and 11-1/2 inches (29.5 cm) in depth—which are the approximately standard measurements of Campani's other night clocks. It is probable that the present simple case originally was completed with additional woodwork and bronze decorations. The brass back plate of the

[839] Morpurgo, "Orologi del Campani in Vaticano", 68–66.

movement is of an unusual inverted pear-shape, varying from Giuseppe Campani's standard back plates, and is inscribed in the customary manner, "*Joseph Campanus Inventor Romae*".[840]

The clock movement originally was made silent by means of a crank lever escapement. The short pendulum, attached to the verge staff of the present anchor escapement (which is a later replacement), is presently equipped with a lenticular bob instead of the original flat adjustable bob in the shape of the eight-pointed star that Campani favored for the clocks he made for members of the Chigi family.

Among the earliest imitators of Giuseppe's projection day-and-night clock was also Johann Philipp Treffler.[841] Unquestionably based upon Campani's invention was a clock that Treffler produced for the Landgrave Karl of Kassel around 1677, after his return to Augsburg. There is no doubt that the model from which Treffler based his own was in fact the projection day-and-night clock made by Giuseppe for the Grand Duke.[842] Treffler was familiar with the ducal clock collection, which he had maintained as part of his responsibility, and he may even have serviced the ducal Campani night clocks during his employment at the Medici court.

It is likely that by the time that Treffler made his clock, the Campani patent had expired, but even if it had not, Treffler would have had no qualms about violating it, for after his departure from Italy he no longer was subject to the rule of the Medici court or of the Holy See. Furthermore, even if Campani had known of the copy, it is unlikely that he would have bothered to have Treffler brought to task.

The movement of Treffler's night clock for the Landgrave consists of an inverted crown wheel and verge, with the verge staff connected directly to the pendulum crutch placed below it; this arrangement appears to be found only in clocks made by the Campani brothers and by Treffler. The dial painting depicts the figure of Atlas holding the globe of the celestial world upon his back executed in oil upon a wooden panel, an image that appeared in several other night clocks by Treffler.

Although Treffler's clock case of walnut veneered on oak reproduced the general characteristics of the cases of Campani night clocks, its detail indicates that it was produced in Augsburg. Measuring 1 meter in height and 11.5 cm in width, the base is 68 by 40 cm. Above the center of the chapter ring of silvered brass is a small painted cover that conceals the lens of the

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[840] The author is indebted to Dott. Ing. Ettore Gabrielli of the Uffizio della Floreria Apostolica for details and measurements of the timepiece.

[841] As previously noted, Treffler had emigrated to Florence following the end of the Thirty Years War and found employment as mechanician and clockmaker of the Medici court for two decades from about 1656 until when he returned to his native Augsburg in 1677. Lenner, "Johann Philipp Treffler".

[842] M. Loeske, "Interessante Uhren im Hessischen Landesmuseum in Kassel", *Deutsche Uhrmacher-Zeitung* 54 (1930): no. 52.

night dial. The arrangement of the night dial duplicates that devised by Giuseppe Campani. The back plate is inscribed in Italian "*Gio. Filippo Trefler* [sic] *Augusta*", indicating that it had been produced within a short period after Treffler's return to Augsburg. Fixed to a metal stand attached to the back panel in the clock's interior is an oil lamp, and behind it is a large metal reflector. The possibility exists that during the period of his employment in Florence, Treffler also may have made such a clock for the Grand Duke Ferdinand II. In a published work about the craftsmen of Augsburg Paul Von Stetten wrote:

> Treffler [who] was in Florence for a long time as the art-clockmaker to the old Grand Duke, is one of the first to make perpendicular [pendulum-regulated] clocks. He was also a great lover of the optical arts. In his bedroom was erected a magic lantern through which he had a clock [dial] moving clearly on the wall by means of a shadow hand and shadow numerals. . . .[843]

In another work published a few years later, Von Stetten described Treffler once more, as a turner having real mechanical genius but somewhat lacking in theory. He noted that Treffler was greatly experienced in the production of "items of optical art", however, and that among other such he had produced a magic lantern that took the place of a clock at night because it cast the hour numerals on the wall. These numerals and a pointer were fixed upon a glass that was operated [turned] by means of clockwork. In both of his works, Von Stetten identified his source as having been the writings of Johann Joachim Becher.[844]

Although Treffler's day-and-night clock is not dated, some clue to the period in which it was made is suggested in Becher's work. In late 1677 or early 1678, Becher traveled from Vienna to Holland, visiting Germany en route. He stopped off at Mecklenburg and Augsburg and returned by way of England, during which his work *De Nova Temporis dimetiendi ratione*, in which he mentioned having met Treffler, was published in London.[845]

In an article published in modern times describing the clocks in the Hessischen Landesmuseum, the writer noted "The clock by Gio. Filippo Trefler of Augusta can be assigned to the first half of the eighteenth century [sic]. . . . It is not clear why this Trefler Italianized his good name Johann Philipp on his clock. It is possible that the clock was ordered in Italy, and he probably believed that by this means of this old-fashioned method to attain advertising for himself".[846]

In an inventory listing the 41 clocks owned by Ferdinand de' Medici, son of Grand Duke Cosimo III who predeceased his father in 1713, were five night clocks in addition to a projection

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[843] Paul von Stetten, *Erläuterungen der in kupfer gestochenen vorstellungen aus der geschichte der reichsstadt Augsburg. In historischen briefen an ein frauenzimmer* (Augsburg: C.H. Stage, 1765).

[844] Bedini, "Johann Philipp Treffler": 28.

[845] Johann Joachim Becher, *De nova temporis dimetiendi ratione, et accurata horologiorum constructione, theoria & experientia* (Londini: Apud Marcum Pardoe, 1680), 8.

[846] M. Loeske, "Interessante Uhren im Hessischen Landesmuseum in Kassel," *Deutsche Uhrmacher-Zeitung* 54 (1930): 547–48.

day-and-night clock. The latter was described as a table clock having a repeating movement, measuring more than 3/4 *braccio* in height (ca. 43 cm),[847] with a case of *granatiglio* (cocus wood) and olive wood. Its gilt copper dial plate indicated the hours and minutes on a pewter chapter ring, with an "eye" in the dial plate enclosing a glass that indicated the 12 hours, on which is introduced from the outside a brass tube [*cannone*] with two glasses that can be raised in order to reflect the hour of the night on the wall, that after the said *cannone* are removed, there is introduced into that "eye" the coat of arms of the house [of Medici] of gilt brass, having the balls in silver, with a gilt brass handle above it. This somewhat confusing description appears to have been in all probability of the projection night clock made by Giuseppe Campani for Grand Duke Ferdinand II.[848]

The unusual characteristic of this timepiece apparently led to the production of others in various forms made for the court by other clockmakers several decades later, by which time Campani's patent had expired. One example of a later night clock of modest size was produced by Niccolò Rosso in about 1680. The back plate was signed "*Niccolò Rossi Firenze*". His name appeared also in an entry for August 1701 among the *provvisionati* patronized by Cardinal Francesco Maria de' Medici.

The gilt movement of the Rosso clock measures only 7 cm in diameter and is not of the dimensions of those made by the Campani brothers. Its daytime dial has the hours Roman style I through VI and a second dial of glass painted with the hours I through VI in reverse order that revolves against a fixed index. It has a balance wheel instead of a pendulum regulator. The copper dial plate, engraved with a design of foliation in mercury gilt, is attached to an iron plate with cherub spandrels. A large toothed wheel attached to the hour wheel causes the small glass dial painted with the hours to revolve. A second glass dial attached to the other is painted with a fixed hand or index. A small lamp in the interior of the case attached to the back provides illumination that is magnified by a lens attached in front of the lamp. An image of the dial is projected in enlarged form on an opposite wall or ceiling.[849]

A notable example of such a timepiece, unsigned and privately owned in Milan, has a movement likewise regulated by a balance wheel instead of pendulum. Housed in a case of dark walnut with simple, severe lines and approximately 30 cm in height in a Bolognese architectural style, the daytime dial is marked I through XII. The mystery dial for illuminated projection is

[847] A Florentine *braccio* could measure 0,5836 m or 0,5512 4 m; Carlo Pedretti, *Studi vinciani: documenti, analisi e inediti leonardeschi* (Librairie Droz, 1957), 37.

[848] Alvar González-Palacios, *Il tempio del gusto: le arti decorative in Italia fra classicismi e barocco ; il granducato di Toscana e gli stati settentrionali*, vol. 1 (Milano: Longanesi, 1986), 36–37; "Guardaroba, Palazzo Pitti, appartamento del Ferdinando de' Medici figlio di Cosimo III" (n.d.), fasc. 1222, cc. 8r, 9r, 10v, 14v, 15r-v, 16r-v, 17r-v, 26r, 50v, 51r, 54r-v, 67r, 69v, 70r-v, 71r, 86r, Archivio di Stato di Firenze.

[849] Morpurgo, *Dizionario degli orologiai italiani*, 149; Enrico Morpurgo, "L'orologio notturno di Niccolò Rosso," *La Clessidra*, no. 12 (1958): 30–32.; then in the collection of Conte Pier Lamberto Mosca Lamberti.

marked I through X. The original regulator was a steel balance wheel, later replaced with a pendulum. The dial plate is of painted copper features spandrels in the form of heads of *putti*. The movement is unsigned. The horological historian Antonio Simoni suggested that a clock of the same period as the one previously described, having a painted copper dial plate with a single hand or index on a circular *cartelle* with a similar arrangement, bore the maker's name, Vincenzo Roffeni of Bologna.[850]

The vogue for projection night clocks maintained their popularity in Italy for a time, and even later in Germany, for later in the century they were described and illustrated in several German publications. In 1685, Johann Zahn of Würzburg produced a work in which he illustrated a projecting telescope. Jerome Langenmantel, editor of Kircher's autobiography, was one of Zahn's teachers, and in his book Zahn confirmed his debt to Kircher.[851]

In the same year, Johann Christoph Sturm (1635–1705), a mathematician and physicist, published a work entitled *Collegium Experimentale sive Curiosum. . . .* In the second part, he described and illustrated a "*Lanternae Megalographica*" consisting of a night clock for the bedroom that projected the dial image upon the opposite wall or ceiling. It appears to have been an attachment to a flat table clock having a vertical glass dial with the hand moved from the arbor of the clock by verge and crown wheel. It did not attribute the invention to a specific individual or nationality. It described and illustrated the parts of the mystery dial.[852]

FIGURE

In this same work, Sturm described and illustrated a projection night clock of which he claimed to have been the inventor. He specified that his clock was designed "for the bedrooms of rich persons" and because of the disturbing smell and smoke generated by the lantern, he recommended that it be placed in an adjacent room and the image projected through an opening in the wall. These specifications coincide exactly with Becher's statement about Treffler's clock, and it seems very likely that Sturm was familiar with Becher's work.

A description of the clock by Giuseppe Campani (similar to the one in the collection of the Vatican), which by means of a large glass plate illustrates the 24 incidents of the life of Christ, is provided in Eschinardi's work in Problems 89 through 92, as follows:

Problem 89. In this investigation an attempt is made to determine whether a single lens—either convex, spherical, or hyperbolical—placed behind an opening can project a correct representation in a dark chamber of an object from the exterior. In Problem 91, I demonstrate through optical-geometrical rules the artifice of that wonderful lantern, the so-called "magic lantern;" with the assistance of a necessary figure, I teach the

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[850] Antonio Simoni, "Un secentesco orologio a lanterna magica," *La Clessidra* 15, no. 8 (1959): 17–19.

[851] Johann Zahn, *Oculus artificialis teledioptricus sive telescopium ex abditis rerum naturalium et artificialium principiis protractum nova methodo* (Herbipoli: [s.n.], 1685), 256–57.

[852] Johann Christoph Sturm, *Collegium experimentale sive Curiosum, in quo primaria hujus seculi inventa & experimenta* [...] (Norimbergae: sumptibus Wolfgangi Mauritii Endteri, 1676), 236–41.

way and the sure method to project images through it [the lantern] to whatever distance and with the dimension that one desires.

Eschinardi then considers the theory behind the magic lantern and briefly discusses the innovation brought about by this discovery with the optical theories of the times.

Problem 92 offers a case similar to the one just mentioned. In it I teach and demonstrate in an optical-geometrical way a sure method for transforming every large image into a small one and vice versa giving it the size desired. Moreover, I show that it is possible to transform a spherical image into a plane one. Following the method of either Problem 91 or 92, it is possible to show whatever movement in the above-mentioned representations of images using small movable figures, deriving both pleasure and usefulness from it. For example, it is possible to show the Nativity of the Lord using small figures—some of which are steady whereas others are movable. These little images are placed inside a box made of whatever material; even if the figures are dull it is sufficient to illuminate them in the frontal part. A very clever and useful representation of the hours by night made in the big size [*in magna amplitudine*] although using a little clock is the one that has been invented recently by the above praised Giuseppe Campani.[853]

The phrase *in magna amplitudine* refers to the size of the hours, the image of which is projected in Campani's device. However, the expression may also refer to a large public area such as a public square or a theater in which the image of the hours is projected. Knowledge of the circumstances of Campani's first demonstration of his invention and its use would be helpful to translate this passage accurately, but it is not available.

A century later, in 1762, a clock similar to the one illustrated by Schübler was invented by a mechanician in Paris named Musy, who maintained a shop on the Rue des Vieux-Augustins at the sign of the *Roi de France.* He invented a clock for invalids that combined a candle and alarm and an illuminated dial, which served as both a night light and as a heater for medical potions. He described his timepiece as serving at least six functions, including "(a) heating a boullion or some other liqueur; (b) sounding a small bell at all hours to alert the invalid or those attending that it is time for taking medicine; (c) there is always all through the night a soft light glowing, which does not fatigue the eyes nor interrupts the sleep; (d) there is in the body of the mechanism a transparent dial for the same *bougie*, which marks the hours; (e) and there is a morning alarm".[854]

The fashion for the night clock persisted until the end of the seventeenth century, but for the most part, even during the later years, continued to be limited to the homes of the wealthy and patrons having palatial residences that could accommodate the large size in which generally they were made. A few of modest size suitable for the more modest although wealthy residences were produced. The demise of the palatial night clock came by the end of the century, by which time its novelty had worn off and was replaced by new horological fashions. Other factors that contributed to its eventual loss of favor was the invention of repeating work by the mid-1670s that made them

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[853] Eschinardi, *Centuriae opticae* (1668) 129, 221-222.

[854] Granville H. Baillie, *Watchmakers and Clockmakers of the World* (London: N.A.G. Press, 1929), 229; Henry Havard, *L'horlogerie* (Paris: C. Delagrave, 1893), 63.

redundant, particularly in England where the night clock had been introduced at about the same time.[855] Still another contributing factor was the realized potential hazard in the clock's design, in which a naked flame was enclosed in a wooden case, although there is no record that any night clock suffered from fire damage.

Although few details are known about the later years of Pier Tommaso Campani, he continued to produce elaborate night clocks for princely patrons for the remainder of his life. Among his patrons was Benedetto Pamphilij, who changed his lifestyle considerably after he was elected cardinal, and thereafter he filled his palace with incredible numbers of pieces of fine furniture and furnishings, silver, and other costly items, including clocks. Among those who happily served his exotic tastes was Pier Tommaso Campani. In August 1681, Pier Tommaso billed the Cardinal for four *testoni* and 20 *baiocchi* for having cleaned the great [large] night clock and replaced the pendulum rod and raised the bracelet [*rachialetto*] with a new aperture. Among the clocks in the Cardinal's collection was a night clock of ebonized pearwood measuring 2-1/2 by 2 palms. The copper dial plate, situated between two columns, featured a painting of the allegory of Neptune in a boat upon the sea.[856]

Giuseppe fulfilled commissions for clocks with less and less frequency as time went on, for his priority now had become the production of lenses and telescopes, which kept him fully occupied. Nonetheless, although his astronomical activities had priority, occasionally he still engaged in clockmaking, either to favor a particular patron or to indulge in another invention he had conceived.

By the early 1670s, as the Campani papal patents began to expire, other clockmakers throughout Italy occasionally ventured to produce night clocks, although none managed to duplicate the silent escapements. By the 1660s, the style already had made its way also into England. Grand Duke Ferdinand II had sent an Italian night clock, presumably made by Giuseppe Campani, as a wedding gift to Queen Catherine of Braganza, wife of King Charles II.

It has been speculated that the night clock of the Queen Consort Catherine de Braganza would had been one of relatively modest size for her bedside. It may have been the one that later became the property of a British peer, which did not have a silent escapement movement, and the movement is not signed. It is presumed to have been made by either Giuseppe or Pier Tommaso Campani before the invention of the crank lever escapement. In operation quite noisesome, it is equipped with a bar balance as regulator instead of a pendulum.

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[855] See: Rare Charles II Ebonized Night Clock, circa 1670 (n. 374), in Sotheby's auction catalogue: *Clocks, Watches, Wristwatches, Barometers and Scientific Instruments* (London: Sotheby's, 1990): London, Thursday 10th and Friday 11th May 1990.

[856] Lina Montalto, *Un mecenate in Roma barocca: il Cardinale Benedetto Pamphili (1653-1730)* (Firenze: Sansoni, 1955), 200.

The clock is housed in an elaborate case veneered throughout its outer surface with tortoiseshell over gold leaf, with ebony trimming, and having mirrored panels at both sides of the clock case. The dial plate is framed on each side by twisted columns having gilt bronze capitals and bases. The openings of the dial plate are of the early period of the Campani night clocks. The dial painting in oils on copper is in the style of Francesco Trevisani. The subject features the seated Three Fates weaving the Thread of Life while a naked Chronos, or Father Time, hovers overhead threatening to cut the Thread with his scythe. The relatively small size overall of the clock confirms that it was intended to be used close beside the bedside, where the lighted dial would be readily visible, and not to be observed from the reaches of a palatial bedroom. The clock's small size and the unusual elaborate tortoiseshell decoration of the clock case appear to be further confirmation to suggest that it may have been intended for a feminine owner.

This may have been the particular clock, mentioned in the diary of Samuel Pepys, that inspired several of the most notable English clockmakers of the period, including Joseph Knibb, Thomas Tompion, and Edward East, to develop a typically English version of the night clock and to produce examples that have survived.[857]

The marriage of King Charles II and Catherine took place on May 14, 1662, and 2 years later, Samuel Pepys noted in his diary that he had seen her night clock in her bedroom on June 24, 1664:

> After dinner to White Hall; and there met with Mr. Pierce, and he showed me the Queene's bed-chamber, and her closett, where she had nothing but some pretty pious pictures, and books of devotion; and her holy water at her head as she sleeps; with her clock by her bed-side, wherein a lamp burns that tells her the time of the night at any time.

For many years after her widowhood, Queen Catherine remained in England among her many friends, to whom she frequently presented substantial gifts. It is possible that her night clock had been such a gift to a loyal friend among the aristocracy. The clock was one of several owned in an estate in Canterbury that had been damaged by German bombing during World War II. It had been taken by the owner to a London clockmaker, presumably for repair, but left without instructions. Eventually the owner, identified only as a wealthy member of the peerage, gave permission to dispense of the damaged clock by sale.[858]

Meanwhile, in his later publications, Matteo had no hesitation in claiming one or several of Giuseppe's achievements as his own, including the controversial lens grinding lathe. This tendency

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[857] "The clock measures 38 inches to the top of the finial, 25 inches in width, and 10 inches in depth": Pepys, *Diary*, vol. 1, 165; Lillias Campbell Davidson, *Catherine of Bragança, Infanta of Portugal & Queen-Consort of England* (London: Murray, 1908).

[858] [Scientific Editor 2: Unknown source of information, perhaps to be found among Bedini's private correspondence].

of Matteo to preemption was obvious and noted by the historian Giovanni Mazzuchelli. About Giuseppe Campani, he wrote that: "He distinguished himself in his time in studies of mechanics; and for some of his inventions, that were by others contrasted, as we will subsequently say, he became noted in the republic of letters. He had a brother by name of Don Matteo, of whom we will speak later. . . ". After describing Giuseppe's *Ragguaglio*, Mazzuchelli added: "Our Giuseppe in this small work boasts of having discovered a lathe of his own invention, for working and polishing lenses perfectly for telescopes; this was a matter of grave concern with Matteo his brother, who pretended to have been he who was the inventor, and to have been the first to concede to the same Giuseppe the favor of demonstrating that he was the author, and to publish this small work, but then finding himself badly *repaid***,** with a stamped sheet gave notice of the truth, and behind this wrote also a handwritten Manifest seen by us communicated to us in 1753 by Carlo Antonio Janzi, who advised he had preserved it in pen in Milan at the home of Mr. Abbot Antonio Francesco Roggeri". In his entry for Matteo Campani, Mazzucchelli wrote, "From his pretensions to discoveries, published by his brother Giuseppe, we have said all that is necessary in our article about the latter".[859]

Despite his developing estrangement from Giuseppe, Matteo nonetheless had managed over the years to achieve wide recognition in the scholarly world of Rome and Florence. His constant intimate association with many members of the Jesuit faculty of the Collegio Romano provided a link to other scholarly and academic communities. In Florence he had developed an intimacy with Vincenzo Viviani and was well-acquainted with Francesco Redi, chief physician to Grand Duke Ferdinand II and later also to Cosimo III. Matteo also had been associated with him in his experiments, as was confirmed in Redi's works. Redi wrote:

> Many other and similar attempts I have shown in other times to very many valiant men, among whom I could name several priests of your venerable Society of Jesus, and in particular the most famous Portuguese preacher Father Antonio Veira, Father Adam Adamando celebrated professor of mathematics, Father Erasmus Scales, and Father Anton Michele Vinci, lecturer on theology and philosophy in your Florentine College, and finally Signor Matteo Campani the Virtuoso very well known by all the *letterati* of the world for his most noble and useful inventions.[860]

[859] Biblioteca Apostolica Vaticana, *Vat. Lat. 9623*, fols. 403v, 404r-v, 405r, *Vat. Lat. 9624*, fols. 142v, 143r. The entries for the Campani brothers remained among Mazzuccelli's unpublished manuscripts. Count Giovanni Maria Mazzuchelli (1707–1765), Italian biographer and literary historian, was known particularly for his literary encyclopedia *Gli scrittori d'Italia: cioé notizie storiche, e critiche intorno alle vite, e agli scritti dei letterati Italiani* (Brescia: Bossini, 1758), vol. letter B.

[860] Francesco Redi, "Esperienze naturali," in *Opere di Francesco Redi gentiluomo Aretino, e Accademico della Crusca*, vol. 2 (In Venezia: Per Gio. Gabbriello Ertz, 1712), 8–9. Francesco Redi (1626–1697/8) was a biologist and entomologist, head physician and superintendent of the ducal pharmacy at the Medici court, and member of the Accademia del Cimento. As a biologist he pioneered in the study of helminthology, and his work on the reproduction of insects greatly impressed his contemporaries. [Gillispie, *Dictionary of Scientific Biography*, vol. 11, 341–42].

Among other figures occupying significant roles at the Medici court of Grand Duke Ferdinand II but about whom relatively little is known was Count Annibale Bruto della Molara. His name occurred infrequently except for occasional mentions in a biography of Grand Duke Ferdinand II, and as the equerry who frequently transmitted communications from the Grand Duke to Viviani, often relating to Matteo and Giuseppe Campani.

Described as exceedingly handsome, at various times Bruto Della Molara was given the titles of Count and Cavalier (Knight). One day, some time after the Grand Duchess Vittoria della Rovere had given birth to a child, she discovered her husband passionately diverting himself sexually with one of his pages of honor, none other than Count Annibale Bruto della Molara. As a consequence, she forbade her husband access to her quarters, and 18 years passed during which the Grand Duke's efforts to return to his wife's favor proved to be in vain.

Throughout this period, the Grand Duke was accustomed to rove about the city after nightfall accompanied by Bruto della Molara and other young men of the court whom he selected as a guard for his person and whom he had chosen because they shared like inclinations. They often spent the night hours roaming together around to various houses where there were beautiful women and single women, with whom Bruto in the presence of the Grand Duke diverted himself, although not with spinsters who may become pregnant. Bruto enjoyed special privileges, and even was provided with sleeping quarters in the personal apartment of Prince Leopold, and he served as liaison between the Grand Duke and other members of the court. He frequently brought messages in person or in writing from the Grand Duke to Viviani, for example, often relating to Giuseppe Campani's clocks and instruments.

The Grand Duchess knew no forgiveness, and the domestic situation remained coldly unresolved. Eventually the Grand Duchess prevailed upon a learned Jesuit in San Lorenzo to preach a sermon during the Lenten season on the sin of sodomy. As a consequence, as was reported, although for 36 years until then Bruto had been a favored "red page" in ducal favor, he now became a "black page".[861]

Giuseppe Campani's association with the Medici princes, meanwhile, continued unabated, with more commissions forthcoming for lenses and telescopes of greater observing power. Undoubtedly, some were for the diversion of the Grand Duke and Prince Leopold, while others were intended for observation and experimentation by members of the Accademia del Cimento. Nonetheless, at the same time his mind remained alert for new dimensions in time measurement that might lead him into as-yet-unexplored adventures in time.

[861] Walter Bernardi, *Il paggio e l'anatomista: scienza, sangue e sesso alla corte del granduca di Toscana* (Firenze: Le lettere, 2008), 76–78.

Meanwhile in London at the Royal Society during this period, the secretary, Henry Oldenburg, had become increasingly interested in developing communication between the Royal Society and savants and others engaged in scientific activity in foreign countries, and he urged Englishmen abroad to cooperate in this endeavor. In January 1669 in a letter to John Dodgington, secretary to the English ambassador to the Republic of Venice, Oldenburg suggested that in addition to calling upon distinguished men of science in Milan, Florence, and elsewhere, Dodgington was "to make acquaintance at Rome with the two famous Artists of Telescopes and Microscopes, Eustachio Divini and Giuseppe Campani, and to inquire among intelligent persons, which of those two excels in the working of Optick Glasses, and to bring over [back to England] two telescopes of ye same length, one from each of those Masters". He also was to visit and convey his greetings to various others in Rome, among them the journalist and publisher Nazari and the scholars Ricci and Gottignies.[862]

Dodgington responded in due course, "I shall send you 2 Telescopes & 2 Microscopes of the Sri. Eustachij Divini & Giuseppe Campani, with such other Curiosities as Padre Kircherus [Athanasius Kircher] will impart to me".[863]

On January 30th, Dodgington wrote again, noting that he was awaiting Oldenburg's instructions and selection:

> Yr Instructions touching Prospectives & Microscopes I have perused & have this acct. Both Eustachiij & Campana doe work them in Perfection; as well one as t'other. But I cannot send you any without particular direction, upon yr Consideration thereof.
>
> There are 3 sorts of Prospective Glasses. One from 20 to 50 Palmes; These are for the Heavens, Planets & some with 2 Glasses others with 4. These cost from 80 to 250 Crownes a peece, without the Case, wch is Generally made in the place where they are to be used.
>
> For Terrestrial objects there are of 2 and 4 Glasses from 35 to 100 Crownes. Those of 2 Glasses only, are little used, and serve only for small perspectives, and yet these are esteemed at about five & twenty shillings a peece. Microscopes with several Glasses, are from 18 to 50 Crownes".[864]

Still anxious to determine the superiority of the instruments by one of the Italian makers over the other, 2 years later Oldenburg wrote to Cassini inquiring which of the telescopes were superior, those of Campani or of Divini, to which Cassini replied: "Actually we so much prefer this telescope of 35 feet which we have from Campani over the telescope of 36 feet which we have from Divini, so that we use the former and lay the latter aside except when we have need of two telescopes of almost equal size and not very disparate quality".[865]

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[862] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 6, 421–23: letter 1364, from Oldenburg to John Dodgington on January 10, 1669/70, and vol. 7, 411-12: letter 1605, from Dodgington to Oldenburg on January 23, 1670.

[863] Ibid., 381-83: letter 1591, from Dodgington to Oldenburg on January 23, 1671.

[864] Ibid., 405-06: letter 1602, from Dodgington to Oldenburg on January 30, 1671.

[865] Ibid., vol. 10, 266-67: letter 2347, from Oldenburg to Cassini on September 29, 1673; Ibid., 317-18: letter 2373, from Cassini to Oldenburg on October 29, 1673.

Oldenburg was just as interested in what was happening in France, and in 1675, he received a letter from Justel, reporting about the optical instrument maker Phillipe Claude Le Bas, "Optician to the King", who maintained a shop in the Galleries of the Louvre. Justel wrote: "There is here a good lens maker named Le Bas who has made a microscope not so long as one's hand which is better than those of Divini and Campani, which are very big. Only the field is smaller; it goes into one's pocket very easily".[866]

[866] Ibid*.,* vol 11, 453-55 : letter 2722, to Oldenburg from Justel on August 12, 1675; Daumas, *Les instruments scientifiques*, 100.

Chapter XVI

PERPETUUM MOBILE

(1668–1700)

O speculators about perpetual motion, how many vain chimeras have you created in the like quest? Go and take your place with the seekers after gold.

Leonardo da Vinci[867]

It was inevitable that in the course of the years, as Giuseppe Campani explored innovative means of time-telling, that he would be tempted to experiment with a rolling ball as a form of time measurer. The principle of a rolling ball clock has an interesting history, long predating Campani's involvement with them. It was one of a wide range of timekeeping devices that were attempted, some of which were successful, for measuring time by counting events that were periodically repeated, such as the movements of celestial bodies, which have been used as systems of reference from the dawn of civilization. Even the period of a day, the shortest period known to astronomers, is much too long to be an adequate division of time for daily life. When compared to such historic examples as the water clocks of the ancients, for example, the rolling ball time standard appears to have been a logical development. Historically, it may be said to have preceded the appearance of the verge escapement of medieval clocks.

It may be said that the concept of perpetual motion has perpetually maintained a strong appeal not only for the illiterate and irrational but for the venturesome as well. It was a principle investigated and applied by practical men of science as well as amateurs as the Renaissance period was nearing its end. It was a time standard that had been introduced as a new principle in engineering much earlier than was hitherto assumed. It had been not only a theoretical speculation of several sophisticated technical writers but also had in fact been investigated and applied by practical men of science in the form of several devices that took the form of timepieces. Although it has been suggested that the rolling ball time standard might have been based upon Galileo's experiments with the properties of bodies moving on an inclined plane, rolling ball clocks in fact had been produced long before his time. The principle was utilized not merely for amusement in fashionable circles, but also by practical men of science and mechanicians near the end of the Renaissance period in serious research for new sources of power. Consequently, it is not surprising

[867] Leonardo da Vinci, *Forster Bequest Manuscript II*, fol. 92v, Victoria and Albert Museum.

that many attempts were made in the past, particularly in the seventeenth century, to achieve perpetual motion by horological means, although it far exceeded the sphere of horology inasmuch as a ball rolling down an inclined plane had been introduced as a new principle much earlier than it has hitherto been assumed.

The use of the rolling ball principle as a time standard was based upon the production of constantly repeated equal intervals of time. In horological attempts, instead of a balance or pendulum, it featured one or more crystal or metal spheres or balls continuously descending along a spiral track, and in this manner apparently providing motive power for the timepiece. Inasmuch as the movement in rolling clock timepieces operated in absolute silence and was concealed within a clock case, it was possible for an observer to imagine that the movement was motivated only by the movement of the balls, and that in fact perpetual motion has been achieved.

After a specific principle had been formulated, as expected, inventive minds sought to develop it for practical application, as with clockwork. Not to be overlooked is that the popularity achieved by rolling ball clocks was because they also served as attractive diversions. They were conversation pieces, desirable possessions, and useful as expensive gifts intended for eminent patrons. Because of their cost and their rarity, these toys for adults frequently also became symbols of status and were prominently featured in *Wunderkammern* and cabinets of curiosities.[868]

The rolling ball time standard operated as the time standard in a number of timekeepers that were produced first in Germany and later in England before Campani ventured to experiment with the principle. It was a concept that particularly had intrigued various contemporary German clockmakers and became the objective of some of the ingenious mechanisms they devised. It is conceivable also that the Kircher Museum in Rome featured some models or original unusual timepieces or mechanical devices that Campani may have seen during visits to the Collegio Romano. Some time later, Matteo's friend Francesco Eschinardi also became preoccupied by the rolling ball time standard and subsequently published on the subject.[869]

Although it was unlikely that Giuseppe Campani had seen any of these devices, he may have read about them, or he may have seen drawings, perhaps in one of the several works by the Jesuit polymath Gaspar Schott in which he described and illustrated a variety of mechanisms and time measurers. A German Jesuit teacher of moral theology and mathematics who had studied in Rome with Kircher, Schott lived most of his life in Augsburg. He carried on an extensive

[868] Hans von Bertele, "The Rolling-Ball Time-Standard," *La Suisse Horlogère* (1956): pt. 1, 63-72; pt. 2: 67–78; Hugo von Bertele, "On the 'Perpetuum Mobile,'" *NAWCC Bulletin* VII, no. 65 (October 1956): 278–83.

[869] Francesco Eschinardi, *De impetu tractatus duplex: primus de impetu in communi: de motu locali: et de machinis : secundus de fluidis in communi: decomparatione fluidorum cum solidis: et de mensura aquarum currentium : additur in fine, quamplurium problematum, seu quaesitorum solutio ex doctrinis praecedentibus* (Romae: Ex typographia Angeli Bernabò, 1684), 144.

correspondence with the leading men of science in his time. In addition to other works, in 1657 he published *Mechanica Hydraulico-Pneumatica*, followed by *Magia Universalis Naturae et Artis* in 1659 and *Technica Curiosa* in 1664. These publications served as a mine of curious facts and observations and were much read in his time. Featured in each of the ones mentioned were descriptions of timepieces, generally taken from other unidentified sources.[870]

Particularly replete with them was *Technica Curiosa*, a title that may be partially translated as “Technical Curiosities” or “Artificial Wonders”, comprising twelve books. A great number of horological movements, their sources not identified, are described and illustrated in the one entitled *Mirabilia Chronometrica, sive Technasmata varia ad Temporum Dimensionem Mehcanicam Spectantia*. Few of the descriptions and illustrations have been totally deciphered, and the talent of his illustrator is seriously questioned.

In Libri IV of *Mirabilium Mechanicorum,* Schott described a clock or perpetual motion mechanism attributed to a priest, Wilhelm Schroeter. Six balls are fed into a trough at the top of the clock cabinet, which drop one at a time upon a wheel made with cup-like receptacles. As the wheel turns, the balls are dropped by gravity from the wheel into a tube that feeds them to another wheel also having cup-like attachments. The balls progress from that wheel to yet another through a tube to a second and then a third wheel. From this point, the balls fall into a horizontally placed tube along which they roll to a second train having three wheels. The balls are picked up by the bottom wheel and brought again to the top of the movement in reverse order, to begin their journey anew. The continuous motion of these wheels is intended to operate a two-wheel train at the front of the movement to indicate the time.

Schott described and illustrated two other rolling ball timepieces. One appears to consist of a winding device with an endless belt. Balls were introduced through a chute-like opening and held and moved on a continuous belt having attachments at regularly spaced intervals. The balls were carried through a tube between these attachments, to finally escape at the base of the movement.[871]

As noted, the earliest examples of record relating to the principle of the rolling ball clock appears to have been successful achievements resulting from the dedicated preoccupation of several talented German clockmakers and were produced for notable state figures in the early decades of the seventeenth century. Particularly interesting were ornate table clocks made by Christoph

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[870] Gaspar Schott, *P. Gasparis Schotti ... Mechanica hydraulico-pneumatica, qua praterquam quod Aquei elementi natura, proprietas, vis morix, atque occultus com aere conflictus, a primis fundamentis demonstratur ; omnis queque generis experimenta hydraulico-pneumatica ...* (Francofurti: Excudebat Henricus Pigrin, 1657); *P. Gasparis Schotti Regiscuriani e Societate Jesu ... Magia universalis naturae et artis.* (Frankfurt a.M.: Sumptibus Haeredum Joannis Godefredi Schönwetteri Bibliopol. Francofurtens., 1659); *Schott, Technica curiosa.*

[871] Ibid., figure 25.

Margraf between 1595 and 1604 for Emperor Rudolph II, "which, in place of a balance, has small rolling balls".[872]

An example of considerable merit was the so-called "Tower of Babel". Made in 1600 by Hans Schlottenheim of Augsburg, it was constructed in the form of an octagonal wooden tower, approximately 4 feet in height, and heavily ornamented in gold and silver. Originally intended for Emperor Rudolph II, in 1602 it was acquired instead by the Elector Christian II of Saxony.

In addition to its elaborate decoration, the timepiece was noted for its remarkable system by means of which a series of eight to twelve rolling balls provided a time standard, one of which always was waiting at the top of the track. When released, each ball required exactly 1 minute to complete its journey downward, where it shifted a pin that released the movement before it dropped into a pocket on an elevator that brought it to the top. At the same moment that the movement was released, another ball waiting at the top began its journey, the elevator moved up a step, and another ball appeared at the top. As the dial mechanism advanced 1 minute, the figure of Saturn struck a bell. The Tower of Babel clock was destroyed in the Allied bombing of Dresden in World War II. A similar clock, now in the Herzog Anton Ulrich Museum in Braunschweig, had been produced in 1601 for Duke August the Younger of Braunschweig by Christof Rohr, a clockmaker from Leipzig.[873]

Undoubtedly among the finest examples in this genre are three such clocks produced by the clockmaker Nicholas Radeloff of Schleswig. Appearing suddenly in Denmark at the end of the Thirty Years War, he found employment at Castle Gottorp near Schleswig, where he worked for the next two decades until 1668. Radeloff made a lavish use of precious materials for ornamentation and developed an unusual automatic ball replacement system. Little is known about his personal life. One of his clocks is in the treasury of the Danish kings at Rosenborg Castle near Copenhagen and another came to light in the Danish National Museum.[874]

In succeeding decades of the seventeenth century, other German clockmakers found it profitable to experiment with the rolling ball time standard. Among the surviving examples is one known as "the Singing Bridge" made in 1674 by Matthaeus Halleicher of Augsburg. Constructed in the form of a bridge 4 feet 7 inches in length and 2 feet in height, the movement is housed within a clock case 11 inches in height situated at the center and featuring a clock dial with a single hand. The open side of a channel on the bridge portion faces outward and contains two parallel steel wires stretched to slope downward from right to left, along which a steel ball runs slowly at regular

[872] Feldhaus, "Kugellaufuhren"; Erwin Neumann, "Christopher Margraf and the Invention of the Rolling Ball Clock," *La Suisse Horlogère*, no. 1 (1958); "Christoph Marggrav" May 8, [prior1595], State Archives, Dresden.

[873] Bertele, "Rolling-Ball Time-Standard", pt. 1, The Tower of Babel, 69–71.

[874] Ibid., 71–72, re. Nicolas Radeloff.

intervals. The steel wires are tuned to musical notes to produce a pleasant singing sound. As the ball reaches the lower end of the channel, it rolls off the wires into one of several cups fitted to a conveyor running the entire length of the clock. As the ball drops into the cup, its impact releases the movement, which shifts the belt sufficiently far to deposit another ball at the upper end of the wire track, and at the same time the clock hand moves forward. Each ball requires one quarter of a minute to run down the track.[875]

One of the most interesting surviving examples of a rolling ball clock was made by Martin Gerdts, now in the Hessischen Landesmuseum in Kassel. Gerdts was a clockmaker working in Hamburg during the second half of the seventeenth century.[876] He made his timepiece in the form of a metal chest, supported upon bronze feet adjustable for leveling, and its outer surface was ornamented with various types of decoration. Upon lifting the lid, the inside of which is mirrored, an elaborate panel composed of several elements comes into view. The central feature actually forms the chest's cavity and is a representation of the Nativity scene executed with gilt figures. An ox and a donkey appear in the window openings at either side, and the Star of Bethlehem moves as the timepiece strikes. Six panels painted in oils upon copper with Biblical events frame the central scene, depicting Jacob's Ladder, Adam and Eve, David with his harp, and angels playing musical instruments.

Fixed between glass panels directly over the Nativity scene is a zigzag path made of fine steel wire along which small brass balls roll, rather similar to one later described by Grollier de Serviere. The strong spring-driven movement with its striking and chiming mechanism returns the balls to the starting point. Upon completing its run along the zigzag path, each ball falls into a bucket attached to one end of a counterpoised lever. Its fall releases a detent, and the spoon lever, which already is in position, swings upward and carries the ball into a trough at the path's beginning, where it is ready for its next descent.[877]

Undoubtedly among the most impressive in size of the rolling ball clocks was the literally gigantic timepiece of the Vienna Arsenal. According to an account written by a clockmaker who repaired it in 1770, the clock had been built in 1702 by Christoph Schöner of Augsburg. As represented in a surviving contemporary engraving, the fourth tier of the clock case contained a rolling ball mechanism. Surviving is a fairly comprehensive record of its history from 1700 until February 15, 1810, at which time the clock was sold at auction to S. M. Rothschild. Nothing more is

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[875] Ibid., pt. 2, Singing Bridge, 773–74.

[876] Hallo, "Von alten Uhren im Hessischen Landesmuseum und von der Uhrmacherkunst in Kassel".

[877] Silvio A. Bedini, "Perpetuum Mobile," *NAWCC Bulletin* 7, no. 2 (February 1956): 83. [Scientific Editor 2: Bedini received a description of the clock from Paul Adolf Kirchvogel, chief curator (*Abteilungsleigter*) of the Hessischen Landesmuseum of Kassel on August 22, 1952. See in Silvio Bedini's private archive].

known of it after that time. The old Rothschild family records were destroyed during the Nazi occupation of Vienna, and none of the surviving members of the family had any knowledge of the timepiece.[878]

In 1649, one of these elaborate German rolling ball clocks was presented as a state gift to King Charles I of England by an unidentified German prince. The earliest references to it occur in Great Britain's *State Papers, Domestic, 1653*. This was in one of two receipts taken from the Jewel House in Whitehall shortly after King Charles I was beheaded. The receipt listed a number of timepieces among the personal property of the late monarch:

18 die Feb. 1649. Rec'd. one clocke with divers mocions, two globes, one case for a clocke and a glasse, one Bullet Clocke, one clocke with five bells, and one other clocke, all which were lying in Whitehall late in the charge of David Ramsay.[879]

David Ramsay, one of Britain's earliest watchmakers, had served first under James I as Keeper of His Majesty's Clocks and Watches. His appointment continued under the royal successor Charles I and in circa 1627, he was designated his "Page of the Bedchamber and Clockmaker".[880]

It was not until several years later that a published mention of this historic timepiece appeared; it was noted in the work of the English diarist John Evelyn. In an entry for February 24, 1654–1655, reporting a visit to Court, he wrote:

I was shew'd a table clock whose ballance was onely a chrystall ball sliding on parallel wyers without being at all fixed, but rolling from stage to stage till falling on a spring concealed from sight, it was thrown up to the upmost channel againe, made with an imperceptible declivity, in this continual vicissitude of motion prettily entertaining the eye every halfe minute, and the next halfe giving progress to the hand that shew'd the houre, and giving notice by a small bell, so as in 120 halfe minutes, or periods of the bullets falling on the ejaculatory spring, the clock-part struck. This very extraordinary piece (richly adorn'd) had presented by some German Prince to our late King, and was now in the possession of the Usurper, valued at 200 £.[881]

The identity of the clock's princely German donor was never resolved, but it is probable that he had been the nephew of the English King Charles I, young Prince Rupert, Count Palatine of the Rhine and Duke of Bavaria (1619–1682). He had paid his first visit to England in 1636 as the protégé of his royal uncle. Following extensive travel in Europe, he had returned in 1642 for a second visit to London to see his uncle. After a military career as nominal commander of the King's

[878] Ibid., 83-85; Bertele, "On the 'Perpetuum Mobile,'" 283.

[879] F. J. Britten, *Old Clocks and Watches and Their Makers: A Historical and Descriptive Account of the Different Styles of Clocks and Watches of the Past in England and Abroad, Containing a List of Nearly Fourteen Thousand Makers*, ed. Granville H. Baillie, 7th ed. (London: Spon, 1956), 161.

[880] Ibid., 160.

[881] John Evelyn, *The Diary of John Evelyn*, ed. Austin Dobson (London: Routledge/Thoemmes Press, 1996); Edward J. Wood, *Curiosities of Clocks and Watches from the Earliest Times* (London: Richard Bentley, 1866), 98. John Evelyn (1620–1706) was from a wealthy landowning family founded on the manufacture of gunpowder. During the Commonwealth period, he traveled extensively in Italy and France and, after returning to England in 1652, he became a participant in the Royal Society and in coffee-house life. His diary, although sometimes written after the events it records, is a valuable record of his times.

army until the close of the first civil war in 1646, and after the Restoration, he settled permanently in England. Another possibility is that the donor may have been the brother-in-law of King Charles I, young Rupert's father, the Elector Palatine Friedrich V and "Winter King" of Bohemia, who had married the king's sister.[882]

The next contemporary reference to this royal timepiece occurred 5 years later in the famous diary of Samuel Pepys. Under date of July 28, 1660, he reported that he had gone "to Westminster, and there dined with Mr. Sheply and W. Howe, afterwards meeting with Mr. Henson, who had formerly had the brave clock that went with bullets (which is now taken away from him by the King, it being his goods)".[883]

This rolling ball clock, also referred to as a "bullet clock", passed from the king's possessions into the hands of Sir Oliver Cromwell. After the latter's death in 1658, presumably it was inherited by Richard Cromwell, his son, who succeeded him in office. After Cromwell's departure from England, Charles II, who had been proclaimed king on May 8, 1660, was returned to the throne by May 29. In the interim, the clock apparently had been acquired by a Mr. Henson, from whom it was confiscated and subsequently restored to its rightful owner.[884]

In England, the application of the principle of the rolling ball to clockwork was not to be limited to the seventeenth century, apparently, and several examples produced in the eighteenth and nineteenth centuries are particularly of note. A rolling ball clock that was in fact a bullet clock was the invention of Humphrey Gainsborough, brother of the celebrated society artist Thomas Gainsborough. A Nonconformist pastor in the Independent Church in Henley-on-Thames, Humphrey Gainsborough achieved recognition as an inventor, winning a prize in 1761 from the Society for the Encouragement of Arts for the invention of a tide mill and another prize in 1766 from the Royal Society for his invention of a drill plough. Among his other engineering activities was the construction of bridge works and locks in the Thames River. In the course of his experimental work, he had shown a model of a condensing steam engine he had devised to James Watt, and it has been speculated that Watt incorporated some of Gainsborough's ideas on his improvements of the Newcomen atmospheric engine. Gifted but unassuming, Gainsborough never achieved the degree of recognition he deserved for his engineering achievements and inventions.[885]

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[882] Ian Roy, "Rupert, Prince and Count Palatine of the Rhine and Duke of Cumberland (1619–1682), Royalist Army and Naval Officer," ed. H. C. G. Matthew and B. Harrison, *The Oxford Dictionary of National Biography* (Oxford: Oxford University Press, September 23, 2004), http://www.oxforddnb.com/view/article/24281; Editors of Encyclopaedia Britannica, "Prince Rupert: English Commander," *Encyclopaedia Britannica*, accessed June 25, 2018, https://www.britannica.com/biography/Prince-Rupert-English-commander.

[883] Wood, *Curiosities of Clocks and Watches from the Earliest Times*, 99.

[884] Ibid.

[885] Silvio A. Bedini, "Rolling Ball Clocks in England", *Horological Journal* C1, no. 1215 (December 1959): 778–84; George H. Peters, *The Life and Work of Humphrey Gainsborough: Engineer, Inventor and Congregational Minister at Henley-on-Thames, 1748-1776* (Henley: [s.n.], 1948); George Williams Fulcher, *Life of Thomas*

Gainsborough produced at least one other time measurer in addition to his bullet clock, and possibly several more. According to the contemporary inventor Richard Edgeworth, speaking of Gainsborough, he stated, “He was, besides, an excellent workman, and he had early trained his thoughts to the construction of timepieces for ascertaining the longitudes”. In spite of Edgeworth’s statement, no documentation has survived relating to Gainsborough’s efforts in this aspect of timekeeping, but he did produce another timepiece, which was described by Thicknesse in a letter to *The Gentleman’s Magazine*:

> Another curious and most expensive work of his, I had the honour to present to the British Museum, in hopes of depositing it where it may remain as long as brassd can endure, And, as it may be seen there, I will not attempt to describe what I had not the capacity to conceive, the manner of perfectly using: it is, however, a sundial, on a brass claw, which points the time to a second in every part of the globe [. . .].[886]

The dial was deeply inscribed with Gainsborough’s name, but no additional description is known. Although the Museum’s records indicate that it was accessioned on October 29, 1784, the dial disappeared from the collections at some time in the nineteenth century.

The Reverend Gainsborough’s achievements reached public notice primarily through the efforts of Philip Thicknesse, a close friend of the Gainsborough family. Thicknesse, described as an author and eccentric, rose to the rank of captain in the British Army and served as lieutenant governor of Landguard Fort, near Harwich. He frequently contributed to *The Gentleman’s Magazine* using the pseudonym “Polyxena”.[887]

In a letter to *The Gentleman’s Magazine* dated November 14, 1785, almost a decade after Gainsborough’s death, Thicknesse recorded the memory of his friend as “one of the most ingenious men that ever lived, and one of the best that ever died. Perhaps of all the mechanical geniuses this or any nation has produced, Mr. Gainsborough was the first.” And then Thicknesse then went on to describe Gainsborough’s invention of a rolling ball clock:

> I have a clock of his making in my possession, and which I have seen go with accuracy, though all the parts were not finished, (for if it had, it would have been a perfect perpetual motion), that is, a wonderful piece of mechanism, every part of which was made by his own hands. It is a pendulum clock, in which a tin box is charged with a certain number of musket bullets. When the clock goes, a little ivory basket appears loaded with one of them, and having slowly descended to the bottom of the case, it is so received there as to open a valve and discharge the load. It then ascends empty to the clock, and there receives a fresh charge, and thus goes till it has expended the whole of the original ammunition; and had the ingenious artist lived, I perceive there are inactive wheels which were designed to fetch up the bullets, and do what now must be done by hand [. . .].[888]

Gainsborough [...], ed. Edmund Syer Fulcher (London: Sudbury, printed, 1856).

886 Philip Thicknesse, “A Letter to the Earl of Coventry”, *The Gentleman’s Magazine, and Historical Chronicle* 55, no. 2 (1785): 555.

887 James Gillray, *Philip Thicknesse Esqr* (London: James Ridgway, 1790); Wood, *Curiosities of Clocks and Watches from the Earliest Times*.

888 Letter from Philip Thicknesse, *The Gentleman’s Magazine* (November 14, 1785).

Gainsborough's invention was in actuality a bullet clock in the true sense of the name, although in English accounts, the rolling balls or spheres employed for the time standard frequently were referred to as "bullets" even when they were not in fact. Evelyn, for example, described the rolling ball clock of King Charles I as having a crystal ball. Additional details about Gainsborough's "bullet" clock were provided in *The Gentleman's Magazine* by an anonymous but well-informed contributor during the following year:

> The inactive wheels were, as he [Thicknesse] rightly imagined, intended to fetch up the bullets by means of a vane, which was to have been kept in motion by a current of air directed against it; but Mr. Gainsborough was too sensible a man, and too good a mechanic to dream of forming "a perfect perpetual motion"—just such a perpetual motion as this would have been, are the new-invented watches which require no other power to keep them going than motion which is communicated to them by the play of the thigh in walking.[889]

During the last years of his life, Gainsborough suffered poor health, particularly after the death of his wife in 1775. He died in the next year, on August 23, 1776, while on his way to a dinner engagement with friends. Some time later, his brother Thomas, the artist, presented the clock as a gift to Thicknesse. A decade or more later, on December 6, 1788, Thicknesse donated the timepiece to the British Museum. With the passage of time, however, the clock no longer could be found in the Museum collections, nor has it come to light since then. All that survives in the Museum files relating to it is a small pen-and-ink sketch of the clock made by Gainsborough. The sketch, which provides a view of its outer appearance, had been contained in a letter dated November 22, 1788, from Thicknesse to Dr. Morton of the British Museum.[890]

Additional details of the mechanism of Gainsborough's bullet clock were provided by E. J. Wood in his book *Curiosities of Clocks and Watches* published almost a century later. The Gainsborough clock, he wrote:

> told the hour by a little bell and was kept in motion by a leaden bullet, which dropped from a spiral reservoir at the top of the clock into a little ivory bucket. This was contrived so as to discharge it at the bottom, and by means of a counterweight it was carried to the top of the clock, where it received another bullet, which in its turn was discharged like the former.

Apparently, Wood had personally seen the Gainsborough clock in the British Museum, or had access to other sources, for he provided more details. He reported that the bullet traveled in a spiral path in a reservoir at the top of the clock before dropping into the ivory bucket, coinciding with details visible in the pen-and-ink sketch. He noted that the hour was indicated by the sound of a bell, which was not shown in the drawing. The time elapsed for the completion of the journey of one of the bullets thorough its spiral course coincided exactly with the time required for its descent

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[889] Letter from an anonymous contributor, *The Gentlemen's Magazine* (1786): Henry Dircks, *Perpetuum Mobile; or, search for self-motive power, from the 13th to the 19th century*, London 1890, p. 168.

[890] Bedini, "Rolling Ball Clocks in England."

and return to the ivory bucket, so that as another leaden bullet was discharged from the spiral reservoir, the bucket would be waiting to receive it.[891]

Gainsborough's clock may have inspired other later English inventors, such as William Congreve, who may have seen it at the British Museum and in due course developed his own famous rolling ball clock, which he patented in 1808. Born in 1772, Congreve became equerry to the Prince Regent early in the eighteenth century, and in the same period, he was elected a member of the Royal Society. He was appointed lieutenant colonel of the Hanoverian artillery and eventually became comptroller of the royal laboratory at Woolwich. He achieved note for several inventions, including a war rocket he devised that was used effectively in the siege of Copenhagen in 1807.[892]

In 1808, Congreve patented the horological principle that still bears his name in which a metal ball rolls along a grooved path in an inclined plane moving about the center. The continuous channel followed a zigzag path formed by a series of V shapes joined in succession. The ball travels along the channel until it strikes a release device upon reaching its lowest point in the path. This release, or trigger, unlocks the plate, causing it to change its plane of incline to slope in the opposite direction as the little ball then began its journey anew. Timing was achieved by making the angle of tilt wider or narrower by means of a little eccentric near the top of the movement. The principle of time measurement differed substantially from those based upon the isochronous oscillations of a pendulum or a spring balance combination. As well as can be determined, very few of the original Congreve timepiece were produced, although copies were made in modern times. Probably the most notable surviving example, now in the Rotunda at Woolwich, may have been the prototype produced by Congreve himself. Dated 1808, it was inscribed by Congreve to the Prince of Wales.[893]

The rolling ball principle for time measurement was not to be overlooked in France as well, and notable examples were the work of Nicolas Grollier, Baron de Serviere. One of the later timepieces appears to have had in fact a great resemblance to the bullet clock of King Charles I. This particular Grollier clock was one of several described and illustrated by his grandson Grollier de Serviere more than a half century later in his work published in 1719 entitled *Receueil d'Ouvrages Curieux . . .* or "Collection of Curious Works of Mathematics or Mechanics or Description of the Cabinet of Monsieur Grollier de Serviere".[894]

Grollier de Serviere (1596–1689) joined the French army at the early age of 14 and served first in Italy and later at Prague. His profound knowledge of mathematics and mechanics enabled

[891] Wood, *Curiosities of Clocks and Watches from the Earliest Times*, 99.

[892] Edward Wenham, *Old Clocks for Modern Use* (London: G. Bell & Sons, Ltd., 1951), 80.

[893] Ibid.

[894] Grollier de Servière, *Recueil d' ouvrages curieux de mathematique et de mécanique, ou Description du cabinet de Monsieur Grollier de Servière avec des figures en taille douce* (Lyon: Chez David Forey, 1719), 9–12.

him subsequently to obtain an important position in the service of King Louis XIV. Following retirement from military service, he devoted his leisure to mechanics and to the construction of, among other things, a number of unconventional clocks. Included were several rolling ball clocks. Apparently none of the Baron's clocks that were recorded and illustrated in the volume compiled by Serviere's grandson have survived.[895]

One of the Serviere rolling ball timepieces featured a dome supported by six columns rising from a hexagonal base, which in turn supported a conduit formed of parallel brass strips in the shape of a spiral running down from the dome to the base. Brass balls traveled along the conduit and fell into a trough at the bottom, activating a detent that released a mechanism that returned the balls to the starting point. Another of his clocks featured a bucket-like contrivance that returned the balls from the bottom of the channel and dropped them into a trough at the top of the conduit. A clock in the form of a standing picture frame featured a zigzag conduit supported by the frame along which two brass balls moved down alternately. Upon completion of the journey to the bottom by one of them, the other began its descent.

Serviere's fourth rolling ball clock was in the form of a rectangle having a dome supported by eight columns and a conduit similar to the one already described in the first of his clocks, which was entwined around the four columns at the front of the case. Upon reaching the bottom of the spiral conduit, the ball was conducted to the top of the frame once more by means of an Archimedean screw placed between the two rows of columns, remaining always visible. Two dials in the base indicated the hours and minutes, respectively. All four of these clocks took their power from a spring-driven mechanism concealed in the base.[896]

The theme of the rolling ball clock, after having traveled chronologically from Germany to England and then on to France, next appeared on the horological scene in Italy, where preoccupation with the rolling ball clock was first noted in the later seventeenth century. It is not surprising to discover that it was Giuseppe Campani who appears to have been the first Italian clockmaker known to have actually produced rolling ball clocks. The very first published description of Giuseppe Campani's rolling ball clock appeared in a small tract published in 1668 by his brother Matteo Campani, writing under the pseudonym Antimo Tempera. The slim publication was dedicated to Cardinal Prince Leopold de' Medici. Without indicating his relationship to the maker of the clock, Matteo wrote:

> [W]e have lately heard about the most beautiful and curious clock by Signor Giuseppe Campani, which does not measure time by the turning of its wheels but by means of the perfectly natural continuous descent and

[895] Ibid., Preface and Introduction.
[896] Ibid., figures 37-40.

reciprocal movement of two perfect spheres in turn between two most elegant spirals, and which varies but little in timekeeping when the weather changes.[897]

The citation in Matteo Campani's pseudonymous work established the period of his brother's new invention. It was to be noted that just such a rolling ball clock subsequently was listed among the timepieces owned by the Medici princes in Florence. In the inventory for the year 1692 of the Medici palace furnishings of Grand Duke Ferdinand II and Cardinal Prince Leopold, it was described as:

a clock, or instrument called "perpetual motion," of ebonized pearwood, having a spring, brass wheels, and a dial in front with a single hand, with brass channels over which the balls run in three orders, high "b_a 1-1/15" with covering of similar pearwood where the case that rejects the balls, constructed with a frontispiece having two small vases, also in pearwood, with its covering of red fustian.[898]

That timekeeper is one that has survived and is presently displayed in the Museo Galileo in Florence. It was most recently described in 1929 in a work by Giuseppe Boffito as "a clock apparently of perpetual motion . . . set into motion by a ball, which after having followed a helix in the form of three cylinders, provides the motion by means of its fall to a simple mechanism, in order to be cast anew to the beginning of that helix and in order to indicate on the horary dial the time required for its descent. This continues for as long as the mechanism is wound. The mechanism is enclosed in a tall case of carved wood, with ornaments and gilding. In front is the dial of the clock. The instrument is actually broken".[899]

In a catalogue of the Museum's collections, the timekeeper is described as consisting of a "Fall of weights, three helicals in length. This instrument is attached to a clock which appears to operate with perpetual motion. It has an ingenious arrangement in iron which causes a spring to unbend and fling a small ball into an inclined channel or groove made in the form of a triple helical, which, upon passing from one cylindrical helical to another, returns anew to the spring, and which flings it up to renew its journey. In this manner, the play of balls continues as long as the spring of the movement is wound. The movement is enclosed in a tall case of carved wood with decorations and gilding. In the front of the case is the dial of a clock. The clock actually is not in working order. It seems probable that in recent times the movement was converted from spring operation to weights and was at that time mounted on its tall base or pedestal".[900]

The helical path is open to view and it is possible to see directly beyond it inasmuch as there is no part of the clock case behind it and, consequently, no movement or mechanism. The

[897] Campani, *Oriuolo giusto d'Antimo Tempera,* 11.

[898] "[Inventory of the Medici palace furnishings]" (Florence, 1692), carta 111, Inventario Nr. 985, del Guardaroba Mediceo del anno 1692, Archivio di Stato di Firenze.

[899] Giuseppe Boffito, *Gli Strumenti della Scienza e la Scienza degli Strumenti* (Firenze: Seeber, 1929), 211.

[900] Maria Luisa Bonelli and Pietro Pagnini, *Catalogo degli Strumenti del Museo di Storia della Scienza* (Firenze: Olschki, 1954), 211.

movement is situated below the helix, and it is probable that the descent of the ball at the end of its run directly activates the dial work, thus eliminating the necessity for special gearing. The ball is restored to the top of the channel by being flung from the point at which it has come to rest at the base of the helix to the top through a chimney-like opening. A helix is generally defined as anything having a spiral form, such as the curve formed on any cylinder by a straight line in a plane that is wrapped around the cylinder, as an ordinary screw thread. The weights providing the power by their fall are enclosed in the tall pedestal, which appears to be contemporary in period with the movement.

Although the clock is not signed, and no other documentary records relating to it have been found in the Medici archives, it was eventually attributed by general consensus to Giuseppe Campani, as one of the number of clocks and instruments he produced for the Medici princes in this period. It is proposed that this rolling ball clock in Florence was the first of at least two such time measurers that Giuseppe produced. Probably it was commissioned by Grand Duke Ferdinand II or Cardinal Prince Leopold after having seen and been intrigued by some of the German examples.

In addition to the 1692 inventory listing, the only other documentation relating to the Medici falling ball clock, found in the archives of the Museo Galileo, noted that on August 23, 1797, the cabinetmaker on the Museum staff, Carlo Toussaint of Boboli, replaced certain wooden parts of the clock case made of ebony and walnut, glued other parts, and reconstructed the part of the case through which the weights accidentally had dropped. He then gilded anew the vase-shaped decorations and other parts. The records reveal furthermore that, at the time the timekeeper was restored in 1797, its original spring-driven movement was converted to falling weights. Inscribed inside the column at the base of the instrument, together with the date 1797, are the words, translated from the Italian, "Entirely reassembled […] the cabinet work by the cabinetmaker Pasquale Bassetti and the mechanism by Fe[lice] Gori".[901]

Ignazio Gori has been identified as the mechanician employed as custodian of the clocks in the *Officina* attached to the Hall of Physics of the Royal Museum of Natural History, predecessor of the present Museum of the History of Science, where he was assisted by his brother Felice Gori.[902]

[Figure]

A remarkable example of the rolling ball clock, made and signed by Giuseppe Campani, was the one he produced for the Landgrave Karl of Hesse, whom he had supplied with other clocks as well as telescopes and microscopes. The clock became known as the *Kugellaufuhr* or "Falling Ball Clock". Neither the dates when the Landgrave commissioned or acquired it nor when it was made are known, but it was made some time in the late 1660s, at the time that Matteo had

[901] Bonelli, "Oriolo o strumento detto moto perpetuo."
[902] Morpurgo, *Dizionario degli orologiai italiani*, 84.

announced his brother's invention in his publication. It may have been that it was at about that time that the rolling ball clock now in Florence had been acquired by the Grand Duke. The Landgrave might have seen it during one of his visits to the city and requested one of his own. Less likely but possible is that it occurred at the time of the Landgrave's sojourn in Rome, between December 1699 and April 1700, during which he visited Campani's workshop, although the rolling ball clock is not listed among the Landgrave's purchases made during that visit. At the time of the Landgrave's later travel, both he and Giuseppe Campani were approximately 65 years of age, but Giuseppe continued working until he was 80.

[Figure]

The Campani clock for the Landgrave was encased in a stately cabinet of black ebony, the sides of which were glazed with simple gilt ormolu decoration, including bronze finials and bases of the four columns. A gilt bronze balustrade surmounted it, and featured in the pediment surmounting the cabinet was a gilt bronze chapter ring marked with the hour numerals indicated by a single hand. Flanking either side of the dial was a seated allegorical figure carved in ivory. This clock case was supported upon a large cabinet, also of ebony, having draped wreaths in gilt on the front and sides. The supporting cabinet was a later addition made for the purpose.[903]

The Landgrave's *Kugellaufuhr* presented the appearance of being motivated by means of a brass ball that descended continuously along a helix consisting of eight silver curved rails formed in three coils within the frame of the cabinet, backed by mirrors. Inasmuch as only a single ball was visible at any time, the clock appeared to be motivated by this means. In actuality, the clock was powered by three steel springs forming part of a concealed movement situated within the enclosed case behind the mirrors. The escapement consisted of a bar balance pivoted at its center and attached near the top of the front plate. Each arm of this balance was one-half the distance between the top and bottom of the helical path, or approximately as high as the front plate of the movement. Each arm terminated in a spoon-like receptacle with the opening appearing sideways to the right side. This balance rotated continuously in a counter-clockwise motion in jerks of 180°. Upon its release, its speed was regulated by means of a small governor to which two round sliding weights were symmetrically fitted. Geared to the double-ended spoon balance just described was another smaller balance formed by two wires pivoted at the center and having two round sliding weights, one on each arm, to regulate the speed of rotation. When the weights on the governor were pulled further apart, the clock would operate more slowly, and when they were pushed closer together, the rotation of the bar balance became more rapid. This arrangement was similar in principle to the bar

903 See correspondence with Paul Adolf Kirchvogel in Bedini's personal papers.

balance used by Giuseppe Campani to provide completely silent operation of his crank lever escapement that he utilized in his silent night clocks. **[Figure]**

The *Kugelaufuhr* was made operable by placing one ball into the upper spoon-like receptacle and placing the second ball into the trough at the beginning of the channel into the helical path. The ball ran along the groove of the curved rails, and upon termination of its journey at the bottom of the frame, it fell upon a detent and then into a shallow cavity where the spoon-like end of the bar balance scooped it up and carried it upward. When the ball dropped upon the detent, the spring was activated to move the lower end of the bar balance forward to scoop up the ball, and at the same time moving the upper arm forward to cast the other ball, which was being held in readiness, into the trough at the beginning of the helical path. The ball was brought upward by the spoon-like end of the bar balance to the top of the movement and held in readiness until the other, descending ball, had completed its run, an operation that required exactly 30 seconds. Only one ball was in evidence at any time, giving the appearance that when it had completed its run, it was restored once more to the top of the path by mechanical means within the case. **[Figure]**

The ball emerged slowly, moving along the spiral after having been released from its storage in the upper gallery as the preceding ball left the spiral. The continuous rotation of the bar balance was carried over to the dial work by means of the gearing as shown upon the back plate of the movement. As the bar rotated, the hand on the dial was moved by a train, jumping forward on the dial plate every 30 seconds, and in this manner marking the 30 seconds required by the ball to complete its descent. This mechanism was another example of Giuseppe Campani's famous invention of the crank lever escapement in clocks with geared wheelwork that were entirely silent in operation.[904]

The earliest description of the rolling ball clock in Kassel is a brief mention in the *Uhreninventar*, or "Inventory of Clocks", of the Museum Fridericianum in Kassel for the year 1765, in which it was listed as Item XIII.[905]

Two years later, in 1767, the timekeeper was described in greater detail by Friedrich Christoph Schminke in his work, "Description of the Residence and Capital City—Cassel—of the Illustrious Prince of Hesse". He stated, "The Campani clock is operated by means of two alternating balls which run along inclined brass grooves. As soon as one ball has completed its run, the other ball is released by the double-spoon. When the second ball has completed its run, the spoon drops the first ball into the groove, and this completes another run, and so on. Each ball completes its run

[904] See correspondence with Paul Adolf Kirchvogel in Bedini's personal papers.

[905] Bungarten and Museumslandschaft Hessen Kassel, *Groß gedacht!*, nr. VIII.14, pages 360-63, Inventory. n. APK U 66.

and is ready for another in 30 seconds, and it is by means of this motion that the dial, situated at the top of the clock, is moved forward".[906]

For many years, Campani's *Kugelaufuhr* was a featured exhibit prominently displayed in the main hall of the National Museum in Kassel. Then, during World War II, in late October 1943, just as the museum management, fearing air raids, was in the process of preparing the timepiece for removal to safekeeping, an Allied air raid took place on October 22, 1943. The city of Kassel was heavily bombed, the museum building received a direct hit, and the structure and its entire contents, including the *Kugellaufuhr*, were totally destroyed by fire.

Several days after the bombardment, the disconsolate museum curator, the late Paul Adolf Kirchvogel, who had been a pupil of Alfred Einstein, wrote about how he had wandered through the rubble of the building in a futile search for any recognizable items. He was able to recover only the *Kugellaufuhr*'s clockwork movement, which had been severely damaged and survived only in parts, and several brass decorations of the totally destroyed clock case. Fortunately, also surviving in the museum files was a single photograph of the exterior of the *Kugellaufuhr*.[907] **[Figure]**

Several differences are to be noted between the Medici rolling ball clock and the *Kugellaufuhr* in Kassel. Although in basic concept they resemble one another, the absence of mirrors in the former actually provides more realism of the movement of the balls, although the spectacular effect is reduced. The Medici clock, as noted, originally was motivated by a spring, although later the motive power was replaced with falling weights. The tall pedestal on which this clock presently is placed differs in style from the clock cabinet and obviously is of a much later date, confirming that it was a feature added to accommodate the weights.

The rolling ball clock was among the last innovative ventures in time measurement in which Giuseppe Campani engaged. He continued to fulfill commissions for other silent night clocks as requested by his patrons, but otherwise thereafter his time was occupied chiefly with the production of lenses and telescopes.

It is not surprising, however, to find that Francesco Eschinardi, often associated with the Campani brothers through the years, particularly with Matteo, also developed a rolling ball clock a decade later that he described as a bullet clock. He had a lifelong preoccupation with horology, and descriptions of clocks that he had conceived—if not actually produced—appeared in several of his numerous writings. His bullet clock was described and illustrated in a work entitled *Raguagli del*

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[906] Schminke, *Beschreibung der Hochfürstlich-Hessischen Residenz- und Hauptstadt Cassel,* 165; Feldhaus, "Kugellaufuhren."

[907] Letter from Paul Adolf Kirchvogel [Scientific Editor 2: among the many letters from Kirchvogel to Bedini in Silvio Bedini's archive, I was not able to find this one describing in such a detail that tragic bombing. However, in the other letters, Kirchvogel often mentions the destruction of Campani's works occurred in the allied bombing on Kassel].

Padre Francesco Eschinardi . . . dati ad un'Amico in Parigi sopra alcuni pensieri sperimentabili proposti nell'Accademia fisicomatematica di Roma, published in Rome in 1680, the title of which may be translated as "Discourses of Father Francesco Eschinardi . . . given to a Friend in Paris about some experimentable ideas proposed at the Accademy of Physics and Mathematics in Rome".[908]

In this work, Eschinardi stated that, early in 1670, he had discussed with Prince Leopold a clock that he had designed, which, Eschinardi claimed, he had conceived for the use of navigators at sea. In an attempt to avoid loss of precision resulting from wheelwork, he designed the clock with a crown wheel having a cylindrical drum attached to the same arbor. Suspended from this drum was a chain of linked cup-like receptacles or "buckets", somewhat in the form of a conveyor belt. From an opening above the drum, a ball dropped into one of the buckets moving the chain at the same time, thus providing motive power for the escapement. When the bucket containing the ball arrived at the bottom, the ball dropped off by the force of gravity and fell upon a wound spring that returned the ball to the starting point. At the same time it activated a snaffle string, which released a second ball through the opening at the top of the timekeeper. During this continuous operation, the motion provided by the wound spring situated in the base of the case acted to wind up the movement and indicate the correct time upon a dial. The clock's design, as related by Eschinardi, reflected many similarities to that made a century later by of Gainsborough, although it is extremely unlikely that the latter would have been informed of it.[909]As previously noted, in another of his works published 4 years later, *De Impetu Tractatus Duplex*, Eschinardi again described his inventions of a rolling ball clock.[910] Enrico Morpurgo, in his dictionary of Italian clock and watchmakers, referred to Eschinardi's device as the prototype of all timekeepers of this type, which, until the late nineteenth century, formed objects of major attraction in shop windows of watchmakers.[911]

The fascination with rolling ball clocks that had emerged in the seventeenth century reflected a preoccupation with perpetual motion that apparently existed to a greater degree in this period. It is not surprising, therefore, to find that it was in the field of horology that so many more attempts were made to achieve it. Regardless of the date of their production, the category of timepieces that included rolling ball clock in any of its forms remains unquestionably among the most ingenious and intriguing of unusual measurers of time, its fascination deriving as well from man's preoccupation with perpetual motion, despite his awareness that it cannot exist.

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[908] Francesco Eschinardi and Nicolò Angelo Tinassi, *Raguagli del padre Francesco Eschinardi della Compagnia di Giesu' dati ad vn'amico in Parigi ; sopra alcuni pensieri sperimentabili proposti nell'accademia fisicomatematica di Roma* (In Roma: A spese di Nicolò Angelo Tinassi, 1680).

[909] Ibid., Tav IV fig. 24 and pages 28-30.

[910] Eschinardi, *De impetu tractatus duplex*.

[911] Morpurgo, *Dizionario degli orologiai italiani*, 61.

Chapter XVII

THE ESTEEM OF PRINCES

(1664–1705)

the perfection and quality of this telescope, superior to all others used until now, was recognized by everyone

Letter from Prince Leopold de' Medici to Giuseppe Campani on July 12, 1665[912]

Upon learning of the success of Giuseppe Campani's new endeavors, many of the same impressive clients who had acquired his timepieces soon returned to purchase his lenses and telescopes. Consequently, he enjoyed a continuing familiarity with his market. Numbered among them were members of the princely families of Rome and Tuscany, including several of the Barberini family of the late Pope Urban VIII. The Pontiff Alexander VII himself was one of Giuseppe's clients as were also his brother Mario Chigi and his three papal nephews, Flavio, Agostino, and Sigismondo Chigi.

The first two records of purchases from Giuseppe Campani made by members of the Chigi family were by Pope Alexander VII for clocks. On February 7, 1658, the Pontiff ordered payment of 20 *scudi* for a *mostra*, or clock display, and in the following year, he purchased two more clocks for 140 *scudi*.[913] This occurred just at the beginning of Giuseppe's emergence as an independent self-employed clockmaker. During the next several years, Cardinal Flavio Chigi also made several purchases of clocks from Giuseppe. On June 21, 1661, he ordered payment to Giuseppe for a silent clock described as having a pendulum and *sfera* [clock index or hand] with a "*cristallo*" or protective glass to protect the painting having the image of Death. The clock was equipped with its oil lamp or *lucerna* inside a case of black ebony for the price of 80 *scudi*.[914]

[912] *"et ben si è riconosciuta da tutti la perfezione et bontà del med[edesim]o occhiale superiore fin'ora ad ogni altro che si sia adoprato"*: BNCF, Gal. 282, fol. 120r [Scientific Editor 2: and not to Matteo Campani, as indicated in the database of the Biblioteca Nazionale Centrale of Florence and of the Museo Galileo].

[913] ASV, Sacro Palazzo Apostolico, Alexander VII, "Payment of One Clock to Giuseppe Campani from Alexander VII on February 7, 1658, 20 Scudi" (Roma, 1658), Varia n. 772, f. 147; ASV, Sacro Palazzo Apostolico, Alexander VII, "Payment of two clocks to Giuseppe Campani from Alexander VII on October 1, 1659, 140 scudi" (Roma, 1659), Varia n. 773, f. 1111.

[914] BAV, Archivio Chigi, Flavio Chigi, "Ms. Libro Mastro A (1656-1662) del Cardinal Flavio Chigi" (Roma, 1661), c. 209, ; also in "Giornale A del Sig. Card. Flavio Chigi" (from July 31, 1656 to December 1662)" (Roma,

Nine years later, Cardinal Flavio commissioned Giuseppe to make a silent night clock for him encased in ebonized pearwood. He specified that it was to be equipped with irons [*ferri*] so that it could be dismantled when it was to be taken into the countryside. When informed that Giuseppe's lowest price for a clock such as he had specified was 75 *scudi*, the Cardinal decided that it was more than he wished to pay and instead ordered a simpler silent clock, which was delivered on June 18, 1670.[915] Two years later, on December 15, 1672, the Cardinal commissioned Giuseppe to provide him with a silent night clock he planned to present as a gift to Sig. Cav. Ippolito Borromeo and for which he paid 65 *scudi*.[916]

Cardinal Flavio Chigi also acquired telescopes from Campani. In October 1676, he purchased a long telescope of 64 palms equipped with four lenses for which he paid Giuseppe 35 *scudi,* and on July 13, 1680, Giuseppe provided him with another telescope having four lenses for 30 *scudi.* Eight years later, on September 1, 1688, Cardinal Chigi acquired yet another telescope from Giuseppe that was 16 palms in length for 60 *scudi*. Apparently, the Cardinal used these instruments for making observations at his personal pleasure, for there is no evidence that he participated in any of the *paragoni* or contests that were popular pastimes of the virtuosi.[917]

The Pontiff's younger nephew, Don Agostino, Prince of Farnese, also became one of Giuseppe's clients. On November 13, 1666, he obtained a silent night clock housed in an ebony case for which he paid 80 *scudi.* The order specified that the timepiece was to have a *cristallo*, or protective glass, and other decorative refinements. Six years passed before Don Agostino is known to have made another purchase from Giuseppe. Then, on June 4, 1672, he commissioned two night clocks specified to be housed in black cases for 80 *scudi*.[918]

Other princely clients for whom Giuseppe was providing night clocks and instruments at the same time were two of the three Barberini papal nephews, sons of Carlo Barberini and Costanza Magalotti. Both of them had been named cardinals by their uncle, Pope Urban VIII. The oldest brother, Francesco Barberini (1597–1679), who had studied at the University of Pisa, was only 26 when his uncle, shortly after assuming the papal throne, created him cardinal. A short time later, Francesco was elevated to the position of cardinal nephew and eventually became the Vatican's secretary of state, a position in which he was aided and supported by his father. In his status as cardinal nephew and as vice chancellor, Francesco became one of the most influential members of

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1661), n. 456, c. 193r.

[915] Ibid., "Conto dell'Ecc.mo Sig.re Card.le Chigi" (Roma, June 1670), n. 456 c. 201.

[916] Ibid., "Ricevute del Cardinal Flavio Chigi" (Roma, 1672), n. 456 c. 569.

[917] Ibid., (Roma, 1688), n. 456 c. 738.

[918] Ibid., "Libro Mastro A (1656-1668) di Don Agostino Chigi Principe di Farnese" (Roma, Novembre 13, 1666), c. 213; "Libro Mastro B (1669-1675) di Don Agostino Chigi Principe di Farnese" (Roma, June 4, 1672), c. 123.

the Roman curia. His greatest distinction was to have been the founder of the great Barberini library, which in time rivaled even the Biblioteca Apostolica Vaticana.[919]

The youngest of the three brothers, Antonio Barberini, was equally favored by his uncle, who created him cardinal in 1628 when he was only 20, with the ecclesiastical title of Santa Maria in Aquiro. The title later was changed to that of Sant'Agatha alla Suburra, and later still to the title of Santa Maria in Via Lata. Antonio's uncle was no less generous with him than he had been with his older nephew, and he loaded him with benefits, titles, and properties. Included among the benefits was the Order of the Knights of Malta, culminating with the title of prior of the Order, much to the disapproval and irritation of the Order's members.

He also named Antonio titular of the abbey of San Carlo alle Quattro Fontane and of the abbey of Nonantola in 1628, and in the following year, he was appointed *camerlengo* to his uncle the Pontiff. Cardinal Antonio involved himself in local government only to a modest degree, however. He served as papal legate to Bologna, Ferrara, and Ravenna, as well as to Urbino in 1631 and to Avignone in 1633, and he was archbishop of Reims. He had reached the age of 23 when his uncle sent him to take possession of the duchy of Urbino and to govern it for a period of time.

While in Rome, Cardinal Antonio resided with his brother Francesco in the magnificent Barberini palace at the Quattro Fontane, which had been completed for them by Bernini and decorated by the most talented artists in Rome. Cardinal Antonio was by no means lacking in intelligence; he had been an excellent student and attracted individuals of ingenuity about him. He was scarcely adapted to the ecclesiastical life, however. During his years at the papal court, he distinguished himself chiefly by becoming involved with all manner of misdemeanors and scandalous scrapes from which his older brother kept disentangling him.[920]

The wealth amassed by the Barberini family and particularly by the three papal nephews was enormous, surpassing that of previous papal families. Like their uncle, however, the nephews expended much of their wealth on the arts and literature. Rome and its environs were beautified and embellished with the rebuilding of churches and construction of fountains and piazzas, all sponsored by the Barberini family, all of which were marked with the three bees found prominently imprinted everywhere in the Eternal City. The amounts of riches of all types that Urban VIII heaped upon members of his family were so considerable that, upon his death, his successor, Pope Innocent X, immediately launched an investigation into the activities of the Barberini men and the means by which they had acquired their wealth.

[919] Pio Pecchiai, *I Barberini*, Archivi. Quaderno doppio 5 (Roma: Biblioteca d'Arte Editrice, 1959), 184–266; Alberto Merola, "Barberini, Francesco," *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1964).

[920] Ibid.

The investigation led to Antonio's abrupt departure from Rome and flight to France, followed almost immediately by that of his brothers Taddeo and Francesco. All three of them sought and found refuge in France under the protection of the Italian-born French statesman Cardinal Mazarin, who had entered the service of Richelieu and become a naturalized Frenchman. Mazarin had executed several diplomatic missions for Pope Urban VIII in the past, and now he returned the favor.

The hasty exodus from Rome of the Barberini nephews inevitably fueled even more anti-Barberini publicity. Generated largely by their enemies the Pamphili family, it persisted for long after their departure. Eventually, the Barberini nephews were pardoned by Pope Innocent X, and finally Cardinal Antonio was able to recover all his properties and titles; then, in 1662, he also obtained the bishopric of Palestrina.[921]

In the autumn of 1664, Cardinal Antonio, who continued to live in Paris, was sent a telescope made by Giuseppe Campani. It was a terrestrial telescope having a focal length of 4-1/2 palms, and it had been among the first of Giuseppe's instruments that the young instrument maker had allowed to leave his control. It was examined and greatly admired by the Cardinal's associates and described in detail by Huygens in his posthumous *Dioptrica*.[922]

The instrument was so greatly admired and envied by Constantijn Huygens, father of the astronomer, in fact, that he made every effort to obtain it. He even begged the French instrument maker Pierre Petit to intercede through the *Abbé* Charles to convince Barberini to trade the telescope with him for an English microscope, but the cardinal refused. This occurred in the period during which Giuseppe first begun to sell his instruments, and this was one of the earliest telescopes that he had made, but it is not clear whether it was he or another who had sent it to Cardinal Barberini.[923]

Outside of Rome, among Giuseppe's most frequent and constant clients were four Medici princes in Florence: Grand Duke Ferdinand II and his three brothers. Ferdinand had been 10 years old when his father Cosimo II died, and at the age of 17 he undertook a continental tour. The more he became known by the people, the more he was appreciated, and the better liked he became. In 1630, with the outbreak of the plague that raged through Tuscany, most of the members of the upper class who could do so had fled the city, as meanwhile the Grand Duke and his brothers remained in Florence and personally went about among the sick and helping them as much as they could.

[921] Ibid.
[922] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 13, 601-02; see also chapter 9 in this book.
[923] See chapter 9 in this book.

Under Ferdinand's reign, the cultural interests in Florence flourished as never before, with both science and art in the ascendency. He was a generous patron of both the arts and sciences, and like his brother Leopold, he was a true polymath. Also a disciple of Galileo, Ferdinand spent much of his time, as did his brother Leopold, experimenting with telescopes and scientific instruments. He was particularly interested in exploration of the natural world and frequently undertook experiments, often working together with Prince Leopold and with mathematicians or other members of the court. As had other members of his family, Ferdinand also had a particular interest in the Florentine craft of *pietre dure*, the art of hard stone mosaics, the manufacture of which he supported.

No notable events marked the Grand Duke's reign because, as much as was possible, the Grand Duke maintained a policy of avoiding trouble and unpleasantness in politics and public affairs. This was the only safe and sane strategy in a period when Tuscany, a regional state, was too small to face up to the greater European nation states. Although he was forced into occasional involvement in conflict with some of the Barberini pope's relatives, the Grand Duke generally reacted to threats to Florence's security with compliance.

Despite Ferdinand's efforts to appear as a commanding figure, the unfortunate appearance of his features—with a bulbous nose and fleshly Hapsburg mouth, his thick black mustache with rising ends and his heavily lidded eyes, as well as his tendency toward gaining weight—made his figure less than that of a commanding patrician. He lived with total lack of ostentation, was usually placid and courteous and invariably of good nature, with a fondness for hunting and fishing and playing bowls.[924]

Prince Mattias (1613–1657) also was interested in the sciences but to a lesser degree. He headed the Tuscan army and was governor of Siena. He served with some credit as a general in the Thirty Years War, and during his travels in Germany, he acquired an impressive collection of ivory turnings, chiefly from the Castle of Coburg in Bavaria, as well as a number of scientific instruments, many by prominent German makers of the time.[925]

Prince Leopold (1617–1675), who had been one of Galileo's pupils, was a scholar of outstanding merit who distinguished himself as a patron of scholars. He dedicated himself assiduously to the development of the Medici family's collection of fine arts that today fills the Uffizi Galleries, the Pitti Palace, and other Florentine repositories. He maintained a personal

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[924] Marcello Fantoni, *La corte del granduca: forme e simboli del potere mediceo fra Cinque e Seicento*, Biblioteca del Cinquecento 62 (Roma: Bulzoni, 1994), 51–72.

[925] Mattias de' Medici served as a general in the Thirty Years' War. He formed a museum of human curiosities deformities including a hideous dwarf having "thinly scattered tusks for teeth" and a tremendous appetite; it was reported that he was able to gobble up 40 cucumbers, 30 figs, and a watermelon, all before undertaking a massive dinner. Hibbert, *House of Medici*, 282-87.

workshop in which he pursued his scientific research. In 1657, Leopold, together with his brother the Grand Duke, founded the first scientific society, the Accademia del Cimento, of which he also served as president until it was disbanded 10 years later. The Academy's regrettably short life and demise was brought about largely by dissension among its members, and it was effectively terminated in 1667 with Prince Leopold's election to the College of Cardinals and his removal to Rome. Both of the cardinals of the Medici family had died within the previous 2 years, and in this same year, Prince Mattias also died. Insisting that the College of Cardinals must contain a member of the Medici family, Pope Clement IX created Leopold a cardinal, who at this time was 50 years of age.[926]

These three Medici brothers had shared living quarters in the Pitti Palace, maintaining bachelor apartments on the second floor, one half of which was occupied by the Grand Duke's chambers. He lived separately from the Grand Duchess, whose apartments were elsewhere in the palace. The remainder of the second floor accommodated Prince Mattias and Prince Leopold.

Ferdinand maintained excellent relations with his brothers Leopold and Mattias and never were there any conflicts among them. Ferdinand's libidinous third brother, Cardinal Gian Carlo de' Medici (1611–1663), who was a year younger, was another matter, however, and had presented endless problems. In fact, the Grand Duke was actually frightened of him. Gian Carlo's true loves had been three: the theatre, which he enjoyed and supported lavishly; food, which he consumed in considerable quantities; and women, whom he pursued with the insatiable lust of a satyr. He was still extremely young when he had been expelled from Rome because of them, and after his return to Florence, he dedicated himself entirely to pleasure. He maintained a fine villa within the city that he used for love trysts with a succession of mistresses, often making love to several at the same time, and had a carp pond in which he reportedly arranged to have one tiresome rival drowned. When the Grand Duke learned that Gian Carlo had died of apoplexy, his relief was beyond measure.[927]

The Grand Duke had yet another cross to bear, however, for he found his excessively plain and fat wife almost as troublesome as his late brother. Soon after her marriage, in addition to her unlikely physical attributes, she developed a most unsightly double chin. It was an unfortunate marriage; they had been betrothed while still children. Her excessive piety and dedication to the church overpowered their lives. The prim and interfering Vittoria della Rovere experienced considerable difficulty each time in bearing her husband a child, the first two surviving for less than

[926] Middleton, *Experimenters*, 22–24, 324–25; Colonel G. F. Young, *The Medici*, Modern Library (New York: The Modern library, 1930), 706–8; Gaetano Pieraccini, *La stirpe de'Medici di Cafaggiolo: saggio di ricerche sulla trasmissione ereditaria dei caratteri biologici* (Firenze: Vallecchi editore, 1924), 603–32.

[927] Hibbert, *House of Medici*, 286, 332, fn. 7.

a day. It was not until 1642 that she gave birth to a child strong enough to survive, the heir, who became the future Grand Duke Cosimo III.

Ferdinand was not totally blameless in the estrangement with his wife. From his early youth, he suffered from having an unfortunate attraction to handsome young men, whom he preferred to women. This inclination did not improve marital relations, which generally were less than blissful. Then, shortly after having given birth to the child who survived, the Duchess unexpectedly discovered her husband in his bedroom fondling a handsome young page. This *paggio d'onore* was none other than the attractive young Count Annibale Bruto della Molara. The two men jumped apart when they were discovered and interrupted by the Grand Duchess, and for weeks thereafter she refused to speak to her husband.

It happened shortly thereafter, during Lent, that an eminent Jesuit had been invited to preach in the Church of San Lorenzo. The Grand Duchess summoned him to her chambers and obligated him to preach on the subject of sodomy. As customary, the Grand Duke and his wife formally attended church services, together during which he suffered greatly through the sermon. Upon returning to the palace, the Grand Duke summoned Bruto della Molara. After inquiring whether he had listened to the sermon, and learning that he had, the Grand Duke sent him to "reward" the preacher. Subsequently, the Jesuit was reported to have been seriously beaten and to have left the city hastily to return to his monastery.[928]

The Grand Duke's inclination toward young men had been known since his youth. It is a matter of record that on one winter evening, his mother, the widowed Grand Duchess Maria Maddalena of Austria, brought young Ferdinand a list of sodomites whom she thought should be punished by burning them at the stake. Ferdinand objected to her that the list was incomplete, then added his own name to it. After tossing the list into the hearth and watching the burning paper, he told his mother: "They are hereby burned just as you condemned them."

Bruto della Molara served as the Grand Duke's equerry and emissary and, on many occasions, was the conveyor of correspondence from the Grand Duke or Prince Leopold to Viviani, often relating to Giuseppe Campani's work. Together Molara and the Grand Duke, accompanied by other young pages of the court, habitually wandered the streets after dark in search of diversions and misdemeanors. It was not an unusual situation, and Florence's social and cultural history have chronicled many patrons and creators to be well acquainted with bisexuality. Saint Bernardino's fiery sermons denounced Florence's bad reputation abroad, and Savonarola threatened the city's clerics, "Abandon your beardless youths, or woe is you!".[929]

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[928] Bernardi, *Paggio e l'anatomista*, 76-78.

[929] Ibid.; and Luca Ombrosi, Francesco Furino, and Pietro Fortini, *Vita di Ferdinando II, quinto granduca di Toscana. Lo sconcio sposalizio: ottave di Francesco Furino. Novella* (Forni: Bologna University Press, 1886);

When the Grand Duchess eventually attempted a reconciliation, her husband declined, and for 17 years thereafter, from 1642 to 1659, the Duke and his wife lived entirely apart. They were finally reconciled in 1659, and this reconciliation resulted in the birth of their second son, Francesco Maria. There was no real affection on Vittoria's part, however, and during the Grand Duke's final illness, she visited him but once, and only at his request. He was failing with dropsy and apoplexy, but even more he was suffering agonies from the treatments to which his doctors subjected him.[930]

During this time, Divini's telescopes also had become well known in Italy. His first publication, a finely engraved broadsheet of the moon surrounded by the planets, was published in 1649, which he dedicated to Grand Duke Ferdinand II. It established him as the foremost maker of optical instruments in Italy at that time and also attracted attention in France and England. The broadsheet, intended as an advertisement featuring his telescopes, illustrated the moon with Jupiter and its moons, Saturn with its ring, and in the corners were a falcated moon and the planet Venus. Divini indicated that he had made his observations of the moon in its different phases in 1647, 1648, and 1649 using several of his own telescopes, ranging in focal length from 16 to 35 palms (357 to 781 cm) and added that recently he had made an instrument of 45 palms.

For his drawing of the moon, Divini had used an instrument having a focal length of 16 palms with a convex ocular covered with a reticule of his own devising, having "very fine threads like a reticule". In this broadsheet, which was the first accurate representation of the moon up to that time, was also one of the first use made of the micrometer. Divini's production of lenses of high quality and powerful instruments placed him in the lead among instrument makers of his time. He prospered, and his work became known in England and France as well as in Italy.[931]

It was from about that time, following the publication of the broadsheet, that the Grand Duke began to commission telescopes from Divini, who continued to provide him and his brothers with microscopes and telescopes until as late as 1664. It was then that the Medici princes began to purchase telescopes from Campani as well.

Three of Divini's telescopes have survived in the Medici collections. The earliest is a telescope made in the early 1660s consisting of seven tubes, having its six sliding cardboard tubes covered with red marbleized paper. The main or largest tube is 70 cm in length and 77 mm in diameter, and its green paper cover is decorated with gold tooling. The ferrule of each of the draw

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Giuseppe Baccini and Filippo Orlando, eds., *Bibliotechina grassoccia: capricci e curiosità letterarie inedite o rare*, Il Giornale di Erudizione 5 (Firenze, 1886-1899); Pieraccini, *Stirpe de'Medici di Cafaggiolo*, 508.

[930] Hibbert, *House of Medici*, 283–90.

[931] G. Govi, "Della invenzione del micrometro per gli strumenti astronomici," *Bullettino di bibliografia e di storia delle scienze matematiche e fisiche* 20 (1887): 607–14; McKeon, "Établissement de l'astronomie de précision"; "Auzout, Adrien," *Dictionary of Scientific Biography* (New York: Charles Scribner's & Sons, 1970); Divini, *Lettera*, 58–60; Robert M. McKeon, "Les débuts de l'astronomie de précision, 1: Histoire de la réalization du micromètre astronomique," *Physis* 13 (1971): 234–36; Boffito, *Gli Strumenti della Scienza e la Scienza degli Strumenti*, 128–130, plate 80.

tubes at the ocular end is covered with green paper also having gold tooling. The object lens, now missing, was housed in the largest tube. The ocular is a compound eyepiece consisting of three pairs of plano-convex lenses arranged in the smallest draw tube, having a focal length totaling about 150 mm.[932]

The 1690 inventory of the Grand Duke's *guardaroba* described this instrument as having the tube made by Divini with three double lenses and draw tubes that extend to a *braccio*. The lens and its mounting both are inscribed "*Eustachio Divini in Roma Palmi 12*." The objective lens was made by Evangelista Torricelli. The instrument extends to 298 cm.[933]

As both Divini and Campani began to experiment with lenses of greater focal length in order to be able to observe with greater clarity and at further distances, as had other telescope makers of their time, they realized that tubes of the required lengths were too light and flimsy when made of cardboard; they were inclined to bend halfway along their length even when supported with light wire strapping. The telescope makers then turned to the use of wood, producing the tube in sections and assembling them into hexagonal tubes. Each of the sections was assembled from wooden boards glued together and strengthened by wire stays at each end. These joints were then joined end to end, with the object lens housed at one end and the eyepiece at the other.[934]

Divini appears to have been the first of the two rivals to have experimented with using wooden tubes for telescopes. A telescope made by Divini for the Grand Duke in 1664 consisted of six tubes, of which the five larger ones were octagonal and made of wood and covered with red marbleized paper. The largest tube was 89.5 cm in length and 78 mm in diameter in cross section. A sixth tube, round in shape and made of cardboard, also was covered with red marbleized paper. Mounted in a round separate tube of cardboard that slides into the largest tube is the biconvex objective, which is 73 mm in diameter and 155 mm in length. The lens and the aperture ring both are inscribed "*Eustachio Divini in Roma Palmi 12*". The focal length of the instrument is 284 cm from objective to ocular lens, and it has a magnification of 44.[935]

A third surviving telescope made by Divini for the Medici court consists of seven tubes made of wood, six of which are octagonal and assembled from wooden slats stained a brown color, while the seventh tube is cylindrical and made of cardboard covered with red marbleized paper. The largest tube is 156 cm in length and 109 mm in cross section. Five iron rings, two around each end and another in the middle, provide reinforcement. The other five tubes have a ring at either end. A boxwood housing with lens cover contains the objective screwed into a wooden ring glued into a

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932 Van Helden, *Catalogue of Early Telescopes*, 40–41.

933 Ibid.

934 Silvio A. Bedini, "On Making Telescope Tubes in the 17th Century: An Anonymous Italian Manuscript," *Physis* 4, no. 2 (1962): 110–16.

935 Van Helden, *Catalogue of Early Telescopes*, 42.

short cylindrical cardboard tube that slides into the largest tube. The lens appears to be plano-convex, inscribed on the periphery "*Eustachio Divini in Roma 1674*". The ocular lens, which has an aperture of 55 mm and a focal length of 75 mm, also is contained in a boxwood housing with lens cover. The length of the instrument when fully extended is 257 cm with an inferred magnification of 55.[936]

Surviving also in the Medici collection are two more of Divini's housings for ocular lenses. One contains a biconvex lens having a diameter of about 55 mm, exposed diameter of 29 mm, and polished concave section of 25 mm. The cardboard holder containing it is inscribed "*Eustachio Divini in Roma 1666 Acuto per Palmi 26*". It is noted that the glass has a slightly yellow tint and contains some inclusions and bubbles.

Another Divini housing contains a biconvex lens that is mounted in a cardboard ring with a diameter of about 55 mm. Its exposed diameter is 27 mm, and the diameter of the polished concave area is 21 mm. Small bubbles are contained in the glass, which has a slight greenish tint. A nineteenth century label glued to the tube containing the lens is inscribed "*Eustachio Divini in Roma 1665 acuto per bracci 4*".[937]

The Medici princes had long been aware of the work of Giuseppe Campani, having purchased silent night clocks with mercury escapement from the Campani brothers as early as 1656 after having learned of the success of the one made for the Pontiff. After Pier Tommaso and Giuseppe began the commercial sale of other timepieces, members of the Medici family acquired other night clocks from both of them.

When Giuseppe had invented the crank lever escapement, and accidentally the pendulum regulator, he had gone to Florence to seek a letter patent from the Grand Duke, which was granted. According to surviving records, the Grand Duke and his brothers thereafter purchased silent night clocks only from Giuseppe and no longer from Pier Tommaso Campani.

In 1660, Grand Duke Ferdinand II had acquired three silent night clocks having crank lever escapements from Giuseppe, while his brothers Cardinal Gian Carlo and Prince Leopold each purchased one in the same period. Between 1656 and 1670, the Medici brothers purchased at least 12 clocks made by Giuseppe.

The Medici brothers had become informed of Giuseppe's telescopes as soon as the sale of his instruments had been publicized. Although Giuseppe had produced successful telescopes as early as 1662, he had made only a few available for sale commercially until well into the year 1664. Grand Duke Ferdinand II acquired his first Campani telescope in that year, at which time Prince Leopold purchased four more telescopes from Giuseppe and six more in 1665, presumably for

[936] Ibid., 42, 44–47.
[937] Ibid.

experimentation and observation by members of the Accademia del Cimento. Between 1662 and 1705, Giuseppe made at least 25 telescopes the Medicis had requested, all of which were documented and for which records survive.[938]

By the end of the summer of 1664, Giuseppe had begun to furnish telescopes to the Medici court on a regular basis. In September, Giuseppe addressed a communication to Prince Leopold reporting that he had shipped a telescope to him and provided instructions for its use, including a sketch. He wrote:

My telescope, that Your Highness commissioned me [to make], is described and made in the following manner:
D is the telescope
In D is the object lens
In * is a plano-convex lens inclined according to the line
BC with the plane side towards D
In the small tube AB is an ocular lens convex in proportion to
the object lens D, which lens is placed in a horizontal plane in B in a distance proportional from the lens G.
In A is placed the eye, which however must remain such a distance
from the lens B, in a distance proportional from the lens B when
. . . will be distant, if with this is observed and for the
telescope according to ordinary distance.[939]

[Figure]

In the following June (1665), Giuseppe sent a long letter to Prince Leopold accompanying another eyepiece he had made for him. In July of the same year, probably on recommendation of one of the Medici, Giuseppe provided to their friend Cardinal Barberini an instrument having a focal length of 50 palms. To everyone's pleasure, when tested in Florence, it proved to be far superior to all other telescopes of similar length that were available there. Prince Leopold took the occasion to write to Giuseppe to congratulate him on "the perfection and quality of this telescope, superior to all others made up until now, was recognized by everyone". Subsequently Giuseppe published it in his letter to Cassini about the Medicean stars.[940]

It was at this time that Giuseppe—having long been bedeviled by the repetitive comparative tests or *paragoni* being held to determine the superiority of telescopes made by Divini and himself,

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[938] Ibid., 48-53; Bonelli and Van Helden, "Divini and Campani": 3–176; BNCF, Gal. vol. 283, cc. 162–163: letter from Giuseppe Campani with drawing of a telescope written entirely by a scribe without addressee but undoubtedly addressed to the Grand Duke or Prince Leopold on September 6, 1664; vol. 277, c. 57, vol. 313, c. 89: letter from Ottavio Falconieri to Prince Leopold on December 16, 1664; c. 67: letter from Matteo Campani [Scientific Editor 2: the database of the Biblioteca Nazionale Centrale of Florence and of the Museo Galileo are wrongly attributing the letter to Matteo Campani, whereas it is Giuseppe who had signed it] to Grand Duke Ferdinand II on December 23, 1664.

[939] BNCF. Gal. vol. 283, cc. 162–163: letter from Giuseppe Campani with drawing of a telescope written entirely by a scribe without addressee but undoubtedly addressed to the Grand Duke or Prince Leopold on September 6, 1664.

[940] Ibid., vol. 277, c. 198: letter from Giuseppe Campani to Prince Leopold on June 30, 1665; vol. 282, c. 120, letter from Prince Leopold to Giuseppe Campani on July 12, 1665 [Scientific Editor 2: and not to Matteo Campani, as indicated in the database of the Biblioteca Nazionale Centrale of Florence and of the Museo Galileo]; piece of news also published in Giuseppe Campani's Campani, *Lettera di Giuseppe Campani*, 3.

which absorbed much of his time that he could not afford—conceived of a new test for comparing the quality and power of telescopes. This test he believed would resolve the controversy once and for always. He proposed it to Prince Leopold.[941]

Campani's proposal was to obtain a large piece of glass of the finest quality from Venice and have it shipped to Florence. There it was to be split into two parts, one piece for Campani and the other for Divini. All the necessary safeguards were to be applied to ensure that neither could substitute another piece of glass. They were then to be allowed 3 days during which they were to convert their piece of glass into an object lens of an assigned focal length. They were not at any point to be allowed to test the curvature of the lenses.

When completed, the lenses were to be sent to Florence, where a comparison would be made. An impartial body to be appointed would be enabled to assess the skills of the two contestants as lens makers and determine whether or not luck was involved in Giuseppe's production of his instrument of 50 palms. Divini responded by suggesting a similar challenge of his own, but Prince Leopold chose not to act on either proposal; it was no longer necessary, inasmuch as the superior quality of Giuseppe's lenses had been established beyond doubt.[942]

Two months later, in September 1665, Ottavio Falconieri reported to Leopold concerning the telescope that the Medici prince wished to have made by Campani for one P. Cicognini. Falconieri wrote that Campani had one of 10 palms made for Monsignor della Ciaia.[943] However, the latter assured Falconieri that he was willing to leave it to Prince Leopold. Falconeiri went on describing the telescope: "This has the tubes covered as usual, with parchment tinted green and having gold tooling, which can be made more or less rich as one wishes, however, it will not be completely finished before eight days. Concerning the other one of one *braccio* and 1/3, [77,8 cm][944] […] when his Highness wishes it only of two lenses it could be available a day or two after the return of the answer to the present letter, but when it has to be of four lenses it cannot be available until at least the end of the following week. And because your Highness has shown a desire that the large one should be covered with leather, for this he should let me know as soon as possible, so that he could be served in the same amount of time that will be required to complete the small one if it must be of 4 lenses".[945]

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[941] BNCF, Gal. vol. 277, c. 204: letter from Giuseppe Campani to Prince Leopold on July 14, 1665 and vol. 313, cc. 51–52.

[942] Divini, *Lettera*, 67–72.

[943] [Scientific Editor 2: probably Monsignor Frat'Angelo di Pompilio della Ciaia, an important figure of the Papal Court and uncle to Prince Agostino Chigi: Eugenio Gamurrini, *Istoria genealogica delle famiglie nobili toscane et umbre* (In Fiorenza: Nella stamperia di Francesco Onofri, 1668), 483].

[944] A Florentine *braccio* could measure 0,5836 m or 0,5512 4 m; Pedretti, *Studi vinciani*, 37.

[945] BNCF, Gal. vol. 277, c. 219: letter from Ottavio Falconieri to Prince Leopold on September 12, 1665.

Campani explained that he had been awaiting a day of good weather on which he could take his large telescope out of doors, the one that he had made for the Cardinal Antonio Barberini, in order to test it with his lenses. He reported that "the objective of that one he has made for the Most Serene Grand Duke is already finished, and it will be chosen among two that have been completed without defect of redness [*rossiglioni*], which were better than as many as others he has worked, the choice will be made afer comparing the two lenses with with the one of the Cardinal Antonio".[946]

Surviving correspondence confirms that Campani furnished telescopes to Prince Leopold early in the year 1665, as well as another instrument for the Grand Duke, in May of that year, noting that he also had provided one to Prince Mattias. In June or July, he sent more telescopes to Prince Leopold in addition to a proposal for a telescope support. In September and October, he provided Prince Leopold with additional lenses and two more telescopes, and another in December. In 1666, he shipped a telescope to the Grand Duke, and in 1667, he sent three more to Prince Leopold. It is probable as noted that the instruments provided to Prince Leopold in some quantity were for use in experimentation by members of the Accademia del Cimento.

In a letter written on Christmas Day 1665, Giuseppe had informed Prince Leopold that finally he had been able to ship the telescope of 50 palms that the latter had commissioned. He reported that although he had exercised the greatest diligence in selecting the finest material, he had kept it for a time more from a sense of duty but in any case he did not have the good fortune to be able to avoid the veining in all the lenses. Because of the same defect, he had not sent another eyepiece for making celestial observations that was more acute than the one that he already had forwarded, such as one that in due course he planned to send, in order that His Serene Highness can satisfy himself by observing first with one and then with the other.

Campani begged the prince, meanwhile, to do him the honor of informing him of the performance or success of the lens, "although from His Eminence Cardinal Chigi and from Prince Agostino and by all the gentlemen here in Rome who have compared it with the other one that in Florence was judged to be the better one, without anyone having doubted it, inasmuch as it indubitably showed the objects much more clearly". Furthermore, he added, he was enclosing the sheets (the printed placards for testing the instruments) in order to be informed of the thoughts of the said virtuosi. In fact, he did not enclose them after all but promised that he would send the printed forms as soon as he obtained them. It was not until 3 weeks later, however, that Giuseppe was able to obtain and to forward the printed forms that had been missing in his earlier letter.[947]

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[946] Ibid.

[947] ASF, Mediceo del Principato, filza 5534, c. 751r, "Letter from Giuseppe Campani to Prince Leopold" (Roma, December 25, 1665).

Ottavio Falconieri communicated to Prince Leopold from Rome in July 1666, enclosing a separate sheet with the results of observations made of an eclipse that occurred the previous morning at which he also had been present, together with Giuseppe Campani. He was forwarding it not because he esteemed it important to have it seen by His Highness but perhaps because the observations could serve His Highness in some aspects of new evidence. He added that this time Andrea Argoli must have regained some reputation given that he has shown to be more precise than Montanari according to his own opinion and the opinion of other persons there.[948] Andrea Argoli was a professor of mathematics at the university La Sapienza in Rome and taught also at the University of Padua. He was an assiduous calculator of ephemerides for the period 1621 to 1700. For his calculations, he had abandoned the Ptolemaic system, using instead the Tychonian system.[949]

Giuseppe Campani forwarded a telescope to Prince Leopold in Florence in October 1668, then another in August 1669, and again in December. In that year, he also produced the first of a series of telescope for Prince Cosimo, the heir who would become Grand Duke Cosimo III[950]. In 1670, Campani furnished other instruments, two more in July–September, and one more in May 1705. In March 1670, Ottavio Falconieri informed Cardinal Leopold concerning observations in which he had participated earlier in the week. They had observed from the loggia of the Church of the Aracoeli and had been accompanied by Matteo and Giuseppe Campani, who assisted in the observations.[951]

Of the approximately 25 telescopes provided by Giuseppe Campani to the Medici princes between 1664 and 1705, only three have survived in the Medici collections now preserved in the Istituto e Museo Galileo in Florence. Probably the number actually commissioned was greater, but there is only evidence of these ones definitively in the surviving records, which indicate that three had been commissioned by Grand Duke Ferdinand II in 1662, 1665, and 1666; possibly 18 or more by Prince Leopold; one by Prince Matthias; and the onthers by Grand Duke Cosimo III. [952]

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[948] ASF, Carteggio di Artisti, Falconieri, Ottavio, “Letter from Ottavio Falconieri to Prince Leopold” (Roma, July 1666), filza X, c. 160.

[949] Mario Gliozzi, “Argoli, Andrea”, *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1962).

[950] ASF, “Mediceo del Principato”, filza 3939, cc. 3-5.

[951] ASF, Carteggio di Artisti, Falconieri, Ottavio, “Report by Ottavio Falconieri to the Medici,” (Roma, March 10, 1670), filza XI, cc. 322-323.

[952] In 1690, the inventory made of the contents then existing in the *guardaroba* of the chamber of Grand Duke Cosimo III included three telescopes made by Campani and a telescope with lenses made by Torricelli and having the tube made by Divini; a telescope similar to one made by Campani, maker not identified; another telescope made by Torricelli; two telescopes made by Divini, one having an octagonal tube and the other by Torricelli. Undoubtedly, some of these had originally been the property of Ferdinand II and possibly Prince Leopold and had been inherited by Cosimo III. During the same period, as already noted, Giuseppe had furnished the Medici princes with at least 12 clocks. ASF, Guardaroba Mediceo, “Inventario di Robe esistente nella Guardaroba di Camera del Ser.mo Granduca, 12 luglio 1690,” (July 12, 1690), filza 959, c. 29r, pp. 132v, 133r-v, 134r.

Some account of the telescopes owned and used by Grand Duke Ferdinand II can be derived from the manuscript "Inventory of items existing in the *guardaroba* of the chambers of the Most Serene Grand Duke, which until now had been assigned to the care of Sr. Carlo Colzi, who had served as his *guardaroba*". The inventory was compiled and dated July 12, 1690, 20 years after the Grand Duke's demise. All of the items listed were astronomical instruments or parts thereof, except for the clock, noted elsewhere, of the Huygens design made by Salomon Coster.[953]

Four of the telescopes in the Grand Duke's *guardaroba* had been made by Giuseppe Campani. One was a large telescope about 20 *bracci* in length with an objective and an ocular of three lenses. Its tube was covered with green-tinted parchment with touches of gold and inscribed with the Grand Duke's arms, having its *bocchette in bossolo* tinted black. Several telescopes were designated "for taking to the countryside"; one was 7 *bracci* in length, and another was about 6 *bracci* in length. Another Campani instrument with its objective and ocular of three lenses that customarily was taken to the countryside, could be lengthened to 3-5/6 *bracci*; it was noted that its objective had been broken and had been repaired by a court employee, Jacopo Mariani.[954]

The three Giuseppe Campani instruments that have survived, housed in the Istituto e Museo di Storia dell Scienza, appear to be the ones commissioned by Grand Duke Ferdinand II in 1664, 1665, and 1666. The tubes of two of them are made of wood, the largest of which is 42 cm long and 62 mm in diameter.

Made in about 1664 and inscribed in Campani's usual manner, the terrestrial telescope consists of eight draw tubes, seven of them of cardboard and the largest tube covered with leather,

[953] Four telescopes were identified as consisting of telescopic tubes made by Eustachio Divini having lens made by Evangelista Torricelli. One long telescope had only the objective made by Torricelli, and the tube about 1-3/4 *bracci* in length was covered with green parchment with touches of gold, with the three lenses of the eyepiece made by Divini; another similar instrument that could be lengthened to 6 *bracci* had the objective made by Torricelli, and three double lenses as well as the tube covered with green parchment with stamping of gold were made by Divini. One complete telescope, including its objective and three lenses, was attributed to Torricelli, and the tube was covered with red leather with an ivory mouthpiece and a velvet bag that is carried in a suitcase.Two of the telescopes were made by Divini. One had an octagonal wooden tube, covered with marbleized paper, that could be lengthened to 5 *bracci*, equipped with three lenses. Another made by Divini had the objective and acute lens made of rock crystal "but is without lenses," presumably of the eyepiece. Its main tube was covered with green parchment with gold stamping. The Medici collection at present contains three complete telescopes by Eustachio Divini in addition to two eyepieces in housings. An early instrument made between 1660 and 1670 lacks the objective and its housing. It consists of seven tubes made of cardboard, the largest of which is 77 mm in diameter and 70 cm in length and covered with green paper having gold tooling. The other tubes are covered with red marbleized paper, and the ferrule of each at its ocular end is covered with green paper having gold tooling. There are no diaphragms in the tubes. The erector unit and eyepiece are in separate little tubes that slide into the smallest of the draw tubes; the compound eyepiece consists of three pairs of plano-convex lenses arranged at intervals instead of the common practice of using three biconvex lenses. It is known that Divini was experimenting with eyepiece doublets consisting of two plano-convex lenses. The apertures of the lenses and of the two lenses of the eyepiece are 58 mm. Also included in the Grand Duke's *guardaroba* were five boxes containing lenses designated by the letters A through E. Among these were object lenses made by Torricelli, Divini, and Il Tordo in addition to a miscellany of other lenses, none by Campani. Van Helden, *Catalogue of Early Telescopes*, 48-53. ASF, Guardaroba Mediceo, "Inventario di Robe esistente nella Guardaroba di Camera del Ser.mo Granduca, 12 luglio 1690," (July 12, 1690), filza 959, c. 29r, pp. 132v, 133r-v, 134r.

[954] Ibid.

in which the object lens is contained. It features a little tube containing the ocular lens that slides into the end of the smallest tube. In a separate reversible tube is the erector unit fitted in the front of the smallest tube. The largest tube is covered with green leather having gold tooling, while red marbleized paper covers the other tubes, each of which has a ferrule at the ocular end covered with gold-tooled green leather. Draw tubes four to seven have a diaphragm at the objective end, and tubes five and seven are equipped with a second diaphragm inside the tube. The draw tubes, except for the smallest one, are marked in pencil to indicate how far they may be extended. At this extension the instrument is 225 cm long without lens covers, and when collapsed the instrument is 60 cm long with lens covers. There were numerous references, all dating in the 1660s, to a telescope of 10 palms (2230 mm) made by Campani; in all likelihood this is the instrument which Giuseppe had provided to the Grand Duke in 1664.[955]

The second Campani telescope surviving in the Medici collection, made in 1665, consists of 10 tubes made of wood covered with cardboard, the largest of which is covered with green leather with gold tooling bearing the Medici arms. Housings of beechwood-stained black contain the objective and ocular lenses. The threaded housings screw into beechwood rings glued into the objective and ocular tubes. Red marbleized paper cover the draw tubes, each having a ferrule at the end similar to the cover of the largest tube. The biconvex object lens is 157 mm in diameter and has an aperture of 111 mm, a focal length of 11,160 cm, and a radius of curvature of 11,982 mm (on the signed side) and 11,818 mm (on the other side). It is noted that the glass has a slightly red tint and contains some bubbles, and the lens, held in the housing by a threaded beechwood retaining ring, is well polished, although it reveals some scratches.

The compound eyepiece consists of three cardboard tubes covered with red marbleized paper with the ocular tube sliding into the ocular end of the smallest draw tube. The object lens has a focal length of 100 mm, and the ocular lens has a focal length of 102 mm. Housed in a tube marked “Lens less strong” [*Lente meno acuta*], it and can be exchanged for another small tube (the lens of which is missing) marked “stronger lens” [*lente più acuta*].

The draw of the tubes is uniformly 106.5 mm, although at present, all cannot be pulled out. Around the periphery of the object lens is inscribed, presumably with a diamond, “*Ferdinando II. Serenissimo Magno Etrurie Duci. Joseph Campani faciebat Romae anno 1665*”. It has been noted that in the *paragone* held in 1665 Giuseppe used an instrument of 52 palms (11.6 meters) that was rated superior to the one of comparable length used by Divini in the trial. It was in that period that Campani had produced another instrument of the same length in response to the request of the

[955] Van Helden, *Catalogue of Early Telescopes*, 48-53.

Grand Duke Ferdinand II. This is the one with which the Grand Duke was able to observe Jupiter and its satellites on July 11, 1665.[956]

The third surviving telescope, which Campani produced for the Grand Duke in 1666, consists of six wooden tubes, the largest of which is covered with green leather and gold tooling. It is 113 cm in length and 9 cm in diameter. The five other wooden tubes are covered with cardboard and red marbleized paper, their ferrules covered in green leather with gold tooling, and each of these five contain diaphragms. The objective—having a diameter of 65 mm, an aperture of 40 mm, and a focal length of 3,015 cm—is contained in a boxwood housing with a cover, is biconvex with radii of curvature 5,220 and 5,180 mm Inscribed on the edge of the lens is "*Giuseppe Campani in Roma anno 1666*". Contained in a small tube that slides into the front of the smallest draw tube is the erector unit, its two biconvex lenses having focal lengths of 84 mm.[957]

Giuseppe's trade in optical instruments was not to be limited to members of the princely families of Rome and Tuscany, however, and it was not long before he was to add a king to his clientele, when he began to produce lenses and telescopes for the newly established observatory in Paris. It was an association that was built largely upon the friendship of the young astronomer Gian Domenico Cassini.

[956] Ibid., 50-52.
[957] Ibid., 52-53.

Chapter XVIII

EYES ON THE SKIES

(1662–1669)

Au milieu des occupations que me donnaient les affaires publiques, je faisais la nuit des observations astronomiques avec une excellente lunette que m'avait donnée M. Campani.

(In the midst of the occupations public affairs had given me, during the night I made astronomical observations with an excellent telescope that was given to me by M. Campani.)

Gian Domenico Cassini, *Vie, Memoires*

The respected permanent place in the history of astronomy achieved by Giuseppe Campani unquestionably owed much to the numerous celestial discoveries made by others with his lenses and telescopes, especially by Gian Domenico Cassini, and due to a degree to the astronomer's confirmation of the instrument maker's observations and his repeated acknowledgment of the superior quality of Campani's instruments. It was a situation of mutual gain, for it was largely the superior excellence of Campani's lenses that contributed to Cassini successful astronomical discoveries, and it was because Cassini was able to do so that Campani's career became firmly established.

It is not known with certainty just when Giuseppe Campani and Gian Domenico Cassini first became acquainted, but it occurred some time between 1660 and 1662, while Campani was producing his first telescopes. Inasmuch as there is no evidence that Campani ever traveled to Bologna or ventured beyond Rome except to Spoleto and Florence, it was likely in Rome that he and Cassini actually met, during one of Cassini's numerous journeys to the Eternal City on missions for Bologna's Senate or in response to one of the frequent summons from the Pontiff. Until then, Cassini had been aware of only the one instrument maker in Rome whose telescopes he had been using, Eustachio Divini. There is no doubt that, meanwhile, during one of his occasional visits to Rome in the early 1660s, the energetic young astronomer heard mention of an excellent new telescope that was suspected of having been made by a hitherto unknown instrument maker. Inquiries eventually led him to Giuseppe Campani, as in fact Matteo Campani had planned.

Anxious to promote his telescopes, Giuseppe and his brother Matteo certainly were informed of the astronomical achievements of the brilliant young professor at Bologna. After he had completed the construction of a new meridian in the Church of San Petronio in Bologna in 1655, Cassini made numerous observations of the obliquity of the ecliptic, the exact positions of the solstices and equinoxes, and variation of the sun's diameter, publishing his principal observations in 1656 in a work entitled *Specimen observationum bononiensium*.[958]

Having heard mention in 1661 or 1662 of a new telescope said to have excelled all others, Cassini undoubtedly was among those who sought to meet the newcomer so he could test one of his instruments. At the same time that Cassini was impatient to identify and meet the telescope maker, Giuseppe was just as eager to meet the popular astronomer. Cassini became aware of the developing conflict and contest between Divini and Campani, and he happened to be on the scene when the first inconclusive trial of the telescopes was held, during which Campani allowed him use of his telescopes. It was with a Campani telescope that Cassini eventually made some of his important astronomical observations of Saturn and Jupiter. And it was with a Campani telescope that he was to detect the rotations of Mars and Venus.

How Giuseppe Campani and Cassini first became acquainted is indicated to some degree in notes that the astronomer left after his death, which later were compiled into a biographical account by his great grandson Cassini IV. By 1664, at some time after the two young men first met in person, while Cassini was visiting Rome, he wrote that he had been invited by Campani "to come with him to Monte Citorio to observe Jupiter with a number of persons of distinction who were to meet there to test his telescopes".[959] It was while making observations on that occasion that Cassini discovered the shadows of the satellites of Jupiter. Campani subsequently presented him with the gift of an excellent telescope he had made having a focal length of 17 palms, which Cassini later took with him on his voyage to Tuscany and subsequently brought with him when he moved to Paris. It was with this instrument that Cassini discovered the permanent spots of Jupiter in July 1665. Subsequent observations of these spots enabled him to determine the duration of rotation of Jupiter on its axis, which he fixed at 9 hours 56 minutes. The measurement was excellent for his time, because the real duration, according to the latitude of the points of the surface of Jupiter relative to the equator, has been established since then to be between 9 hours 50 minutes and 9 hours 56 minutes.[960]

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[958] Gian Domenico Cassini, *Specimen observationum Bononiensium [...]* (Bononiae: Ex typographia H.H. de Ducijs, 1656).

[959] Jean-Dominique Cassini, "Anecdotes de la vie de J.-D. Cassini", in *Mémoires pour servir à l'histoire des sciences et à celle de l'Observatoire royal de Paris suivis de la vie de J.-D. Cassini, écrite par lui-même, et des éloges de plusieurs académiciens morts pendant la révolution* (Paris: chez Bleuet, successeur de Jombert, 1810), 299, no. 18.

[960] Jean-Dominique Cassini, *Lettera astronomica di Gio: Domenico Cassini al sig. abbate Ottavio Falconieri. Sopra l'ombre de pianetini medicei in Gioue* (In Roma: apresso Fabio de Falco, 1665), 2; "Lettera di Eustachio Divini, con altra lettera del Padre Egidio Franc. de Gottignies della Comp. de Giesu, intorno alle Machie nuovamente scoperte nel Pianeta di Giove. In 8, in Roma", *Journal des sçavans* 39 (November 19, 1666): 709-11.

From its inception, Cassini's career was little short of meteoric. He was only 25 years of age in 1650 when he was selected, with the support of the Marquis Cornelio Malvasia and with the approval of the Bolognese Senate, to occupy the then-vacant chair of astronomy of the University of Bologna. This occurred immediately following the demise of the incumbent, the Milanese Jesuit Bonaventura Cavalieri. As time went on and the range of Cassini's capabilities became more and more apparent and widely realized and appreciated, however, he found it to be a mixed blessing because it involved him with a variety of assignments in addition to his principal occupation of teaching astronomy.[961]

The burden of his non-academic activities on behalf of the Senate of Bologna soon became almost overwhelming. Frequent travel was required, in addition to which the young astronomer often was summoned to Rome by the Pontiff for conferences at the Vatican relating to Bologna's state affairs and other matters. To his advantage, however, it was during these interludes in Rome that he developed or renewed acquaintance with several men of science.[962]

When circumstances finally brought Cassini and Giuseppe together, Giuseppe as noted presented his new friend with the gift of one of his first telescopes. Despite the disparity in age, for Cassini was 10 years older than Giuseppe, the two became lifelong fast friends and colleagues. Within the next year or so, Cassini was using telescopes made by both Divini and Campani, and eventually he favored those of his younger friend.

While in Bologna in the intervals between travel assignments, Cassini became a perpetual house guest in the palace of Senator Marchese Francesco Angelelli. As a member of ancient Bolognese nobility, Angelelli was absent in France much of the time. A more than generous host, in his palace he prepared a room for Cassini's use filled with mathematical instruments. After Angelelli's murder in 1663, Cassini moved to a residence of his own, and his domicile soon became a gathering center for local savants engaged in scientific experiments or others who were preparing dissertations on the sciences. Among those who frequented his new home were Marcello Malpighi and others already known from their published work.[963]

Despite the distraction resulting from his frequent travel to Ferrara, Ravenna, Perugia, and other cities of the Papal States (or abroad to Florence) on behalf of either the Senate of Bologna or the Vatican, Cassini's primary concern remained astronomy. He managed to take advantage at every opportunity on his peregrinations to spend time with scientifically inclined associates in Florence, where the Grand Duke Ferdinand II, who sought his services, extended his hospitality.

[961] Augusto de Ferrari, "Cassini, Giovan Domenico," *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1978).

[962] Cassini, "Vie," 282–84.

[963] Ibid., 276.

There, to coincide with one of his visits, Prince Leopold convened a special session of the Accademia del Cimento for Cassini to attend.[964]

Upon his arrival in other cities, Cassini customarily received and accepted invitations to lodge at the official residences of Bologna's ambassadors. In Rome, for example, he was generally to be found at the palace in Piazza Colonna of the Marchese Campeggi, while in Florence he was welcomed at the home of Count Marescotti. During the summer months, he enjoyed the hospitality offered in villas of other Bolognese nobility outside the city.[965]

Pursuing his interest in solar eclipses, Cassini had been fortunate to be able to make observations of a solar eclipse in front of the Duke of Modena. In 1661, he devised a method for mapping successive phases of solar eclipses, and the following year, he published new tables of the sun based upon observations he made at San Petronio in Bologna.[966]

From the time that Pope Alexander VII assumed the papal throne, Cassini's visits to Rome became increasingly more frequent because the Pontiff repeatedly assigned responsibilities to him requiring his personal supervision and attendance in the Eternal City. As a consequence of this involvement, the astronomer found occasion to associate frequently with a number of the cardinals residing at the Vatican. They represented the central authority of the Church, and some of them belonged to such great families of Rome's nobility as the Colonna, the Barberini, and the Chigi, all of whom supported intellectuals and mathematicians. With many of these prelates, Cassini eagerly exchanged information on their shared mutual passion for ancient science and particularly for the popular new science of astronomy.

The visiting professor from Bologna soon discovered that his popularity also extended to many young ladies of Roman aristocracy who were eager to explore the night skies at the side of the handsome young astronomer. Prominent among them was none other than the wife of the High Constable Colonna. "Often at night", Cassini later wrote, "my observations were honored by the presence of the wife of the High Constable Colonna, who occasionally brought along with her the Countess Stella, a widow with pleasant conversation, and frequently the wife of the High Constable came to bring me in her carriage at the beginning of night, and because of her station being allowed to precede other carriages that accompanied hers, she ordered her driver to stop in some place from which we could make observations. It was on these occasions that I composed in Italian verse the descriptions of the constellations with which she diverted herself by learning them by heart". This

[964] Ibid., 282.
[965] Ibid.
[966] Ibid., 327.

poem, entitled "Cosmografia," was never published in Cassini's lifetime but some verses of it were included in the account of his life that was produced by his great grandson Cassini IV.[967]

It was not long before the personable astronomy professor at the Archiginnasio in Bologna had become well known throughout the Italian peninsula, in addition to Rome. There, of course, he was to be found among numerous colleagues and associates equally concerned with the sciences; among these was Michelangelo Ricci, whom he described as the most knowledgeable mathematician that he found in Rome. Others were Honoré Fabri and Antonio Santini, author of a work on geometry. Cassini also exchanged astronomical speculations with Athanasius Kircher, the German polymath at the Collegio Romano.[968]

In addition to members of the academic world, numbered among Cassini's acquaintances in Rome were knowledgeable men of the local nobility who frequented the academic community. Prominent among Cassini's acquaintances were several members of the powerful Chigi family of the incumbent Pontiff. He developed a particular friendship with Mario Chigi, the Pontiff's brother, who had been appointed general in charge of the pontifical army. Closer to his own age were the pope's nephews, Cardinal Flavio Chigi and Don Agostino. They all had become avid enthusiasts of the popular new hobby of astronomy, and one or more of them habitually joined Cassini when he was in Rome during his surveys of the night skies from the terrace of the Collegio of Propaganda FIde or elsewhere in the city.[969]

Cassini related how on one occasion while he was returning on foot from having made a visit to the papal summer residence at Castel Gandolfo, he was overtaken by Don Agostino in his carriage. The prince insisted that Cassini join him in his carriage and brought him to the presence of his uncle, Alexander VII. The Pontiff received the astronomer with every evidence of the greatest pleasure and kept him in the papal apartments during the entire day discussing various aspects of astronomy. The Pope confided to Cassini how as a young man he had been greatly interested in the subject, and that, while he was serving as papal nuncio to Bologna, he frequently corresponded with various astronomers. He mentioned that in the past he had amused himself by designing and constructing portable sundials. Cassini presented the Pontiff with a system of the spiral movements of the principal planets based upon the hypothesis of a stable earth. A copy was given also to the Grand Duke of Tuscany.[970]

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[967] Ibid., 281: on the wife of High Constable Colonna and on the Countess Stella; Jean-Dominique Cassini, "Frammenti di cosmografia in versi italiani," in *Mémoires pour servir a l'histoire des sciences et a celle de l'Observatoire royal de Paris , suivis de la vie de J.-D. Cassini, écrite par lui-même, et des éloges de plusieurs académiciens morts pendant la Révolution* (A Paris: chez Bleuet, successeur de Jombert, 1810), 313–19.

[968] Ibid., 272-81.

[969] Ibid., 282-83.

[970] Ibid., 271–73, 282, 326. The system of planets is preserved in the Chigi library in the Vatican.

[Figure]

In the course of one of his frequent audiences with the Pontiff, Cassini petitioned for and succeeded in obtaining the latter's agreement to permit the return to the Jesuit astronomer Giovanni Battista Riccioli of a copy of his manuscript work on the subject of the Immaculate Conception of the Virgin Mary. Riccioli had submitted the manuscript for approval to the inquisitor in Bologna. It was a dangerous subject, and the censor had disapproved of it and withheld it, until finally, with Cassini's urging, the Pontiff intervened and the manuscript was returned to its author.[971]

The responsibilities and chores assigned to Cassini by the Senate of Bologna in addition to those he received from the Vatican appeared to be endless. In 1663, Mario Chigi had appointed Cassini superintendent in charge of the repair and improvement of fortifications of the papal stronghold Forte Urbano and, in 1665, designated him inspector for fortifications in Perugia. Earlier, in 1664 while Cassini was in Rome, he had been summoned by the Pontiff to accompany Marchese Carpegna on a mission to regulate the course of the Chiana River. It was during that interval that Mario Chigi had alerted him to the forthcoming appearance of a comet, and he gladly accepted the invitation to observe it with him from the loggia of the Chigi palace.[972]

Michele Giustiniani noted that, in late 1664, when a new comet had made its first appearance, Cassini observed it in the company of the aforementioned Marchese Campeggi and then again from the loggia of the Chigi palace. Cassini later recorded how he regularly had made observations of the phenomenon from that loggia, a roofed open-air gallery that proved to be ideal for his purpose. Usually the young astronomer was accompanied by the Abbot Passionei (future Cardinal), whose function was to record the observations as Cassini described them to him. The Abbot did so by making configurations of the comet in relation to neighboring stars on paper by means of crushed grains of lead. He kept moving the grains about upon the paper around the figure of the comet so that their disposition conformed to those of the stars in the area.[973]

Queen Christina, meanwhile, upon having learned of the location from which the visiting Cassini had been making his observations, expressed the wish to have him continue instead to observe thereafter from her residence, the Palazzo Riario. It was there she had been domiciled since 1659, and it remained her residence until her death three decades later. During her tenure, the palace had become the gathering place for poets, mathematicians, philosophers, and the *letterati* from the various academies in Rome that continued to flourish in that epoch. During the years she had made it her residence, the Queen had surrounded the palace with great gardens and constructed a theater.

[971] Ibid., 271-72.

[972] Ibid., 277-78, 283, 300.

[973] Ibid., 278-79; Michele Giustiniani, *Gli Scrittori liguri, descritti dall' abbate Michele Giustiniani [...]*, vol. 1 (Roma: Tinassi, 1667), 365.

She also had long planned to add an astronomical observatory on the premises, for which Campani was to furnish the instruments, but it never materialized.

During his sojourns in Rome, each evening after dinner, the Queen dispatched her carriage with a page to seek out Cassini and conduct him to her palace along the Lungara. Cassini reported having spent many pleasant hours with her in interesting discussions about the sciences, as they awaited darkness to fall when the comet would begin to appear and they could engage in making observations. While in the presence of Her Majesty, Cassini invariably respectfully removed his headgear, but she always thereupon wrapped her own kerchief around his head to protect him from the night air. Almost every day, several hours before they began to make their observations, her friend Cardinal Decio Assolino made it a habit of coming by and stopping in for a visit with the Queen. During these encounters she took great pleasure listening to Assolino and Cassini arguing on scientific subjects. Often she amused herself by taking sides with one or the other as they argued.[974]

The year 1664, in addition to having become known as the year of the comet, also was a period during which studies were being made of the planet Jupiter and its satellites. It was in the summer of 1664, according to Cassini's account, that he received the abovementioned invitation from Giuseppe Campani "to Monte Citorio to observe Jupiter together with a number of personages of distinction who are gathered there to test out his telescopes, and forthwith that I saw this star I observed two spots on its disk comparable to the configuration of the satellites resulting of those I had seen the previous day and I realized that they were the shadows of two satellites that traversed the disk of Jupiter that was exposed to our view".[975]

Cassini had combined the excellent object lens of focal length 17 feet that Campani had given him with a suitable ocular lens into a telescope that he used during his travels to Tuscany. With it, in July 1665, he discovered the permanent spots upon Jupiter. As previously noted, a study of these spots is what enabled him to determine the duration of the rotation of Jupiter upon its axis, which proved to have been excellent.[976]

Meanwhile, however, Gilles-François Gottignies, a Jesuit professor of mathematics at the Collegio Romano, endeavored to support his own claim of having been the first to make this observation. In an effort to do so, he accused Cassini of manipulating his results in order to adapt

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[974] Cassini, "Vie," 279; Silvio A. Bedini, "Christina of Sweden and the Sciences," 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: Variorum, 1993), 99–117.

[975] Ibid., 299.

[976] Ibid., 330-31.

them to the proper hypotheses. Cassini responded effectively with a public letter resolving the matter that was printed and widely distributed.[977]

Gottignies was not the only one to question Cassini's claim, however. No sooner had Cassini noted and published the times and calculations of his observations of the satellites of Jupiter then a number of colleagues in Italy and elsewhere in Europe each in turn made the same observations and produced calculations in order to confront Cassini's results and verify their own accuracy and reliability. In Florence, however, Giovanni Alfonso Borelli, the Grand Duke's mathematician, previously had been preoccupied with a theory about Jupiter's satellites, and the results he now obtained proved to be totally supportive of Cassini's finding.

Early in 1668, Cassini spent some time in Rome during which he managed to set aside sufficient leisure time when he was actively able to concentrate on making more observations. On January 14th, for example, he recorded that he had observed "the Star rising in the neck of the Whale", and on May 25th he described a lunar eclipse; both of these observations were reported that year in the *Giornale de' Letterati*. During its first year of publication, at least six issues of the *Giornale* contained contributions from Cassini, which he had submitted not only from Bologna but also while he was in Rome.[978]

Michele Giustiniani noted that before the advent of the *Giornale*, Cassini had been in contact with the astronomer Francesco Serra in Rome while making observations, and that, in 1664, Giovanni Luccio, a Dalmatian friend of Giustiniani, also had placed his loggia in Rome at Cassini's disposition for making observations.[979] Shortly thereafter, in 1665, Cassini published his *Astronomical Letter* to Ottavio Falconieri in which he not only described in considerable detail the observations he had made but also furnished the times of anticipated passages of the planets for the succeeding months of August and September, which he did in order that his "unwilling" colleagues could in turn observe and render an accounting of the facts.[980]

During the following May 1665, meetings of three would-be astronomers in Rome frequently took place to engage in a curious experiment. It is not certain which one of them initiated it, but probably it was Cassini. He met with Giuseppe Campani and Agostino Pinchiari in the gardens of the French Fathers of the Trinity to determine whether, without the use of telescopes, the eyesight of Italians could see farther than the eyesight of other nationalities.[981]

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977 Ibid., 328; Giustiniani, *Scrittori liguri*, 1:369–70.

978 Cassini, "Vie," 329–30.

979 Giustiniani, *Scrittori liguri*, 1:366–71.

980 Cassini, *Lettera astronomica di Gio: Domenico Cassini al sig. abbate Ottavio Falconieri. Sopra l'ombre de pianetini medicei in Gioue*.

981 Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, 369, letter n. 1416, footnote 2: letter of Giuseppe Campani to Charles Bryas, May 12, 1665.

It was at about this time that Auzout published in the *Memoires of the Académie Royale des Sciences* a letter addressed to the Abbé Charles. It reflected critically upon Campani's *Ragguaglio*, and in it Auzout also took the opportunity to remark adversely upon Hooke's proposal for a lens grinding and polishing lathe. Auzout criticized Hooke for advocating the use of this machine without actually having tried it; he pointed out the mechanical difficulties involved in trying to perfect it sufficiently for the purpose intended and cast doubt upon Hooke's suggestion that with it lenses having a focal length of 1,000 feet might be made. Auzout went on to emphasize the difficulty of producing good lenses of even 40 feet in focal length. Hooke immediately responded in a reply reprinted in the Académie's *Memoires*.[982]

Abbé Charles, meanwhile, had forwarded a copy Auzout's letter to Giuseppe Campani with one of his own, in which he praised Auzout's writings, noting that the French astronomer and he were in agreement on many points. He also supported Huygens's observations concerning the ring of Saturn, for example, which had been disputed by observations made by Divini with his longest telescopes. Giuseppe was not conversant in French, however, and he asked his friend, Agostino Pinchiari, to translate Auzout's letter for him. Despite Auzout's criticisms of his *Ragguaglio*, it no doubt remained in Giuseppe's mind that the ring around Saturn substantially exceeded the outline of the disk of the planet, as he had indicated in his drawing published in his *Ragguaglio*.[983]

In retrospect, Cassini's dedication to astronomy was unparalleled for, although he had no convenient observatory nor other facilities in which he could work, he managed nonetheless to make his observations while traveling from one location to another through Tuscany and the Lazio while still being detained by missions and judicial inspections relating to the affairs of the Chiana valley. The countless inconveniences resulting from his unsettled movements were reflected in some detail in his published letters to Falconieri. He recounted as well the various means by which

[982] A copy of Auzout's letter produced in the form of a pamphlet was sent to Oldenburg, presumably by the author, but since Hooke was not conversant with French, Oldenburg prepared a summary of it in English for him. Auzout, *Lettre à M. l'abbé Charles sur le "Ragguaglio di due nuove osservationi, etc.", da Giuseppe Campani*.

[983] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, 369, letter n. 1416: letter of Giuseppe Campani to Charles Bryas, May 12, 1665. In acknowledging the letter from the Abbé Charles, later in May, Giuseppe noted that Pinchiari finally had completed reading and translating for him "in the most elegant Tuscan language" Auzout's entire treatise concerning Giuseppe's observations of Saturn and Jupiter that the Abbé Charles had sent to him. He went on to praise Auzout's writing style and commented that he and Auzout were in accord even in some matters that had seemed in contest, such as the determination of the size of Saturn's ellipses. It had not been Giuseppe's intention to determine the sizes of the ellipses, he noted, but that instead it had been to discover and to have the world see by means of eyesight the distinct circle around Saturn. Giuseppe also supported the truth of the Huygenian hypothesis that Divini had occasion to observe in Rome with his longest telescopes. Surely, he wrote, if the Abbé Charles saw that the ring notably exceeded its disk, furthermore, he must be aware that this excess came within the figure of the print altered in two ways (sketch).

he managed to utilize every free moment he could to search the skies with his eyes by means of his instruments, which he always took with him whenever he traveled.[984]

When writing to Falconieri from Città della Pieve in the autumn of 1665, for example, Cassini commented: "In order not to allow all the time to be robbed from the present occupation and travel which I still must do, I will begin in the intervening hours to respond to the erudite motives of your most recent letter, and at the same time to benefit other discoveries. Permit me, therefore, in this scarcity of time to do with interrupted letters that which with unbroken study is not available to me".[985]

While in Magliano in Sabine a week later, Cassini again wrote to Falconieri, "In my preceding letter, which was interrupted by the necessity of traveling again, I present to Your Illustriousness the discovery of the diurnal revolution of Jupiter on its own axis".[986]

Cassini's study of Jupiter had not been limited only to identification of its satellites, for he was interested also as much in determining the planet's rotatory motion on its own axis and in the appearance of the spots as well as of the bands that occurred upon its disk. Cassini did not describe the discontinuity and extreme variability and inconstancy of the time, nor the incessant flow or fluidity and reappearance or settlement of the atmosphere that surrounded the planet; it would not be until succeeding centuries that all of these aspects would be confirmed.

Between Cassini and Campani, possibly also because of personal congeniality and reciprocal sincere understanding, a productive and precious collaboration had been established. The clear and trusting relationship that bound the two observers together was based upon mutual recognition of each other's merits. Placing his trust exclusively in Campani's lenses and telescopes, Cassini praised them at every opportunity, yet at the same time he was careful never to denigrate Divini's work. "In the midst of my occupations that were assigned to me by public affairs [of the Senate of Bologna]", wrote Cassini many years later, "I managed during the night to make many astronomical observations with an excellent telescope that had been given to me by M[onsieur]. Campani, who has communicated to the public the discovery that I had made of the shadows of Jupiter's satellites upon the disk of that planet; that led other astronomers also to observe it". A clear indication of the friendship that existed between the two men is that Cassini expressed no

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[984] Gian Domenico Cassini, *Lettere astronomiche di Gio: Domenico Cassini al signor abbate Ottavio Falconieri sopra il confronto di alcune osservazioni delle comete di quest' anno M.DC.LXV* (In Roma: apresso Fabio de Falco, 1665); *Lettera astronomica di Gio: Domenico Cassini al sig. abbate Ottavio Falconieri. Sopra l'ombre de pianetini medicei in Gioue*; *Lettere astronomiche di Gio. Domenico Cassini al sig. abbate Ottavio Falconieri sopra la varietà delle macchie osservate in Giove, e loro diurne rivoluzioni* (In Roma: apresso Fabio de Falco, 1665).

[985] Cassini, *Lettera astronomica di Gio: Domenico Cassini al sig. abbate Ottavio Falconieri. Sopra l'ombre de pianetini medicei in Gioue*.

[986] Cassini, *Lettere astronomiche di Gio. Domenico Cassini al sig. abbate Ottavio Falconieri sopra la varietà delle macchie osservate in Giove, e loro diurne rivoluzioni.*

resentment when Campani announced Cassini's achievement before he had an opportunity to do so himself.[987]

In Cassini's letter to Ottavio Falconieri, which was published in 1665, he communicated his fundamental observations on the eclipses of the Jovian satellites. On the title page he mentioned that he had first discovered the appearance of the shadows of the satellites of Jupiter in the course of observations he had made in late July of the past year and that they had been achieved "with the large telescope of Sig. Giuseppe Campani in the manner that he immediately made public, and that on many other occasions he continued to observe with the other lesser ones with which the same author favored me". Until the advent of the Newtonian telescope, Campani's telescopes continued to be eagerly sought, were widely used, and eventually were considered to be the finest available in all of Europe.[988]

After having become well known within a very brief period for the high quality of his lenses and telescopes, Giuseppe Campani gradually also began to achieve recognition as an astronomer. This was as a consequence of a series of observations he made by using his own instruments. Although these astronomical observations personally made by Campani were less prominently acknowledged than were the widely heralded achievements of Cassini, they nonetheless constituted an important if indirect contribution to contemporary astronomical knowledge.

It was at this time that Giuseppe published his *Letter Concerning the Shadows of the Medicean Stars*, an open letter addressed to Cassini. Appearing in the same year as Cassini's published communication to Falconieri, in his *Letter* Campani acknowledged what the astronomer had taught him, implying an intimate association of master and pupil and of cooperative scholarship. He commented also on their mutual critics: "I know well, that some [individuals] in order to diminish the credit due to my telescopes, and to you the glory of this so important an observation, if they bring arguments against me in the manner that to me is opposed, stating, that I had not discovered anything new in Saturn. . . . The smoke of envy blinds in such a manner the eyes of these people so that they cannot see, that as much as may be infinite, as you have taught me, the hypothesis of the ancient writers, and the modern ones concerning the celestial bodies, nonetheless few insignificant have been those that knew how to demonstrate any as truth, if not bringing greater glory to the first having the honor of having invented it, than to the second the bliss of having demonstrated it".[989]

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[987] Cassini, "Vie," 280.

[988] Cassini, *Lettera astronomica di Gio: Domenico Cassini al sig. abbate Ottavio Falconieri. Sopra l'ombre de pianetini medicei in Gioue*.

[989] Campani, *Lettera di Giuseppe Campani.*

The discovery of the Jovian satellites was widely acclaimed, and it was described by a writer in the *Journal des Sçavans* in 1666 as being "one of the most wonderful that had as yet been made in the sky", and "one that required research to determine whether the phenomenon observed for the major planets was common as well in other components of the solar system". The writer of the journal added, "It should stimulate every researcher and observer to endeavor to perfect further the large telescopes until it is possible to discover whether or not the other planets such as Mars, Venus, and Mercury, around which no satellites have been observed, do not come to an end or terminate revolving around their respective axes, and the amount of time required for it to take place, by Mars in particular, on which some spots have been observed. . . .".[990]

This was a challenge to discovery that Cassini could not well overlook, and he was determined to find an answer. He decided he would begin with Mars. Thereupon at Bologna during the months of February, March, and April 1666, he proceeded to make a new series of observations of the Red Planet. For this purpose he used an excellent new telescope with which Campani had provided him. His studies of the spots that had appeared on the face of the planet and had been presented alternatively to his eye by the planet's rotation were first described by Cassini in a public notice. The published table contained a fine plate engraved from Cassini's original drawing of Mars upon which the spots clearly appeared more or less dark to which was given the characteristic aspect of the planet. Their displacement from east to west, until their disappearance, and in the reappearance of the spots, with the same characteristics, provided a means to the astronomer for calculating the period of rotation of Mars, which he estimated to be 24 hours and 40 minutes. Once again, Cassini did not overlook an opportunity to publicize his use of a telescope by Campani. The published table bore the inscription, "The Revolution of Mars Upon Its Proper Axis Observed by J. D. Cassini at Bologna With a Campani Telescope in the Months of February, March, and April 1666".[991]

Giuseppe Campani had the opportunity to cooperate closely with Cassini in this endeavor, with one of his own telescopes of 50 palms. It had a focal distance of more than 10 meters, which was exceptional for an instrument of that period. Cassini's observations were confirmed in Rome by Campani. This was yet another occasion when the young artisan in Rome was working in unison with the astronomer in Bologna, to whom he did not neglect to declare his proper esteem and dedication. He wrote:

Sunday night the 28th March at 1-1/4 o'clock of the night, with my usual large telescope, I made an observation of Mars that appeared to be similar to the enclosed drawing with that section more luminous and

[990] Discovery of Jovian sattelites by Cassini, described in Gian Domenico Cassini, "Extrait d'une lettre escrite de Rome, touchant les nouvelles decouvertes faites dans Jupiter," *Journal des sçavans*, fevrier 1666, 99.

[991] Cassini observation on Mars in February, March, and April 1666, with published plate of Mars in "Martis circa axem proprium revolubilis observationes," *Journal des sçavans* 22 (mai 1666): 259–62.

not drawn to an edge [*a fioli*]. Present were *Abate* Falconieri and *Abate* Marucelli. I give most humble reverence to Your Excellency, begging you to command me and I wish to say to Sig. Agostino Pinchiari that I revere him as I do you, your obligated servant. From Rome 3 April 1666.[992]

News of Campani's achievements in astronomy became more and more widely known, and their importance was increasingly recognized during the later decades of the seventeenth century. As noted, his growing fame was partially due to the success of his own astronomical observations as well as to his collaboration with Cassini but chiefly as a consequence of the outstanding superiority of his lenses. Astronomical observations made by Campani himself did in fact help to promote and publicize the excellence of his instruments. In order to evaluate Campani's contributions in astronomy, it is necessary to study his observations as a separate aspect of his activities. According to Nicodemo Jadanza, a nineteenth century historian, a contemporary analysis of Campani's observations was voiced by Huygens who spoke of Campani as a "marvelous observer" and stated furthermore that to Campani must be attributed some important discoveries of his own in this field that previously had not been recognized.[993]

The late Professor Guido Horn d'Arturo, then director of the observatory at the University of Bologna, also rated Campani as a capable observer, in addition to considering him to be the maker of the finest astronomical instruments of his time. He maintained that Campani had determined the rotation of Jupiter and the division of the ring of Saturn at the same time as Cassini had done and possibly even prior to Cassini. It is difficult to determine whether Cassini or Campani actually was the first to identify "the other little planets," that is, the much smaller satellites of Jupiter that Galileo had not succeeded in observing.[994]

Also in April 1666, Auzout had informed Oldenburg that he had read some letters written from Rome reporting that Cassini had discovered some spots on Mars but that no details had been provided. He then went on to add that Divini had put together "a thick letter" in which he claimed that the permanent spot on Jupiter had been first discovered with his lenses and that it was Father Gottignies who had been the first to have worked out Jupiter's rotation. Auzout explained that Gottignies had written a letter on this point, complaining about Cassini.[995]

Several months later, Huygens, who had been invited to the observatory in Paris by Minister Colbert, wrote to Prince Leopold: "As to what concerns the new observations made by Cassini on the shadows of the satellites of Jupiter, they appear to me to be excellent and fecund [intellectually

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992 Campani, *Lettera di Giuseppe Campani*, re. observations of Mars.

993 Jadanza, "Per la storia del cannocchiale," 17.

994 Guido Horn d'Arturo, *Piccola Enciclopedia Astronomica*, Compositori (Bologna 1966), unpaginated, vide Giuseppe Campani.

995 Henry Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 2, 13 vols. (Madison: University of Wisconsin Press, 1966); "Lettera di Eustachio Divini, con altra lettera del Padre Egidio Franc. de Gottignies della Comp. de Giesu, intorno alle Machie nuovamente scoperte nel Pianeta di Giove. In 8, in Roma", 709-11.

productive] and I have no doubt of his veracity, as I have learned there has been doubt from others, and even less after the same day, September 26th of last year 1665, when I was able myself to observe clearly the shadow of the third satellite, which Cassini had predicted would appear".[996]

Details of the observations of the planet Mars that had been reported to have been made in Italy by Cassini and Campani in June 1666 were provided to the Royal Society in London by the Venetian ambassador at the French court. These observations, in addition to those that had been made in England by Robert Hooke, were published in the July issue of the *Philosophical Transactions*. The reports of Cassini and Campani were in the form of printed papers entitled "*Martis circa Axem proprium revolubilis observationes, Bononiae a Jo. Dominico Cassini habitae*".[997] Therein Cassini wrote, in the third person:

l. That with a Telescope of 24 Palms, or of about 15 Feet, wrought after Sig. Campani's way, he began to observe February 6, 1666 (ft.n.) in the morning, and saw two dark Spots in the first face of Mars.

2. That with the same Glass [telescope] on Feb. 14/24 he observ'd in the Evening, in the other face of this Planet, two other Spots, like those of the first, but larger.

3. That upon continuing the Observations afterwards, he found the Spots of these two faces to turn little by little, from East to West, and to return at last to the same situation, wherein he had seen them first.

4. That Sig. Campani, having also observ'd at Rome with Glasses of 50 Palms or about 35 Feet, likewise of his own contrivance, had seen in the same Planet the same Phenomena.

5. That sometimes he [Campani] hath seen, during the same night, the two faces of Mars, one, in the Evening, the other in the Morning.

6. That the Motion of these Spots in the inferior part of the apparent Hemisphere of Mars, is made from East to West, as that of all the other celestial Bodies, and is perform'd by Parallels, that decline much from the Equator, and little from the Ecliptick.

7. That the Spots return the next day to the same situation, 40. minutes later, than the day before; so that in every 36. or 37. Daies [days], about the same hour, they come again to the same place.

8. He [Cassini] promises shortly to give us the particular Tables of this Motion and of its Inequalities; together with the Ephemerides themselves.

9. He represents that some other Astronomers have also made at Rome several Observations of these Spots of Mars, from March 14/24 to March 20/30 with Glasses wrought by Eustachio Divini, of 25. and 45. Palmes: Which Spots he makes little differing from his own, of the first Face; as will by and by appear, by the direction to the Schemes.

10. But, he adds, that those other Roman Astronomers, that have observ'd with Divini's Glasses, will have the Conversion of Mars to be performed, not in 24 h. 40 m. (As he maintains it is), but in about 13 h.

11. And to evince, that they are mistaken in these Observations of theirs; he alleges, That they assure that the Spots, which they have seen in this Planet, (by a Eustachian [Divini] Telescope) the 20/30 of March, were small, very distant from one another, remote from the middle of the Disk, and the Oriental Spot was less, than the Occidental (as is represented by the Fig. O; like that of the first face of Mars.) whereas, on the contrary, He (Cassini) pretends to [provide] evidence by his Observations, made at the same time at Bologna, that, the same day and hour, those Spots were very large, near one another, in the midst of the Disk, the Oriental bigger than the Occidental (as appears by Fig. P, which is that of the second face of Mars.)

12. Besides, he declares, that those Astronomers were too hasty, in determining, after only 5 or 6 Observations, in how much time Mars finish's his Revolution; and denies it to be perform'd in 13 hours: adding, that, though Himself had observ'd for a much longer time, than they; yet he durst not for a great while define Whether Mars made but one Turn in 24 hours 40 minutes or two; and that all, that he could, for

[996] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 6, 53-55, n. 1548: letter from Christiaan Huygens to Prince Leopold, June 22, 1666.

[997] Gian Domenico Cassini, *Martis circa axem proprium reuolubilis obseruationes Bononiae a Io. Dominico Cassino habitae* (Bononiae: ex typographia hh. de Duccijs, 1666).

a long time affirm, was only this, that after 24 h. 40 m. This Planet appear'd in the same manner he did before.

13. But since those first Observations, he affirms to have found cause to determine, that the Period of this Conversion is made in the said space of 24 h. 40 m.; and not oftener than once within that time; alleging for proof:

1. That, whereas Febr. 6 (st.n) he saw the Spots of the first Face of Mars, moving from eleven of the Clock in the night, until break of day, they appear'd not afterwards in the Evening after the rising of that Planet (witness several intelligent persons, which he names, that were present at the Observations:) Whence he infers, that after 12 hours and 20 minutes, the same Spots did not come about; since that the same, which in the morning were seen in the middle, upon the rising of Mars; after 13 or 14 hours, might have appear'd neer the Occidental Limb. But, because he might be imposed upon by Vapors, whilst Mars was yet so neer the Horizon, he gives this other determination, vid.

2. Whereas he saw the first face of Mars the 6 of February at 11 of the clock of the night following: he did not see the same after 18 daies [sic] at the same hour, as he ought to have done, if the Period were absolved in the space of 12 h. 20 m.

3. Again, whereas he saw Feb. 24 in the Evening, the other Face of Mars, he could not see the same, the 13 and 15 day of March, to wit after 17 and 19 days; as he should have done, if the Revolution were made the newly mentioned time.

4. Again, whereas the 27. of March in the Evening he saw the second Face of Mars, he could not see in the 14 and 16 of April.

From all which Observations he Judges it to be evident, that the Period of this Planets Revolution is not perform'd in the space of 12 hours 20 minutes, but in about 24 hours 40 minutes, more exactly to be determin'd by comparing distant Observations: And that those who affirm the former, must have been deceived by not well distinguishing the two Faces, but that having seen the second, taken it for the first.

All of which he concludes with this Advertisement, that, when he defines the time of the Revolution of Mars, he does not speak of its mean Revolution, but only of that, which he observ'd, whilst Mars was opposite to the Sun; which is the shortest of all.

The Figures of the Principal Observations, represented in the book here discoursed of, may be seen in the annexed Scheme; videl.

K. One of the Faces of Mars, as Sig. Cassini observed it March 3 (st.n.) 1666, in the Evening with a Glass of 24 Palmes.

L. The other Face, as he saw it Feb. 14/26 in the Evening.

M. The first Face, as Sig. Campani saw at Rome, March 3, 1666, in the Evening, with a Glass of 50 Palmes.

N. The second Face as the same Campani observ'd it March 18/26, in the Evening.

O. The Figure of Mars, as it was seen at Rome by a Telescope of Divini of 45 Palmes, March 22/30.

P. The Figure of the said Planet, as it was seen the same day and hour at Bologna by Cassini; being that of the second Face.[998]

It was not long before others eagerly contested the results achieved by Cassini and Campani in their observations. First among them were the brothers Salvatore and Francesco Serra, who also had made observations of Mars in Rome. Using a telescope constructed by Divini, they calculated the times of the planet's rotation to be 12 hours. The polemics between the two groups of researchers became incendiary and ended by generating passionate responses also from other foreign colleagues, above all, after the *Journal des Sçavans* in Paris and the *Philosophical Transactions* of the Royal Society in London had published reviews of the works that had appeared

[998] "Observations Made in Italy [by GD Cassini and G. Campani], Confirming the Former [Hook's Observations of Mars], and Withall Fixing the Period of the Revolution of Mars," *Philosophical Transactions of the Royal Society of London* 1, no. 14 (July 2, 1666): 242–45.

in Italy. Salvatore Serra was one of the first astronomers after Cassini to have recognized the rotation of Mars upon its axis, and he described it in a work published in Rome in the same year.[999]

Cassini, having once again been made the target of malevolent insinuations, and in order to defend specifically the priority and accuracy of his calculations, felt the need to publish his *Dissertationes astronomicae apologeticae*. Despite the bold self-assurance and the somewhat arrogant manner with which Salvatore Serra had entitled his publication, he then recovered from the errors by which they were afflicted by publishing. Cassini's theory proved to be exact, to the point that his observations were to be confirmed with modern instruments two centuries later, with the difference of only a single minute in the time of rotation that he had indicated.[1000]

In the 12th issue of the *Philosophical Transactions*, published in May 1666, Divini's observations were featured in an article entitled "Some particulars, communicated from forraign parts, concerning the Permanent Spot in Jupiter; and a Contest between two Artists about Optick Glasses, &c". It reported: "Eustachio de Divinis (saith the Informer), has written a large Letter, wherein he pretends, that the Permanent Spot in Jupiter hath been first of all discovered with his Glasses; and that the P. Gotignies is the first that hath thence deduced the Motion of Jupiter about his Axis; and that Signior Cassini opposed it at first; to whom the said Gotignies wrote a letter of complaint thereupon".[1001]

The entry was footnoted with a comment from the editor, "See Numb. 1. of these Transactions, by the date whereof it will appeare, that Spot was observed in England, a good while before any such thing was so much as heard of". The journal then proceeded to discuss another of Divini's ongoing concerns, explaining:

> The same Eustachio pretends likewise, that his great Glasses excell those of Campani; and that in all the tryals, made with them, they have performed better; and that Campani was not willing to do what was necessary for comparing the one with the other sufficiently well, viz. To put equall Eye-glasses in them, or to exchange the same Glasses.
>
> The said Divini affirms also, that he hath found a way to know, whether the Object glass be good or not, onely by looking upon it, without trying.
>
> That could be of good use, especially if it should extend so far as to discerne the goodness [superior quality] of such a glass, whilst it is yet on the Cement.[1002]

Later in the same year, the *Philosophical Transactions* reported on Divini once more, featured in "An Observation of Optick Glasses, made of Rock Crystal". This was contained in a

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[999] Salvatore Serra, *Anno 1666. Die 30 Martii hor. 2. N. S. Typus Martis cum insignibus maculis Rom[a]e visis D. D. Fratribus Salvatori, ac Francisci de Serris tubo Eustachii Divini palmorum* 25 […] *observata variation eiusdem planet[a]e circa proprium axem revolutionis periodum indicatura[m] horis nempe circiter 13.*

[1000] Gian Domenico Cassini, *Dissertationes astronomicæ, apologeticae* (Bononiae: [s.n.], 1666).

[1001] "Some Particulars, Communicated from Forraign Parts, Concerning the Permanent Spott in Jupiter; And a Contest between Two Artists about Optick Glasses, &c.," *Philosophical Transactions of the Royal Society of London* 1, no. 12 (May 7, 1666): 209–10.

[1002] Ibid.

Letter, of Eustachio Divini, printed in Italian at Rome, as the *Journal des Sçavans* extracts it; it reported, "Though it be commonly believed, that Rock-Crystal is not fit for Optick-Glasses, because there are many Veins in It, yet Eustachio Divini made one of it, which he saith proved an excellent one, though full of Veins".[1003]Attempts to produce astronomical lenses from rock crystal had been made as early as in Galileo's time but without success. The problem appeared to have been the persistent presence of inclusions in the matrix that made it impossible to achieve clarity.

In April 1666, writing on this topic to Oldenburg, Auzout added also that Divini claimed that his large telescopes excelled those of Campani, and that they had performed better in all the trials that had been held. He also complained that Campani had always refused to do what was required in order to properly compare their two instruments, that is, to provide identical lenses to each of the eyepieces or exchange the eye lenses. "There is one splendid innovation which I don't know", Auzout went on, "there is a way Divini says he has discovered, of being able to tell upon seeing an objective whether it is good or not, without trying it out. He explains nothing further. I confess I do not possess this secret; if one of you gentlemen can guess what it is, it will be particularly useful if one can apply it while the glass is still cemented down".[1004]

It was in May 1668, just after Cassini's return from Bologna to Rome after having completed negotiations on behalf of the Grand Duke of Tuscany, that he received exciting news from Paris from d'Estrées, the French ambassador to Rome.[1005] The fame of Cassini's astronomical tables as well as of his important discoveries had brought him to the attention of King Louis XIV and of his minister Jean Colbert. Both were anxious to enhance the prestige of the newly founded Academie Royal des Sciences by offering enrollment to a few prestigious foreign members. The King offered Cassini membership in the Academie as one of its regular correspondents and invited him to come to Paris for a sojourn of limited duration to assist in the planning and construction of the new astronomical observatory being built in Paris, the first stones for which had already been placed in 1657. Colbert offered the young astronomer the most advantageous conditions, a pension

[1003] "An Observation of Optick Glasses, Made of Rock-Crystal," *Philosophical Transactions of the Royal Society of London* 1, no. 20 (December 17, 1666): 362.

[1004] Oldenburg, *The Correspondence of Henry Oldenburg*, 103: letter from Auzout to Oldenburg, April 25, 1666. Letter from Auzout to Oldenburg, April 23, 1666.

[1005] It had been at the palace of the French ambassador d'Estrées in the presence of Rome's collected savants and elite that Cassini had observed the lunar eclipse of May 26, 1666. While waiting for the eclipse to occur, he had favored the d'Estrèes' guests by expounding on astronomical subjects, ranging from the spots of Mars that he had observed over a period of several years, to Saturn's globe and ring and the spots in the midst of the moon's surface that were in the form of little islands and lakes, a phenomenon which had not yet been observed by others. This first account would be of sufficient interest to the virtuosi in Paris. Celestial phenomena that were reported to have been observed in Rome were compared with that seen by observers at Montmartre in Paris and published in the *Journal des Sçavans* the following July. Gian Domenico Cassini report of lunar eclipse in *Journal des Sçavans* (July 1667).

of 9,000 *livres*, free lodging, and 1,000 *eçus* toward the costs of his voyage. It was an offer that Cassini did not wish to refuse, and he responded with enthusiasm.[1006]

At the same time, Cassini forwarded to the Academie the tables of the movement of Jupiter's satellites of Jupiter together with the ephemerides of all the eclipses of these satellites that had occurred in the same year. He had arranged to have them published in Bologna. These were the first to have been published, and he invited the French astronomers to observe these eclipses in order to deduce the difference of the meridian between them with greater exactitude than was possible by observations of eclipses of the moon.[1007]

Before accepting the offer from the French, it had been necessary for Cassini to obtain approval from his employers, the Senate in Bologna and Pope Clement IX, to allow him to leave Bologna for a temporary assignment, while at the same time retaining all his titles and emoluments. He finally gained approval of all his conditions as well as authorization to travel, from the Senate of Bologna and the Pontiff.

With permissions granted, and laden with honors and graces from Pope Clement IX, Cassini finally departed from Rome on October 15th 1668. Accompanied by the wife of the Bolognese ambassador to the Medici court, he made his way first to Florence, arriving 5 days later. His first obligation was to call upon Grand Duke Ferdinand II to present his compliments, at which time the latter summoned Viviani and Auzout to join them. Auzout also had been chosen for membership in the Académie and now gave Cassini letters he had brought from France, in addition to a copy of the proposed plan of the royal astronomical observatory that was about to be constructed.[1008]

Cassini's visit aroused anew Viviani's interest in astronomical observation, and after the astronomer's departure for Paris, he wrote to Cassini thanking him for his several letters describing "his observations of the new Whale Star and the eclipse of the sun". Viviani added that he had been prevented by a cloudy sky from observing these two phenomena sufficiently well to obtain a clear idea about them. He added that when time permitted he hoped to use the Grand Duke's large telescope to see whether it would be possible to distinguish with it more of the things that Cassini had been observing. As for observing Jupiter, Viviani reported that, since the night of the 23rd until the present time of writing, the best telescopes had been in the care of the Grand Duke's personal attendant, or equerry, Annibale Bruto della Molara. Due to the latter's unwonted hindrances, Viviani had not been able to use them yet, but he planned to do so during the remainder of the year. Viviani also complained that he had been deprived of his good telescope of 5-1/2 *bracci* that had disappeared from the palace the previous year. He added that Auzout, who may have made

[1006] Cassini, "Vie," 286–89.
[1007] Ibid., 285-86.
[1008] Ibid.

observations in Rome, now was gravely afflicted, still ill with fever, and his condition was not without some fear to his friends.[1009]

Viviani went on to ask Cassini to inform him in writing which hours would be best for observing the sky at night. He hoped to be able to make satisfactory observations on the nights of November 15 through 17 and again on November 23 so as to be able to compare his observations with those being made by Cassini and to calculate the difference in longitude between their respective meridians, although he was aware that it would be a very small one. He offered to be responsible for recording it.[1010]

Although by this time Giuseppe Campani was working almost full time on the production of lenses and telescopes for savants engaged in astronomical observation, periodically he found himself still involved with his horological endeavors, unable to escape fulfilling requests for distinguished clients and occasionally inventing new and unusual timepieces. For almost the entire decade after Cassini had moved to Paris, however, Campani's principal endeavors became the production of lenses and telescopes for the Paris observatory, commissioned by his primary clients King Louis XIV and his Minister Colbert.

Huygens, throughout the years he spent at the Paris observatory, also demonstrated considerable interest in Campani's instruments and commented on their superiority, perhaps with a touch of envy. The two maintained a correspondence, of which unfortunately only a small part has survived. In Campani's published letter to Cassini, he mentioned having received a letter from Huygens in which the Dutch astronomer thanked him for having confirmed the observations of Saturn that Huygens had made in 1659.[1011] This confirmation must have been received by Giuseppe after Huygens had read the *Ragguaglio*, a copy of which, according to Raffaello Caverni, he already owned. Caverni also reported a letter written by Huygens to Prince Leopold in that, in addition to other matters, Huygens confirmed his doubts about the new lathe mentioned by Campani:

> First there came into my hands a Narration of the new observations of Saturn made by Giuseppe Campani, in which, other than confirming my hypothesis of the Saturnian ring, I found a most beautiful discovery of a lathe for making lenses, proposed here for the first time. At first view, however, it appears to me to be barely possible, thus it appears that others also doubt, inasmuch as that which is most important, is the fact that the lenses that were worked with this lathe are superior to those that are produced by the customary method, without any machine at all, nor yet for that which I know that the controversy is ended.[1012]

As already noted, surviving also are fragments of a correspondence concerning a telescope which Campani had presented to Cardinal Antonio Barberini, papal legate to the court of King Louis XIV. The correspondence was between Constantijn Huygens (brother of the astronomer), the

[1009] BNCF, Gal. vol. 252, c. 144. Letter from Vincenzo Viviani to Cassini, November 10, 1668.
[1010] Ibid.
[1011] Campani, *Lettera di Giuseppe Campani,* 11.
[1012] Caverni, *Storia del metodo sperimentale*, vol. 2, 395.

French astronomer Adrien Auzout, and Pierre Petit, the French maker of telescopes. Constantijn Huygens, father of the astronomer, had seen the Campani telescope in 1662 in the Cardinal's Paris residence. The Dutch statesman had become so enamored of it that he was determined to acquire it for himself, and he had attempted to obtain it by any means. Pierre Petit informed Huygens that the latter's father had begged him to intercede on his behalf with the Abbé Charles, because he was convinced that Cardinal Barberini was willing to trade the telescope for an English microscope.[1013]

The Cardinal apparently was too much attached to the telescope, however, and intended to keep it for himself. Petit then described the instrument, but, unwilling to praise any of his competitor's work, he sought to minimize its merits, stating that he too would be capable of making lenses like those made by Campani, if only he could obtain some of the optical glass of the same quality that Campani used. Huygens had not been convinced at first by the claims made by his father and others of the greater excellence of the Campani telescope. In 1664, after completing construction of one of his own mirror telescopes, Huygens sent it to Paris to Auzout to have it compared with the Campani instrument. The judgment of the French savant, whose competence he could not question, left him no doubt that Campani's telescope was superior to the one Huygens had made.

Auzout, who himself was a maker of astronomical lenses, could do no less than admit that never before had he ever seen lenses as clear and polished as those made by Campani. The matter so aroused the curiosity of Huygens, it is said, that, in 1666, he had traveled to Paris to examine personally the Campani telescope. His judgment, expressed in a letter to his brother Constantijn, is sufficiently important to quote: "The beauty of the Campani telescope at the home of the Abbé Charles", he wrote, "consists in that it is without colors of iris [chromatic astigmatism], that one perceives point of points in ocular glass; that the opening is sufficiently large without, however, that the objects appear at all bent or warped, and that it represents [shows the image] very distinctly because of the good quality of his glasses".[1014]

Huygens had examined the instrument with considerable attention and reported all technical details. He had taken note of every one of its measurements and set to work to produce an instrument having similar specifications. It appears that he had experienced some difficulty in marking the fine glass and in obtaining a good form or mold for constructing the object lenses, as Huygens himself later recounted. It was formed in a fashion illustrated in a sketch by Marco Tappi, the first lens having a distance from the second that was double their communal focal distance.[1015]

[1013] See Chapters IX and X in this book.

[1014] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 6, 48, n. 1546: Christiaan Huygens' letter to his brother Constantijn, June 18, 1666.

[1015] Marco Tappi, "Ricerca storica sulle realizzazioni ottiche di Giuseppe Campani" (Doctoral dissertation, Università degli Studi di Bologna, 1978).

The eyepiece was composed of three perfectly equal lenses of one inch [*pouce*] and 10 lines of focus (4.79 cm). The objective had a focus of 2 feet and 4 inches (75 cm), and the total length of the instrument was 3 feet and 3 inches (102 cm). The aperture, however, was 19 cm, the diameter was 17 mm, the distance from the eye to the first ocular lens was 39 mm, from the first to the second, 93 mm, and from the second to the third, 100 mm. The measurement was expressed in feet used in the land of the river Rhine: 3l.39 cm.[1016]

The optical system of the first two lenses of Campani's telescope was telescopic, and had re-erected the image formed in the objective without altering its dimensions. The finer quality of the telescope was therefore due to the telescopic system contained in the eyepiece, to the absence of chromatic astigmatism, notwithstanding the discreetly ample aperture, and the absence of spherical aberration. These qualities, now noted by Huygens, had already been reported by Campani in his *Ragguaglio* in 1664.[1017]

Huygens's praise was fully justified and shared by Prince Leopold. In 1666, in a letter to Huygens, the latter reassured the Dutch astronomer that his hypothesis on the Saturnian system had received a favorable confirmation from Campani's observations, whose telescopes, when tested in Florence and compared with others, had always proven to be the best. This letter is significant because it reported also on Leopold's opinion relating to the lathe that Campani had said that he had invented. "But concerning his Lathe," Leopold wrote, "even here it is believed by many that it is no more than a most competent artifice allowed and inadmissible because others do not walk the same true road of fabricating lenses well." Apparently, this is what Leopold believed, an opinion shared generally, that in reality the new "machine" was an invention most perfectly conceded and yet inadmissible by those who suspected its truth.

As already noted, Jadanza concluded that the invention of the terrestrial telescope with an eyepiece that combined three lenses, that Huygens exposed in Proposition LIV of his *Dioptrica*, must without question be attributed to Campani, who had also found the means if not of eliminating chromatic aberration, at least reducing it "even if in an empirical manner".[1018]

As the superior quality of Campani's instruments became more and more acknowledged, he acquired an increasing number of clients in the scientific world for his work. It was while Cassini was still teaching at Bologna, for example, that among those with whom Campani had begun corresponding directly was Charles Bryas, known to the world of astronomy as the *Abbé* Charles, a

[1016] Ibid.; and Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 6, 68-69, n. 1553: Christiaan Huygens' letter to his brother Constantijn July 22, 1666.

[1017] Campani, *Ragguaglio di due nuoue osseruazioni*, 13-14.

[1018] See Chapters IX and X in this book.

cleric passionately interested in science, to whom in 1664 Campani had sent a copy of his *Ragguaglio*.

In November 1668, Cassini was already preparing to move to France when Henri Justel wrote to inform Oldenburg, "Cassini will come to France if the Pope gives him permission. It is said that the King will pay his traveling expenses and give him two thousand crowns per annum. The observatory needs someone as skillful as he. M. Auzout has compared the lenses he made with those of Campani, and found the latter to be a little clearer; but that those of Divini are not as good as those of M. Auzout. He has not been able to see what M. Cassini had detected with his telescopes. They have observed Saturn and Jupiter, and have seen the shadow of the third satellite with the large telescopes. M. Auzout has seen it with his seventeen foot telescope. The Cardinal de' Medici [Prince Leopold] tells me he has seen Jupiter better than ever, he has observed five bands at least and [in the widest] in actuality that moves across. He has seen the shadow of the satellites with a thirty five foot telescope [. . .]".[1019]

Oldenburg had realized some time earlier that in Auzout he had a valuable source for information about events occurring in the scientific world outside of England, particularly in Italy. "Since, then you are willing to charge yourself with some philosophical commissions", Oldenburg had written to Auzout in June 1668, "our philosophers will be very glad to be informed through you about the dispute between Divini and Campani over the goodness of the lenses on which they are working; and also about the discoveries said to have been made by the learned Cassini, of the motions of the satellites of Jupiter about their own axes, and of the motion of Venus about its axis".[1020]

Several months later, in September, Oldenburg congratulated Huygens on the good news he had received concerning his sea-going clocks, "but the trial which you will make during the voyage to be made to Cayenne will be more convincing. What do you think of the new kind of clock whose motion takes place in a vacuum to avoid inequalities produced by the air? I have been told that it has been described in a work printed at Rome, from whence I have also had news that hail stones have fallen near Siena".[1021]

The timepiece mentioned by Oldenburg was, of course, Matteo's nautical clock. Apparently Oldenburg had been uninformed of Matteo and his invention and that it was being tested in Florence by request of the Grand Duke, and referred to Matteo's publication describing it.

[1019] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 5, 128-32, n. 997: letter from Justel to Oldenburg (November 4, 1668).

[1020] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 4, 481-83, n. 895: letter from Oldenburg to Auzout (June 28, 1668).

[1021] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 6, 220-24: letter from Oldenburg to Huygens in September 9, 1669.

Oldenburg was aware of Huygens's interests in nautical clocks: actually, the previous month, the Dutchman had written him: "The news of my clocks since the return from Crete remains very good and I shall later be able to tell you the details worth knowing, but up to now there have been reasons preventing me from doing so".[1022]

In October 1669, Huygens in Paris informed Oldenburg: "The only one of Campani's large lenses which I have tried is that which M. Cassini brought here, which is only of fifteen feet. It is very good and well worked but in these medium lengths this is not rare. We have here some of 17 and 22 feet which are rather better".[1023]

In November, Oldenburg wrote to Francis Norwood, the author and traveler, rhapsodizing somewhat on the subject of lenses and telescopes. He considered the "optick Glasses, it being one of ye noblest & usefullest instruments in ye world, & for ye improvement of wch, the wits and hands of all ingenious & Industrious men all over Europe, are now employed. We are here in London at this very present working of a 60. Foote glasse, & yt succeeding well, the Artist, Mr. George Cock, intends to set upon one of 100. foote". Then writing about Auzout, Oldenburg added, "A great Parisian Philosopher [Auzout], lately gone into Italy, writeth word, that there he had met with one Campany, an excellent workman of Optick glasses, employing likewise a Turne; And yesterday I was assured, yt Mr. Nevill, lately returned from those parts, hath brought one of them with him, very good, but short, wch I long to see".[1024] The reference may have been to Henry Neville (1620–1694), author of *The Isle of Pines*.

In retrospect, it was the lenses that Campani provided that enabled Cassini to open up the skies with the series of discoveries he had made first in Italy and later in Paris. Although his success was unquestionably primarily due to his determination and talents as an observer, it also owed to a great degree to his use of the "free" lenses, or lenses without tubes, required by the great focal length and related to the dimensions of the lenses in view of the need to reduce the effect of chromatic aberration.[1025]

In his own right, Campani also proved to be a capable observer (it is difficult to determine which of the two was the first to identify the other "little planets" [*pianetini*] or satellites of Jupiter that were so small that Galileo never succeeded in seeing them). A clear and trustful rapport linked

[1022] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 6, 211-13, n. 1277: letter from Huygens to Oldenburg (August 25, 1669).

[1023] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 6, 289-92, n. 1307: letter from Huygens to Oldenburg (October 20, 1669).

[1024] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 5, 172-73, n. 1009: letter from Oldenburg to Norwood (November 16, 1668); Cassini, "Vie," 300; Solange Grillot, "L'emploi des objectifs italiens à l'Observatoire de Paris à la fin du 17ème siècle," *Nuncius* 2, no. 2 (1987): 150–51.

[1025] Ibid., 145–55. Surviving in the University of Bologna is an object lens of 22 feet focus constructed by Campani in about 1700, of greenish glass having a 93-mm diameter inscribed along the margin "*Giuseppe Campani in Roma*." It was the objective of a telescope having a tube of cypress wood. Similar lenses of even greater power up to 100 feet were used by Cassini for his observations. [Bologna, Museo della Specola, Universita degli Studi di Bologna].

the two, who mutually recognized each other's merits, determined as they were to achieve the truth more than exact personal affirmation. Cassini found that Campani's lenses were absolutely indispensable in fulfilling his observations, and on the other hand Campani always took great pride in having been of service to the astronomer and in having had a role in the latter's achievements. It was a period that represented indubitably the high point of astronomy in Italy and, according to many, in Europe as well.

Chapter XIX

COMMISSIONS FROM THE SUN KING

(1669–1680)

> *Our Academy of Sciences has need of one of the telescopes of Sieur Campani, I beg you to send and inquire from him and order him to make two of the finest and longest of which he is capable*
>
> Letter from Minister Jean Colbert to the Bishop d'Estrées on September 10, 1671[1026]

Departing from Bologna in February 1669, Gian Domenico Cassini arrived in Paris on April 4. He was accompanied on his journey by one of his Bolognese disciples, Count Ercole Zani, who was *en route* to England for purposes of study, prior to which he planned to spend some days in the French capital.

Immediately upon his arrival, Cassini set out in search of lodgings and had been directed to the King's Library, where he expected he would be able to remain. He was warmly greeted by Pierre De Carcavi, the King's librarian, a mathematician and an Academician. He was informed, however, that no room presently was available on the library premises. All of its space was already occupied by Carcavi and his family and by the celebrated Christiaan Huygens, who had been invited to Paris by Colbert 3 years earlier and had been immediately lodged in the King's Library.[1027]

It became apparent at once to Cassini and to others that in the original planning of the observatory, which was currently under construction, no provision had been included for lodgings for the astronomers, neither in the completed observatory nor elsewhere during the interim while they were awaiting the structure's completion. When Colbert was informed of the lack of accommodations for Cassini, however, he promptly ordered that a habitation was to be prepared for him in the Louvre gallery, the development of which was under the supervision of the architect Claude Perrault (1613–1688).

Five days after Cassini's arrival in Paris, he was personally conducted by the architect to the Tuileries to render homage to the King. In the days that followed, the young Italian was so overwhelmed by the many courtesies and favors he received from the monarch, he later wrote, that

[1026] Depping and Depping, *Correspondance administrative sous le règne de Louis* XIV, 96.

[1027] Pierre de Carcavi was born in Lyon, became an academician in geometry in 1666, and was appointed librarian of the King's library. He died in April 1684.

he no longer harbored any thoughts of ever returning to Bologna, where he had left his home and affairs in the hands of his friends, the Monti family.[1028]

Cassini had expected to begin work as soon as the observatory could be made habitable, but the extended delay that lay before him made him increasingly impatient. Furthermore, the lodgings he had been assigned at the Louvre proved to be most uncomfortable. He thereupon proceeded to make his own arrangements and rented a house at Ville-l'Évéque, a short distance from the western gate of Paris. There he was pleased to find that the rental included a garden in which he could install his instruments and from which he would be able to make his observations.[1029] At the time that he had departed from Bologna to Paris, he had expected his absence to be for a limited period, and consequently he had brought with him only his favorite telescope, the one having a focal length of 17 feet that Campani had given him; it is to be noted that, although several references made by contemporaries to this same telescope stated varying lengths, it had a focal length of 17 Roman palms (379 cm). Later he would also have available to him for his use others provided by Campani, having a focal length of as much as 136 feet.

Immediately upon moving into the new quarters that he had found, Cassini lost no time before turning his eyes to the skies and beginning to search them with his prized Campani telescope. With it, while he was still in Italy, he had discovered the rotation of Jupiter and of Mars around their own axes, in addition to the eclipses of the sun by Jupiter's satellites. The same instrument in France provided him with his first glimpse of Iapetus, Saturn's second satellite. And again several years later, in 1672, it was with a 50 palms Campani lens that he had located the third satellite, Rhea. This first grand result, the discovery of Iapetus, a new satellite of Saturn, proved to be of considerable interest, and the French Académie, and particularly Colbert, remained greatly impressed by the excellence of this Campani instrument with which it had been achieved. At that time, there was the general belief in France that all that still remained unknown about the heavens could be discovered with telescopes of the greatest length. A we shall see, Colbert then proposed henceforth to equip the recently founded observatory entirely with these instruments and ordered Campani to send to France the largest and most excellent telescope that he was able to make and to continue to perfect his art in order to make them longer.

[1028] [Scientific Editor 2: in fact, it seems that Cassini had a very hard time in his first French years: "He confessed [to the English Ambassador] to being deeply unhappy and to being homesick; he complained about the climate, and divulged that he was sorely tempted to heed the entreaties of the pope, Clement IX, to return to Italy. The only consideration which kept him in Paris was the offence which his early departure would give to Louis XIV": David J. Sturdy, *Science and Social Status: The Members of the Academie Des Sciences, 1666-1750* (Woodbridge: Boydell Press, 1995), 181–84.

[1029] Louis Figuier, *Vies des savants illustres du dix-septième siècle* (Paris: A. Lacroix, Verboeckhoven et Cie, 1891), 516.

Francis Vernon, the English traveler and author, reported to Oldenburg that while in Paris he had called upon Cassini soon after the latter's arrival there, noting that he had been well received by the young astronomer "with all demonstrations of civility & courtesie I could Expect From a Gentleman of his worth & temper, and as For Telescopes", he added, "hee told mee he brought only one of Signor Campani's of 24 Palms [sic] in Length. Unwilling to encumber himself during his journey and until he found suitable lodgings in Paris, he had brought nothing else with him".[1030]

Reporting to Oldenburg in a letter from Paris, Cassini noted, "When Campani's telescope of 18 Roman feet [sic] was compared with another of slightly greater length at Mr. Picard's, it appeared the more excellent. I would be glad to know the length of that English telescope that is said to have excelled over another of Campani's instruments".[1031]

In Rome, meanwhile, Giuseppe Campani soon found himself occupied almost entirely with commissions from the Sun King to provide lenses and telescopes for the Observatoire de Paris. These were assignments to which he had to give priority, a situation that would continue during the major part of the next decade. It was through César d'Estrées, bishop of Laon, that Colbert conveyed his orders for lenses to both Divini and Campani, the artisans in Rome. The bishop was entrusted with various missions of particular sensitivity at the papal court in Rome. In fact, in an earlier period, César d'Estrées had operated in secret in fear of the Pontiff's displeasure.

The son of Maréchal François Annibal d'Estrées, the Duc d'Estrées was a brother of François-Annibal d'Estrées, French ambassador to Rome and of Vice-Admiral Comte d'Estrées. In 1655, César d'Estrées became Bishop of Laon, and 2 years later, he was elected a member of the French Académie. In 1666, he was named French ambassador to Lisbon. Five years later, in 1671, by order of Louis XIV and with the concurrence of Pope Clement X, he had been sent to Rome to serve as mediator between the papal nuncio and the bishops of Alet, Beauvais, Pamiers, and Angers, which he reconciled. In May 1672, he was created cardinal. In 1677, he was called back to France to be sent to Bavaria where he remained for 2 years, returning later to Rome.[1032]

In the first commission for instruments that Colbert submitted to d'Estrées in September 1671, he explained how the Académie Royale des Sciences "has need of one of the telescopes of Sieur Campani, I beg you to send and inquire from him and order him to make two of the finest and the longest of which he is capable. As he is extremely assiduous in multiplying their strength, I beg you to tell him that in case he finds a means of augmenting by half or double the most recent that he made, that were 55 palms of [focal] length, that amounted to nearly 36 or 37 French feet, beyond

[1030] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 5, 497–98, no. 1155: letter from Vernon to Oldenburg on May 4, 1669.

[1031] Ibid., 576–78, letter 1194: letter from Cassini to Oldenburg on May 31, 1669.

[1032] César d'Estrées (1628-1714) returned to Rome in 1691 remaining until 1703. He died in December 1714.

the best that he would have to supply, the King would give him an even more considerable gift to make him very content. And if he is still persuaded and gives at the same time much of an appearance that he has found a means for cutting them, in case he wishes to communicate his secret and send it to France, His Majesty will give him again a compensation that would please him". Colbert added, "His Majesty has ordered me to write to you on this matter and to inform you, on his behalf, that you are to make Campani aware of all the entreaties that you consider necessary of the contents of this letter".[1033]

Colbert's instructions to d'Estrées made eminently clear that he was to commission as much work for lenses and telescopes from Campani as he was capable, and that he could offer as enticement the fact that "besides the advantage he will have in selling them, the King will make him a substantial present". In the course of the next few years, Colbert was to be responsible for having materially assisted the development of the Paris observatory and its shift from the use of traditional instruments to the newly conceived tubeless telescopes by providing more money for lenses and less for mounts.[1034] Campani complied with Colbert's urgings by producing an object lens having a focal length of 34 feet for which he received payment of 1000 *eçus*. It was with these Campani lenses that Cassini discovered two new satellites of Saturn: as we shall see, he had found the first of them in October 1671 with the lens of 17 palms and the second in December 1672 with the lens of 34 feet. Three years later, in 1675, he was to discover the division of Saturn's ring, which now bears his name. Throughout this period, Cassini managed to make observations also from the gardens of the Abbaye de Saint-Martin-des-Champs, which subsequently housed the Conservatoire des Arts et Metiers.

Cassini's first astronomical observations made on French soil had been of the spots on the sun, of which he sought to establish the apparent position on the sun's disk in order to recognize and follow their movements. It was an undertaking that despite anticipated difficulties, on the contrary, proved to be easy because the spots appeared to be mounted one upon the other and constantly changed position. He established that they traversed about 27 degrees of the circumference of the sun from one day to another, and he hazarded the hypothesis that they reappeared after a revolution of 27 days. He compiled a report of his observations that was sent to the King at Fountainbleau, which he subsequently communicated in Latin during a seating of the

[1033] Depping and Depping, *Correspondance administrative sous le règne de Louis XIV*, vol. 4, 96-97.

[1034] Grillot, "L'emploi des objectifs italiens à l'Observatoire de Paris à la fin du 17ème siècle", 151; A. F. O'D Alexander, *The Planet Saturn: A History of Observation, Theory, and Discovery* (London: Constable, 1962), 111–12, 278; Pierre Clément, "Lettres de Colbert," in *Histoire de l'Observatoire de Paris de sa fondation à 1793*, by Charles Wolf (Paris: Gauthier-Villars, 1902), 157–61 letters from Colbert to d'Estrées on September 10, 1671 and January 15, 1672, and replies of July 13, 1672; King, *History of the Telescope,* 56–60. The cost was 4,400 *livres*. Depping and Depping, *Correspondance administrative sous le règne de Louis XIV*, vol. 4, 77: letter from Colbert to d'Estrées on November 30, 1671.

Académie. The report was not accepted by the Academie for publication, however, because it had not been written in French. Accordingly, Cassini was forced to ask Carcavi to translate his text into French for him so that it would be acceptable.[1035]

The outstanding quality of Campani's lenses, despite the fact that Cassini's discoveries attested to it, had not been acknowledged at first in the Academie without discussion. The Academicians involved with astronomy—Cassini, the Abbé Jean Picard, Olé Roemer, Carcavi, Huygens, and Claude Perrault—often gathered together at the observatory to make comparative tests of object lenses produced by French and Dutch makers with those made by Divini and Campani. Many of these tests that were being made for the purpose of comparing telescopes were held in the presence of the foremost French optical instrument makers, and each time the Italian lenses proved to be superior to all others.[1036]

Colbert did not deign to take part in these discussions, although he expressed considerable interest in the conclusions reached by others. The Italian telescopes were invariably of better quality than those constructed by the French and the Dutch makers, yet the latter instrument makers insisted on constructing ever-larger telescopes. In his history of the telescope, Henry King noted that Nicolas Hartsoeker constructed lenses having focal lengths of 155 and 220 feet, while lenses made by Auzout actually arrived at focal lengths of 300 and 600 feet (approximately 200 meters). It finally became apparent to the observers using the instruments that it was not only the focal length of the lenses that made the Italian ones superior.[1037] Eventually, even Colbert himself prized the Italian telescopes much more highly than did the others at the Académie, despite the claims of the French optical instrument makers, and in particular of Pierre Borel, who poorly supported the superiority of the Italian object lenses over those that he made.[1038]

To Campani, the procedure that was being followed at the Paris observatory in making these comparisons appeared to be somewhat questionable. He was amazed, for one thing, by the distance from which the French succeeded in reading the characters of test placards with the naked eye, and he advanced the hypothesis that in France the French feet were much shorter than those of Italian measure. Campani confirmed to Auzout, furthermore, in opposition of the doubts advanced about his lens grinding and polishing lathe, that he could most successfully produce lenses without the use of forms or molds.[1039]

Campani insisted on maintaining secrecy concerning all details of his techniques despite the fact that virtually everyone, all but Hooke, expressed skepticism about the existence of his lathe.

[1035] Cassini, "Vie", 292.
[1036] King, *History of the Telescope*, 59-60.
[1037] Ibid.
[1038] Grillot, "L'emploi des objectifs italiens à l'Observatoire de Paris à la fin du 17ème siècle", 145-55.
[1039] See Chapter IX.

Auzout demonstrated, however, that he kept an open mind, accepting Campani's opinion, and it is true that very probably, in order to learn the opinion of an expert, he sent Campani the scheme of a machine for comparison with the one constructed in about 1650 by the French artisan de Méru, a King's counsel at Nevers.[1040]

In the *Journal of Observations* that Cassini maintained, he mentioned the gatherings of the Academicians involved with discussions on the subject of astronomy, noting that occasionally they became extremely active. He mentioned how, for example, upon returning from a meeting held May 13, 1673, he had been greatly perturbed by Borel's recriminations and grievances. Cassini reported that he had become so disturbed because of it, in fact, that he had been unable to make any observations for several days.

In June 1673, Colbert wrote to d'Estrées: "As you know that the French are great imitators, I would say, for your satisfaction, that we have here two Frenchmen, one of whom you know, that is Sieur Borel, who has furnished us with as many telescopes as we wish. He has already provided one of 50 feet, and promises to make them of whatever length that one wishes, and the other has made one of 63 feet, the lens of which is clearer than those of any we have seen until now. As you can see, we do not lack for telescopes for the work of our Académie".[1041]

It appears that Borel had set himself upon the same road already followed with success by Campani, that is, of surrounding his activity in mystery. In 1676, from the page of the Journal des Sçavants, Borel communicated that he had confided his secret to a member of the Académie and to have had expectations of some good reason to have it published. In the meantime, for those who wished to exercise his spirit to discover his secret, Borel published a long anagram in which he contained all the essentials in few words.[1042] Pierre Borel claimed that he had discovered a new method of working glass that was very certain and very easy for producing any sort of object lens. He made known furthermore, that he was disposed to procure for members of the Académie objectives of 10, 25, and 60 feet made by means of his new method. He advised also that those who were unable to make use of machines for producing large objectives could serve themselves with shorter objectives of 14 to 20 feet. With these, he noted, anyone could be assured of their excellent quality, and make new celestial discoveries. The historian Maurice Daumas stated that this was no more than a publicity stunt, very common in that period, that by selecting such means as the Académie and the scientific periodicals to provide confirmation of their affirmations, these artisans

[1040] See Chapter IX.

[1041] Jean-Baptiste Colbert, *Lettres, instructions et mémoires de Colbert ... publ. d'après les ordres de l'Empereur... par Pierre Clément*, ed. Pierre Clément, vol. 5. Fortifications, sciences, lettres, beaux-arts, bâtiments (Paris: Imprimerie impériale, 1868), 350–51, no. 107, , letter from Colbert to d'Estręes on June 30, 1673.

[1042] "Avis sur les grandes lunettes," *Journal des sçavans* XIII (Lundy 6 juillet 1676): 155–56; Daumas, *Les instruments scientifiques*, 42-3.

served themselves in order to advertise their own works.[1043] It was the day after a reunion of the Academicians that the lenses of Campani finally were judged to be superior to those made by Borel.[1044]

The French Académie, and particularly its sponsor Colbert, remained greatly impressed by the excellence of the Campani instruments that Cassini used. So much so that Colbert proposed to equip the recently founded observatory entirely with Campani's instruments, and ordered that Campani be instructed to send to France the largest and most excellent telescope that he was able to produce and to continue his efforts to perfect his art in order to make instruments of greater length.[1045]

Colbert did not spare cost in his efforts to procure the best objectives, seeking those having always greater focal length. Becoming convinced that Campani and Divini had a secret for the production of the large objectives, accordingly, he offered them a sumptuous compensation for revealing their secret. The offer was not accepted by either of the artisans, however.[1046]

Late in 1671, Cassini, writing from Paris, confided enthusiastically to the French astronomer Abbé Jean Picard, "We shall soon have fine large telescopes from Rome, because I have written at Msgr. Colbert's request. Campani and Divini are having a contest to determine which one succeeds best. Campani had already made one of 60 palms; but because he himself was not yet completely satisfied with it, he is at work to improve it".[1047]

Christiaan Huygens, who then was lodged at the Paris observatory, also had become greatly interested in Campani's instruments and looked forward to using them. "We have just written to Italy to obtain lenses of Campani", he wrote to his brother Constantijn in September 1671, "of the longest telescopes that he makes, and to stimulate him to make the largest. It has been proposed to him also if he wished to communicate his working methods. We also are going to make attempts on producing glass here to determine whether we can make some without defect".[1048]

Several months later, Huygens mentioned to Constantijn how "in the mean time Campani and Divini were hard at work to determine who could produce the better lenses for us of 40 or 60 palms of focal length, and I think that we will have them soon".[1049]

[1043] Daumas, *Les instruments scientifiques*, 42-3.

[1044] Charles Wolf, *Histoire de l'Observatoire de Paris de sa fondation à 1793* (Gauthier-Villars, 1902), 114, 158–61.

[1045] King, *History of the Telescope*, 59.

[1046] Ibid.

[1047] Pisa, Biblioteca Universitaria, Ms. 423, fasc. 14, letter from Cassini to Jean Picard from Paris on December 3, 1671. Jean Picard (1620–1682) was the first to apply the telescope to the measurement of angles. He was known especially for accurate measurement of a degree of a meridian.

[1048] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 7, 102, no. 1842: letter from Christiaan to Constantijn Huygens on September 11, 1671.

[1049] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 7, 120-22, no. 1856: letter from Christiaan Huygens to Constantijn Huygens on December 4, 1671.

During the next 8 years, between 1671 and 1679, Cassini undertook a project of intensive study of the moon's surface. On the night of September 14, 1671, the same day on which finally he was installed at the observatory, Cassini had sketched, with the aid of the observatory's draughtsman Sébastien Leclerc, that area on the surface of the moon that the Italian astronomer Giovanni Battista Riccioli had named "the Sea of Humours". On the following day, the same draughtsman, under Cassini's direction, made sketches with crayons of the phases of an eclipse. Cassini subsequently produced a hand-written manuscript atlas consisting of 57 plates of drawings in colored crayons of each area, noting the month, day, and hour of the year that the observations had been made. It was from these drawings that Cassini produced the large "Map of the Moon" that was 20 *pouces* in diameter that he subsequently presented to the Académie in 1679.[1050]

At the end of October 1671, again using his Campani telescope, as previously noted, Cassini also discovered a satellite of Saturn, the first since Titan. It had occurred in December 1672, only a few days after his installation at the Paris Observatoire, that he discovered another of Saturn's satellites with his telescope of 34 feet. In his report of these observations, which he did not present until January 14, 1705, Cassini noted:

> That [telescope] which served us for the discovery of the new Phase of Saturn, which of this Satellite was of 17 feet, and which had been given to us as very excellent by M. Campani. This was the same telescope that we used to discover the revolutions of Jupiter and of Mars on their axes, and the Eclipses of the Sun in Jupiter made by the interposition of the Satellites.
>
> It was judged that by the *lunettes* of one that was larger we would be able to see that Planet, when one ceased to see it by means of the one we have been using. It was for this reason that M. Colbert gave the order to M. Campani to send as soon as possible the largest and the finest that he had, and to endeavor at the same time to perfect his art, in order to be able to make one that was of longer reach. He sent the one of 34 feet that is presently exposed on the terrace of the Observatory, where it was placed in the month of December 1672. . . .
>
> To be used in the meantime for testing, M. Campani has sent us four objectives of 80, 90, 100, and of 136 feet, which M. Colbert, prevented by his death, did not have time to test in the skies; the following year we were to discover even two more Satellites around Saturn that were closer than the others, and the revolutions of which were very much shorter [. . .] .[1051]

"The telescopes having been subsequently perfected by M. Campani, who succeeded in making lenses of such excellence as having up to 136 feet of focus", wrote Cassini's son, Jacques Cassini, "my father in 1671 and 1672 discovered the Fifth and the Third Satellites of Saturn; and in 1684 he perceived two other inner Satellites. Already known was the number of five that one

[1050] Wolf, *Histoire de l'Observatoire de Paris de sa fondation à 1793*, 168-70.

[1051] Gian Domenico Cassini, "Reflecions sur les observations des satellites de Saturne & de son anneau," in *Mémoires de Mathematique et de Physique tirez des registres de l'Academie Royale des Sciences, Histoire de l'Academie Royale des Sciences, Année 1705* (Paris: Gabriel Martin, J.B. Coignard fils, Hippolyte Guerin, 1730), 21, 23.

presently observes around this planet".[1052] On this occasion, a medal was cast representing the Saturnian system with the legend "*Saturni satellites primum cogniti*".[1053]

In January 1672, in communicating with Bishop d'Estrées, Colbert had requested again that he keep urging Divini and Campani to increase the production and quality of their instruments.[1054] Now made aware that Colbert would be in constant persistent pursuit of equipment for the Paris observatory, and that in fact it appeared to have become a matter of royal priority, the French ambassador in Rome attempted to maintain constant contact with the two Italian instrument makers. Early in February, d'Estrées informed Colbert: "It has been some time since I last saw Campani; no doubt when his work has been completed he will come to give me an account of it. As for Eustachio Divini, he had begun to work on a lens of 120 palms that broke in the course of it. He has had to begin another of the same size, and he hopes that it will succeed well; meanwhile he is finishing the ocular lenses for the telescope of 70 palms, of which already I have spoken to you. He has made a third lens of this focal length, with which he believes he has achieved to be of a much greater perfection than the two others. We will test it this week, and I will not fail to send some news of it by the first ordinary [. . .]".[1055]

The role of d'Estrées was not limited only to conveying orders for instruments from Colbert to the two instrument makers, for he also was required to test the instruments himself in Rome before forwarding them on to Paris. Maintaining contact with Colbert on the matter of the telescopes, in April, d' Estrées informed him: "I have tested a lens of 50 palms by Campani that has proven to be very successful; it is necessary also to test one by Divini of 60 palms, who always has the hope of succeeding in making one of 120 palms. Two of his lenses already have failed [. . .]".[1056]

Continuing to bring pressure to bear upon Campani and Divini through the French embassy in Rome, Colbert exerted every effort to obtain object lenses that always were of the most excellent quality. Not only was he convinced of the superiority of Italian object lenses but also of Italian superiority in the production of the optical glass itself. This awareness finally led him to make an effort to compete with Italian glassmaking by establishing a glass industry in France at Tourlaville and importing prime materials from Italy for the purpose. The French optical instrument makers, one named Pasquin and later also Nicolaas Hartsoeker, were sent by Colbert to the glass

1052 Jacques Cassini, "Nouvelles découvertes sur les mouvements des satellites de Saturne," *Histoire de l'Académie Royale des Sciences* Année 1714 (1717): 361.

1053 Cassini, *Mémoires pour servir a l'histoire des sciences et a celle de l'Observatoire royal de Paris,* 337.

1054 Colbert, *Lettres, instructions et mémoires de Colbert*, 5. Fortifications, sciences, lettres, beaux-arts, bâtiments:320, no. 78, letter from Colbert to d'Estrées on January 15, 1672.

1055 Depping and Depping, *Correspondance administrative sous le règne de Louis XIV*, vol. 4, 582–83: letter from d'Estrees to Colbert on February 9, 1672.

1056 Depping and Depping, *Correspondance administrative sous le règne de Louis XIV*, vol. 4, 583, letter from d'Estrees to Colbert on April 12, 1672.

manufactory to produce large lenses. For this endeavor, Colbert also solicited Cassini, exerting pressure on him to involve himself in procuring the materials generally considered to be the best components to be used by the new French glass industry that he had established. The historian Giorgio Abetti noted that Colbert urged Cassini to write to Florence to have them send to him "*materiam vitri ex Arno*" as noted on October 1st by Cassini in his *Journal of Observations.* This was a particular silicilic stone found in the riverbed of the Arno in Florence desired to be exported to France for the new glass factory.[1057]

Cassini turned for advice in the matter to his friend Viviani, with whom he had continued to maintain a correspondence. Viviani generously arranged to provide the raw materials for glassmaking and shipped four cases of it from Florence by way of the ports of Livorno and Marseilles. The shipment was addressed to Minister Colbert in the name of the French King and directed to the head of the French port. From there the shipment was to be forwarded to Cassini.

The content of two cases consisted of ash of *Soda del Levante* and two other cases contained *Tarso.* After a delay of some 3 months, the cases eventually arrived at their destination, following numerous misadventures during shipment. Cassini acknowledged receipt of the cases, explaining that not having known specifically to whom the cases were directed, it had not been possible to be informed of their forthcoming arrival. When the cases finally were received, the materials proved to be satisfactory, and in February 1672 Cassini responded by sending Viviani reports of his astronomical observations and requested his advice and guidance.[1058]

Abetti doubted that the material from Florence actually was in fact so special, and he was of the opinion, furthermore, that the glass made in Venice was in fact greatly superior to that being produced in Florence. The fact remained that in support of Colbert's astronomical endeavors, many thousands of French *francs* were paid to Italian optical instrument makers for their services, in addition to the astronomical sum of 11,000 *francs* that had been expended to transport the tower of Marly, which had housed a machine that had served to pump water, in order that it could be used as a support for the long aerial telescopes. Obviously, to Colbert, expense was no object.[1059]

In Florence, meanwhile, scientific activities taking place at the Medici court were being reported in great detail by Thomas Platt in July 1672 to Oldenburg at the Royal Society. He mentioned how one of the Grand Duke's musicians, Pietro Salvetti, who had applied himself to the study of mathematics, "began to delight himselfe of Opticks & of its other parts, & not being content with the Theory, took upon himself to putt it in practice by makeing Telescopes of all sizes,

[1057] See Chapter VIII (New Worlds) in this book; Wolf, *Histoire de l'Observatoire de Paris de sa fondation à 1793*, 159–60; Giorgio Abetti, "Per il centenario di Gian Domenico Cassini," *L'Universo* 6 (1925): 259.

[1058] BNCF, *Gal.* 255, c. 224. Letter from Cassini to Viviani on February 9, 1672.

[1059] King, *History of the Telescope*, 59-60; Wolf, *Histoire de l'Observatoire de Paris de sa fondation à 1793*, 162–69; Abetti, "Per il centenario di Gian Domenico Cassini".

as also Microscopes in imitation of those of Campani & Divini. I can tell you that he lately shew'd one of his Microscopes to the grand Duke, w^{ch} was Jiudged by all much better than any of the best His Highness hath, and I was an Eye Witness to this, that as for magnifying, termination & clearness, it was found most excellent".[1060]

As previously noted, in January 1672, Colbert again expressed to d'Estrées his satisfaction with the efforts that had been made by Campani to produce lenses of 90 palms. Then he added, "It would be very advantageous if the Sieurs Campani and Eustachio Divini applied themselves also to produce their telescopes to the highest degree of perfection, and if that of 120 palms on which the last-named is working, is successful, I have no doubt that our astronomers will obtain from it much that will be productive and useful [. . .] ".[1061]

The d'Estrées responded to Colbert from Rome in July 1672: "As far as the telescopes are concerned, Eustachio Divini and Campani each have made two of 50 palms. I have approved the one made by Campani, that appeared to me to be very clear and very good; and Monsieur Auzout, who is more knowledgeable than I, is of the same opinion. I have been assured that the one by Divini is not inferior. He also has made one of 60 palms, but it has not been found to be of the same perfection. He is working on those of 120 palms, and has not lost hope of successful results. I encourage him as much as I am able, and in doing so I am doing as you wish. You will do me the favor to instruct me if I am to send to you the two telescopes of 50 palms, that the connoisseurs consider to be very satisfactory. Perhaps one could be sufficient, but inasmuch as the one whose work is not preferred would be discouraged, and it is important to encourage them to do well. I believe it would be more appropriate to take both of them, since the one who has not been preferred would be discouraged; it is important to stimulate them to do well".[1062]

Colbert quickly resolved the problem of keeping both instrument makers satisfied, and in his response to d'Estrées, he reported, "You would give me infinite pleasure if you would collect both telescopes of 50 palms, each of those that Campani and Divini have made, in order that they can serve us usefully for observations that the King still continues to make".[1063]

A month later (September 1772), d'Estrées advised Colbert that by means of a memorandum attached to his letter he was informing him concerning the status of the shipment of

[1060] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 9, 181–89, no. 2037: letter from Thomas Platt to Oldenburg on July 27, 1672. Thomas Platt was an English visitor to Florence who was admitted to the intimacy of Magalotti's circle. Thomas Derham stated he was a master of Italian, Spanish, French, and Dutch languages and recommended him for secretary to Sir Joseph Williamson.

[1061] Colbert, *Lettres, instructions et mémoires de Colbert*, 5. Fortifications, sciences, lettres, beaux-arts, bâtiments:320–21, no. 78, letter from Colbert to d'Estrées on January 15, 1672.

[1062] Depping and Depping, *Correspondance administrative sous le règne de Louis XIV*, vol. 4, 583-85, no. 39: letter from d'Estrees to Colbert on July 13, 1672.

[1063] Colbert, *Lettres, instructions et mémoires de Colbert*, 5. Fortifications, sciences, lettres, beaux-arts, bâtiments:332, no. 87, letter from Colbert to d'Estrées on August 5, 1672.

telescopes for which Colbert had been waiting, so that he had nothing further to add in his letter. He noted that every precaution had been taken to have the instruments delivered safely into his hands. "I am beginning to be very hopeful", he went on, "of those instruments of 120 palms, and I find that the makers have spoken to me of them more boldly for some time. The Académie Royale will have the honor of having had the first of such length. I have assured the makers that they will be well compensated for their efforts, and certainly they will merit it".[1064] Two days after, Colbert promptly advised M. Arnoul, Intendant of the Galeres in Marseilles, of the forthcoming shipment of the two telescopes of 50 palms to be used for the King's observations and asked Arnoul personally to receive them.[1065]

Cassini had left Paris and had been traveling about France for some time seeking favorable sites from which to make astronomical observations. In mid-November 1772 he informed Colbert from Marseilles that he had found a more appropriate location for observation of "fundamental refractions" on one of the mountains. "It was after having observed in Tolon, that most meridional city of France […]", he wrote, "the height of the pole with all the diligence that it deserves, that I found a degree to be more septentrional than the one that is shown in the geographical maps; and after having found, on one of the mountains, one of the cleanest places in the kingdom to observe the fundamental refractions, I have returned to Marseilles. There I received from the Intendant Campani's telescope of 50 palms with four lenses, which I have immediately tested to my full satisfaction, terrestrially as well as on other stars. After several days of snow, I have observed the return of the spot in the sun as I had expected since the last apparition in the past month, and I have shown it to others who are interested. I will leave tomorrow, so I can be at the Observatory's residence as soon as possible".[1066]

Later that year, Huygens informed his brother Lodewijk that on that particular evening, December 16th 1672, at the Observatoire they would be able to "take out and test our telescopes we have received from Rome. Sig. Cassini, who lodges at the observatory, told me that he has tested on Saturn the one by Campani of 36 feet, and that it had a marvelous result. If the one by Divini of 47 feet is good, it too will be another fine item. My apartment within the observatory is close enough, but the season is not exactly very long. In the summer it will be very beautiful here". It was on this

[1064] Depping and Depping, *Correspondance administrative sous le règne de Louis XIV*, vol. 4, 585 : letter from d'Estrées to Colbert on September 14, 1672.

[1065] Colbert, *Lettres, instructions et mémoires de Colbert*, 5. Fortifications, sciences, lettres, beaux-arts, bâtiments:334, no. 89, letter from Colbert to M. Arnout on September 16, 1672.

[1066] Depping and Depping, *Correspondance administrative sous le règne de Louis XIV*, vol. 4, 591: letter from Gian Domenico Cassini to Colbert on November 15, 1672.

occasion that Cassini again saw the new satellite, Iapetus, that had been lost to view despite its discovery in October 1671.[1067]

This instrument provided even more stupefying results; in the same month, in fact, with it Cassini had discovered the fifth satellite of Saturn in order of distance, which he named Rhea. She was the mythical wife of Saturn and mother of Jupiter, Neptune, and Pluto. Consequently, on Christmas Eve Cassini proudly reported to Louis XIV, having made his discovery of the new satellite by means of this instrument. The discovery of the two new satellites, Iapetus and Rhea, became the subject of a volume published by Cassini in the following year. The work, entitled "Discovery of two new Planets around Saturn" offered the results of the two observations to the King in a dedication of homage, proposing to name them the "Ludovican satellites" as the satellites of Jupiter had been named by Galileo "Medicean" to honor the Grand Duke of Tuscany.[1068]

In a communication to Oldenburg in October 1673, Cassini was explaining how he had endeavored to observe the diameters of Jupiter's satellites by means of the time of their immersion in Jupiter's disk, measured by their passage across the face of the planet. "The diameter of the aperture in the object lens in the 35-foot telescope tube that we employ for the observations of Jupiter and Saturn is three inches", he wrote, "whereas in the 21-foot telescope it is two and a quarter inches or even something more, especially for Saturn. Actually, prefer we so much more this telescope of 35 feet which we have from Campani over the telescope of 36 feet which we have from Divini, that we use the former and lay the latter aside except when we have need of two telescopes of almost equal size and not very disparate quality".[1069]

In the previous spring, in 1673, d'Estrées had notified Colbert that he had delayed informing him until after the departure of His Majesty, when Colbert would have sufficient leisure to enjoy the

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[1067] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 7, 234-35, letter 1915: letter from Huygens to Lodevijk Huygens on December 16, 1672.

[1068] Gian Domenico Cassini, *Découverte de deux nouvelles planètes autours de Saturne, Paris 1673* (Paris: chez Sebastien Mabre-Cramoisy, 1673).

[1069] Oldenburg, *The Correspondence of Henry Oldenburg,* vol. 10, 317-18, letter 2347: letter from Cassini to Oldenburg on October 29, 1673. Soon after the publication by Huygens in 1673 of *Horologium Oscillatorium*, Auzout wrote to the author to inform him that he had received three copies of his publication from André Reynaud and that consequently he had sent one copy to Michelangelo Ricci, another to Giuseppe Campani, retaining a copy for himself. Without regard to what Huygens had written to him, Auzout wrote, he had mistakenly sent the copy to Giuseppe Campani, who made lenses and telescopes, being unaware that Huygens had been corresponding not with Giuseppe, the maker of telescopes, but with his brother, Matteo Campani. Giuseppe acknowledged having received the book, informing Huygens: "Yesterday was consigned to me by Monsieur Auzout on your behalf a book on the motions of pendulums for clocks, which I esteem highly, and that will succeed beautifully and profitably as much greater as the scolding of his rectitude, and valued and admired by me to the greatest degree. I will lose no time and will read it hoping to derive from it correction and profit, and meanwhile I thank you infinitely for this honor you have done me, and I beg you to give me an opportunity in the future with some command of yours to render me worthy for thanking you for this gift made to me, which I do not merit". Huygens, *Christiani Hvgenii ... Horologivm oscillatorivm.* Translated in English: *The Pendulum Clock or Geometrical Demonstrations Concerning the Motion of Pendulums as Applied to Clocks*; Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 7, 372-73, letter 1984: letter from Auzout to Huygens on January 24, 1674; page 362, letter 1975: letter from Giuseppe Campani to Christiaan Huygens c/o la Bibliothéque du Roi on November 30, 1673.

telescopes of Campani and Divini that he had sent him during the last year. “Thus I have learned that they have been very successful”, he added, “I have no doubt that you will arrange that they will be well treated in compensating them. That would encourage them to set to work on larger lenses in accordance with their plan; and since they have been waiting since last year, I believe that you will not continue to procrastinate further”.[1070] Then, early in June 1673, d’Estrées responded to a communication from Colbert, he wrote:

> You have foreseen in your letter of May 13th, what I have written on the subject of Messrs. Divini and Campani. The payment for their telescopes should greatly satisfy them, as they exceed by one-third the price that Cardinal d’ Medici paid Divini for a lens of equal size. I would definitely encourage them, as I already have done, to work on larger ones, and to inform you of the progress of their work. Divini has reminded me that he has sent two lenses to France, one of 60 palms, the other of 66 palms. Campani has sent us only one of 60 palms, but meanwhile he has been paid equally. I believe, Sire, that you will find it proper to send a new payment to Divini.[1071]

“Concerning the telescopes”, Colbert responded on June 30th 1673, “it is true that Divini has sent me two lenses, and that Campani sent me only one, which was accompanied by its tube, and after examining them, I found that the one merited as much as the other. Thus, they must be content, and I believe that the advantageous payment that His Majesty has given them will give you greater facility to stimulate them to bring their telescopes nearer to even greater perfection”.[1072] Although these object lenses made by Campani and Divini were not of a very great range, the makers were paid in total 4,400 *livres*. Meanwhile, in the same year the French instrument maker, Philippe Claude Le Bas, was paid 800 *livres* for both the large lenses of 60 feet and the small one of 20 feet that he had made.[1073]

Colbert continued to request lenses from Campani that were yet larger, but it was not until 1681 that Campani succeeded in his endeavor to construct telescopes of a much greater focal length. For these he produced four lenses, which he offered to Colbert. One was of 100 palms focal length, another of 130, a third of 150, and the fourth of 200 palms. He was informed that the lenses had found acceptance with the Académie Royale des Sciences, and approved also at the same time was the method that Campani proposed for supporting long telescopes as well as the method for managing tubes of such great length that he had designed, and which he described and illustrated

[1070] Depping and Depping, *Correspondance administrative sous le règne de Louis XIV*, vol. 4, 585-86, n. 39: letter from d’Estrées to Colbert on May 30, 1673.

[1071] Ibid., 586-87, n. 39: letter from d’Estrées to Colbert on June 6, 1673.

[1072] Colbert, *Lettres, instructions et mémoires de Colbert*, 5. Fortifications, sciences, lettres, beaux-arts, bâtiments:350–51, no. 107, letter from Colbert to d’Estrées on June 30, 1673.

[1073] Jules Guyffrey, *Comptes des bâtiments sous le règne de Louis XIV*, vol. 1 (Paris: Imprimerie nationale, 1881), col. 712 (year 1673).

not long thereafter in a broadside he dedicated to Colbert, and which subsequently was illustrated by Bianchini in his work on Venus.[1074]

[Figure 4]

Cassini maintained that with Giuseppe's objectives he had been able to make the first observations without the use of a tube, that is, he had made with aerial telescopes, and was able to do so with considerable facility. The method that had been proposed by Huygens, however, proved to be much more difficult for Cassini in practice. Together with his objectives, Campani exported various systems to serve them. An engraving of the period illustrated such a system in which are represented two telescopes to which have been applied mechanisms to facilitate terrestrial and celestial observations. The caption described:

> Method of managing with facility Telescopes of any length, whether for Terrestrial as well as for Celestial [observations], invented in Rome by Gioseppe [sic] Campani, and applied in testing the four that he fabricated for the observatory of S.M.C.[ma], the first of which is of 105 Roman palms, the second of 130, the third of 150 and the last of 205, dedicated to His Excellency, M. Colbert.[1075]

[Figure]

The tubeless telescope, which had been initiated by Huygens, eliminated the need for a supporting structure such as Campani had devised for testing his long lenses. Campani's structure, dedicated to Minister Colbert, was illustrated in an engraving made in 1681 by the Accademia Fisico-matematica Romana (Academy of Physics and Mathematics in Rome) and subsequently republished by Bianchini. The test bed for terrestrial and celestial telescopes was rigged somewhat like a ship and allowed the observer to use the counterweight S to orient the heavy telescope almost by the touch of a finger. An inherent problem was that even a breeze could swing it out of alignment. The Accademia commissioned an elaborate scaffolding 79 feet (100 palms) long. The French Academie approved a lesser contraption for a 100-foot telescope, requiring the manipulation of five heavy pulleys while observing. de Gottignies, Jesuit professor of the Collegio Romano, devised an improved version consisting of a 50-foot beam. Bianchini preferred Campani's test bed, however, and he believed that a 50-foot telescope was required to view the spots of Jupiter, Saturn's rings, and the planets, but to see all of the satellites of Saturn, a telescope of 100 feet was necessary.[1076]

[1074] Francesco Bianchini, *Hesperi et phosphori nova phaenomena, sive Observationes circa planetam Veneris : unde colligitur I.descriptio illius macularum, seu celidographia, II.vertigo circa axem proprium, vel perieilesis spatio dierum 24 cum triente, III.parallelismus axis in orbita octimestri circa solem, IV.et quantitas parallaxeos methodo Cassinianâ explorata*, Nunc primum editae (Romae: Salvioni, 1728), pl. VII; Giuseppe Monaco, "Un parere di Francesco Bianchini sui telescopi di Giuseppe Campani," *Physis* 25, no. 3 (1983): 413–31.

[1075] Bianchini, *Hesperi et phosphori nova phaenomena*, pl. VIII.

[1076] Wolf, *Histoire de l'Observatoire de Paris de sa fondation à 1793*, 162–67; Gian Domenico Cassini, "De l'origine et du progrès de l'astronomie, et de son usage dans la géographie et dans la navigation," in *Recueil d'observations faites en plusieurs voyages par ordre de Sa Majesté pour perfectionner l'astronomie et la geographie*

Within a short time, a series of great discoveries were being made with Campani's telescopes that confirmed all that had already been said about them.[1077] The most sensational of these was the discovery made in 1675 of the division of the ring of Saturn that was subsequently named "the Cassini division" in honor of the astronomer.[1078]

While observing with a telescope equipped with a new objective of 100 palms that Giuseppe had sent to Paris, Cassini noted for the first time the obscure band that circled Saturn almost immediately below the equator. He fixed his attention above all to the ring, of which he magisterially described the structure, although none until then having been observed and then retained, "the breadth [width] of the ring is divided by a dark line in two equal parts, of which the inner, which is closer to the globe, appears very clear, and the external somewhat little dark. From the colors of these two zones there was more or less the difference between raw or native silver and burnished silver. . . . The appearance of the ring is caused by a mass of very tiny satellites, having diverse movements that one of them can not be evaluated separately". [1079]

In March 1684, using the objective of 136 feet, Cassini discovered two more satellites of Saturn that were named Tethis and Dione. By this time, there was no longer any doubt about the excellence of the Campani instruments.[1080]

Since Minister Colbert had died unexpectedly in 1683, shortly after Cassini received the lenses and before Campani had been paid for them, the Marquis of Louvois, who succeeded Colbert, wished to close the account and wrote to Campani to inquire the price of the lenses. Recalling the generosity of Colbert with his previous order, and hoping for the same response from his successor, Campani hesitated to place an exact price on the work. In the meantime, the largest of the lenses—an exceptional objective of 205 palms (or 212 mm), had been accidentally broken in half while Cassini's assistant was helping the astronomer manage the long tube. Louvois was then ordered by the widowed Queen Marie Therese to return the lenses to Campani and to pay him the

(Paris: de l'Imprimerie royale, 1693), 35–36; Bianchini, *Hesperi et phosphori nova phaenomena*, 58–59; Monaco, "Un parere di Francesco Bianchini sui telescopi di Giuseppe Campani," 419, 426–31; Ad. Siret, "Gottignies, Gilles-François de," *Biographie Nationale* (Bruxelles: Académie royale de Belgique, 1885).

[1077] Gian Domenico Cassini, "Nouvelle decouverte des deux satellites de Saturne les plus proches, faite à l'Observatoire Royal," *Mémoires de l'Académie royale des sciences depuis 1666 jusqu'en 1699*, 1730, 701–2.

[1078] King, *History of the Telescope*, 59.

[1079] "Observations nouvelles de M. Cassini, touchant le globe & l'anneau de Saturne," *Journal des sçavans* V, no. Lundy 1 Mars (1677): 56–58; Cassini, "Reflecions sur les observations des satellites de Saturne & de son anneau," 19; Grillot, "L'emploi des objectifs italiens à l'Observatoire de Paris à la fin du 17ème siècle", 151.

[1080] It was in March 1684, while testing his object lens of 100 palms, that Cassini discovered two other satellites of Saturn, those closest to the planet. His discovery of the new satellites was made while observing with Campani instruments, which were longer than 35 feet, having excellent object lenses of 100 and 136 feet, and by means of two others of 90 and 70 feet. Cassini indicated that all four lenses had been used as aerial telescopes. These were the only contributions to astronomical knowledge he achieved with the aerial telescope. At the same time, Nicolaas Hartsoeker at the Paris observatory was using lenses of 155 and 250 feet. Biblioteca Vallicelliana, *Ordine dato al Sig. Campani dalla Corte di Francia*, S. 83, tomo VIII, cc. 1220-1227; Monaco, "Un parere di Francesco Bianchini sui telescopi di Giuseppe Campani," 417–18; Giorgo Tabarroni, "La lente spezzata del Campani conservata nell'Istituto di Fisica dell'Università di Studi di Bologna," *Strenna Storica Bolognese* 17 (1967): 433–41.

amount of 3,000 *scudi*. Payment was delayed once more, however, due to the unexpected death of the French Queen in 1683, as we learn from a manuscript in Italian in the Biblioteca Vallicelliana of Rome, entitled "Order Given to Signor Campani by the Court of France":

The order was given by Signor Colbert, Prime Minister of the Most Christian King, to Giuseppe Campani, that he was to produce a telescope of the greatest length that he was able to achieve by means of his diligent industry, offering to give him a reward proportionate to the progress that he would make in this genre of work. Immediately upon receiving the commission Campani set to work on the project and in February 1672 sent to France a telescope of 50 palms, for which he requested 500 *scudi* (as he previously received for one of similar length that he had produced for the Most Serene Grand Duke of Tuscany); but that Royal Minister whised to compensate him with 600, as an encouragement to invent a means of working yet larger ones for the observatory of His Majesty. Shortly after, in the year 1681, Campani explained how he had most felicitously found a means of working them of much greater lengths, and he offered four lenses, one of 100 palms, another of 130, a third of 150, and the last of 205 palms, all of which he sent to Paris by means of the papal nuncio Monsignor Ranucci. The response was that they were very much acceptable to the Academie Royale des Sciences, as indeed was his invention for raising and easily managing tubes of great length that the same author invented, and not long afterward published in a print at the time he understood that the discovery of the stars, and secondary planets around Saturn had been achieved with these lenses, which are still called *Ludovicee Stars* after the glorious name [Louis XIV] of that monarch […] Sig. Colbert, happy for the success of the lenses, was about to send compensation, when his death occurred and interrupted its execution. The Signor Marchese di Lovaij [Marquis of Louvois] succeeded to the position, and inquired by means of Sig. Cassini the price Campani believed appropriate to his work; but he [Campani] seemed to be reluctant to manifest a clear request, because of the generosity experienced in the previous lens of 50 palms, and therefore he did not express himself. Meanwhile, when Her Majesty the Queen came to know that one of the said four lenses had been broken into two parts by the one who assisted at the mechanism [aerial telescope] while it was being used in the Observatory, she doubted that the general agreement was still valid, so she offered 3,000 *scudi* once they were sent back to the author. Signor de Lovaij was happy to approve the opinion of the Queen, when he learned, regards to the sale, that she did not wish to separate that lens from the others. But the delay in responding prejudiced Campani by the time they were shipped back to Italy the French Queen had become ill and she died soon after.[1081]

Campani's lens of 205 palms, mentioned in the foregoing, that had been split into two parts and subsequently had been repaired by Campani by applying mastic with great care, was not in fact the largest Campani lens that Cassini had used in Paris, for in the Observatory there is another signed by Campani that measures 49 meters of focal distance, corresponding to approximately 220 Roman palms, having a 22-cm aperture, and providing an enlargement of 600.[1082]

[Figure]

In a letter to Cassini that has not survived, Campani reported that in the course of a conversation with Queen Christina in Rome, she had informed him that she was contemplating the conversion of a building in the gardens of her palace into an observatory. She added that she still hoped that Cassini would come to Rome to become her astronomer in residence, and she asked Campani to inquire from Cassini whether he would consider a return to Italy. In his response,

[1081] Biblioteca Vallicelliana, *Ordine dato al Sig. Campani dalla Corte di Francia*, Ms Bianchini S. 83, tomo VIII, parte III, cc. 1220-1227.

[1082] Grillot, "L'emploi des objectifs italiens à l'Observatoire de Paris à la fin du 17ème siècle", 150.

written on August 13th from Paris, Cassini asked Campani to act as an intermediary with Christina. With the salutation "Mio Sig.e Oss.mo," [*Osservantissimo*: Most Worthy] he wrote:

Nothing could have given me more pleasure than the notice given me by yourself that Her Majesty the Queen of Sweden has in consideration my observations, and desires to know whether I should have in mind to return to Italy.

I confess that nothing would have kept me for such a long time without seeing my native land, except for the desire to respond to the favours that I receive from His Most Christian Majesty, who honours me with a most important position in his royal observatory, with an annual bonus of three thousand *scudi*, and the wherewithal necessary for making observations.

This consideration has made me overcome the discomfort from the climate, so different from that of my native land, for I am little suited to the rigours of winter, and to endure such a long absence from my old patrons and from my dearest friends.

Although I have managed to accustom myself to this city by means of the selection of a wife favourable to my heart, who has given me two sons of exceptional spirit, nevertheless the love of country always returns, and at present the new motive given me by the letter from you causes in me a violent feeling, that if I could possibly understand it, and to be thus conforming to the wishes of His Most Christian Majesty, I would not delay a moment before returning to Rome to the feet of Her Majesty, to render her the most humble gratitude for her kindness in adding to the honours she already rendered me in Bologna and in Rome, by this new demonstration of the memory she retains of her humble servant, and to respond to the honour of her commands. I will not lack for attention to determine, in the event that I can extend myself with the permission of His Most Christian Majesty, whether I can take some measure to ensure the success of this plan, which is the response that you are to give most humbly in my name to Her Majesty.

Most recently I have observed with your lens of 100 feet an appearance of a little stream or river as in a lake, near the mark of Aristano, according to Riccioli. This spot near the group on the twenty-second day of the Moon is to be seen as a great conch shell of the whitest appearance in the centre, and in the days following it seems that from this it raises a small white cloud that extends little by little towards the southern margins of the lake indicated.

The Marquis Cuvori has not yet come to the observatory, in which I have made the preparations to compare the lenses, I will go one day this week to Versailles to solicit the remuneration of the remainder due to you after such a long time.[1083]

Cassini accompanied this letter to Campani with his drawing of the system of Saturn based upon the observations he had made with Campani's telescopes at the observatory in Paris. He added also a description of new discoveries he had made in the Saturnian system on July 13, 1685, information that apparently Cassini wished to have Campani communicate to Queen Christina. The foregoing has been copied and translated from Cassini's letter preserved at the observatory at Kassel, together with the largest telescopes that Campani had ever made, which were 145 palms in length, the object lens of which was 8 by 2 lines of diameter, and the eyepiece was 3 *pouces*.[1084]

[1083] "Lettre de Giov. Dom. Cassini a Giuseppe Campani de Paris le 13 Aout 1685," in *Memoires concernant Christine Reine de Suede, pour servir d'eclaircissement a l'histoire de son regne et principalement de sa vie privee, et aux evenemens de l'histoire de son tems civile et literaires: suivi de deux ouvrages de cette savante princesse qui n'ont jamais été imprimés*, vol. 2. Appendice des Pieces Justificatives (Amsterdam et Leipzig: chez Pierre Mortier, 1751), 147, 150.

[1084] Recent efforts at Kassel to find the original letter have been unsuccessful. Jeanne Bignami Odier, "Le Fonds de la Reine à la Bibliothèque vaticane," in *Collectanea vaticana in honorem Anselmi M. card. Albareda*, vol. 1, Studi e testi 219 (Città del Vaticano: Bibliotheca apostolica vaticana, 1962), 159–89; Per Bjurström, ed., "Christina and the Scholars," in *Christina, Queen of Sweden - a Personality of European Civilisation, Etc.: Eleventh Exhibition of the Council of Europe*, trans. Patrick Hort, Roger Tanner, and Sten G. Lindberg, Nationalmusei Utställningskatalog. No. 305. (Stockholm: Stockholm, 1966), 44–53, 364–375; Cassini, "Vie", 336-37.

This letter is of particular importance, for not only does it confirm the close and lasting friendship that existed between Cassini and Campani but also the fact that apparently Giuseppe Campani was more closely associated with Queen Christina than merely as a maker of astronomical instruments. Regrettably, no account has survived of his meetings with her on Cassini's behalf, nor of his subsequent report of the meeting to Cassini.

After the lenses finally had been returned to him from Paris, Campani proceeded to mend the broken one, and then offered them for sale for the amount of 1,000 *doppie*, an amount slightly more than the 3,000 *scudi* promised by the French queen.[1085] Queen Christina had expressed a desire to purchase them, as part of the equipment she would need for her planned grand observatory, but she died before she could order payment for them.[1086]

This large lens that had been broken in half and glued together again, commissioned by Minister Colbert, was contained in a frame, and it end up in the Instituto delle Scienze of Bologna as a gift by pope Benedict XIV, together with Giuseppe's workshop.[1087] That particular lens does not, however, appear to be the longest Campani objective used in France, for Abetti reported that the largest telescope used by Cassini is still preserved in the Paris Observatory. It bears the signature of Campani and measures approximately 49 meters of focal length, which corresponds to about 220 Roman palms, 22 cm of aperture, and furnishing an enlargement of 600.[1088]

In the inventory made in 1793 of the instruments surviving in the Paris Observatory, which was published in 1810 by Cassini IV, more than 26 objectives by various makers were listed. At least one was signed by Campani*,* and bore the date 1672.[1089] In his account of his life, Cassini wrote:

Campani continued to produce other telescopes even much longer, and he sent me three objectives of different sizes. Minister Colbert having unexpectedly died, Giuseppe requested the return of the lenses that he had sent me, in order to satisfy the Queen of Sweden. She also had planned my return to Rome, and wished to make an observatory in a building that was in the enclosure of the Palazzo Riario on the Lungara, where she lived. I did not have any intention to leave the service of the King, however, who provided me with benefits and was pleased with my services. It is why, with the permission of His Majesty, that I returned to Campani the latest lenses of which the range is of an extraordinary length and inconvenient in use; it is in truth a task to make use of them, without any prince until now having desired them.[1090]

1085 Monaco, "Un parere di Francesco Bianchini sui telescopi di Giuseppe Campani," 418. 1 doppia = 3,15 scudi.

1086 Cassini, "Vie", 305. Biblioteca Vallicelliana, *Ordine dato al Sig. Campani dalla Corte di Francia*, Ms Bianchini S. 83, tomo VIII, parte III, c. 1224.

1087 BUB, Assunteria d'Isituto, Diversorum 11, n. 15: Luigi Wood, *"Inventario delli Strumenti, e Lavori diotrici del fu Giuseppe Campani e che sono stati consegnati dal Sig.re Abb.e Uti a Ercole Lelli per spedirli a Bologna, ed ivi consegnarli all'Istituto delle Scienze a tenore degli ordini di N.ro Signore Papa Benedetto XIV"*, September 28, 1747, c. 10. Tabarroni, "La lente spezzata del Campani conservata nell'Istituto di Fisica dell'Università di Studi di Bologna".

1088 Abetti, "Per il centenario di Gian Domenico Cassini," 260.

1089 Cassini, *Mémoires pour servir a l'histoire des sciences et a celle de l'Observatoire royal de Paris , suivis de la vie de J.-D. Cassini, écrite par lui-même, et des éloges de plusieurs académiciens morts pendant la Révolution,* 211. Grillot, quoting the same source, mentions two objectives made by Campani of 34 and 35 feets: Grillot, "L'emploi des objectifs italiens à l'Observatoire de Paris à la fin du 17ème siècle", 152.

1090 Cassini, "Vie", 305.

Found among the papers of the late Minister Colbert was an undated listing entitled "Telescopes and microscopes ordered to be made by Sieur Campani" listing the lenses and instruments commissioned from Campani for the Paris Observatoire:

First of all, two telescopes of four lenses, of two *tois* of length[1091]
Plus two telescopes of four lenses, of two feet of length
Plus two telescopes of two lenses of which the ocular is concave,
Plus two other telescopes of six *pouces* of length
Plus two other telescopes of four lenses, of which the tube is not at all broken.[1092]

For the year 1687, the *Comptes des Batiments* noted, "For delivering: 4,000 *livres* to Signor Campani, in Rome for 4 large telescope lenses that he had sent in 1683, by order of the King, to serve the Observatory for astronomical observations".[1093] But it seems that these 4,000 *livres* were not to spare expense, the lenses were not paid for, and this was with the approval of Cassini, because they were too large, therefore too difficult to be used.[1094] On the basis of Gian Domenico Cassini's statement, Cassini IV noted that the large objectives at the Observatory may not have been those of Campani, as one had believed, but those of Borelli, Huygens, and Hartsoeker.[1095]

[Figure]

In 1695, the aging Cassini returned to Italy with his son for the purpose of reviewing the status of the meridian at the church of San Petronio. He made several stops along the way, first visiting relatives at his birthplace in Perinaldo then stopping off in Florence, where he called on Vincenzo Viviani. Before going on to Bologna, he also interrupted his journey at Rome to conduct affairs at the Vatican. During this period, he undoubtedly also refreshed his friendship with Giuseppe Campani, perhaps to acquire more lenses and instruments or just for social visits. If such occurred, it was not recorded by either of the participants. Cassini remained in Italy for approximately one and one half years, before returning to Paris in the spring of 1696.[1096]

The success of Campani's lenses at the observatory of Paris served to promote not only his instruments but also resulted in haing his achievements become increasingly recognized and well known in the world of astronomy in Europe as the second half of the seventeenth century advanced. This was due not only to the quality of his lenses and his collaboration with Cassini but also to astronomical observations he personally had made and to his publications relating to them.

[1091] A *tois* is 6.39459 feet.

[1092] BNF, Archives et Manuscripts, Mélanges de Colbert 174, Correspondance de Colbert de janvier à avril 1677, fol. 87: "Lunettes et microscopes, à faire faire [pour le Roi] par le sieur Campani".

[1093] Guyffrey, *Comptes des bâtiments sous le règne de Louis XIV*, vol. 1, col. 1085 (year 1687).

[1094] Cassini, "Vie", 305.

[1095] Ibid., 305.

[1096] Gian Domenico Cassini, *La meridiana del tempio di S. Petronio tirata e preparata per le osservazioni astronomiche l'anno 1658, revista e restaurata dal Sig, Giov. Domen. Cassini* (Bologna, 1695).; Cassini, "Tableau chronologique de la vie et des ouvrages de J.-D. Cassini", 327, 342-43.

According to Jadanza, Huygens spoke of Campani as “a marvelous observer” and stated that to Campani must be attributed some of the important discoveries in this field that had been recorded.[1097] It can be maintained that Campani’s astronomical observations served, as was usually the case, as a means of promoting the excellent quality of his instruments, which the most celebrated observers in Europe were anxious to obtain. In order to judge fully his contributions to the development of astronomy, a separate study of this aspect of his activity, his observations, is required. Available texts are limited, however.

[1097] Jadanza, “Per la storia del cannocchiale”, 17.

Chapter XX

"FLEAS LARGE AS A MAN'S FIST"

(1686–1700)

> *I have succeeded in inventing a Microscope very different from all others which have been constructed until now, both in the facility with which it can be adjusted as one desires, as in other aspects as noted by the one who has made the observations in the printed article.*
>
> Letter from Giuseppe Campani to A. Bassetti on May 10, 1687.

The publication of the *Micrographia* by Robert Hooke in 1655 evoked new interest in the microscope as a scientific tool and, in particular, aroused curiosity about the remarkable hitherto hidden world that it revealed.[1098] As a consequence, professional optical instrument makers at work in this period began to experiment with the development of the microscope. The pioneers were Italian, and it is not surprising to find that among the earliest at work in this new area of optics and the development of the compound microscope were the rivals Eustachio Divini and Giuseppe Campani, and that once again they were competing as seriously as before.

The first version of the Italian compound microscope took the form of an instrument with a sliding tube that somewhat resembled a miniature telescope. It was produced in three versions, identified by the number of its major components, which were tubes made of cardboard. Usually the main, or outer, tube was covered with vellum or shagreen, and the sliding components were covered with colored paper. Each tube was slightly larger than the previous one and slid easily over the former. An external collar at the lower end of each tube served as a stop to the next one. The instrument generally was supported upon a three-legged tripod made of brass or wrought iron.[1099]

All three versions of the sliding-tube microscope were developed within a short time of each other during the pioneering period, and their similarities and differences became immediately apparent upon comparison. The ocular lens was enclosed in a turned wood or metal diaphragm attached to the open upper end of the main tube, while the object lens was contained in a similar turned wood or metal cell attached to the bottom of the lowermost tube. The rims of the external collars of the sliding tubes were marked with the digits 1, 2, and 3 in either Arabic digits or Roman numerals and served as keys to the magnification obtained of the several lengths as noted on each

[1098] Hooke, *Micrographia*.
[1099] Bedini, "Seventeenth Century Italian Compound Microscopes".

tube. The lowermost tube slid within a metal socket ring of a tripod support, which served as a means of adjustment between the objective and the item to be examined.

An example of the four-tube instrument, in the Museo Copernicano of the Osservatorio Astronomico di Roma, is frequently illustrated in histories of the microscope. It is tentatively dated from about 1668 and attributed to Eustachio Divini, although it is unsigned. The outer covering of the body tube is of grey paper with the digits 1, 2, and 3 inscribed on the collars of the tubes. It slides within a socket ring for adjustment of the distance between the objective, which is attached to a nosepiece in a metal cell and the item to be examined. The eyepiece consists of two plano-convex lenses with the convex surfaces in contact, contained within a metal holder at the upper end of the body tube. Originally, the instrument had a magnification of 41 to 143 diameters. When fully extended, it measures 16-1/2 inches (41,91 cm) in height with the largest tube having a diameter of 1-1/2 inches (3,81 cm). **[Figure]**

Another version of the instrument consisted of three cardboard tubes which slid one over the other. The major difference was that the smallest of the tubes was the uppermost, and the largest or outer tube was the lowermost or body tube. The smallest, uppermost, tube was fitted with a turned wooden casing enclosing the ocular lens. A coarse screw-thread on its outer surface provided for the attachment of a turned wooden dust cover to protect the lens. The object lens was enclosed within a turned wood diaphragm inserted into the lowermost end of the body tube. It was supported on a three-legged tripod consisted of a wide band of brass or wrought iron. The distance between the lenses could be varied by sliding the body tube up and down within the socket-ring. Both versions were produced at approximately the same time and at least one surviving example of each are dated one year apart.[1100]

[Figure]

A third version, which was developed somewhat later, differed from the others in several features. It consisted only of the body tube with a single draw tube, both made of cardboard. An example, made of cardboard and covered with gilt-stamped green vellum or paper, is to be found in the Museo Galileo in Florence. It incorporates the innovation of a field lens, attached to the upper end of the body tube and enclosed within a turned wooden case. The object lens is contained within a wooden case screwed into the nosepiece at the lower end of the body tube. The eyepiece is contained within a draw tube that slides over the body tube within another turned wooden case at its upper end. The container for the eyepiece consists of three parts, with wooden rings into which the two lenses are fitted. Regrettably, the lenses are missing, making it impossible to reconstruct the original lenticular system other than to note that a field lens was included. As with the two other

[1100] Marinella Calisi, *Storia e strumenti del Museo astronomico e copernicano di Roma: guida alle collezioni* (Roma: Osservatorio astronomico, 2000), 129.

versions, the distance between the lenses was controlled by sliding the draw tube up or down. A tripod support into which the body tube is inserted is attached to a round wooden base by means of its three feet.[1101]

[Figure]

It was in the late 1640s or early 1650s that Eustachio Divini ventured into experimenting with the microscope, less than a decade since he first began to make telescopes. His name first appeared in print in relation to the microscope in Gaspar Schott's *Magia Universalis Naturae et Artis* published in 1657. In the Fourth Syntagma of the 10th Book of Volume I, Schott described the microscope as a tool of investigation, dividing the instrument into six classes. The fourth class was explained as follows:

> Some people take longer tubes, a foot in length, and more than a thumb's breadth in thickness, and close each end with glass, as before described, and they set it up vertically on a tripod as shown in Figure D (vii). At the bottom of the tube they scatter minute gold or silver dust; they throw in flowers, plants, leaves of trees or anything they like, and view them downwards from above. It is scarcely credible how many wonderful things hidden and concealed in past ages have been detected by this kind of microscope, as I will presently more fully set forth. Very excellent microscopes of this model are made at Rome by Eustachius Divini, whom I have frequently already mentioned.[1102]

Much of Schott's published work was derived from that of Athanasius Kircher and he may in fact have been indebted to the same source for parts of his *Magia Universalis.* His descriptions of the microscope appear to have resulted not from personal observation but from reliance upon verbal descriptions by others, unfortunately erroneous, as exemplified by the misinterpretation of the instrument's appearance and the manner of its use.

[FIGURE]

Three years later, Count Carlo Antonio Manzini of Bologna, an amateur of the sciences with a special interest in optics, published his comprehensive work on optical instruments "The Glass To The Eye" [*L'Occhiale all'Occhio*]. He greatly admired Divini and his work and included Divini's portrait in this volume. Highly praising his achievements in optical instrumentation, in these pages he was the first to describe a microscope that Divini had constructed in 1648 based upon Proposition 37 of the *Dioptrice* of Johann Kepler. This was a compound instrument utilizing convex lenses for both the eyepiece and the objective; the latter was the smaller of the two, and in proportion as the objective was reduced, so was the magnification and the perfection of the instrument increased.[1103]

[1101] Bonelli and Pagnini, *Catalogo degli Strumenti del Museo di Storia della Scienza*, 172–74.

[1102] Gaspar Schott, *Magia universalis naturae et artis*, vol. 1, Book 10 (Herbipoli: Henricus Pigrin, 1657), Syntagma 4, pages 533-538, and plate XXV.

[1103] Kepler, *Dioptrice seu Demonstratio*, prop. 37; Manzini, *Occhiale all'occhio.*

Although engaged primarily in the production of astronomical instruments, as general interest in the microscope increased, Divini devoted more and more of his efforts to making improvements of the new instrument. Several years later, in about 1667, he succeeded in developing an improved type of lens for the instrument. It was of the doublet system, consisting of two plano-convex lenses placed in contact at the poles of their convexities, each plane face being external. This lens was described by Honoré Fabri in his *Synopsis Optica* in 1667 and favorably reviewed in the next year in the *Giornale de' Letterati.* Divini's instrument was described as being two Roman palms in height, with duplicate (double) lenses and reverse side of his invention, that is, "instead of an ocular lens he placed two convex lenses in one part, and a plane lens in the other, in such a manner that both touched each other at the highest point of their convex surface". With this invention, it was claimed, it was possible to view the field as apparently plane and without curvature such as occurred with other compound microscopes having ordinary lenses. It was probably with such a microscope of this type, made by Divini, that the embryologist Marcello Malpighi made observations.[1104]

As Divini's work on the instruments progressed, it achieved wider and wider recognition. In late July 1668, the French scholar Henri Justel informed Henry Oldenburg at the Royal Society that he had "learned from Rome that Eustachio Divini's microscope makes a flea appear almost as large as one's fist and a fly nearly a palm long and the remainder in proportion. It is made up of four lenses. The two objectives are as usual; but the two eye pieces are plane on one side and convex on the other, and he joins them together on the side of the convexity so that the two convex sides touch at a point. The tube is as big as a man's leg; the eye pieces may be a little less large than the palm of the hand. What is remarkable is that it has a very large field or space of vision, nearly two palms in size. It sells for forty crowns".[1105] Obviously, the size of the instrument had been greatly exaggerated in the report from Rome.

Surviving examples of Divini's sliding-tube microscopes differed substantially from the ridiculous image of the Divini instrument that had been illustrated in 1657 in Gaspar Schott's *Magia Universalis*, which appeared to be almost twice the height of a man. It is apparent that Schott's illustrator had not actually seen a Divini microscope and perhaps was guided only by a

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[1104] L. Belloni, "Malpighi, Marcello", *Dictionary of Scientific Biography* (New York: Charles Scribner's & Sons, 1974); Howard B. Adelmann, *Marcello Malpighi and the Evolution of Embryology* (Ithaca, N.Y.: Cornell University Press, 1966); Domenico Bertoloni Meli, ed., *Marcello Malpighi: Anatomist and Physician*, Biblioteca Di Nuncius 27 (Firenze: L.S. Olschki, 1997), 64–66.

[1105] Oldenburg, *The Correspondence of Henry Oldenburg,* vol 4, 561-65, n. 929: letter from Justel to Oldenburg in late July 1668. Henri Justel (1620–1693) was the son of Christian Justel, librarian and counselor to King Louis XIV. As a scholar, Justel was Oldenburg's regular source of news from Paris for many years; he was host in Paris to an assembly of learned men visited by many travelers from England. He sold his private library secretly since he was a Protestant, and in 1681, he emigrated to England, where he was elected a Fellow of the Royal Society and was appointed by the king librarian of the royal library at St. James. "Justel, Henri (1620–1693)," *The Oxford Dictionary of National Biography* (Oxford: Oxford University Press, n.d.).

verbal description, such as the report from Rome. Oldenburg related Justel's description of a Divini microscope at a meeting of the Royal Society held on August 6, 1668, that also seemed to be too huge to be practical. Oldenburg obviously had received a garbled description combining two instruments, for the account incorporated features of Divini's improved sliding-tube instrument, which he first achieved probably in 1668 and produced thereafter.[1106]

Six months later Oldenburg included a description of Divini's improved model in the *Philosophical Transactions,* which reported:

Eustachio Divini hath made a *Microscope* of a new Invention, wherein instead of an Eye-glass convex on both sides, there are two plano-convex Glasses, which are so placed, as to touch one another in the middle of their convex surface. This Instrument, of which *Hon. Fabri* treats largely in his *Opticks*, [Prop. 46, 1667, pp. 131–138] hath this peculiar, that it shews the Objects flat and not crooked, and although it takes in much, yet nevertheless magnifies extraordinarily.

After providing specifications of size and the lenses, the account continued:

As they viewed with this Microscope the little grains of sand searched, they perceived an Animal with many feet, its back white and scaly, but less than any of those hitherto observed. For, although the Microscope shewed every grain of sand as big as an ordinary Nut, yet this Animal appeared no bigger than one of those grains of sand seen without a Microscope. Whence may be concluded its smallness, which occasioned one of the beholders to give it the name of the *Atome of Animals*. It is almost 16-1/2 inches high, and adjusted at 4 different lengths. In the *first*, which is the least, it shews lines 41 times larger than they appear to the naked Eye: In the *second*, 90 times: In the *third*: 111 times: and in the *fourth* 143 times. Whence one may easily calculate, how much it augments surfaces and solidities.

The Diameter of the Field it discovers, or the subtense of the visual angle, measured upon the Object-plate, in the *first* length is of 8 inches and 7 lines: in the *second*, of 12 inches and 4 lines: in the *third*, of 13 inches: and in the *fourth*, of a little more than 16 inches.[1107]

Early in the following November, Oldenburg informed Huygens that he had received news from Italy that Egidio Francesco de Gottignies, a Jesuit professor at the Collegio Romano, had made a microscope that could enlarge an object more than 350 times in diameter, and that those made by Divini did not even approach it, neither for the augmentation nor for the field. "If that is made having a spherical figure, it is more than has been made here", he noted, "or elsewhere, as far as I know."[1108]

Two surviving examples are known of the earlier form of microscopes made by Divini, of the type having the largest tube at the upper end. As noted, one is in the Museo Copernicano of the

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[1106] *Birch, History of the Royal Society of London*, vol. 2, 313.

[1107] Henry Oldenburg, "Microscope of a New Fashion by the Means Whereof There Hath Been Seen an Animal Lesser than Any of Those Seen Hitherto," *Philosophical Transactions* 3, no. 42 (December 14, 1668): 841–42; "Old Italian Microscope," *Journal of the Royal Microscopical Society*, 1885, 518–19, fig. 106.

[1108] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 6, 519-20, letter 1773: letter from Oldenburg to Huygens on November 1, 1669. Egidio Francesco Gottignies, S.J. (1630–1589), mathematician, was born in Brussels, entered the Jesuit order in 1653 and after studies at the novitiate at Maline went on to Rome. In 1662, he joined the faculty of the Collegio Romano where he taught mathematics. He disputed with Cassini over some of his discoveries. J. C. Hoefer, ed., *Nouvelle biographie générale depuis les temps les plus reculés jusqu'à nos jours, avec les renseignements bibliographiques et l'indication des sources à consulter*, vol. 21. Florus-Fryxell (Paris: Firmin Didot frères, 1858), 352–53.

Osservatorio Astronomico di Roma at Monte Mario and another is in the Museo di Fisica of the University of Padua. The latter bears the signature "*Eustachio Divini in Roma 1672*". It consists of four cardboard tubes, the outermost of which is covered with green colored parchment having gilt stamping. The lower half of the lowermost tube has a broad projecting spiral band of cardboard covered with parchment that combines with a corresponding spiral cut into the cardboard supporting cylinder to which the base is attached. Encircling this cylinder is a small brass three-footed socket ring on which the signature is inscribed.

The objective consists of a biconvex lens fitted by means of a screw into a brass tube 5.5 cm (2,165 inches) in length that projects from the bottom of the lowermost tube. It is screwed by means of a thread on the outside into the object holder, which is kept firmly in place by means of a spring. The object is focussed by raising or lowering this small metal tube on its screw thread. The eyepiece consists of a yellow biconvex lens enclosed within two wooden rings in a turned wooden diaphragm attached to the upper end of the largest tube. The two plano-convex lenses, of which Divini's special eyepiece consists, is missing in this example. Each tube terminates in an external collar that serves as the stop for the next tube. On these collars are marked the points of different extension, I, II, III, and IV in the same manner as on the instrument in the Museo Copernicano in Rome.[1109]

[Figure]

In addition to the rivalry that already existed between Divini and Giuseppe Campani relating to the production of astronomical instruments, a new competition subsequently arose between them concerning the development of the compound microscope. Divini had been a pioneer in developing the microscope not long after he had become engaged in the production of astronomical instruments, and some years elapsed before Campani began experimenting with the new instrument. There is no doubt that he was fully aware of the growing interest aroused among men of science in this new area of endeavor and that this new type of instrument was closely associated with his own work with telescopes. There is no doubt also that he had been kept well informed of Divini's achievement with the microscope.

The prospects offered by this new field intrigued Campani, but it was not until after about 1670 that he ventured into it. This was a very active period for him, in which he was already constantly engaged with the production of telescopes and clocks. On authoritative testimony including that of Huygens, it is certain that Campani already had begun to produce sliding compound microscopes prior to 1686. When Huygens learned that Johannes Georg Steigerthall, a

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[1109] P.A. Saccardo, *Atti del Reale Istituto Veneto delle Scienze*, vol. 2, no. 7, 1891, 817–27; "Eustachio Divini's Compound Microscope," *Journal of the Royal Microscopical Society*, 1891, fig. 84 and 85.

physician in Leiden, was planning to visit Italy in that year, he requested the physician to obtain information about that new instrument called the microscope.[1110]

The development of the compound microscope was promoted to a large degree in the later seventeenth century by the Accademia Fisicomatematica Romana. This was another scientific society, modeled somewhat after the Accademia del Cimento, which met on the first Sunday of each month for discussion and occasionally to witness experiments. Its founder, Monsignor Giovanni Giacinto Ciampini, had emerged recently as a patron of the arts and sciences with the assistance of his brother, a senior official in the Curia, who had introduced him to Cardinal Ottoboni, who subsequently was elected Pope Alexander VIII. Ciampini was a corresponding member of the Royal Society of London, the Academie Royale des Arts et Sciences in Paris, and of Queen Christina's Arcadians, in which he had taken the name of Immone Ocio.

When, in 1677, Ciampini established the new Accademia, prominent men of science in the Eternal City and elsewhere in Italy became interested. They began to attend the meetings being held weekly in Ciampini's palace in Piazza Navona. The membership of his Accademia consisted of laymen and ecclesiastical scholars who gathered to discuss the range of subjects of science and mechanics. Queen Christina provided the new Accademia with moral if not financial support.[1111]

The interests of its founder, Ciampini, ranged from sacred rites to architecture. His palace provided the most compelling ambiance for the scientific and erudite speculations that took place during the meetings, in its large library with every nook and cranny filled with antiquities and ancient monuments. While seeking a motto for the Accademia, proposals included the symbol of *Innesto* meaning "graft" with the phrase *Utraque Unum*, and another was a telescope with the legend "*Et Remotissima Prope*".[1112]

During the major part of its existence, the Accademia used the *Giornale de' Letterati* as its own journal. The pages of the *Giornale de' Letterati* reflected the current interest in the sciences throughout that period, and it was in fact a periodical distinctly biased toward the sciences. It copied the style of the French *Journal des Sçavans* that had first appeared 3 years earlier. The Italian periodical had been initiated in 1668 by the Abate Francesco Nazzari from Bergamo, a learned

[1110] Huygens, *Oeuvres Complètes de Christiaan Huygens,* vol. 9, 109, n. 4: "Descriptio novi Microscopii, autore Dn. Josepho Campano, ejusque usus, A. Dn. Schelstrateno, Vaticanae Bibliothecae Praefecto, in literis d. 13 Junii a. 1686. Romae exaratis, communicata". In 1688, Johannes Georg Steigerthall was inscribed in the "Album Studiosorum" of the University of Leiden as "Neinburgensis aetatis 21".

[1111] Middleton, "Science in Rome"; Antonella Romano, "A l'ombre de Galilée? Activité scientifique et pratique académique à Rome au XVIIe siècle," in *Naples, Rome, Florence: une histoire comparée des milieux intelletuels italiens (XVII-XVIII siècles)*, ed. J. Boutier, B. Marin, and Antonella Romano (Roma: Publications de l'École française de Rome, 2005), 209–42. "Spoletino", in Crescimbeni, *Le vite degli Arcadi illustri*, 2, 200–201, 207–213, 238; Magnus von Platen, ed., *Queen Christina of Sweden: Documents and Studies* (Stockholm: Kungl. Boktryckeriet P.A. Norstedt, 1966), 369; Masson, *Queen Christina* 347, 361.

[1112] Michele Maylender and S. E. Luigi Rava, *Storia delle accademie d'Italia*, vol. 2 (Bologna: A. Forni Editore, 2002), 16.

professor of philosophy at the university La Sapienza in Rome, who edited it until 1679. From 1675, Ciampini assumed the direction of a homonymous journal and financed its publication. Both journals contained reports of astronomical observations, reviews of serious books, and a miscellany of notes of scientific or literary interest. Nazzari's Journal terminated in 1679 and Ciampini's *Giornale de' Letterati* continued until 1683.[1113]

Ciampini's *Giornale* published reviews prepared by many of Ciampini's friends, which included many of Rome's virtuosi. A great number of the features were the work of the Jesuit Francesco Eschinardi, professor at the Collegio Romano, where in 1659 he taught logic, physics in 1660, and metaphysics in 1661. In addition to his position as professor of mathematics, Eschinardi also was equally in charge of the revision of the construction plans of the Compagnia de Gesu building, all of which had been sent to Rome to the Superior General.[1114]

Although only a partial list of the Accademia's membership has survived, to be noted among its active members were Michelangelo Ricci and members of the Jesuit faculty of the Collegio Romano, prominent among them, besides Francesco Eschinardi, Daniello Bartoli, the medical astrologer Agostino Fabri, and other scholars from the Republic of Venice. Others who participated as visiting members included the mathematician Michelangelo Ricci, the anatomist Tommaso Petrucci, Urbano Davisi, the cartographer Vincenzo Coronelli, Adrien Auzout, Paolo Falconieri, Alfonso Borelli, Giovanni Domenico Cassini, Gottfried Wilhelm Leibniz, Athanasius Kircher and Francesco Bianchini. Others who attended from time to time included, who later became Cardinal, Gian Domenico Cassini, and the brothers Francesco and Salvatore Serra from Genoa. As time went on, celebrated professors of every science and of every liberal art came to take part in the Accademia's activities, those living in Rome and others who visited from afar. Many observations were made in these meetings that already had been or later were published by their authors in various treatises, on occasion published with funds provided by Queen Christina. The publications ranging from full length volumes to tracts consisting only of a few pages designed for circulation primarily among the Academicians or for distribution to contemporary scientific journals.

The name of Giuseppe Campani was not noted as a member, but he was a frequent participant at meetings, particularly those concerned with his special interests: optical instruments. Neither mention of Matteo Campani appears in Ciampini's membership records and, surprisingly, apparently he was not a member of the Accademia. He was cited, however, on three occasions in

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[1113] Silvia Grassi Fiorentino, "Ciampini, Giovanni Giustino," *Dizionario Biografico Degli Italiani* (Roma: Treccani, 1981); Amelia Cosatti, *I periodici e gli atti accademici italiani dei secoli XVII e XVIII posseduti dalla Biblioteca* (Roma: Accademia nazionale dei Lincei, 1962), 86–87.

[1114] Villoslada, *Storia del Collegio romano dal suo inizio (1551) alla soppressione della Compagnia di Gesú (1773).*

Nazzari's *Giornale de' Letterati,* and his Vacuum clock was mentioned, and he also participated to some reunions.[1115] Matteo's interests, meanwhile, had wandered into other regions: in 1676, Matteo's article on the subject of fair weights and measures was published. It was entitled "The Bridled Scale, that is an invention of Matteo Campani, useful and easy to use that compells the weigher to provide the correct weight".[1116]

In addition to current literary or philosophical topics, the Accademia's interests encompassed a wide field of scientific experiments and speculations that ranged from the possibility of human flight, the design and use of scientific instruments for surveying, meteorology, and astronomy, to the construction of wheeled vehicles of bizarre shapes. There was a wide range of discussion in the field of natural philosophy. The importance of the Accademia may be said to have been its reflection of the complete freedom that existed during this period during which the virtuosi ranged over amateurs and men of science, including ecclesiastics in Rome, who were capable to discuss openly questions of scientific doctrine. It was a time when the men of intellect and talent generally were to be found in the medical profession, in the Church, and in the arts. There is evidence that during this period there was a favorable attitude toward science in elevated ecclesiastical circles, as indicated by their involvement. As previously noted, some members of the Jesuit faculty of the Collegio Romano, for example, published on scientific matters from time to time.

An example was the experiment that had led to the invention of the barometer and had been held in February 1645 in the residence of the dissipated young Prince Giovanni Carlo de' Medici, recently created cardinal and brother of Grand Duke Ferdinand II of Tuscany. Less than 3 months after his promotion, Prince Gian Carlo arranged to have demonstrated in his palace the same Torricellian experiment that had been held in Florence in the previous year, perhaps with the intention to brag a little about the flourishing state of the sciences in Florence. Attending were three of Rome's important men of science, Emmanuel Maignan, Nicola Zucchi, and Athanasius Kircher. Each of them eventually published descriptions of what they had observed; Maignan's account in particular provided a number of interesting details of the event.[1117]

Although the scientific exercises or experiments at the Accademia were performed only on each Sunday, they were sufficient to keep Monsignor Ciampini occupied all week collecting the required materials and preparing equipment for the new experimental demonstrations. Ciampini at

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[1115] For instance see: "L'oriulolo giusto d'Antimo Tempera utilissimo à naviganti. In 8. In Roma per Michel Ercole 1668," *Giornale de' Letterati* Dell'anno 1669, no. 8 (1669): 114–16.

[1116] Gardair, *Giornale de' letterati de Rome,* 249. Videt: Matteo Campani, "La Stadera Imbrigliata, ovver inventione utile e facile che obliga il pesatore a dare il giusto peso, di Matteo Campani".

[1117] Kircher, *Musurgia universalis,* 11; Maignan, *Cursus philosophicus concinnatus ex notissimis cuique principiis*, 1925–36; Zucchi, *Experimenta vulgata non vacuum probare, sed plenum, et antiperistasim stabilire*, 4.

his own expense personally supplied the major part of the abundance of equipment and instruments needed for the experiments contemplated, although several prelates also helped to defray expenses for equipment and materials.

Anticipating the need to provide more frequent nourishment for the avid minds of the members having multiple interests, Ciampini instituted "a great evening conversation" that was held at his palace five nights of the week except Wednesday and Saturday. In addition to the registered members of the Accademia, the meetings were attended also by such others who came by reason of scholarship, birth, or subject interest. The status of the Accademia was raised to greater summits also by the occasional presence of Monsignor Albani, who later became Pope Clement XI, and by important scholars visiting Rome.

Girolamo Toschi, Archdeacon of the Reggio Emilia and grand-nephew (or descendant) of the famous Cardinal Toschi, was elected the Accademia's secretary. His role was to record all proposals suggested or demonstrated at meetings, the experiments made, and, in fact, all subjects mentioned or discussed. The intent of the new Accademia was further explained in a letter from Toschi. The new academy, he wrote, dealt with "natural philosophy based upon experiment, in imitation of the celebrated *Accademia del Cimento* that was assembled in Florence under the protection of Cardinal de' Medici, and of other well-organized ones in England, France, and Germany. In ours, four general subjects will form the substance of our academic operations, namely, philosophy, medicine, mathematics, and mechanics. . . . By 'philosophy' is to be understood speculations about the elements, and the natural history of man, fishes, plants, winged creatures, quadrupeds, insects, fossils, and other such subjects. Under the title of medicine, leaving aside dogmatics, and pharmacy, except to the extent that it brings in some new and singular experiment, are comprised mainly anatomical subjects, whether relating to man or to any other animal or vegetable. It also includes alchemy, especially that which leans towards the consideration of the metals, their transmutations or alterations, and every other new chemical invention. In mathematics come cosmographical speculations, that is, concerning geography, hydrology, the winds, also navigation, meteorology, and astronomy. This subject also includes the new discoveries in arithmetic, geometry, and music and other mathematical sciences. Lastly, under the name of mechanics come in optics, horology, painting, sculpture, architecture both civil and military, the drama, and similar matters".[1118] It is apparent that the academicians were determined to not overlook any subject worthy of discussion.

[1118] Luigi Magnani, "Gerolamo Toschi e l'Accademia di Filosofia naturale," *Archeion* 9, no. 2–3 (April 1928): 170, 184; also in "Gerolamo Toschi e l'Accademia di filosofia naturale," in *Atti e memorie della R. Deputazione di Storia Patria per le Provincie Modenese*, vol. 5, Serie, VII (Modena: Società Tipografica Modenese, 1928), 162–85; Campani, *Nova experimenta physico-mechanica*.

For the meetings held in the period during which Toschi served as secretary, he reported in extreme detail and provided complete and comprehensive documentation of each project undertaken by the various members. Among them were demonstrations of "how by itself the spirit of quicksilver ascended on high and how it did not penetrate glass; the members examined with new interest the electrical quality of a magnet or lodestone; the descent of weights, and the velocity of their motion; the proportion resulting between the weight of a moving object and the force of movement, whether natural or assisted by levers or wheels; the reason for the flooding of the Tiber".[1119] Although the results of the work of the Accademia did not in fact prove to be of great importance, nonetheless they provided an informative reflection of scientific attitudes and endeavors in Rome during the second half of the seventeenth century.

One of the phenomena that the members of the Accademia discussed with animation at every meeting was the suspension of the column of mercury 76 cm high in the glass tubes, the celebrated experiment of Torricelli.[1120] The first documentation of this experiment was a letter written by Torricelli on June 11, 1644, in which he discussed the concept of air pressure. Many meanwhile valued his singular quality, among them Matteo Campani, who supported it in the meeting of the Accademia held on September 19, 1677, and who responded to many of the most recent arguments on the subject, including those who spoke of magic. Matteo Campani was described by the secretary Toschi as one of the most convincing supporters of Torricelli, and he made mention in his notes of Matteo's work on mercury that had been published in 1666, *Nova experimenta physico-mechanica*, in which he presented a large part of the observations made in the Accademia.[1121]

The Accademia continued meeting on every Sunday at first, and then met only on the first Sunday of the month. The meetings were described as being devoted to proposing and examining the most useful quests and "unbinding the doubts with the most evident reasons, and examining the antique and the new in the most sensational experiences; often without neglecting to retrace the rarest eruditions of the ancient times and of the most miserable of their relics".[1122]

In 1682, the Accademia published a report on the comet that appeared in August of that year and about the observations of it that had been made. As Adelmann had noted, "the success that

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[1119] Ibid.

[1120] According to the surviving minutes, the Accademia's early meetings were frequently concerned with the Torricellian experiment, interest in which had been revived by the publication in 1677 of a book by Daniello Bartoli, the official historian of the Society of Jesus. He wrote extensively also on morals, poetry, and other scientific works. Carmine Jannaco described Bartoli as an outstanding figure, "the Bernini or the Caravaggio of Italian seventeenth century prose", and "the greatest representative of those writers who . . . while sincerely interested in the investigations of science and sometimes contributing to them personally, when describing them allowed themselves to be guided by their literary taste, more than pure scientific purpose". Bartoli, *Tensione e la pressione disputanti*; Carmine Jannaco, *Il Seicento* (Milano: F. Vallardi, 1963), 586.

[1121] Magnani, "Gerolamo Toschi," 170, 184; Campani, *Nova experimenta physico-mechanica*.

[1122] Maylender and Rava, *Storia delle accademie d'Italia*, 2:16.

attended the researches of the seventeenth century virtuoso was due not alone to his new approach to the problems of science, but also, in no small part, to the tools at his disposal, some of them greatly improved and many new or almost new at that time [. . .]". Especially to be mentioned, he commented, were the telescope and the microscope.[1123]

Of particular note among other publications undertaken under the Accademia's sponsorship were two short tracts on microscopes published in 1687 in Rome by the printer Giangiacomo Komarek. One describing the invention of a microscope by member Carlo Antonio Tortoni was entitled "Instructions for the Two Types of Tortoni Microscopes Newly Invented and Brought to Light", and the other was a public letter from Tortoni to Jerome Langenmantel with new information brought to light by Giovanni Battista Vacondio. Its somewhat overburdened title was "Letter in which it is mentioned the prerogative of the said Microscope, and its composition, with many experiments made, with the demonstration of the parabolic figure, and with various designs of enlargement, that the same provides".[1124]

These two instructional pamphlets probably accompanied one of two models of Tortoni's version of the screw-barrel microscope, featuring the focusing mechanism of the lenses, which he claimed to have invented. It had been demonstrated in Ciampini's palace on August 5, 1685. Despite the considerable interest the invention evoked among attending members, Tortoni refused to disclose its technical details, claiming concern over plagiarism, and during the Accademia meeting, he refused to discuss the instrument's internal construction at all.[1125] Tortoni, an active member of the Accademia, was a priest from the Ascoli Piceno region in the Papal Marches. After being appointed a chamberlain at the court of Pope Alexander VII, he made his home in Rome during the last decades of the seventeenth century. Little more is known about him, other than that he was interested in the sciences and in the development of scientific instruments of his time.

Ciampini proved to be particularly interested in optical instruments and worked directly in cooperation with some of the optical instrument makers who were members of the Accademia. Among these were Pietro Celebrini, "gentleman of Todi dedicated to Nature and having the additional virtue of an inclination to Mechanics as demonstrated on more than one occasion in this Accademia"; Paolo Antonisio, "citizen of Civita Castellana"; and, Ciampini wrote in its publication

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[1123] Adelmann, *Marcello Malpighi and the Evolution of Embryology*, 6.

[1124] Carlo Antonio Tortoni, *Lettera scritta da D. Carlo Antonio Tortoni Sac. All'Illustriss. Reverendiss. E Dottiss. Sig. Il Sig. D. Girolamo Ambrogio de Langenmantel Dottore dell'uno, e l'altra Legge, e Canonico Meritissimo nella Collegiata di S. Nauritzio in Augusta. Di nuove data in luce Da Gio. Battista Vacondio, Dottore dell'una, e l'altra Legge. Nella quale si accennano le prerogative del detto Microscopio, e sua composizione, con molte sperienze fatte, con la dimostrazione della figure Parabolica, e con alcuni disegni de gli ingrandimenti, che porta il medesimo* (Roma: Gio. Giacomo Komarek, 1687); *Istruzione delle due sorti di Microscopi tortoniani nuovamente inventati* (Roma: Gio. Giacomo Komarek, 1687).

[1125] Carlo Di Napoli, *Nuove inventioni di tubi ottici: dimostrate nell'Accademia fisicomatematica romana l'anno 1686* (In Roma: Nella Stamperia di Gio: Giacomo Komarek Boemo, 1686), 5; "Novum microscopium authore Carolo Antonio Tortono, sacerdote piceno, Roma degente," *Acta Eruditorum* Octobris, no. 10 (1685): 478–80.

New Inventions with the pseudonym of Carlo di Napoli, Giuseppe Campani, whom he listed among the most celebrated artisans in working optical lenses, the one who constructed telescopes of 200 Roman palms for the Royal Observatory of Paris enabling Cassini to make new celestial discoveries of the planet Saturn, of its ring and of its five satellites.[1126] According to reports, the meetings of the Accademia occasionally developed into virtual battlefields in a war of virtuosity among members claiming to have produced new inventions.[1127]

Earlier at the Collegio Romano, Gottignies, who also had been experimenting with microscopes, succeeded in constructing one that was considered to have been excellent. Other members of the Collegio Romano's faculty had begun to undertake microscopical observations, of which some had been reported in Fabri's *Synopsis optica* (1667), already noted, as well as in Eschinardi's second publication, *Centuria problematum opticorum* (1668), which was published in the same year, a large part of which he devoted to the use of microscopes.[1128]

Although Divini and Campani had produced a number of sliding-tube microscopes, as also had other experimenters in the Accademia, few of the instruments have survived. Because of the nature of their construction and materials of which they were made, they were readily damaged. Only one surviving example of a sliding-tube microscope signed by Campani is known, in the Conservatoire National des Arts et Metiers in Paris. The instrument consists of three cardboard tubes covered with paper, the outermost one of which was the largest and lowermost. The lower end terminates in a turned wood holder containing the objective and the eyepiece is contained in a similar case attached to the upper end of the innermost tube. A screw thread on the outside of the eyepiece is provided for the use of a cover to protect the lens. The instrument is supported upon a three-legged brass tripod having a wide socket ring bearing the inscription "*Giuseppe Campani in Roma 1673*".[1129] **[Figure]**

Another sliding-tube microscope which may be attributed to Campani, although it is not signed, is in the Museo Galileo in Florence. It consists of two cardboard tubes, of which the body tube is the larger and outermost lower tube, with a draw tube sliding within it. The body tube is covered in green vellum with gold tooling in two bands around the top and bottom, slides within a split ring socket that forms part of an iron three-legged tripod support. The draw tube is decorated with a band of vellum, with tooling followed by a plain band of vellum. Marbleized paper covers

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[1126] Di Napoli, *Nuove inventioni di tubi ottici: dimostrate nell'Accademia fisicomatematica romana l'anno 1686.*, 5, 10–11, 17; "Carlo di Napoli," *Dizionario di opere anonime o pseudonime di scrittori italiani o come che sia aventi relazione con l'Italia* (Milano, 1852), 221.

[1127] Middleton, "Science in Rome".

[1128] Honoré Fabri, *Synopsis optica* (Lugduni: Sumpt. Horatii Boissat, & Georgii Remeus, 1667); Francesco Eschinardi, *Dialogus opticus, in quo aliquibus quaesitis compendiose repondetur* (Romae: typis H.H. Corbelletti, 1667).

[1129] Bedini, *Science and Instruments in Seventeenth-Century Italy*, 399; and "Seventeenth Century Italian Compound Microscopes", 391.

the cardboard below. Two marker lines on this tube indicate the points to which the tube may be withdrawn when certain lenses were used. The single biconvex objective is enclosed in a turned wooden nosepiece attached to the lowermost end of the body tube. The lenses of the eyepiece, which are now missing, were contained within a turned wooden tube at the upper end of the split ring socket. The instrument dates to the third quarter of the seventeenth century. At one time attributed to Galileo, it now is accepted as a work by Campani.[1130]

[Figure]

Filed away in the Vatican Archives is an interesting anonymous manuscript consisting of a hand-lettered series of instructions relating to a sliding-tube microscope entitled "Manner of Using the Microscope".[1131] Prepared for the guidance of someone unfamiliar with the instrument who was about to use it for the first time, the hand-drawn illustration on the reverse of the document depicts a sliding-tube instrument having five tubes shown in three stages of distension. The eyepiece is enclosed within a case at the upper end of the largest and outermost tube while the objective is enclosed in a turned wooden nosepiece at the lower end of the body tube. The item to be viewed is placed upon a slide laid upon the surface on which the instrument is standing. The instructions follow:

The instrument called the Microscope is constructed with five tubes, each of which is marked with three sorts of numbers, namely, I-II-III. in order to use it; its proper use is for examining distinctly the most minute objects, which the eye is not normally capable of doing, the use of which is much easier if shown with the three following figures.

Firstly, with Figure C, in which all of the tubes are closed, except the first, that is, the largest, which is to be opened [extended] until the number I of the aforementioned first tube joins with the number I of the second tube, and thus will be united all the numbers I, which are six in number, as in the aforementioned Figure C [marked on the tube]. In this manner, it will enlarge less, and will be the most clear, and will serve suitably for the objects that are most easily visible.

Adjusted in this manner, its base must be placed upon a flat and solid surface, well illuminated, and one places the object one wishes to examine under the lower glass, as for example in E, being cautioned, however, that the objects that tend to appear white should be placed upon a black field, so that they will not cause confusion: and because the objects are not equal in height, one cannot provide an exact sign and a true establishment of distance of the lower glass to the object, it will be necessary, looking into the instrument to steady with one hand the band of the base and with the other hand take the smallest tube marked D, making certain that the hand does not shadow the object. One raises or lowers said tube D little by little, until the eye meets the point best for seeing the object, without taking the eye from it.

Secondly, when the tubes are raised to the number II, of which there are eight, as is demonstrated in Figure B, the object will be much more greatly enlarged, by raising and lowering always the aforesaid tube D, as has been previously noted, until the eye finds the most suitable point.

And finally, when the tubes are raised to the number III (which also are eight in number as shown in Figure A) by means of raising and lowering as before the tube D, and finding its proper point, the instrument will enlarge to the maximum, and will serve for the objects that are imperceptible to the eye.

And because it can happen that this Instrument does not always demonstrate with the usual clearness and distinctness, which may happen because the lenses, which are enclosed, collect moisture, it will therefore

[1130] Gerard L'E. Turner, *Catalogue of Microscopes: Museo di Storia della Scienza, Firenze* (Firenze: Giunti, 1991), 26–29.

[1131] "Modo di Adoperare il Microscopio", ASV, Archivio Chigi, Ms n. 373, vol. E, VI 205.

become necessary to remove them, and polish them with a clean cloth, but softly without the use of force, because it is possible to scratch the polish, and surface of the said lenses.[1132]

[Figure a and b]

The document is contained in the Chigi Family Archives which forms part of the Archivio Segreto Vaticano, filed among the private papers of Pope Alexander VII, who reigned from 1655 to 1667. The strong similarity of the instrument depicted in the drawing to the sliding-tube telescope in the Museo Copericano confirms that the document related to a microscope made by Giuseppe Campani, who already had furnished the Pontiff and his nephews with clocks and telescopes. Further confirmation of its authorship is the fact that this document is bound together with a manuscript folio Nr. 374 entitled "Notices Upon the New Silent Clocks, and on the Other Noisesome Clocks, That Have, Like the First, the Pendulum for a Regulator". That document concerns the pendulum-regulated silent night clocks invented by Giuseppe Campani in 1659 and for which he had been issued a letter patent from Pope Alexander VII.[1133]

[Figure]

Among contemporary figures known to have used microscopes made by both Divini and Campani was the embryologist Marcello Malpighi of Bologna. Often called the founder of microscopic anatomy, he made extensive use of the microscope to study the structure of secreting glands, to discover the deeper portion of the epidermis that came to be known as the "Malpighian layer", and to find loops of the capillaries in the kidneys called the "Malpighian tufts" as well as masses of adenoid tissue known as "Malpighian corpuscles" in the spleen. He described the structure of the human lung and of the brain and spinal cord, and the metamorphosis of the silkworm.[1134]

Malpighi mentioned his use of microscopes several times in his writings including his study of galls, which was published in his work entitled *Opera posthuma*.[1135] As he informed Filippo Bonanni, he used only the simplest microscope having but one lens which, although it did not magnify very much, it nonetheless covered a large field. It is possible that this "simplest of microscopes" may in fact have been the selfsame single lens microscope found in the collection that had been acquired from Malpighi by the Istituto delle Scienze in Bologna. Although Malpighi may have used microscopes made by Divini even earlier, his use after 1671 of at least two microscopes made by Divini is confirmed, described as *piccioli cristalli* (small crystals). In February 1671,

[1132] Ibid.

[1133] Ibid., and MS No. 374.

[1134] Adelmann, *Marcello Malpighi and the Evolution of Embryology*, 6.

[1135] Marcello Malpighi, *Opera Posthuma*, Amsterdam 1700; Fabrizio Lomonaco, "Pietro Piovani e il «Bollettino del Centro di Studi Vichiani» (con una «Lettera aperta» in appendice)," *Bollettino del Centro di Studi Vichiani* 36 (2006): 17; Cesare Preti, "Malpighi, Marcello," *Dizionario Biografico degli Italiani* (Roma: Treccani, 2007).

Malpighi lent a microscope, probably of a simple type, to Jacob Barner, during the period that he was trying to obtain Divini instruments from Rome.

Coincidentally, a single-lens microscope made and signed by Campani is among the collection of the Istituto delle Scienze of Bologna. It was not listed among the surviving instruments, tools, and equipment of Campani's optical workshop which Pope Benedict XIV had purchased in 1746 for the Istituto, so it must have been acquired by the Istituto from another source. It is signed in Italian, not in Latin, which was the language in which he signed his clocks, but in the same manner that he used for his optical instruments, "*Giuseppe Campani in Roma*", and it may be assumed it had been made for sale. It is the only example known of this instrument to have been made by Campani but that he did in fact make single-lens microscopes is confirmed in one of his price lists for his instruments.[1136]

Since this instrument was not listed in the inventory of the workshop items purchased by Pope Benedict XIV from Campani's daughters, it must have been obtained previously by Ferdinando Marsigli, or the possibility exists that it may in fact have been the one owned and used by Malpighi. It can be identified as an example of "the microscope having a single lens, or for worked lines, that serves for observing transparent objects, and the fluids, enlarging admirably with clarity", which Campani listed for sale at the price of 10 *scudi*, as listed on the price list that Campani had given to Landgrave Karl of Hesse.[1137]

[Figure]

It is apparent from Malpighi's correspondence that after 1671 he used at least two instruments made by Divini, as substantiated by Tortoni's report that the embryologist used *piccoli cristalli* made by Divini. He wrote:

> the ingenious Malpichi [sic], who works with the anatomy of plants, uses several small glasses made by Signor Eustachio Divini, the parts of which were made here in my very own hands by the aforesaid Divini shortly before he left Rome, which consisted of various lenses bound in their cases [holders] in the manner of the first ancient figure with its handle of that Microscope described by Filarete [. . .].[1138]

It is possible that Malpighi had owned Divini microscopes prior to 1671, and it is certain that he was aware of them many years previously, because as early as May 12, 1661, the Italian physician and astronomer Giovanni Alfonso Borelli had informed him about a Divini microscope that he considered to be among the most excellent he owned.[1139]

[1136] Klaute, *Diarium Italicum*, 159.

[1137] Ibid.

[1138] Tortoni, *Lettera nella quale si accennano le prerogative del Microscopio*, 10.

[1139] Giovanni Alfonso Borelli, Letter of May 13, 1661, Biblioteca Universitaria di Bologna, ms 2085, IX, 49-50; W. E. Knowles Middleton, ed., "Some Unpublished Correspondence of Giovanni Alfonso Borelli," *Annali dell'Istituto e Museo di storia della scienza di Firenze* 9 (1984): 128–32; Ugo Baldini, "Giovanni Alfonso Borelli," *Dizionario biografico degli italiani* (Roma: Treccani, 1971).

Malpighi dealt with several suppliers in Rome from whom he purchased instruments. Among them was Antonio Bonfigliuoli, who purchased microscopes for him directly from Divini. Early in 1671, he was directed by Malpighi to purchase "also the acute microscope that he [Divini] is making with two lenses, as well as the other that raises and lowers".[1140] The microscope described as "raising and lowering" was Divini's improved model of the sliding-tube type, described in *Giornale de' Letterati* for 1668, and its description was summarized later in the *Philosophical Transactions*.[1141]

Early in 1684, Malpighi's house had caught fire during the night, according to his account, reporting that he had lost "what few goods I had, for I have lost all my wife's linens and her few jewels and effects, as well as my writings, and microscopes". The news of the loss spread widely, as Malpighi communicated it to his friends, and they responded generously. The Duke of Modena, when informed of the calamity, promised to send him microscopes, and the anatomist received several microscopes from the astronomer Geminiano Montanari and one from Prince Marcantonio Borghese. Inasmuch as, by the late 1670s, Divini was no longer working and had left Rome and retired to his original home in Sanseverino Marche, the microscopes that were sent as gifts to Malpighi after his fire unquestionably were screw-barrel microscopes made by Giuseppe Campani.[1142]

In a letter to Malpighi accompanying his gift of a microscope in 1686, Prince Borghese noted that the instrument he sent Malpighi was a new invention that just had been made in Rome only 2 months previously. Attached to his letter was a document that appeared to contain instructions for the instrument's use: "With this microscope it is provided that the object will positively be seen lighted, and not only by reflection as was done before: and thus the advantage of observing better these structure of the little animals, of the liquids, and other objects that appear".[1143]

Jacopo Bartolomeo Beccari, upon his death in 1766, in his last will and testament bequeathed to the Institute of the Sciences in Bologna a microscope believed to have been the one with which Malpighi made many of his discoveries. The instrument was mentioned in Beccari's

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[1140] Letters from Malpighi to Bonfigliouli, January 7 and 24, February 7 and 21, March 11 1671, Biblioteca Universitaria di Bologna, ms 2085, X, 9.

[1141] "Osservatione di un animaletto invisibile, fatta con un microscopio che si descrive," *Il Giornale de Letterati, per tutto l'anno 1668 (Tinassi)* 4, no. 28 Aprile 1668 (n.d.): 52–54; Henry Holdenburg, "Microscope of a New Fashion by the Means Whereof There Hath Been Seen an Animal Lesser than Any of Those Seen Hitherto," *Philosophical Transactions of the Royal Society of London* 3, no. 42 (December 14, 1668): 841–42.

[1142] Gaetano Atti, *Notizie edite ed inedite della vita e delle opere di Marcello Malpighi e di Lorenzo Bellini: volume unico* (Bologna: Tip. Governativa alla Volpe, 1847), 240.

[1143] Marcello Malpighi, *The Correspondence of Marcello Malpighi*, vol. 3. 1684-1688 (Ithaca, NY: Cornell University Press, 1975), 1192.

eulogy, but by the time the eulogy had been delivered, the instrument had disappeared and never was recovered.[1144]

The success of Campani's screw-barrel microscope also came to the attention of the Royal Society in London. At a meeting in May 1686, a note from Justel was read "about a new sort of microscopes made by CAMPANI at Rome with three glasses, and not above three inches long, which were very distinct, but did not magnify so much as the great ones".[1145]

Later in the same year the Royal Society's records again reported that a communication from Justel was read, "giving an account of a sort of little microscope made at Rome by Campani, which was but three inches long, but which he claimed to be better than the biggest ever made by him; and that the *animalcula in semine canino* are plainly visible therein".[1146]

[Figure]

The invention of the screw-barrel compound microscope proved to be an important milestone in the evolution of the compound microscope, and it generated considerable interest in the seventeenth century scientific world because of its advantages over previous versions of the instrument. Evolving from the earlier sliding-tube type, the invention had been claimed by several who had produced early rudimentary versions. Notable among the contenders for the honor had been an early pioneer in optical instrumentation, Johann Wiesel (1583–1662) of Augsburg, who from about 1640 described himself as *opticus* or optician. Although his telescopes were relatively well known, little information about his microscope exists. Although they were described in correspondence, no example is known to have survived.[1147]

There is a mention of an instrument, for example, equipped with three lenses. On another occasion, Wiesel praised the "glass screwed little box" in which one could see a flea magnified to the size of a large cricket. This may have been a description of the cell to contain the lens, made of two circular pieces of boxwood or other closely grained wood that screwed together to hold the lens in place.[1148] In a letter of February 17, 1650, to Johannes Hevelius in Danzig, Wiesel noted that he

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[1144] Iacopo Bartolomeo Beccari (1682–1766), basically a physiologist, had an early interest in literature and poetry, and at 15 began the study of philosophy under the canon L. Trionfetti; he also studied geometry and trigonometry but primarily dedicated himself to the study of medicine under I. Sandri, a student of Malpighi. He received the degree of physician from the University of Bologna in 1794 where he continued his studies. After 1711, when Malpighi established the Institute of the Academy of Science and the Arts, Beccari taught experimental science there. Mario Crespi and Aldo Gaudiano, "Beccari, Iacopo Bartolomeo," *Dizionario Biografico degli Italiani* (Roma: Treccani, 1970).

[1145] Birch*, History of the Royal Society of London*, 483.

[1146] Ibid., 517 [Scientific Editor 2: "the little animals in dog semen"].

[1147] Inge Keil, *Augustanus Opticus: Johann Wiesel (1583-1662) und 200 Jahre optisches Handwerk in Augsburg*, Colloquia Augustana, Bd. 12 (Berlin: Akademie Verlag, 2000). [Scientific Editor 2: Silvio Bedini did not know this book, but he exchanged letters with Inge Keil, the author of the abovementioned book. Bedini, in the draft of of his book, acknowledged Inge Keil for providing him with the information about Wiesel].

[1148] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 1, 310-11, n. 207 and 208: letter of Wiessel to Christiaan Huygens, December 12, 1654; vol. 13, 676.

had made a microscope with three lenses for the Kurfürst (Prince-elector) of Bavaria that measured 5 *zoll* in height. In another letter written to Hevelius 2 years later, Wiesel's description of his microscope is nearly the same. However, in a postscript he added, "When all is adjusted to look through, the eye shall be put into the mouthpiece. And after having put under there something higher, the other screw shall also be screwed out a little higher [. . .]".[1149]

Again, in an inventory of a *kunstkammer* in Stuttgart, mention is made of what appear to be screw-barrel microscopes, which may relate to instruments made by Wiesel. The entry described "two microscopes of the same size and appearance, which can be screwed up and down, each having 5 cylinders or tubes, of which the outermost is covered with black *corduan* [cordovan leather] and ornamentally gilded, under most there are disks of brass which can be turned around, with different objects glued on it, the length of it [microscope] wholly screwed together, is one foot [approximately 30 cm]".[1150]

The next major development in the compound microscope was the introduction of the field lens, the date and inventor of which remain uncertain. The earliest published reference occurs in an account of European travels by the French traveler Balthasar de Monconys. In mentioning Wiesel's shop, Monconys described a microscope that had been made to his design in 1660 there at Augsburg by the son-in-law of the optician Johann Wiesel. In his travel account, Monconys erroneously named Giuseppe Campani as Wiesel's son-in-law, who in fact was Danish-born and named Daniel De Pierre or Depiere. Monconys provided details of the construction and application of his microscope, noting that it had two foci, one for magnification and the other for distinctness. The description of the instrument stated the distance from object to first lens was 1-1/2 inches (3.81 cm), the focal length of first or object lens was 1 inch (2.54 cm), the distance from first to second lens was 15 inches (38.1 cm). The focal length of the second lens or field lens was 2-1/2 inches (6.35 cm); the distance from the second to the third lens was 1-2/3 inches (4.23 cm); and the focal length of the third (ocular) lens was 1-2/3 inches. The distance from the observer's eye to the third (ocular) lens was 2/3 of an inch (1.69 cm).[1151]

In his *Synopsis Optica* published in 1667, Honoré Fabri confirmed the fact that the first microscope with a field lens had been produced in Augsburg and that it had been made to Monconys' design. In October 1665, De Pierre sent a microscope to Dresden, which survives in the

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[1149] Keil, *Augustanus Opticus*, 134.

[1150] Ibid., 314.

[1151] Balthasar de Monconys, *Journal des voyages de Monsieur de Monconys ... Où les sçavants trouveront un nombre infini de nouveautez, en machines de mathematique, experiences physiques, raisonnemens de la belle philosophie, curiositez de chymie, & conversations des illustres de ce siecle; outre la description de divers animaux & plantes rares, plusieurs secrets inconnus pour le plaisir & la santé, les ouvrages des peintres fameux, les coûtumes & moeurs des nations, & ce qu'il y a de plus digne de la connoissance d'un honeste homme dans les trois parties du monde ...* (Paris: Louis Billaine, 1677), 117, fig. 128.

Physikalische-Mathematiker Salon. It consisted of three lenses, wooden tubes, and appears to be of the screw-barrel type.[1152]

As reported by Christiaan Huygens, his father Constantijn saw a real microscope as early as 1621. The first example of a field lens is clearly described for the first time in the papers of Christiaan Huygens, who in November 1654 received from Johann Weisel of Augsburg a telescope and a microscope, each having a field lens.[1153]

Suggestions for topics to be discussed at meetings of the Accademia Fisicomatematica Romana frequently were submitted by the members in writing in advance of the meetings. On special occasions, a particular instrument was selected for general consideration, and members brought examples of such instruments, which they had developed or upon which they been working. Ciampini, aided by his assistant Giuseppe Teutonico, established the practice of preparing the experiments at his own expense in advance of each meeting.

It was on just such an occasion, on August 5, 1685, that the subject selected to be featured was the new invention of the microscope. The meeting proved to be of considerable importance, and it was to have significant impact on the development of the screw-barrel microscope. At least 12 versions were displayed on that occasion, by as many makers, among them Carlo Antonio Tortoni, Marcantonio Cellio, Pietro Celebrini, Willem Homberg, Paolo Antonisio, Anonimo Filarete, Giuseppe Campani, and possibly several others. Eustachio Divini, who certainly would have been represented, as noted, had departed from Rome several years earlier and retired to his birthplace, where he died in that same year.

Ciampini published the proceedings of that meeting in one of the Accademia's most important tracts, the full title of which, in translation, was: "New Inventions of Optical Tubes Demonstrated at the Academy of Physics and Mathematics in Rome in the Year 1686". Although the author of the tract was given as Carlo di Napoli, it was generally believed that in fact this was another pseudonym used by Ciampini. The tract resulting from this meeting, issued under the auspices of the Accademia, provided a major contribution to the history of the microscope, reporting as it did particularly the development of the several forms of the seventeenth century instrument.

The text of the tract consisted of 19 pages with three plates, one of which displayed microscopes with details of several and the two other plates with illustrated aerial telescopes. Enumerated in this work were the benefits accruing to the use of microscopes and telescopes, and

[1152] Fabri, *Synopsis optica*, 153; Keil, *Augustanus Opticus*, 332; Jean Louis Sponsel, *Das grüne Gewölbe zu Dresden: ein führer durch seine gesichte und seine sammlungen*, vol. 2 (Dresden: Bard, 1928), 47.

[1153] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 13, 513: "De Microscopia" and page 676.

after having described the advances that had been made up until that time, the author discussed many discoveries demonstrated in his Accademia.[1154]

The plate featuring microscopes in *Nuove Inventioni* depicted 12 forms of the compound microscope, each of them a late seventeenth century development. Figure 6 was the invention of the Dutch naturalist and chemist Willem Homberg (1652–1715), an instrument supported upon a brass tripod having a wide split-ring socket that was slit so that it was spring-like and clasped the main tube elastically, thus enabling it to be slid up or down and made to remain in the position selected. The text stated: "With this new invention the object was demonstrated much more greatly enlarged and more distinct and having a wider field of vision".[1155]

[Figure - plate]

As previously noted, it was at this gathering of the Accademia that Carlo Antonio Tortoni presented his invention of a microscope that was somewhat in the form of a screw-barrel instrument. Tortoni's microscope was equipped with five lenses, of which one was not spherical, and constructed on the principle later to be found in the Wilson screw-barrel microscope. It was immediately praised by his fellow members, who noted that its small tube [*parvulus tubus*] was a prodigious innovation and eminently desirable because of its manageability and convenience, and because it made possible observation of objects in great magnification. As previously noted, Tortoni refused to reveal the principle of the internal structure of his instrument, however, to the great frustration of other members. He made wide distribution of a letter in which he described his instrument, an announcement that was subsequently published in Rome in 1687, and a version of which appeared as well in the *Giornale de' Letterati* in the same year.[1156]

This little tract of "New Inventions" had relatively wide distribution at the time, and a copy reached the Royal Society of London, where it was discussed at the meeting. The proceedings were reprinted in Nuremberg in 1689 in the *Miscellanea Curiosa,* and once again in the *Galleria di Minerva.*[1157] The plate illustrating microscopes was subsequently reproduced in other publications as well, accompanied by excerpts from the text, often erroneously interpreted. Figure 7 in the illustration depicted an improvement, consisting of a standing post to which was attached a ring supporting the main tube of the telescope. The microscope illustrated appears to have been the invention of another unidentified maker, and the post support apparently was a Homberg invention.

[1154] Di Napoli, *Nuove inventioni di tubi ottici*.

[1155] Ibid.

[1156] Tortoni, *Istruzione delle due sorti di Microscopi*; Savile Bradbury, *The Microscope: Past and Present* (Oxford: Pergamon, 1968), 75.

[1157] Salvatore Rotta, "L'accademia fisico-matematica Ciampiniana: un'iniziativa di Cristina?," in *Cristina di Svezia: scienza ed alchimia nella Roma barocca*, ed. Wilma Di Palma, Nuova biblioteca Dedalo ; Serie "Nuovi saggi" 99 (Bari: Dedalo, 1990), 146.

It has a great similarity to the apparatus described and illustrated by Robert Hooke in 1665 in his *Micrographia*.[1158]

It was soon apparent that, of the several versions of the screw-barrel microscope displayed and compared, the one that achieved the greatest success was the one produced by Giuseppe Campani. After having experimented extensively with improvement of the sliding-tube microscope, of which he had produced a number of examples, he invented the screw-barrel version in 1684 or 1685. It was immediately recognized as a considerable improvement over sliding-tube instruments, for it permitted more precise focusing. At the time it was presented at the Accademia in August 1686, from the very first inspection it was rated to be entirely superior to the competing instruments. His microscope was of small dimension, as also were most of the others presented, but it had a magnifying power and a profundity of field that were considerably greater than of the other instruments. Judging from surviving examples, they were in proportion a little less complicated than the others. Campani's screw-barrel microscope was illustrated as Figure 8 in the folding plate of *Nuove Inventioni*, and described as follows:

Signor Gioseppe Campani, who is foremost among the most celebrated artisans in the working of Optical Glasses, demonstrated in another [meeting of the] Academy another microscope larger than that of Tortoni, about 5 *oncie* in length that showed the object with great clarity, with the reservation, however, that since the object [examined] was so close to the small object-lens, it remained obscure in some parts of its surface towards the eye; however, he remedied this defect in the next [meeting of the] Accademia with a new Invention of a tripod or ring with screw-thread into which the Tube was inserted, which is better understood from Figure 8.

This [instrument] is composed of two Tubes in order to be able to extend them. The first A toward the eye contained two lenses of 1-1/2 *oncie*, which combined in focussing; they are formed one of 1-1/4 *oncie* and the other B situated toward the object [to be viewed] is of three *minuti* of an *oncie*. At the extremity of the second Tube C is inserted a piece of wood made as a screw, as shown in the figure, in which is inserted a brass ring D that is threaded on the inside with a mating screw-thread. This ring has three arms which support the flat brass plate E with an opening in the middle, in which is inserted a small vase of the width of the opening in which between two glasses is enclosed the object which is to be observed, and of these small vases one can make as many as needed, so that it will be easy to changing them each time.[1159]

The stage of Campani's microscope was not described in the *Nuove Inventioni* but a form attributed to Cellio has some similarities. It was noted that Cellio, "whose excellent works are already well known, also wished to provide evidence of his ingenuity and his ability in this Art, since in other meetings of this Accademia he had exhibited two Microscopes, one of a length of about three *oncie* and the other smaller, which worked to the highest degree . . . and surpassed the other one".[1160]`

Cellio had made an improvement consisting of a brass ring socket without a screw thread on which the body tube moved easily. The platform of the support between the two arms was double

[1158] Birch, *History of the Royal Society of London*, vol. 2.
[1159] Di Napoli, *Nuove inventioni di tubi ottici*, 5–6.
[1160] Ibid.

and the band of the base between the two platforms were two openings opposite each other through which a plate with a number of openings was inserted with rings of talc upon which were placed the objects for study. The plate could be pushed back and forth to position an individual object directly under the lens. A round plate supported on two springs was placed directly below the opening in the base, which kept the slide holder rigid and tightly in place and pressed it against the upper platform surface for better viewing.[1161]

A microscope in the Museo Galileo in Florence may have been the one that Campani had sent to the Grand Duke prior to his development of the screw-barrel instrument. It consists of a body tube and one draw tube made of cardboard covered with gilt-stamped vellum. The ocular lens is biconvex and enclosed in a turned wood cell attached to the upper end of the draw tube. There is a wooden diaphragm within a cardboard cylinder. Another cardboard cylinder within the body tube contains a boxwood cell for another biconvex lens situated 70 mm from the eyepiece. The second lens is removable and can be used alone. The nosepiece of turned wood includes a casing for the objective. It is supported on a wrought iron tripod having a spring socket ring with three flat iron feet. The body tube may be raised or lowered in the socket ring.[1162]

Pleased with the reception that his microscope had received from his peers in the Accademia, in 1687, Campani forwarded one of his new microscopes of the screw-barrel type to Apollonio Bassetti, Tuscany's secretary of state in Rome. Campani had been commissioned to make the instrument for young Cosimo III, Grand Duke of Tuscany. With the instrument he included a copy of the illustrated article in the *Giornale de' Letterati* in addition to a report of the observations made of Saturn by Cassini with Campani telescopes. Somewhat proudly, he wrote:

> I have succeeded in inventing a Microscope very different from all others which have been constructed until now, both in the facility with which it can be adjusted as one desires, as in other aspects as noted by the one who has made the observations in the printed article. It is my pleasure, therefore, in order to completely fulfill so much honor I have been given, to deem it necessary to share it with His Serene Highness, under whose patronage I am most appreciative of being. I am therefore about to beg the kindness of your illustrious self to give to the aforesaid Most Serene Patron the aforementioned Microscope as the most recent tribute of my total homage, with my most profound and most humble reverences; and of your bounty I take confidence in giving a hand-glass [*occhialino da pugno*] [for yourself] in acknowledgment of the singular regard I profess for you [. . .].[1163]

Campani carefully selected the material with which he constructed the body of his screw-barrel microscopes. He chose closely-grained woods, which he turned on one of his lathes. His preference was for *coccus* and *lignum vitae*. *Coccus* is a dark, closely grained wood used in Italy

[1161] Ibid., 6-7 and fig. 9.

[1162] Bonelli and Pagnini, *Catalogo degli Strumenti del Museo di Storia della Scienza*, 172–74; Turner, *Catalogue of Microscopes*, 26–29.

[1163] ASF, "Mediceo del Principato", filza 3053. Letter from Giuseppe Campani to Apollonio Bassetti, May 10, 1687.

during the seventeenth century for small carved objects, for making flutes and some scientific instruments, and for inlaying. It is derived from several sources, including *Brya* or *Amerimnum ebenus*; green ebony, a small leguminous tree of Jamaica; *Inga vera* or "Porcupine Wood"; and *Aporosa dioica* (Euphorbiaceae) or Kokra Palm from the East Indies.

Campani's screw-barrel microscope was described and illustrated for the first time in 1685 in the *Giornale de' Letterati*, in an illustrated article entitled "Description of New Microscopes Invented by Giuseppe Campani, and Their Uses".[1164]

[Figure a complete; b. Dismantled]

The same description and illustration subsequently were reproduced in Leipzig in the July 1686 issue of the *Acta Eruditorum* with the same title in Latin, "Description of New Microscopes invented by Giuseppe Campani, and Their Uses". The description was in the form of a letter in Latin from Emmanuel Schelstrate submitted to the editor of the journal, Otto Mencke, a professor at the university. Schelstrate was a theologian and assistant prefect of the Vatican Library who maintained close relations with Monsignor Ciampini and with the activities of his Accademia. He frequently reported on them to Mencke for publication in the *Acta*'s pages. His account of the screw-barrel microscope was one of his reports.[1165]

The engraving accompanying Schelstrate's article illustrated the instrument in the three ways in which it could be used. At the left was a large representation of the microscope placed upon a table as it would have been used for laboratory examination, with a human eye looking into the eyepiece; the second view illustrated the singular use of the microscope for studying transparent bodies, as an observer is shown holding the instrument up to his eye and looking through it; and finally, a physician in the third illustration showed how the instrument would be used for examining wounds and scars of the human body, as a physician is shown using the instrument held to his eye to examine the leg of a patient while an assistant illuminates the scene with a candle the light of which is reflected to the patient's leg by means of a mirror. The text is virtually the same as that which had appeared in the *Giornale de' Letterati*:

Description of a New Microscope, Invented by the Honorable Josepho Campano [sic] and Its Use. Sent by the Honorable Schelstrateno, Prefect of the Vatican Library, in a letter from Rome of the 15th of June, in the year 1686. This most distinguished man has added to his clever inventions a microscope, the maximum height of which is five thumbs [*pollice*] and the minimum height of which is less than three thumbs, and which can be constructed much smaller. It excels all the others constructed up to this day, even though they contain many lenses, in the magnifying of objects, in the greater extension of its field, in its resolution and in its use. For it magnifies objects more than any other microscopes, even six or seven times larger. It exhibits a field larger than its own diameter, and even more than this when it is extended. It wonderfully preserves its clarity (which very often is greatly diminished by too much magnification of objects) even in the very

[1164] Bedini, "Seventeenth Century Italian Compound Microscopes", 403-05.

[1165] Bradbury, *The Microscope*, 23. Vide "Emmanuel de Schelstrate," *Nouvelle Biographie Générale* (Paris, 1867).

extremities of objects. Further, its use is unique, since the base on which the object is placed under the microscope serves at any inclination you wish, while always retaining a satisfactory reception of light. This microscope is useful for observing objects of every type: transparent, opaque, solids, and fluids; these latter are included between two slides, in which things stored and animalcules can so be preserved for some days that any part of the animalcule can be exactly represented by a very easy task. Hence the motion of transparent nerves, humors, and *chyle* and even animalcules in the seed of any living things are far more easily observed here than with the help of the spherical lenses already discovered by the Honorable Leeuwenhoek. And add that with the base removed from this microscope, it serves for inspecting wounds and diseases of living things and everything else, even the smallest parts of any members of the anatomy of the subject bodies.

We add a diagram, in which in Number One the shape of the microscope appears and the use which it has in common with other microscopes is shown; in Number Two appears the singular use of this microscope for studying transparent bodies; and in Number Three its use for observing wounds and scars.[1166]

[Figure]

The 10 or more surviving signed examples of Campani's screw-barrel microscopes reveal little variation from one to another. Generally, they were constructed of a dark, closely grained hardwood, probably *coccus* as noted, and consisted of two barrels, the lowermost of which was the outer barrel. It had a fine thread on the outside by means of which it could be focused by screwing it up or down upon the stand. The inner barrel was about 2 inches (5.8 cm) in length and had a coarser thread on the lower l-1/4 inches (3.175 cm), providing for adjustment between the object lens and the ocular lens. The objective was contained in a wooden cell screwed into the nose of the instrument, which had a pinhole opening. The ocular lens had a turned wooden dust cover that could be screwed into place to protect the lens. A three-footed brass stand had a wide band into which the instrument was inserted.

Campani produced two of the surviving screw-barrel instruments for the Landgrave Karl IV of Hesse. Another had been preserved in the Physikalisch-Mathematische Salon in Dresden but was destroyed in an air raid during the bombing in World War II. The latter was made of olive wood, 11 cm in height (4.33 inches), and was supported upon a brass stand bearing the inscription "*Giuseppe Campani Roma 1696*." The instrument contained two biconvex lenses, the objective of which was described as a little lens which was "very convex". This microscope probably had been purchased by the Elector of Saxony, and according to tradition it had been used by Johann Friedrich Böttger (1682–1719) who produced the first true porcelain in the Western world. He first began working with china clay and felspar soon after 1701 in the laboratory of the Elector. In 1711, he combined feldspar with koalin, resulting in the first true porcelain. Until then, kaolin had been used only for powdering wigs. Porcelain products in this new material were first marketed by 1716. Gloede stated

[1166] Emmanuel Schelstrate, "Descriptio novi microscopii, autore dn. Josepho Campano, ejusque usus a Dn. Schelstrateno, Vaticanae Bibliothecae Praefecto, in literis," *Acta Eruditorum*, no. June 13 (1986): tabula X.

that the instrument in the Dresden museum had been taken from Böttger's collection and brought to Dresden where it was added to the Elector's collection on July 23, 1728.[1167]

[Figure]

Yet another stage in the development of the screw-barrel was an instrument the body of which was turned from a dark, closely grained wood with a vase-shaped body and equipped with a brass nosepiece, which was focused by screwing it up or down, but there was no adjustment for the distance between the lenses. An interesting unsigned vase-shaped screw-barrel microscope in the Science Museum in London, it was turned from a closely grained wood, probably pear, and is supported upon a heavy turned wooden ring having three carved console feet. No adjustment is provided for the distance between the ocular and the object-lens, both biconvex with the convex surfaces toward each other, which were fixed in place, but a plano-convex field lens was added. The nosepiece is focused by screwing it in or out of the socket ring. Believed to have been owned and used by Malpighi, was previously the property of the University in Bologna, then became part of the Frank Crisp Collection, and now is in the Science Museum in South Kensington, London.

Another similar example acquired in Italy in 1880, now in the Medical Museum of the United States Army Pathology Division, is of particular interest because of its optical structure. It is supported on a brass tripod having a supporting socket ring with three flat curved legs. The objective is a biconvex lens 7/16 of an inch (1.111 cm) in diameter, the field lens is plano-convex 1-6/16 (4.445 cm) inches in diameter with the plane side toward the objective. The eyepiece consists of two biconvex lenses, the lowermost of which is 1-1/16 inches in diameter (2.698 cm) and the upper of which is 12/16 of an inch (1.905 cm). Although unsigned, it is believed to have been made by Campani. This version was neither described nor illustrated in the publication of the Accademia Fisicomatematica, but it bears some similarity to one form of the instrument attributed to Marcantonio Cellio, an Italian astronomer and author of several published works.[1168]

[Figure]

In his *Micrographia Curiosa* published in 1691, Filippo Bonanni illustrated and described a compound microscope having virtually the same arrangement for holding the object as had been devised by Cellio, with the difference that the instrument Bonanni described utilized a spiral spring instead of a spring plate. The second part of Bonanni's work is one of the earliest treatises on microscopy, containing important observations on early microscopes and exact descriptions of

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[1167] August Coester and Ernst Gerland, *Beschreibung der Sammlung astronomischer, geodätischer und physikalischer Apparate im Königlichen Museum zu Cassel: Festgabe für die 51. Versammlung deutscher Naturforscher und Ärzte im Auftrage des Herrn Ministers der geistlichen, Unterrichts- und Medicinal-Angelegenheiten* (Kassel: Hof- u. Waisenhaus-Buchdruckerei, 1990), 46–47; Max Engelmann, "Optische Instrumente im Mathematichen Salon zu Dresden," *Mittelungen aus den Sachsischen Kunstsammlungen* 7 (1916): 63–64, fig. 12A.

[1168] Bedini, "Seventeenth Century Italian Compound Microscopes", 410-12.

Bonanni's own instruments. It contains the first description and illustration of the method of holding an object between two flat plates held together by a spiral spring, the first microscope focused by means of a rack and pinions, the first that had a substage condenser that could be focused, and the first made with more than a single lens.[1169]

[Figure]

Filippo Bonanni (1638–1725) was born in Rome, entered the Jesuit order, and eventually became assistant to Athanasius Kircher. He subsequently succeeded him as teacher of mathematics at the Collegio Romano. In 1698, Bonanni was appointed curator of the museum founded by Kircher at the Collegio and produced a work describing its collections. Considered to be one of the most learned Jesuits of his time, Bonanni made extensive studies in a variety of fields, ranging from numismatics to natural sciences. He constructed a microscope with three lenses based upon the Tortoni system, and from his microscopical studies of natural objects, in 1681, he produced a work entitled "Recreations of the Eye and of the Mind in the Observation of Snails".[1170]

The question occasionally arises as to whether Galileo used a microscope. It was not until 15 years after Galileo first worked with the optical instrument he called an *occhiale* or *occhialino* that the term "microscope" was first used, yet it seems fairly clear that Galileo's *occhialino* in fact functioned as a microscope. According to one of his former students, John Wodderborn (a.k.a. Wedderburn), Galileo made use of his telescope, which had a concave ocular lens, greatly drawn out as a sort of microscope. He described the incident in a work published in 1610:

> I will not now attempt to explain all the perfections of this wonderful *occhiale*; our sense alone is a safe judge of the things which concern it. But what more can I say of it, than that by pointing a glass to an object more than a thousand paces off, which does not even seem alive, immediately recognize it to be Socrates, son of Sophronicus, who is approaching! [. . .] I heard a few days back the author himself [Galileo] narrate to the Most Excellent Signor Cremonius various things most desirable to be known, and amongst others, in what manner he perfectly distinguishes with his telescope the organs of motion and the senses of the smaller animals, and especially in a certain insect which has each eye covered by a rather thick membrane, which is, however, perforated with seven holes, like the visor of a warrior, and allows it sight. Here hast thou a new proof that the glass concentrating its rays enlarges the object [. . .].[1171]

During his travels in Europe, Jean du Pont de Tarde (a.k.a. Giovanni du Ponton), paid a visit to Galileo on November 12, 1614. He found the sage ill in bed and, following a discussion of astronomical discoveries, he reported that Galileo told him: "the tube of a telescope for looking at the stars is no more than two feet in length, but to see objects that are very near, but which we

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[1169] Filippo Buonanni, *Micrographia curiosa: sive rerum minutissimarum observationes, quae ope microscopii recognitae, et expressae describuntur* (Romae: Typis Dominici Antonij, 1691), 26.

[1170] Filippo Buonanni, *Musæum Kircherianum, sive Musæum à P. Athanasio Kirchero in Collegio Romano Societatis Jesu jampridem incæptum, nuper restitutum, auctum, descriptum, & iconibus illustratum ... a P.P. Bonanni* (Romæ: typis Georgii Plachi, 1709); *Ricreatione dell'occhio e della mente nell'osservation' delle chiocciole: proposta a'curiosi dell opere della natura* (In Roma: per il Varese, 1681); Pietro Omodeo, "Bonanni, Filippo," *Dizionario Biografico degli Italiani* (Roma: Treccani, 1972).

[1171] William Benjamin Carpenter, *The Microscope and Its Revelations* (London: J. & A. Churchill, 1901), 122.

cannot see because of their small size, the tube must have two or three lengths. He tells me that with this long tube he has seen flies which look as big as a lamb, and he has learned that they are covered all over with hair, and have very pointed nails, by means of which they keep themselves up and walk on glass, although hanging feet upwards, by inserting the point of their nail into the pores of the glass”.[1172]

The microscope as such is not mentioned in Galileo’s papers, but a reference to it occurs in *Il Saggiatore*, written between 1612 and 1622. Galileo wrote, “I might tell Sarsi something new if anything new could be told him. Let him take any substance whatever, be it stone, or wood, or metal, and holding it in the sun, examine it attentively, and he will see all the colors distributed in the most minute particles, and if he will make use of a telescope arranged so that one can see very near objects, he will see far more distinctly what I say”.[1173]

Two instruments in the form of compound microscopes attributed to Galileo in the collection of the Museo Galileo in Florence have been a source of confusion and controversy over a period of some years. According to the museum’s records, they had formed part of the original collection of instruments of the Accademia del Cimento at the time of its dissolution in 1667. They are constructed entirely of brass, supported upon a ring socket having three scroll feet. They have two adjustments, one for the distance between the eyepiece and the object lens, accomplished by screwing the body tube up or down on the socket ring of the support; in this they operate in an identical manner as the Campani screw-barrel instrument. The lenses, which are missing, were stated to have been constructed by Galileo, a claim obviously in error. In actuality, the two instruments had no association with Galileo and had been produced as models in the mid-nineteenth century and were sent to London to be displayed at the Science Museum opening.[1174]

[Figure]

Although Queen Christina died in 1689, the Accademia continued under Ciampini until his death in 1698. It was caused by toxic poisoning from fumes of mercury with which he was experimenting. After his death the organization was disbanded, and the members went their separate ways.[1175]

While major advances in the development of the microscope were being made in Germany and Italy, the subject proved to be of interest also in the Netherlands. The Dutch inventor Cornelius

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[1172] James R. Newman, *The World of Mathematics*, vol. 2 (London: Simon and Schuster, 1956), 732.

[1173] Galileo Galilei, *Il saggiatore: nel quale con bilancia esquisita e giusta si ponderano le cose contenute nella libra astronomica e filosofica di Lotario Sarsi ...* (Roma: Appresso Giacomo Mascardi, 1623), 105.

[1174] Bonelli and Pagnini, *Catalogo degli Strumenti del Museo di Storia della Scienza*, 172–74; Turner, *Catalogue of Microscopes*, 26–29.

[1175] Middleton, “Science in Rome”, no. 29, 143; Maylender and Rava, *Storia delle accademie d’Italia*, 2:11–17; Vincenzo Leonio, “Vita di Monsig. Gio. Giustino Ciampini romano detto Immone Oeio,” in *Le vite degli Arcadi illustri*, by Giovanni Mario Crescimbeni, vol. 2 (In Roma: Nella stamperia di Antonio de’ Rossi ..., 1710), 195–254.

Drebbel was in Prague in 1619, but later in the same year he was in London where it was that Willem Boreel claimed to have seen a microscope owned by the fellow countryman. Boreel attributed the invention of the microscope, and the construction of the one in the hands of Drebbel, to Sacharias Jenssen. Some other historians attributed it to Drebbel.

This microscope is reported to have measured 1-1/2 feet (ca. 45 cm) and rested upon three feet formed as dolphins. It is not certain whether this was in fact a microscope with two convex lenses and not a Galilean telescope–microscope with a concave ocular lens. Boreel's claim was defended by P. Harting. The historian Cornelis De Waard subsequently made a thorough search of the Middleburg archives and stated that nowhere in scientific literature is a microscope mentioned prior to Galileo.[1176]

In 1622, Jacob Kuffler, Drebbel's son-in-law, traveled to Italy with one of Drebbel's microscopes and visited Paris on his way to Rome. There he demonstrated the instrument to Nicolas-Clude Fabri de Peiresc, who was surprised that the mites walked in the wrong direction, proving that it was not a simple microscope or a Galileian type. After this demonstration to Peiresc, Kuffler proceeded on to Rome but died of the plague in November 1622 before he was able to demonstrate the instrument there. Through the intermediary of Peiresc, his microscope first became known in Italy in 1624. In a letter to Federico Cesi, the physician and naturalist John Faber (1574–1629) wrote on April 13, 1625: "I mention also this new *occhiale* for viewing minute objects, and I call it a microscope".[1177]

Microscopes clearly modeled upon those made by Giuseppe Campani during the second half of the seventeenth century were made by François Baillou of Milan in 1738, several decades after Campani's death. Presently only eight microscopes by Baillou are known, the earliest dated 1734 and the latest 1764. Recently, a trade brochure published by Baillou has been found. A predecessor optician in Milan was Pietro Patroni, whose products were dated from 1715 to 1726.[1178]

[1176] Edward G. Ruestow, *The Microscope in the Dutch Republic: The Shaping of Discovery* (Cambridge: Cambridge University Press, 1996), 6–7; Albert Van Helden, "The Birth of the Modern Scientific Instrument 1550-1700," in *The Uses of Science in the Age of Newton*, ed. John G. Burke (Berkeley: University of California Press, 1983), 71.

[1177] Gerrit Tierie, "Cornelis Drebbel (1572-1633)" (Dissertation, Leyde, 1932), 10; Adam Max Cohen, *Technology and the Early Modern Self*, 1st ed (New York, NY: Palgrave Macmillan, 2009), 174; David Freedberg, *The Eye of the Lynx: Galileo, His Friends, and the Beginnings of Modern Natural History* (Chicago: Univ. of Chicago Press, 2002), 152.

[1178] Turner, *Catalogue of Microscopes*, 30–31; Alberto Lualdi, "A Trade Brochure of François Baillou," *Bulletin of the Scientific Instrument Society* 40, no. March (1994): 16–17; Christie's, *Fine Scientific Instruments* (London: Christie's, 1995), 48–49.

APPENDIX

Contributions to the Development of the Compound Microscope

Contributions by Eustachio Divini

1. A focussing arrangement by means of a combination of draw tubes;

2. Adjustment of focus between the objective and the object by sliding the tube up and down on a metal tripod with socket ring, which permitted only one coarse adjustment;

3. The first application of a doublet lens consisting of two plano-convex lenses combined at their convexities; a combination that continued in use into the nineteenth century.

Contributions by Giuseppe Campani

1. The invention and perfection of the screw-barrel instrument permitting relatively accurate adjustment of focus between lenses and between the objective and the object;

2. Reduction of the size of the instrument to enable greater flexibility in use;

3. Development of a slide holder as part of the instrument that permitted a variety of uses and control of a light source.

Contribution by Marcantonio Cellio

1. The multiple slide holder.

Contribution by Bonanni

1. The spring-type of slide holder.

Contribution by Willem Homberg

1. The focussing adjustment.

Chapter XXI

LITIGANTS AND LEGACIES

(1680–1710)

> *Throughout the world of the western Mediterranean, women were coming to depend far less on the generosity of their husbands than on that of their own kin, whose award of a dowry became a prerequisite of marriage, the burdens of which it was held to sustain. Dowry has been called pre-mortem inheritance, in which a daughter's share of her father's estate is served up early, when she needs it to enter and establish a new home, rather than at the time of her father's death.*
>
> Jack R. Goody and S. J. Tambiah, *Bridewealth and Dowry* [1179]

In a study of the inventions and achievements of the Campani brothers, surviving records of investments and business dealings unrelated to their achievements are normally of relatively little interest. Nonetheless, they serve to illustrate how in their time and clime it became possible for untutored lads of limited education and training emerging from the remote countryside to achieve fame and fortune. It was due largely to the fact that during a period in which they had little competition, because of papal letter patents, their products were both unusual and intriguing and because of elevated prices were made desirable exclusively for the uppermost levels of society having status and wealth. Judged by the standards of their time, by the time of their deaths, both Pier Tommaso and Giuseppe Campani had become relatively wealthy. Both had followed the practice of demanding high prices for their specialized clocks and instruments in an exclusive market peopled by the elite and the wealthy.

In addition to Giuseppe Campani's income from the production of timepieces and scientific instruments, in later life he also derived lucrative income from ventures into real estate. He had invested wisely and owned extensive landed property in the forms of houses, vineyards, land, properties, fields, and mountain sites. As examples, in 1669, Giuseppe rented to a certain Vincenzo from Verona a five-room apartment in the house in which he then was living, providing in addition the use of the well and the cellar in which the wine was kept, for 45 *scudi* a year, beginning December 3rd.[1180]

[1179] Jack Goody and S. J. Tambiah, *Bridewealth and Dowry*, Cambridge Papers in Social Anthropology 7 (Cambridge: Cambridge University Press, 1973), 64.

[1180] Archivio Storico del Vicariato di Roma - Archivio storico diocesano, "Offici della Curia del Cardinale Vicario di Roma", Pinus Landus, Off. 31, vol. 245, parte 3, cc. 598r *et seq*. (December 2, 1669).

Three years later, Giuseppe had employed a vintner named Biagio Buti Ascani da Monte, in the diocese of Senigallia, who was to maintain the several vineyards and olive groves Campani owned in the countryside and the greenery areas that then still existed outside Rome in Albano, Genzano, and Agro Romano. He paid Buti an annual salary of 60 *scudi* from November 18, 1670, until December 18, 1672.[1181]

As a consequence of his marriage, in the course of time Giuseppe became more and more involved in the community life of Albano, his wife's hometown outside of Rome. In April 1675, Giuseppe lent 50 *scudi* for the period of 30 days to Bernardino, son of the late Giuseppe Benedetto, marshal of Albano. The notarial act is of interest because it was written in Rome "in the usual house of the above-mentioned Giuseppe Campani, located in an alley called Via de Sora".[1182] The Via Sora, interrupted today by the Corso Vittorio, leads from the Via del Governo Vecchio to the Via del Pellegrino and is a short distance from Matteo's church in Via Parione. The street name is derived from the Boncompagni family, the Dukes of Sora, who were proprietors of the Palazzo Sora. This three-story edifice, the design of which is attributed to Bramante, was formerly owned by Savelli then Fieschi. In November 1675, Giuseppe made another loan of 50 *scudi* to the same Bernardino Benedetto for expenses incurred by the latter's marriage to Agostina, to be repaid within 1 month's time. Young Benedetto may have been one of his wife's relatives.[1183]

Although the careers of both Pier Tommaso and Giuseppe kept advancing over the years, however, later there was little public notice about Pier Tommaso. Subsequent to his early successes in the production of ingenious clocks and automata, little more became known about him during his later years, nor even the year of his death. Presumably, he continued his successful career in clockmaking, as indicated in a record that on August 16, 1681, he received payment of 4 *testoni* and 20 *baiocchi* from Cardinal Benedetto Pamphilj "for having cleaned the grand clock at our place, making a new pendulum, and raising with new apertures the *bracchialetto*".[1184]

Few records relating to Pier Tommaso's later circumstances have been found. He was still alive and active 6 years later at the time of the death of his brother Matteo in 1687. Apparently he was still at work in 1694, when it was recorded that he had produced a special timepiece for Cosimo III, Grand Duke of Tuscany. Achille Sansi, a historian of Spoleto, based this information upon two letters he reported having discovered in the Archivio Comunale of Spoleto, but which now cannot be found.[1185]

[1181] Ibid., vol. 254, c. 660r-v (December 18, 1672).

[1182] Ibid., vol. 263, cc. 535r-v (April 27, 1675).

[1183] Ibid., vol. 263, pt. 2, c. 575 (November 27, 1675).

[1184] Montalto, *Un mecenate in Roma barocca*, 206; Morpurgo, *Dizionario degli orologiai italiani*.

[1185] Achille Sansi, *Storia del Comune di Spoleto dal secolo XII al XVII, seguita da alcune memorie dei tempi posteriori*, vol. 2 (Foligno: Stabilimento di PSgariglia, 1886), 292.

With the passage of the years that Pier Tommaso and Giuseppe continued to enjoy increasing affluence with their work, however, Matteo was experiencing growing financial difficulties. He frequently rented out rooms in the church and rectory premises of San Tommaso in Via Parione. Presumably this was a practice permitted to parish priests to enable them to acquire a supplementary income with which to augment their meager salary. Matteo had engaged in this practice for a number of years, in fact, possibly ever since he had become pastor of the Church of San Tommaso, In addition to single rooms and apartments of several rooms of the premises of the church and the rectory, he rented others in a property or two he owned jointly with his sister Ursula in the surrounding area. The rents were modest, usually 1 *scudo* a month per room. In almost every instance, he was identified in the notarial acts as the pastor of the Church of San Tommaso.

As examples of typical leases, in September 1669, a document of "an obligation of payment and a lease for the Reverend Don Matteo Campani" recorded that he had rented to Lorenzo Savignone of Rome, son of the late Michele, a two-room apartment "located in the area of the Church of San Tommaso . . . facing the garden of the Collegio Nardini" for the sum of 9 *scudi* and 850. The tenant was already in arrears in making payment, and despite his promises, he had still failed to do so. Matteo extended Savignone's lease on the understanding that the overdue payment would be made.[1186]

Several months later, another lease contract was made by Matteo with a certain Tommaso Ferraiolo, son of the late Giovanni Battista, for an apartment on the first floor of or above the church of San Tommaso or possibly attached to the church building. The contract conceded the right to Ferraiolo to the use of the chamber in the cellar of the church in which oil was stored, as well as the church's well. The rooms had originally been rented some 9 months earlier to Ferraiolo by Bonaventura Martinelli, son of a certain Francesco Martinelli of Spoleto who appears to have been operating on Matteo's behalf as the administrator of the building. Ferraiolo had been paying a monthly rent, and now they had mutually decided to regularize the lease.[1187]

In September of 1669, Matteo leased an apartment of two rooms for the sum of 26 *scudi* a year to Lucia Mariana Baldeschi of Rome. The rooms were situated next to each other on the second floor of the church and allowed access by the tenant to the church cellar where the olive jars were kept.[1188]

[1186] Archivio Storico del Vicariato di Roma - Archivio storico diocesano, "Offici della Curia del Cardinale Vicario di Roma", Pinus Landus, Curia del Cardinale e Vicario, Off. 31, vol. 245, cc. 39r-v, 74r-v, *obligatio 9 et 850 et locatio resp. Matteo Campani* (September 5, 1669).

[1187] Ibid., vol. 245, pt. 3, cc. 39, 79. 689r-v, 646r-v, location for Matteo Campani (December 10, 1669).

[1188] Ibid., vol. 245, c. 79 (September 10, 1669).

In January 1670, Matteo leased to a certain Andrea Zolio, son of the late Nani Zolio of Rome, a two-room apartment on the last floor facing the gardens of the Collegio Nardini, until December 13th with the provision that he could not sublet.[1189]

A two-room apartment over the passageway [corridor] inside the Church of San Tommaso was rented by Matteo 2 years later to a certain Giovanni Paolo Provenzano, the lease to begin on November 1st, for the sum of 10 *scudi* a year, with the usual obligations that the building was to be kept free from any noise or form of annoyance and disturbance.[1190]

In November 1671, Matteo leased a two-room apartment facing the garden of the Collegio Nardini to a certain Giuseppe Donati, the tenant to move in the following January and to pay an annual rent of 24 *scudi*.[1191]

A month later, Matteo rented to Faustina Cornacchia of Rome, widow of the late Andrea Dolvesi, a two-room apartment over the well and the sacristy of the church, the lease to begin in mid-December, for the sum of 12 *scudi* annually, to be paid 1 *scudo* each month.[1192]

In a contract drawn up in his rooms in August 1674, Matteo leased to a certain Paolo Sanesi a room on the church premises situated over the sitting room of his own apartment for an annual fee of 12 *scudi*, to be paid in monthly installments. Again the usual stipulations were made, that the tenant was not to sublet the rooms and was to engage in some specified ameliorations. Matteo agreed to keep the premises peaceful and to protect the tenant from any form of violence that might occur in the building.[1193]

Presumably Matteo added the income from the rents to the church's coffers and used it for the church's maintenance. On the other hand, he may have been permitted to use this income for his own expenses, for apparently he had been living in reduced circumstances for a number of years.

Another member of the Campani family who also had settled in Rome, about whom very little is known, was a sister named Ursula. She remained an unmarried spinster, not widowed or a member of a religious order. Her name appeared as a partner with her brother Matteo in a contract drawn for a loan of 60 *scudi* made by them to a certain Margharita Zana de Staricchi and the latter's daughter Vittoria. Although Ursula was identified as a partner in the loan, she did not invest any of her own money in it. The contract had been drawn up in what was identified as her own home, "the house of Mistress Ursula" [*Domina Ursula*] situated adjacent to the Church of San Tommaso in

1189 Ibid., vol. 246 c. 190 (January 1670).
1190 Ibid., vol. 251, pt. 3, cc. 326r-v, location for Matteo Campani (October 31, 1671).
1191 Ibid., vol. 251, cc. 684r-v. (November 14, 1671).
1192 Ibid., Pinus Landus, vol. 251, pt. 3, cc. 684r-v, location for Matteo Campani (November 14, 1671).
1193 Ibid., vol. 259, c. 184r-v, location for Matteo Campani (August 8, 1678).

Parione. Perhaps Matteo, being a pastor, required the name of another participant in the negotiation.[1194]

In Castel San Felice, meanwhile, the years had been passing quickly and, in December 1664, the marriage of Veronica Campani was announced. She was Angelo's daughter by his second marriage to Sebastiana, and thus half-sister of Matteo, Pier Tommaso, Ursula, and Giuseppe. She was married at the age of 20 to Fabiano Fedeli, son of Pietro Fedeli in Castel San Felice. In an agreement made in the following month, January 1665, between Angelo Campani and the bridegroom, Angelo promised a dowry of 300 *scudi*, although he had limited means at the time. There is no mention of lands or other properties in lieu of money, yet apparently he had difficulty in meeting his obligation. He offered, meanwhile, a number of items, including a walnut box, a straw mattress, a large and a small tablecloth, eight used shirts, etc. It must have been with considerable embarrassment that finally Angelo had to turn to his sons and ask them to contribute toward the dowry. Even more embarrassing to him and insulting was the fact that neither Matteo nor Pier Tommaso responded, or even informed him that they were unable to come to his assistance. Giuseppe, on the other hand, responded immediately, sending his contribution directly from Rome, presumably for the entire amount required, a fact that Angelo would not readily forget.[1195]

Fabiano Fedeli, the bridegroom, then proposed to have the dowry become part of his family patrimony, naming his mother Gismonda Fedeli and his brother Felice as those who would be responsible for administering it. Obtaining Angelo's agreement to this arrangement, probably given with some reluctance, it then was recorded in a notarial document. Among the witnesses to the agreement was also a certain Giovanni Carucci, who was said to have been Angelo's father-in-law, perhaps the father of his first wife, the late Eufemia.

This arrangement for the future administration of the dowry was most unusual, and it is surprising that Angelo and Veronica agreed to it. The only explanation appears to have been that the aged Angelo agreed to his son-in-law's proposal because of his embarrassment over his personal inability to provide the dowry and was anxious not to impede his daughter's marriage. However, neither he nor his daughter could have anticipated the forthcoming consequences that would be created by the arrangement.[1196]

Later, early in February 1666, a notarial act was drawn up at Castel San Felice in the house of the Fedeli family, describing Veronica as the daughter of Angelo Campani and the wife of Fabiano Fedeli, and referred to her dowry of 300 *scudi* that had now become part of the Fedeli

[1194] Ibid., vol. 244, c. 248r-v (June 6, 1669).
[1195] ASSp, "Archivio Notarile", notary Giacinto Fedeli (Castel S. Felice), arch. II, protocollo 577 cc. 17-25 (January 25, 1665), Castel San Felice but not noted (December 4, 1664).
[1196] Ibid.

family patrimony. It is possible that either Veronica or her father had second thoughts about the disposition of the patrimony and were insisting on a change. The document consisted of a formal request made to Veronica to surrender any further claim to the Campani family patrimony, stating that she should be satisfied with the dowry she already had received. Specifically mentioned in the document was Veronica's half-brother, Giuseppe Campani, and her two other half-brothers were also alluded to in general. It noted that also present at the time was a certain Vincenzo Lanciano of Spoleto; although his role was not identified, he may have been present as a proxy for the absent Giuseppe Campani.[1197]

It was during this period that Pier Tommaso, who had been living in Rome for a number of years, became involved in a series of legal actions with his in-laws, the Vittorini family in the nearby town of Scheggino, which had been the home of his late wife Rita Vittorini. It became apparent that Alessio Vittorini, father of the deceased Rita, owner of many properties in the diocese of Spoleto, had amassed a substantial fortune in the early 1640s. His son, Carlo Vittorini, acting on his father's behalf, had in August 1668, by means of a notarial act, conveyed to his brother-in-law Pier Tommaso income derived through leases made between 1642 and 1668 of certain lands that had formed part of the dowry of his late wife Rita. The annual yield of income from the properties was 20 *scudi*. Since Pier Tommaso was occupied by his business in Rome, he arranged for his father Angelo in October of that year to stand as his proxy in the settlement of several of his contracts. This proxy enabled the latter to draw up the foregoing agreement.[1198]

Three years later, in September 1671, Pier Tommaso, widower of Rita Vittorini and "father and legitimate administrator" of his daughters Maria Giuditta, Eufemia, and Gerolama Antonia, decided to sell back to his father-in-law some of the properties he had received as part of Rita's dowry, together with all connected interests.[1199]

Previously, Pier Tommaso had received this yearly income (the nature of which is not specified and reads "*annuus census seu redditus*") from a certain Maria, daughter of the late Paolo Borgiano, who may have been the mother of his late wife Rita.[1200]

As the years passed, Angelo Campani, becoming aware of his increasing years and "being a prudent man" (as the notary wrote on fol. 83 following a common formula), in March 1674 decided to make his last will and testament well ahead of his demise, while he remained in good health. The will began with specifications for his burial in the parish church of San Felice after a ceremony to be attended by eight clergymen and the bishop of Spoleto, and he asked to have 30 masses

[1197] Ibid., 52–54 (February 9, 1666), different hand, neither plate nor date indicated. Document in poor condition.

[1198] Ibid., notary Luca Dolci, (Scheggino), arch. II, protocollo 441, cc. 43–45 (August 17, 1668).

[1199] Ibid., cc. 174r–176r (September 23, 1671).

[1200] Ibid., cc. 30-30-32, 174 and 177, (October 12, 1671).

celebrated in his name by the priest in the parish church. Angelo then affirmed that in the event that his daughter Veronica, who was then married to Fabiano Fedeli of Castel San Felice, should become a widow, she had the right and the opportunity to return to reside in her father's house. This implied that her husband may have been suffering from a terminal illness at that time. Thus, in the event of her widowhood, she would have the use of her father's house permanently. Meanwhile Sebastiana, Angelo's second wife, who occupied the house, was made heir to all of Angelo's properties, leaving to her solely the entire income from all of them.

The will then continued to deal with his surviving sons. To Pier Tommaso, stated to be a son by his first wife Eufemia, Angelo bequeathed 20 *scudi* to be received at any time from 1 year after Angelo's death, provided that Pier Tommaso did not seek anything more from his father's estate. This amount appeared to be the balance remaining after the amount that Pier Tommaso had borrowed from his father in the past.

Next, the will specified that Matteo, also a son by his first wife Eufemia, was deprived of 5 *scudi* any portion of Angelo's estate because he had once adopted a niece against his father's wishes. Angelo bequeathed 25 *scudi* to each of his three grandsons—Veronica's sons Pietro Felice, Gerolamo, and Francesco Tommaso—to be given all at one time after his death.

Finally, as his sole heir [*erede universale*], Angelo named his son Giuseppe, like the other two named, born of his first wife Eufemia. Angelo made no mention in his will of the children of Pier Tommaso and of Giuseppe, nor was there any provision for them.[1201]

Angelo died shortly after in the same year. In the last will and testament that Sebastiana made on March 18, 1677, she noted that her husband was deceased. Sebastiana named her daughter Veronica as her sole heir, although not specifying what she was to inherit. She provided for her own funeral in great detail, concerning the numbers of candles to be used, clergymen to attend, and masses to be said.[1202]

Fabiano Fedeli also died, and Veronica became a widow. Early in the year 1680 or earlier, the widowed Veronica Fedeli, now finding herself without a father or a husband, was married a second time, to Fabiano Campana. Presumably he was a member of a branch of the Campani family, hence the change of name. It is a curious coincidence that both husbands had the same given name and that her second husband's family name should be a version of her own.

Veronica appeared to have been beset by one legal problem after another. On March 28, 1680, Veronica and her second husband Fabiano Campana lodged a complaint against Giacomo Fedeli, relative of her first husband, for not having appeared at the drawing up of this notarial act,

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[1201] ASSp, "Archivio Notarile", notary Giacinto Fedeli (Castel S. Felice), arch. II, protocollo 582, cc. 175-179 (March 21, 1674).

[1202] Ibid., protocollo 584, cc. 153-157 (March 18, 1677).

despite his promise to do so. His presence, as stated, would have proven very important as Veronica claimed not to have any closer relatives from her father's side than the three brothers, Matteo, Pier Tommaso, and Giuseppe Campani, who long before had moved permanently to Rome. Her next of kin at the drawing up of this act was Giovanni Maria, son of the late Pompeo Campani, presumably a relative of Angelo Campani.[1203]

Not having a sufficient number of relatives to act as witnesses on her behalf in order to validate this document, Veronica proceeded to appoint her second husband, Fabiano Campana, as her proxy. The issue at stake was of the greatest importance to her, for Veronica was determined to recover possession of her dowry from her first marriage, the patrimony to which she claimed she was entitled to inherit upon the death of her first husband, the late Fabiano Fedele. This patrimony, stated to be worth 300 *scudi*, was in fact the dowry that Veronica [or her father] had given to the Fedeli family at the time of her marriage to Fabiano.

It was at this point, when Veronica now had need of the money and requested it, that the unanticipated problem with the dowry arose. The Fedeli family now claimed to have invested this money, as documented in a notarial act drawn up on January 27, 1665, and it became clear that they were not inclined to return it to Veronica. She had lost control of it when her father had agreed to have the dowry become part of the Fedeli family patrimony, and apparently she had no recourse.[1204]

In concept, the dowry was in a sense a daughter's share of her father's estate, which she had to obtain early when it would be most useful. It could consist of cash, real property, or movable property. Quite often, however, real property was considered to be too valuable to be alienated to a daughter because of the fear that its possession thereafter fall out of the family. There were two important legal features relating to the dowry, namely, who retained the ownership and control over it during the marriage and the disposition of the dowry if the marriage was dissolved. In medieval Italy, it was the wives who retained legal ownership over their dowries; however, husbands were allowed to use, manage, and invest their wives' dowries during the marriage.[1205]

If and when the marriage was dissolved, however, the husband was required to return the dowry in its entirety. If land formed part of the dowry, the husband could not sell or give away any part of it without the consent of the wife or her guardians. Husbands who mismanaged or failed to return the dowry at the marriage's termination could be sued by their wives. When the husband predeceased his wife, his heirs were required to return the dowry to the widow; she then could

[1203] Ibid., notary Luca Dolci, (Scheggino), arch. II, protocollo 447, cc 37-39 (March 28, 1680).
[1204] Ibid.
[1205] Diane Owen Hughes, "From Brideprice to Dowry in Mediterranean Europe," *Journal of Family History* 3 (1978): 281, 284.

decide to return to live with her natal family, to remarry, or to continue to live on her own. Information on the size of the dowry, its composition, terms of payment, names of bride, groom, respective fathers, and place of residence was provided in marriage contracts written by notaries.[1206]

A woman in Italy and elsewhere in the western Mediterranean world could not marry without having a dowry from her own family. It became a recognized prerequisite of marriage that she had to obtain when she entered into marriage and into a new home, not at the time of her father's death. A bride's father and her dowry provided the chief protection and guarantee of her sexual purity, and an undowered girl might be considered to be a threat to moral stability.

Women generally married in their late teens and men in their late twenties, and frequently there was a gap of 10 years between the ages of the bride and the groom. When the wife predeceased the husband, the statutes and codes in some communities established that the dowry had to be restored to her parents, if they were still living, or to her children. In other communities, husbands were entitled to have returned to them what they had contributed as counter-dower.[1207]

Sebastiana Campani died in the early months of 1681, having outlived her husband Angelo by several years. Although she had designated Veronica as her sole heir, difficulties arose in the legal proceedings relating to the division of Sebastiana's property. Since both Veronica's father, Angelo Campani, and Fabiano's father, Pietro Fedeli, each of whom could have served as witnesses, now were deceased, Veronica arranged on April 29, 1681, to have her second husband, Fabiano Campana, son of Giovanni Battista Campana, appointed procurator. Two other relatives on her father's side who were mentioned were Paolo and Giovanni Maria, sons of the late Pompeo Campani of Castel San Felice.

Veronica was forced to nominate her husband Fabiano as her procurator, inasmuch as she had no other close relatives at that time to serve as witnesses, a requirement stipulated for this notarial act according to the laws of the community. She claimed that the partition that had been made of her mother's dowry had been unfair and that she deserved part of that dowry that had been inherited by Giuseppe Campani. Fabiano was to go to Rome to reclaim from her half-brother Giuseppe part of Sebastiana's dowry, of which she was the sole heir; he was to collect from Giuseppe money, which she claimed that Giuseppe owed in restitution.[1208]

On September 1st, another copy of the notarial act of April 29, 1681, was drawn up, again in the house of Fabiano and Veronica Campana. It was filed with the names of witnesses changed to

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[1206] Aloysius Siow and Maristella Botticini, *Why Dowries?* (Hong Kong: School of Economics & Finance, 2001), 9, 10, 24, 28; David Herlihy, "The Medieval Marriage Market," *Medieval and Renaisance Studies* 6 (1976): 3–27; Hughes, "From Brideprice to Dowry in Mediterranean Europe."

[1207] Ibid.

[1208] ASSp, "Archivio Notarile", notary Luca Dolci, (Scheggino), arch. II, protocollo 447, cc. 49-50 (April 29, 1681).

include those of Andrea, son of the late Carlo of Sant'Anatolia di Narco, and Paolo Eleuteri, son of the late Domenico.[1209]

An inventory was made that year of the late Angelo Campani's personal property still remaining in his house. The house was described as being situated with one side close to the town walls and the street and bordering upon the property of Gerolamo Felici, son of the late Giuliano. On the other side, it bordered on properties of Pietro, son of the late Domenico. A list of the movables in Angelo's house was drawn up within the house itself. An incomplete copy of the list survives, missing the next to final page.

The cellar contained a small barrel, perhaps for olive oil or a wine butt, a funnel, a ladder, and a stool. In the dining room were seven stools, seven paintings without frames, two dining tables, four chairs, two large plates—one of tin and one of brass—three brass candlesticks, two lanterns—one of tin and one of brass. Then were to follow descriptions of the objects in the first room on the left, but the page listing them is missing.

There were four rooms on the first floor of the house, including the kitchen, and four rooms on the second floor containing items similar to those on the first floor. One room appeared to have been used as a workshop for working with wood and metals; it contained an iron anvil, two pairs of bellows, and an oven with several iron tools inside, as well as woodworking tools consisting of seven hatchets, three axes, three large augers, and two large and small planes. Veronica's husband, Fabiano Campana, was designated caretaker of the premises and promised to deliver these items at the proper time to Angelo's heir, Giuseppe Campani.[1210]

Later that year, in October, Veronica and Fabiano Campana speculated on land tracts in the diocese of Spoleto, in La Pieve within the region of Sant'Anatolia di Narco. In addition to having made several purchases and rentals of tracts, Fabiano journeyed to Rome to receive from Giuseppe Campani the sum of 27.5 *scudi* that Veronica and Fabiano required to pay for their annual rent. Veronica considered this money to be her due, undoubtedly as that part of Sebastiana's estate that had gone to Giuseppe Campani.[1211]

Several years passed, and in April 1687, Fabiano and Veronica Campana sold a tract of land to Pietro Paolo Bonifaci of Cerreto for 100 *scudi*. They were mentioned together with their relatives Paolo, son of Pompeo Campani, and Andrea, son of the said Paolo, as their only relatives available and present at the signing of the document because her three half-brothers had long since moved to live in Rome.[1212]

[1209] Ibid., cc. 106 (September 1, 1681).

[1210] Ibid., vol., cc. 50–52 (May 2, 1681).

[1211] Ibid., vol. 586, cc 154-157 (October 3, 1681).

[1212] Ibid., vol. 450, cc. 34r–35r (April 27, 1687); also cc. 36r–37v, which appears to be an extension of the foregoing.

Fabiano Campana and Veronica were the parents of three sons, Carlo Andrea, Tommaso, and Mauro Antonio. In September 1701, Carlo Andrea and Tommaso Campana sold a tract of cultivated land near Sant'Anatolia di Narco to Achille Gentiloni of Castel Valle (?) in the diocese of Spoleto.[1213]

As previously noted, Giuseppe occasionally leased rooms in his house in Rome to others, and frequently he made modest loans of money. It was at this time that Giuseppe Campani made a loan of 600 *scudi* on interest to Angelo Antonio Bianchini of Castel di Martignano, who is believed to have been a merchant or money lender. The amount consisted of 300 *scudi* through Monte di Pieta and 300 *scudi* through the Banco di Santo Spirito. Leonardo Librio was appointed as banker to oversee payments to be made and Lorenzo Medei of Castel San Felice served as Campani's proxy. Antonio Olivieri drew up forms in the Curia Innocentiana in Rome for Campani's loan to Bianchini. Bianchini signed a promise to pay the loan with Lorenzo Medei appointed as procurator for Campani at Castel San Felice.[1214]

On June 1, 1670, Giuseppe lent 50 *scudi* to Giovanni Battista Farina, a messenger of the pope [*cursor Papae*] for a period of 6 months with interest of 10 *giuli* for each *scudo*, to use for his business. The guarantors were impressive and consisted of Abbot Antonio del Rio, son of Alfonso, nobleman of Milan, and Giovanni Francesco Caffaro, son of Bartolomeo of Cremona, both of whom were frequently involved together in transactions.[1215]

In March 1674, Giuseppe sublet an apartment in Rome that he was renting from a certain Timoteo Tiziani [Taviani?] to a certain Fausto Vulpio [Volpi] son of the late Bernardino, for 1 year for 55 *scudi*. The apartment consisted of five rooms on the first floor and another, probably a spacious living room, on the ground floor. The lease also allowed the sub-tenant to use the wine cellar and the water well. The apartment was located in the Via dei Savelli in Rome next to the house of the Cardinal G. Boncompagni.[1216]

During the last two decades of his life, Matteo Campani frequently was ill for long periods. This was indicated as early as 1670 in a letter he had written from Pisa to Viviani in which he mentioned that he had been suffering from fever and often was so ill that he had been unable to leave his rectory. He stated that he had been suffering from the fever for a long time and that he still had been unable to recover, partly due, he thought, to conditions that were injurious to his health in the rooms that he maintained in the church building's tower that was high in the air, "where Aeolus

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[1213] Ibid., vol. 457, cc. 116-117 (September 3, 1701).

[1214] Archivio Storico del Vicariato di Roma - Archivio storico diocesano, Curia Innocentiana, Antonio Olivieri, cc. 70–71, 76r–79v, 80v–81r.

[1215] Archivio Storico del Vicariato di Roma - Archivio storico diocesano, Pinus Landus, Curia del Cardinale e Vicario, Off. 31, vol. 247, parte II, cc. 238-240 (June 1, 1670).

[1216] Ibid., vol. 258, parte I, cc. 428-429, 449 (March 4, 1674).

[Greek god of the winds] holds sway". The doctors have given him little if any good advice, he added, but such was the will of God.[1217]

In 1677, Matteo Campani produced a brief dissertation entitled *Circinus sphericus*, which he appended to one of his books, *Horologium solo naturae motu*. He described the *circinus sphericus*, or "spherical compass" as a mechanism used for turning and polishing lenses of a spherical form. The dissertation presented a theoretical concept of a lathe very similar to the one proposed by Robert Hooke. Matteo had no background in making lenses and, at this late stage in his life, when apparently he had become disassociated with his brother Giuseppe, this dissertation appears to have been material copied from Giuseppe's work that Matteo now claimed as his own.[1218]

During the final decade of his life, Matteo was ill with increasing frequency and forced to spend long periods in bed, with the consequence that he was progressively subject to periods of depression. In May 1687, a month before his death, while Matteo was lying sick in bed suffering from serious terminal illness, he sent for his notary, Olimpio Ricci. He requested that he return to him the copy of his last will and testament that he had made, presumably for the purpose of making changes in it. He had written this document in the same bedroom of his house in which he now found himself. It had been signed and sealed before seven witnesses on June 6, 1680, 7 years earlier. It is obvious from the state of the handwriting at the bottom of the page that Matteo was in serious physical condition even then. The notary returned the document to him intact with seal unbroken as originally sealed and as noted by Matteo thereon.[1219]

Several weeks later, on June 4th, Matteo drew up a new document in which he bequeathed all his worldly goods and personal possessions to his brothers Giuseppe and Pier Tommaso and to his half-sister Veronica. To Giuseppe he bequeathed the parcel of land situated just outside the main gate (*Porta Granda*) of Castel San Felice, together with the stable and hut pertaining to that property with their respective belongings. The piece of land was precisely located on the hill identified as *Il Colle* and was the piece of property that had been purchased by Angelo Campani from the community shortly before his death.

Matteo stipulated one condition, however, that Giuseppe was to agree to provide to their half-sister Veronica free and complete access to the cistern located in their late father's house, within the city walls of Castel San Felice, which Giuseppe now owned. To Pier Tommaso and Veronica, Matteo bequeathed his portion of the inheritance he had received from the estates of his father and his mother, divided equally between them, in addition to his unspecified personal

[1217] BCNFi, *Gal.,* vol. 255, cc. 127-128, letter from Matteo Campani to Viviani on January 18, 1670.
[1218] Campani, *Horologium solo naturae motu*, 20-25.
[1219] Archivio di Stato di Roma, "Offici della Curia del Cardinale Vicario di Roma", Olimpio Ricci, Off. 36, vol. 156, c. 351 (May 19, 1687).

possessions, that were to be divided equally in the same manner. This notarial act was drawn up in Matteo's bedroom as he lay confined by illness. The document was signed by Matteo, his handwriting reflecting his increasingly weakened condition, and by two witnesses from the region of Spoleto, Bernardo Vignati, son of the late Feliciano Vignati, and Antonio Martinelli, son of the late Francesco.[1220]

Apparently Giuseppe either had not responded or had not agreed to Matteo's stipulation, and less than a week later Matteo canceled the disposition of his personal and real properties that he had specified and made new provisions: "By means of the present document", he wrote, "having few days left to me, and having made a disposition of my paternal and maternal inheritance in equal parts to my brother Pier Tommaso and my half-sister Veronica, today I revoke and annul said disposition, and specify that instead the inheritance is to go to my church, and as a matter of courtesy, I leave to each Pier Tommaso and to Veronica the sum of 10 *scudi*", while his sole heir was to become the Church of San Tommaso in Via Parione. No provision was made for Giuseppe. After the foregoing, a note had been added stating that the document had been hand-written at Matteo's direction by the curate of the church, Giuliano Naldini, and then signed by Matteo in his own hand.[1221]

Another document drawn up the following day in Matteo Campani's house by the notary Olimpio Ricci and attached to the foregoing revised last will and testament, reported that Lucia Mariani, born in Florence the daughter of the late Mariano Mariani, had submitted to him a document that she affirmed had been written by the Reverend Giuliano Naldini and signed by Matteo, stating that Matteo's final request was that it be inserted as part of his last will and testament. The document noted that Matteo had died the previous evening, at about the first hour of the night. In his final hours, Matteo was attended only by Lucia and Father Naldini; his brothers were not present. The document was witnessed by Bernardo Vignati of Spoleto and by Giuseppe Tognono, son of the late Jacopo, and attached to Matteo's last will and testament.[1222]

In another document, also dated June 11, 1687, the notary Ricci reported the opening of the will and the codicil in the presence of Pier Tommaso and Giuseppe Campani. The notary stated that, on May 20, 1687, Matteo had, before seven witnesses who were present, given to the notary the sealed testament and that 5 days later he had submitted to the notary before five witnesses, and that Matteo had passed away the previous evening in the first hour of the night:

[1220] Ibid., cc. 403-404, *donatio del Matteo Campani al Giuseppe, Pier Tommaso, ed Veronica Campani* (June 4, 1687).

[1221] Ibid., cc. 450-451 (June 10, 1687); N. Tommaso and B. Bellini, *Dizionario della Lingua Italiana* (Unione Tipografico Editrice, Turin), specifies that *legittimata* means the share of an inheritance, vol. II, p. 1801 (1862).

[1222] Ibid.

heri vesperi hora prima noctis circiter vitam cum morte cummutavit. Ad odum R. D. Mattheus Campana de Alimenis huius ecclesiae S. Thome in Parione Rector post diuturnam infirmitatem omnibus ecclesiae sacramrentis refectus obijt, et peracto celebri funere in hac eadem ecclesia eius cadaver tumultum est anno sue etatis 67 circiter.[1223]

The notary then proceeded to read aloud the entire text of the testament and promised that every care would be taken to ensure that Matteo's wishes would be observed. The notary then stated that, as he was speaking, identification of Matteo's corpse, which was lying upon a table in the next room of his apartment, had been made by the curate, Father Giuliano Naldini, son of the late Naldino of Bomarzo in the region of Bagnoregio, and by Francesco Callignoni, both of whom were about 33 years of age, who also witnessed that Matteo had died the previous evening. The document was drawn up by the notary in Matteo's house and witnessed by Lorenzo Savignone and Antonio Vaccio, both of Rome.[1224]

The inventory of Matteo's personal property listed 94 separate entries, one of which was an impressive library consisting of 178 books. It included 60 quarto volumes, 100 octavo volumes, and several others in 16mo. that Matteo had kept in the bedroom in which he died. Specially noted were copies of Christiaan Huygens's *De Demonstratione Geometrica*, an Italian translation of the first volume of Virgil's *Aenid*, Girolamo Cardano's *De Medicina*, vol. I, a manuscript copy of Matteo's *Dell' Orologio Muto* annotated in his hand in pencil, a copy of the *Saggi* of the Accademia del Cimento, and several sermons.

Of interest among his furnishings were a walnut faldstool, the interior of which contained two books, several telescope models and several manuscripts, a pendulum clock in an ebonized pearwood case 1 palm in height having a copper figure depicting the Dawn (Aurora), and eight old paintings. The room next to his bedroom contained a small tapestry-covered table with two drawers, one of which contained clockmaker's tools and miscellaneous clock parts and another containing several manuscripts. Noteworthy also were five paintings: two within gold frames were portraits of popes, two framed portraits were of cardinals, and another portrait in a white frame was of Grand Duke Ferdinand II.

In the same room was "an imperfect small machinery with several wheels and lead weights for the discovery of perpetual motion". This was the last of the inventions with which Matteo had been engaged and concerning which he had corresponded with Viviani. Listed next in the inventory was "a walnut wardrobe having five drawers, in the first of which is a little copper box with its

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[1223] Ibid., c. 453r-v, opening and reading of the testament and codicil of Matteo Campani (June 11, 1687).
[1224] ASVR, *S. Tommaso in Parione, morti,* 1651-1708, f. 182.

padlock, a tin container for pen and ink, several fans, and some writings". Matteo's personal clothing was included, each item of which was described as being old and very much worn.[1225]

On a desk [*studiolo*] having 11 drawers inside of which were various writings, and four silver *posate*, that is, four spoons and four ordinary forks, of about 9 *oncie*, and in one there were various clockmaking tools.[1226]

Matteo's personal quarters consisted of three rooms: a kitchen, a sitting room, and a bedroom. The inventory also listed bed sheets, blankets, bed linen, underclothes, chairs, etc. Judging from the furnishings and the quality and amount of his clothing, Matteo had lived a very frugal life. His clothing included two ragged overcoats, two ragged soutanes, and most of the rest of his clothing was described as ragged and old.

One of the unresolved mysteries in Matteo's life relates to Lucia Cecilia Mariani, the "niece" whom he had adopted and who had been living in the rectory with him since soon after his arrival in Rome in the early 1650s. It was for having proceeded with her adoption against his father's orders that he had been disinherited. Lucia was born in Florence, the daughter of the late Mariano Mariani and his wife Caterina Cristina Balduinetti, daughter of Vincenzo Balduinetti, who had died more than 70 years earlier, and his wife Ginevra. Matteo had written to Viviani seeking a copy of Lucia's birth certificate, who was born between 1630 and 1640. Matteo had been seeking this information and requesting this document for a long time. There is no possibility that Lucia could have been his niece, for she would have had to be the daughter of one of Matteo's brothers or of his sister, not recorded as a member of the family of Angelo Campani. Presumably throughout this period Lucia may have been employed as Matteo's housekeeper.[1227]

It is not surprising to find Matteo Campani venturing into other fields than the specific scientific endeavors with which he customarily occupied himself. As noted, in 1676, for example, Matteo published an article in the *Giornale de' Letterati di Roma* related to the world of commerce. Entitled "The restrained [bridled] Steelyard [balance], or a useful and easy invention that obligates the weigher to render accurate weight".[1228]

Despite the illogic of some of Matteo's scientific claims and the lack of success of his horological inventions, he was acquainted with and widely recognized and acknowledged by men of science of his time due largely to his gregarious personality. Among those he had befriended, particularly in Rome and in Florence, were Francesco Eschinardi, Stefano Gradi, Vincenzo Viviani,

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1225 ASR, "Offici della Curia del Cardinale Vicario di Roma", Olimpio Ricci, Off. 36, vol. 156, cc. 469r–471v, *Inventario . . . Mobili hereditazioni del Matteo Campani* (June 12, 1687).

1226 Ibid.

1227 BNCF, *Gal.*, vol. 255, cc. 207, letter from Matteo Campani to Viviani on December 5, 1671.

1228 Gardair, *Giornale de' letterati de Rome*, 150 Videt: Matteo Campani, "La Stadera Imbrigliata, ovver inventione utile e facile che obliga il pesatore a dare il giusto peso".

and Francesco Redi. In fact Redi, physician to Grand Duke Ferdinand II, had cured Matteo of a stomach disorder he described as being caused by worms and mentioned him also in his volume on experiments on various natural causes (*Esperienze intorno a diverse cose naturali*). It was published in 1687, the year of Matteo's death. In this publication of an open letter addressed to Athanasius Kircher, Redi wrote "Other many, and similar attempts I have shown in other times to a great many of the most eminent men, among whom I could name various priests of your most venerable Society of Jesus […] and finally Signor Matteo Campani, a virtuoso very well known to all the letterati [scholars] of the world for his most noble and most useful inventions".[1229]

In the 20th century, many changes have been made inside the little Church of San Tommaso in Rome's Via Parione, which had provided the first home in Rome for the Campani brothers. It has been transformed substantially from its appearance in the time of Matteo Campani. Inside the church on the right side of the main door there had been a memorial plaque to Saint Filippo Neri and another commemorating gifts of donors. On the left side, the history of the church was inscribed on marble. The interior of the church has been revised, the travertine columns covered with the usual false columns of painted stucco, which nonetheless preserved the beauty of its three cupolas, a large one at the center and two smaller ones at the sides. The oratorio of the Confraternity was removed to the second floor adjacent to the room containing cupboards and wardrobes.

The walls of the oratorio now are painted in coral, with an altar between two wardrobes in which are stored the most precious objects of the church—several candlesticks, a gold chalice, and a reliquary of the Madonna enclosed in a work of chiseled gold and silver, which had been a gift from Pope Pius IX. Great antique copes are well preserved. Items dearest to the hearts of the members of the Confraternity, however, the personal robes [*indossato*] of Filippo Neri, have been transferred to the nearby Chiesa Nuova.[1230]

Meanwhile, with the passing years, as Giuseppe Campani's world entered the eighteenth century, the pace of his activities do not seem to have been materially diminished, except that now he was occasionally annoyingly preoccupied with domestic problems in Castel San Felice. Ever since his father's death, at which time he became his principal heir and the executor of his estate, he found himself involved with unpleasant family affairs. One of these was the forthcoming wedding of Maria Felice Fedeli, daughter of his half-sister Veronica.

[1229] Francesco Redi, *Esperienze intorno a diverse cose naturali, e particolarmente a quelle che si son portate dall' Indie, fatte da Francesco Redi* (In Napoli: nella stamperia di Giacomo Raillard, 1687), 9.

[1230] Matizia Maroni Lumbroso and A. Martini, "Due chiese romane dedicate a S. Tommaso e le loro confraternite," *Fede ed Arte* 9, no. October–December (1961): 428–31; Armellini, Cecchelli, and Tacchi Venturi, *Le chiese di Roma dal secolo IV al XIX*, 470–72.

It turned out that there was a serious problem in providing a dowry for the bride, for which her mother had the responsibility. Inasmuch as Veronica's father had died some years previously, followed soon after by the death as well of Fabiano Fedeli, her first husband and father of Maria Felice, Veronica was experiencing difficulty in providing her daughter with a suitable dowry. Having no other alternative, in August 1699, Veronica had sold a tract of land in Giormezzano to a certain Francesco, son of the late Giovanni, for 200 *scudi*. Her intention was to use the money as part of her daughter's dowry, and she planned to add to the sum by means of an appeal to her half-brother Giuseppe Campani in Rome.[1231] Early in September 1701, Maria Felice's brothers, Carlo Andrea and Tommaso Fedeli, sold a tract of land that they owned near Sant'Anatolia to Achille Gentiloni of Castel Valle, presumably to add to their sister's dowry.[1232]

Maria Felice Fedeli, daughter of the late Fabiano Fedeli and Veronica, was married in Castel San Felice on September 2, 1699(1701?) to Giovanni Domenico de Benedictis. The contract was drawn up in the former home of Angelo Campani, which now had been inherited by Giuseppe Campani. He had traveled to Castel San Felice for the occasion, probably being required to do so in his role as the present head of the bride's family, following the death of the bride's father and step-father, and possibly in the hope that he might provide some financial support for the dowry.[1233]

Veronica Campana died in June 1710. Her last will and testament was drawn up on June 23, 1710, at Scheggino, not Castel San Felice. It specified that she was the daughter of the late Angelo Campani and the wife and widow "of her last husband" the late Fabiano Campana of Castel San Felice, son of Giovanni Battista Campana. It noted that her brother, Giuseppe Campani, still dwelt in Rome. Veronica was buried beside her father in the family tomb in the church of Castel San Felice. Her will ordered the purchase of four tall wax candles of 4.5 pounds each and the appointment of 12 clergymen and the bishop of Spoleto for the funeral mass and that the bishop of Spoleto should receive due payment for his service at Veronica's funeral. Money was to be given to the clergymen for masses to be celebrated after her death. The will instructed her son Pietro Felice concerning maintenance of some lands that he inherited at her death, including some already mentioned at Giomessano that she had sold, and ordering that her sons must not claim any part of the lands she had previously sold. Her daughter Maria Felice Campana was to receive part of Veronica's possessions.[1234]

1231 ASSp, "Archivio Notarile", notary Luca Dolci, serie II, vol. 456, cc. 49-51 (August 11, 1699).
1232 Ibid., vol. 457, cc. 116-117.
1233 Ibid. vol. 456, cc. 57-59 (September 2, 1699).
1234 Ibid., cc. 94v–95v (June 23, 1710).

Chapter XXII

THE TWILIGHT YEARS

(1700–1715)

For very long tubes are cumbersome, and scarce to be readily managed, and by reason of their length are very apt to bend, and shake by bending, so as to cause a continual trembling of the Objects, whereby it becomes difficult to see them distinctly, whereas by his [Huygens] Contrivance the Glasses are readily manageable, and the Object-glass being fixed upon a strong upright Pole becomes more steady.

Isaac Newton[1235]

In Paris, meanwhile, following upon the death in 1682 of the French astronomer Jean Picard, Cassini assumed the responsibility for continuing and completing measurement for an arc of the meridian northward of Paris toward Dunkirk and southward toward Perpignan. Concerning this proposal, Cassini had personally presented to Colbert a “Project for the Prolongation of the Meridian as far as the two seas for the Measurement of the Earth”. He made preparations to guide the equipment of the technicians to work in the south of France while the astronomer and mathematician Philippe de La Hire was to occupy himself with the reliefs to be made in the northern region. These operations were abruptly interrupted in the next year by Colbert’s death, however; subsequently, his successor, the Marquis de Louvois, decided against their importance.

It was not until 1700 that these operations were to be resumed, and despite his age, Cassini once again made the wearying journeys, moving from one region to another and making the even more difficult measurements. In 1711, the Genovese amateur astronomer Marchese Paride Maria Salvago informed his friend Eustachio Manfredi that, although Cassini still enjoyed otherwise perfect health, he had lost his sight. Nonetheless, he continued to attend meetings of the Academie

[1235] Isaac Newton, *Opticks, or a Treatise of the Reflections, Refractions, Inflections and Colours of Light, by Sir Isaac Newton, Reprinted from the 4th Edition with a Foreword by ... Albert Einstein ... Introduction by ... E.T. Whittaker, ...*, 4th ed. (New York: Whittlesey House, 1931), 103.

and spent much of his time dictating his memoirs to a secretary. Cassini passed away after 2 days of illness on September 14, 1712.[1236]

The death of Colbert in 1683 had not only deprived the observatory in Paris of its principal mentor, so that it gradually lost its former impetus, but also deprived Campani of one of his most lucrative sources of income. As a consequence, by the time that Campani had reached his sixties, he no longer experienced the same pressure of work that had been imposed upon him as before in recent years by multiple requests from France for lenses and telescopes. Nonetheless, he continued to be in fact just as actively engaged with other clientele for whom he continued to produce optical instruments and lenses.

The fame of Campani's astronomical instruments that had reached England and in Europe earlier in his career was sustained to the last years of his life. In England, for example, his work was particularly highly esteemed. In discussing telescopes then being made in London, Robert Hooke, for example, noted that he had found some instruments equal in every way to those made by Campani, although much shorter in length. In Holland, Huygens had read with great interest notices concerning Campani's instruments, and in a letter to Prince Leopold, he compared lenses made by common means with those that Campani had made on his lathe, as he claimed, working directly from the glass without molds. As previously noted, the French telescope maker Pierre Petit claimed that he would be able to make telescopic lenses equal to those of Campani if only he could have had access to the glass that Campani used; he never managed to do so, however.[1237]

During at least the later several decades of his life, Campani maintained a shop and/or observatory on Monte Gianicolo, high above the Vatican and in the close vicinity of the Church of San Pietro in Montorio and the adjacent Franciscan convent. It was during this period that Campani became associated with two young astronomers. One was Giacomo Filippo (a.k. in France as Jean-Philippe) and the other was Monsignor Francesco Bianchini. Maraldi was Cassini's nephew whom his uncle brought to Paris. Cassini instructed him in astronomy and he became Cassini's devoted collaborator.[1238]

Soon after Monsignor Bianchini returned to Rome in 1684, he became a member of Monsignor Ciampini's Accademia Fisico-matematica. It was sponsored by Bianchini's patron, Cardinal Ottoboni, and met in the Cardinal's palace. It is probable that Bianchini first met Campani

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[1236] Gabriella Bernardi, "Cassini Maps," in *Giovanni Domenico Cassini: A Modern Astronomer in the 17th Century* (Cham: Springer, 2017), 101–10.

[1237] King, *The History of the Telescope,* 61–64; Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 4, 266, no. 1078: Letter of Petit to Christian Huygens, November 28,1662 [Scientific Editor 2: wrong year: it cannot be November 28,1662, as indicated in Huygens' O.C. vol. IV, but most probably 1664].

[1238] Cesare Preti, "Maraldi, Giacomo Filippo," *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 2007); "Éloge de M. Maraldi," *Histoire de l'Académie Royale des Sciences* Année 1729 (1731): 116–20.

at one of the Accademia's meetings; they soon became fast friends and from that time until Campani's death, they remained closely associated in making observations and in experimenting with telescopes.

Campani provided Bianchini with instruments for his observations, particularly those that the Monsignor used for the establishment of the meridian in the Church of Santa Maria degli Angeli. Among the instruments was a telescope of 50 palms focal length (1.17 meters) with which Bianchini reported he could discern a star of the first magnitude even in full daylight from inside the church while observing across the opposite openings in the wall.

For his observations, Bianchini also used a small telescope made by Campani of 1-1/2 palms (33 cm) with a reticule; for the most part, while observing within his house, he used a Campani telescope of focal length of 23 palms (5.13 meters). He constructed a meridian also in that lodging, which he described as being "in some of his rooms under Montecavallo. In the room in which I slept and where I studied", he wrote, "I did not have to take more than two or three steps to make observations, having the position of the window at mid-day lined exact with the aperture in front of a garden, that left me free, and with sufficient space to accommodate telescopes of that length (23 palms) and even larger".[1239]

Upon being informed that Campani was engaged in developing a mechanical device for elevating aerial telescopes, with which he had been experimenting for the past 3 years, Bianchini was eager to participate, and he made arrangements for them to meet soon after his arrival in Rome. The relationship between the two men, the savant Campani, now in middle age at 49, and the eager young scholar less than half his years, which had begun at first as colleagues engaged in mutual endeavors, had quickly developed into a close friendship.

Bianchini had already distinguished himself as a historian and student of the natural sciences. He was born at Verona, a member of a family of local nobility, in addition to his early studies in mathematics, physics, and astronomy, since he was destined for a career in the Church, he later also studied theology. Although he advanced to a deaconship, he never became a priest. After he had moved to Rome, Cardinal Pietro Ottoboni, who had become Ciampini's patron, appointed Bianchini custodian of his library, and later when the cardinal became Pope Alexander VIII, he generously extended many favors to him. After raising Bianchini to the offices of papal chamberlain and canon of Santa Maria Maggiore, the Pontiff asked him whether he had any special wishes. When Bianchini replied that he desired only his blessing, the Pope thereupon awarded him two more canonries and appointed him librarian to his nephew. The latter was Cardinal Pietro Ottoboni, who arranged for Bianchini to lodge in his own palace.

[1239] Biblioteca Vallicelliana, Ms. U. 23, c. 154., c. 170, reported by Bianchini in a letter to Father Carbone on March 27, 1723.

The papal successor, Pope Clement XI, sent Bianchini as an emissary to Paris and also employed him to form a museum of Christian antiquities in Rome. After his appointment as secretary of the Congregation of the Calendar, which followed soon after, Bianchini published on the subject of the problem of calculating the paschal date. In 1685, he illustrated Cassini's new method for measuring the parallaxes of the planets, particularly those of the sun. Most famous were Bianchini's observations of the planet Venus, of which he determined the period of rotation and which he described in a *Hesperis et Phosphori*, published almost a half century after the event.

Therein Bianchini described problems that had been facing astronomers at this time. He discussed the "paths" or "seas" of the planet Venus, noting that they did not differ from those that had been observed upon the moon in about 1666, and by Cassini and other astronomers. His astronomical observations were collected and published in 1737 by Eustachio Manfredi.[1240]

Until now, even the most talented lens makers of the times had been unable to extend the focus of object lenses up to beyond barely 50 or 60 palms. Because the instruments then available proved to be inadequate, attempts at lunar observation eventually had to be abandoned. The difficulties in developing lenses to meet the required standards were so considerable that neither Divini nor Campani had as yet been able to produce telescopes of sufficient size capable of obtaining a clear vision of the patches on Venus.[1241]

The problem causing considerable difficulty in the construction of telescopes having greater focal length was derived from the instrument's necessarily increased weight. Every attempt inevitably resulted in bending of the instrument a curve developing somewhere midway between the eyepiece and the objective. Although this particular problem had been anticipated early in the course of the process of raising the great telescopes skyward from a horizontal position, and a solution had constantly been sought, one that was entirely satisfactory had not yet been found.

The solution eventually was realized in a new invention—the "aerial telescope", the use of telescopes without tubes. It appears to have been Minister Colbert who had provided the initial inspiration for experimenting with telescopes without tubes. This was confirmed in a document found among the Bianchini papers, which stated:

> Doubting that because of the difficulty of raising [telescope] tubes there was such poor assurance of keeping them straight due to their extraordinary length, the Most Christian King generously arranged to have

[1240] Francesco Bianchini, *Francisci Blanchini Veronensis Astronomicae, ac geographicae observationes selectae Romae, atque alibi per Italiam habitae, ex eius autographis excerptae una cum geographica meridiani romani tabula a mari supero ad inferum, ex iisdem observationibus collecta et concinnata cura et studio Eustachii Manfredi in Bononiensi Scientiarum Instituto Astronomi*, ed. Eustachio Manfredi (Veronae: Typis Dyonisii Ramanzini, Bibliopolae, apud S. Thomam, superiorum permissu, 1737); Bianchini, *Hesperi et phosphori nova phaenomena*; Salvatore Rotta, "Francesco Bianchini," *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1968); Enrico Celani, "Il Carteggio di Eustachio Manfredi con Francesco Bianchini," *Rendiconto delle sessioni della Accademia Reale delle Scienze dell'Istituto di Bologna*, 1891, 144–45; "Éloge de M. Bianchini," *Histoire de l'Académie Royale des Sciences* Année 1729 (1731): 102–15; "Éloge de M. Maraldi."

[1241] King, *The History of the Telescope,* 61-64 ; Caverni, *Storia del metodo sperimentale*, vol. 2, 395.

transported to the Observatory a great wooden tower [the tower of Marly]. Not deterring the astronomers from their work, on the other hand, this tower instead possibly could have many uses, and could be applied to still other important matters, such as for communicating some notices quickly to persons at great distances in times of war and in peace. [Meanwhile], a means had been studied of using only the lenses of the telescope without having need of the tube, in order to observe the objects of the sky; and of the earth, during the day as well as during the night. This had that advantage of clarity and distance that equaled, or at least perceptibly did not lessen, the latter.[1242]

It was Huygens who had been the first to attempt a means for developing the aerial telescope that ultimately provided a solution. In 1680, he experimented with the use of a narrow silk thread for directing the telescope's lenses to the same distance of the foci despite the tube's limitations. By means of this thread, the eyepiece and the object lens could be kept in perfect alignment with the object to be observed, with the axis being directed from the objective to the eyepiece, regardless of the elevation to be achieved, by utilizing a long thread between the ocular and object lenses to align them perfectly.[1243]

As Bianchini had related, Campani followed suit and developed the arrangement further. According to Bianchini, it had been Cassini who had urged Campani to attempt to construct telescopes of such great length in order to bring the focus of the objective lenses up to 100, 150, and even to 205 palms. In Bianchini's view, it had been Colbert's enthusiasm that had inspired Cassini, and Colbert's enthusiasm in turn had derived from the resulting liberality of King Louis XIV, substantially reflected in the latest of the telescope lenses that Cassini received that Campani had sent to the Observatory in Paris in about 1682. Although Cassini meanwhile had managed to utilize these same lenses to discover four new satellites of Saturn that Huygens had not noticed in his observations of the planet, he had not managed to use the same lenses again after having undertaken and completed the method proposed by Huygens.

Nonetheless, according to Bianchini, it was not until about 1712 that Cassini managed to make some last additions–the same year of his death–, which he brought to the attention of the Academie Royale.[1244] Cassini claimed that the method for making observations without tubes that had been proposed by Huygens was, in his experience, much more difficult in actual practice, and he noted further that it had been by using Campani's lenses that he had been able to make the earliest observations with the greatest ease by means of the aerial telescope.[1245]

"New Inventions of Optical Tubes of the Accademia Fisicamatematica Romana Demonstrated in the Year 1686", as the tract was entitled, enumerated the benefits accruing to the use of microscopes and telescopes. After noting the advances that had been made up to that time,

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[1242] Biblioteca Vallicelliana, *Ordine dato al Sig. Campani dalla Corte di Francia*, Ms Bianchini S. 83, tomo VIII, parte III, cc. 1222

[1243] King, *The History of the Telescope,* 61-64 ; Caverni, *Storia del metodo sperimentale*, vol. 2, 54-56.

[1244] Bianchini, *Hesperi et phosphori nova phaenomena*, 59.

[1245] Cassini, "Vie", 305.

many discoveries demonstrated in the Accademia were described, and aerial telescopes were illustrated in two of the three plates.[1246]

[Figures]

It was in 1684, at about the same time that the Jesuit de Gottignies had been engaged in constructing his device for elevating telescopes, that Campani finally had succeeded in devising a successful comparable operable mechanism of his own design, which in fact proved to be far superior. He erected it first up on the Janiculum hill in Rome, because that was one of the highest points of the city. For his base, Campani selected the gardens of the Villa Doria Pamphilj, just outside the gate of the Porta San Pancrazio. The Villa, known also as Bel Respiro, has been built in about 1650 for Prince Camillo Francesco Maria Pamphilj. It contained the largest park in Rome, having a perimeter of 9 km, with open vistas that extended as far as Monte Mario and the *Campagna* to the Soratte.[1247]

This site on the mountain top was particularly suitable for Campani's experiment, having an elevation of 82 meters above sea level. It is possible but unconfirmed that in fact it had been on the premises of the villa's great park that Campani had been maintaining his observatory and workshop, where it may have been his permanent installation to which the Landgrave of Hesse and his party had come to visit him in 1699. The details of the scene depicted in the engraving of Campani's broadside of his aerial telescope support suggest that the erection of Campani's telescope-elevating mechanism actually had been placed on a terrace of the Villa Pamphilj on the Gianicolo. Faintly visible in the distance are six of Rome's legendary seven hills, and immediately below the terrace wall are indications that appear to be part of the Trastevere dominated by the Church of Santa Maria in Trastevere.

The identity of the artist who produced the broadside is not known, but undoubtedly the drawing was made from Campani's own specifications. Campani had dedicated his broadside to Minister Colbert, and although it is undated, it had been produced prior to Colbert's death in 1683.

The broadside, re-published by Bianchini, was entitled "Method for managing with facility Telescopes of whatever length, whether for terrestrial or celestial [observation], invented in Rome by Giuseppe Campani and practised in testing the four [lenses] constructed by him for the observatory of His Most Christian Majesty [title of the King of France], that the first one is of 101 Roman palms, the second of 120, the third of 150, and the last one of 205, dedicated to His Excellency Colbert".[1248]

[1246] Di Napoli, *Nuove inventioni di tubi ottici*.

[1247] Carla Benocci, *Il parco di Villa Doria Pamphilj* (Roma: Flli. Palombi : Comune di Roma, Assessorato alla cultura, Centro di coordinamento didattico, 1990); Masson, *The Companion Guide to Rome*.

[1248] Bianchini, *Hesperi et phosphori nova phaenomena*, table VIII. According to Giuseppe Monaco, the drawing of plate VIII was previously published in 1681 as a separate sheet and later attached to Francesco Bianchini's

The mechanical arrangement that Campani invented made it possible to extend the length of an aerial telescope to almost 70 palms (15.63 m; 615,35 inches), by means of which an observer was enabled to view even the patches on the moon. Bianchini worked together with Campani, assisting him in erecting this telescope-elevating equipment in the Villa's gardens. He described the event almost a half century later in *Hesperis et Phosphori*, in which he wrote: "in 1684, in the gardens of the Pamphilj outside the Janiculum gate, we saw the erection of Giuseppe Campani's machine: thanks to it, for the first time the extension of the tube happily reached the length of almost 70 palms to observ the lunar spots". The engraving was reproduced in Bianchini's *Hesperi et phosphori*, from which it became widely known.[1249]

The means required for elevating long telescopes that Campani had devised differed from all others that had been proposed or developed until then. Bianchini claimed that this device required no more assistance for observing than that of one person to observe; a single man bearing all that was required for any large telescope, and he claimed that the entire mechanical structure could be prepared in a quarter of an hour. Experimenting also by making observations in daylight brought the same distinction and clarity, he stated, that one would have had with the telescope tube.[1250]

It was a simple matter to find any object to be observed by means of this method, using lenses having as long a focus as it was seen under a very minute angle and which was convenient to the major sign to follow the motion of the stars with the ocular lens, and the motions of the planets by gazing intently in such a manner that if one doubted to hope to discover in the celestial bodies by means of telescopes. It was Campani's conviction that a method more certain than this could not be invented. But that which had even greater success was the reflection that could serve to communicate many notices to a distance of many miles without need of sending a messenger (an ambassador), particularly if put into operation with lenses that he had made, which by means of the said inventions could, in a period of time, compete with those using a different artifice.

Campani's mechanism combined the use of one of his object lenses for making both celestial and terrestrial observations. These were represented in the engraved broadside, featuring two telescopes, to which Campani had applied devices designed to facilitate terrestrial and celestial observations. Listed and identified on the broadside are the components of both of the mechanisms, the parts of each of which are listed side by side:

The First Mechanism

Parere in 1702. Monaco, "Un parere di Francesco Bianchini sui telescopi di Giuseppe Campani", 419 and illustration at page 421.

[1249] *"[...] a Josepho Campani, a quo vidimus anno 1684 in hortis Pamphiliis extra Porta Janiculensem huiusmodi machinam elevari: per quam ad palmos circiter septuaginta extensio tubi primum feliciter adhibita fuit ad Lunae maculas observandas"*. Ibid., 58.

[1250] Ibid. Table VIII. Biblioteca Vallicelliana, *Ordine dato al Sig. Campani dalla Corte di Francia*, Ms Bianchini S. 83, tomo VIII, parte III, cc. 1222-1223.

AB Form of the telescope of parallelepiped shape
C Staff with its ring that embraces the mast so that it can support the Telescope
DE Axle of the Telescope
I Instrument with toothed wheel **I**, to turn and shorten the cords, each of which are composed of two and its trigger **K** which forms the small wheel (roller)
FG Cord tied in each of the four sides, and sustained by the bridge **H** with its small ladder (stool) and which can be raised or lowered to render the direction of the telescope more easily **QR** Mast of cylindrical form situated between the telescope and one of its two cords **R** Pulley, which revolves around the mast, according to whether the telescope is being elevated in the air by the counterweight **S** with a cord for raising it **T** Tripod prepared for raising or lowering the telescope.

The Second Mechanism

AB Shape of the telescope made in cylindrical form in several parts
CDEFG Wooden tube in four parts **CD**, **DE**, **EF**, **FC**, to sustain the axle **RQ**
CHI, **KHN**, **MHE**, **PHS** Cords doubled that intersect themselves to uphold from the bridge **H** in the extremity of which is **CG**, the instrument for shortening it, described in the other mechanism
O Supporter of the telescope, which can be raised or lowered, and placed in a straight line
IL Various forms of supports.[1251]

Campani's engraved brochure illustrated two diverse solutions for avoiding the arching of the tube, the first of which was used with telescopes of square section and the second with those of circular section. For the first, use of the metallic pole H called "bridge", normally attached to the surface of the four faces of the long parallelepiped and equipped, at the extreme end, with a cradle in which runs the cable FG, the tension of which opportunely was regulated by means of the instrument IKL, thus correcting the arching that can be verified perpendicularly to the four faces. The second mechanism is served by a sustaining tube that runs under the instrument and brought some support IL, which the central axis, gliding along the lateral rack-railway, then was raised and lowered in such a manner as to correct the eventual bending of the tube.

The great post QR, attached into the ground, was furnished with three tie rods that should guarantee its immobility. The pulley R assured it the movement in height, pulling the hanging attached to the staff C and to the counterweight S, either the azimuthal movement, through the proper channel the pivot (or hinge) attached in the upper extremity of the post, of which is furnished the structure that carries the pulley R.

The tube of the telescope was held in a fixed position by means of two blocking elements, the one situated close to its center of gravity and consisted of the ring that encircles the mast, soldered welded to the stirrup C; this consisted of a bench T, provided with regulating screws, to which was anchored the tube shown with the observer looking through the eyepiece.

Bianchini preferred Campani's elevating device to others that were being proposed and stated that in order to view the planets and their disks and diameters, as well as Jupiter's spots and

[1251] Ibid.

Saturn's rings, a telescope having a focal length of 50 feet would be required. It was his opinion, furthermore, that to view all of Saturn's satellites, a telescope of 100 feet would be needed. With the production of lenses of longer focus, tubes of greater weight would be necessary; they would be increasingly unwieldy, at a consequent increased cost.

An attempt to solve this problem was among the final major projects that Campani undertook, the production of a telescope elevating mechanism that had been commissioned by Cardinal de Polignac.[1252] Bianchini reported how Campani had been subsidized by the Cardinal to undertake the construction of a machine or mechanical device for elevating objectives having as much as 100 and 200 feet of focal length to be used for making celestial observations. to which the Cardinal planned to dedicate himself in the future.

It was not until August 1709 that Campani finally completed the project for de Polignac. In the interim, however, the Cardinal had been appointed a papal ambassador and was to remain out of the country on various assignments for the next sixteen years. Then, in 1725 he was appointed French ambassador to the Vatican. Upon the Cardinal's return to Rome, he learned that Campani had died a decade earlier. His heirs, however, namely, his daughters, had been assigned to provide the required telescopes and to erect the mechanism which he had commissioned.[1253]

Campani's promised production of an aerial telescope for the Cardinal was the subject of discussion also in a letter by the Bolognese nobleman Francesco Zambeccari written from Rome in mid-September 1705 to Vittorio Stancari at Bologna. Zambeccari reported how, during a recent sojourn in Rome, he had paid a visit to Campani's shop, and therein, in addition to other items, the instrument maker had shown him a manuscript.

The manuscript was Campani's account for "combining telescopes without tubes of whatever length" containing complete details and instructions—namely, his notes on the construction of aerial telescopes with a description of his mechanism for elevating them. The use of the latter, Zambeccari reported that Campani had told him, was of the utmost simplicity so that even a boy would be able to prepare all that was necessary in not more than 15 minutes without assistance from anyone. Campani considered this procedure to be a great invention, and he declared that he was disposed to sell it but only for a great price. At that time Campani had not yet completed the project commissioned by Cardinal de Polignac, and what he was disposed to sell was a mechanism of the same sort that represented the state of the art. He then showed Zambeccari

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[1252] Melchior de Polignac (1661–1742), from a family of ancient French nobility, was a diplomat under Louis XIV and Louis XV. Destined for the church, he was ambassador to Poland 1695–1697, retired but recalled to favor at court in 1702, plenipotentiary at Congress of Utrecht 1712–1713, cardinal 1713, minister at Rome 1725–1732, archbishop of Auch 1726, and a member of the French Academie. J. C. Hoefer, ed., *Nouvelle biographie générale depuis les temps les plus reculés jusqu'à nos jours, avec les renseignements bibliographiques et l'indication des sources à consulter*, vol. 40. Philoponus-Preval (Paris: Firmin Didot frères, 1862), cols. 607–610.

[1253] Bianchini, *Hesperi et phosphori nova phaenomena*, 4.

another invention that he proposed would be useful for raising the memorial column at Montecitorio with facility.[1254]

In Bianchini's judgment, the method for using the aerial telescope proposed by Huygens resulted in being no more than ever inconvenient as far as the necessity to eliminate, at least in part, the foreign rays. The Dutch astronomer had been constrained, especially in observations of the craters of the moon, to surround the object lens with a sheet of cardboard that, as one could argue, served as a screen to every minimal breath of wind that created notable disturbance.

On the other hand, the method adopted by Cassini presented a notable improvement when compared with that of Huygens; the two movable frames with which the object lens had been furnished successfully facilitated the alignment of the eyepiece and object lens with the celestial object to be observed. The inconveniences, however, were not entirely eliminated if one considered that the external still somewhat disturbed the imagery and that the positioning of the object lens, even if it was facilitated by a small quadrant on which could be read the height of the star to be observed, had always to be entrusted to a second person.

It was the same Campani, Bianchini had noted in his manuscript, who had suggested to Cassini to place a small telescope close beside the object lens to further facilitate the work of the assistant. Bianchini attributed the concept of this idea entirely to Campani who, on the basis of this testimony, could consider himself the creator of that simple but precious application of the "seeker instrument" that, even to this day, remains extremely useful.[1255]

Early in the 1700s, Campani had constructed a telescope for use during his own astronomical observations of such a notable size and having such power and clarity that from the convent of San Pietro in Montorio on the Gianicolo, using such a telescope of 30 palms, he was able to see the hand on the clock of the campanile of Frascati's Duomo 11 miles distant.[1256]

The superiority of the telescope without tubes, according to Bianchini, was undisputed, although Campani's method did not in fact eliminate all the problems indicated. While the cords, if stretched taut, could eliminate the possibility that the long tube would curve, a problem remained of the difficulty of maneuvering or holding the instrument still without motion, given that its mass could not be of entirely overcome, even if they were stretched.

In making observations during succeeding years, both Campani and Bianchini continued to use telescopes without tubes. In 1712, Bianchini took with him from Rome to the royal observatory in Paris an apparatus for elevating aerial telescopes of 50 to 60 French feet (l foot = 32.48 cm) that

[1254] AABo, 'Serie Storica Specola XVII-XIX sec.', B37.9, letter from Francesco Zambeccari to Stancari on September 12, 1705.

[1255] Monaco, "Un parere di Francesco Bianchini sui telescopi di Giuseppe Campani", 429.

[1256] Biblioteca Vallicelliana, *Ordine dato al Sig. Campani dalla Corte di Francia*, Ms Bianchini S. 83, tomo VIII, parte III, c. 1223.

subsequently was modified by the French for use with objectives of even greater focal length. This was the mechanism that had been devised by Campani in 1709, completed after an unknown number of years of experimentation.[1257]

Campani's instruments were prized also in Germany. During the instrument maker's later years, one of his telescopes was purchased by or for Frederick III, Elector of Brandenburg, who later became Frederick I of Prussia. It was a terrestrial telescope approximately 18 feet (548.64 cm) in length, equipped with the "three Roman eyepieces", as the Campani ocular lens had become known, which had focal lengths of 4-1/2 (11.43 cm), 4 (10.16 cm), and 5 inches (12.7 cm).[1258]

When the erection of an observatory for Berlin was being contemplated, in May 1700, Gottfried Kirch was summoned there to become its first director. The son of a tailor of the same given name, Kirch had studied at Jena. He was married to Maria Margaretha Winkelmann, whom it is believed had become interested in astronomy through association with Christoph Arnold of Sommerfeld, the so-called "astronomical peasant". She also eventually distinguished herself as an astronomer, and Kirch and Maria became parents of 14 children, two of whom also became astronomers. Kirch earned his living by compiling ephemerides and by publishing almanacs, activities that were continued after his death by his son, having his father's name.[1259]

The astronomical observatory in Berlin was founded officially on July 11, 1700, the Prince Elector's birthday. Because the spendthrift Prince had provided only the most meager funding for it, the construction of the observatory consequently made slow progress. While waiting for the building to be completed, Kirch continued to make observations from his own home and from the private observatory of the wealthy amateur astronomer Baron von Krosigk.

Kirch noted that, on September 7, 1700, the Baron had acquired the Campani telescope from the Elector's collection. According to his own account, Kirch used this instrument occasionally over a period of time. He was unable to make more frequent use of it, although he wished to do so, because he lacked the solid mounting required for supporting the long tube. Because of its length, it was difficult to manage the tube without one. In 1729, the Campani telescope at Berlin was being used also by his son, Christfried Kirch, who noted that its focal length was 16 feet, 11-1/2 inches–516.89 cm. In the observatory's archives the instrument was described in the records as "A tube [telescope] with lenses made by Joseph Campani, having 3 ocular [lenses], with a focal length of 18 feet (518.16 cm), or when using a single eyepiece, a focal length of 16 feet–487.68 cm. The tube

[1257] Cassini, "Nouvelles découvertes sur les mouvements des satellites de Saturne", 364; Reaumur, "Description d'une machine portative", 299–306, 1 plate, Paris 1739.

[1258] Berlin-Brandenburgische Akademie der Wissenshaften, Preußischen Akademie der Wissenschaften (PAW) *Archiv, Nachlas Kirck nr. 19;* Shelf No. 1.XIV-27; Volumen Actorum betreffend Das Observatorium und den Abstronomum von Annus 1713 bis 1746, July 14, 1725.

[1259] "Gottfried Kirch," *Dictionary of Scientific Biography* (New York: Charles Scribner's & Sons, 1973).

with a mounting is located at the balcony, the lenses are maintained in the room below". Eventually the telescope was lost and has not been found.[1260]

The reputation for superiority of Campani's instruments among astronomers in Germany continued even in his later years. Following the death in 1705 of Georg Christoph Eimmart, the Nuremberg astronomer, the senate of Nuremberg voted to acquire the entire contents of his private observatory and to construct a new installation at Altdorf. As the new observatory was nearing completion, efforts were made to equip it with the finest instruments available.

Accordingly, the German astronomer Johann Heinrich Müller wrote to Eustachio Manfredi at the observatory of the University of Bologna in January 1712, inquiring about the quality of the lenses the observatory had acquired from Rome, whether they were considered to be fine. He went on to inquire also whether it would be possible to purchase a telescope of 30 feet from that "celebrated artisan in Rome, Giuseppe Campani", and whether he was still alive. Müller asked Manfredi as a personal favor to go to Rome in person to determine whether such an instrument was available, and to establish the price, which he anticipated would be substantial.[1261]

Whether Manfredi was able to assist Müller at that time in acquiring a Campani telescope is not known with certainty. Four months later, in May 1712, however, Manfredi wrote to Bianchini in Rome that he was "requesting on behalf of Professor Müller the prices of two telescopes". Müller had written: "The scarcity of opportunities to make observations, or actually, the absence of a formal observatory, has interrupted for a long time our communication until now, which to me had been of great profit and pleasure".[1262]

Among Campani's prospective clients of his later years was the wealthy Bolognese geographer and naturalist General Luigi Ferdinando Marsili (a.k.a. Marsigli). A member of an old Bolognese patrician family, he had been educated in accordance with his family's status by the best teachers of his time with emphasis on the sciences. In his youth, he had studied mathematical sciences with Giovanni Alfonso Borelli, astronomy with Geminiano Montanari, and anatomy with Marcello Malpighi.

In the course of a distinguished military career spanning more than two decades, Marsili managed to assemble large collections of antiquities, scientific books, and instruments and mechanisms, as well as important geological and botanical specimens during his travels. He served for the Venetian Republic at Constantinople in 1679, and when the Turks threatened to invade

[1260] Berlin-Brandenburgische Akademie der Wissenshaften, Preußischen Akademie der Wissenschaften (PAW) *Archiv, Nachlas Kirck nr. 19;* Shelf No. 1.XIV-27; Volumen Actorum betreffend Das Observatorium und den Abstronomum von Annus 1713 bis 1746, July 14, 1725.

[1261] AABo, 'Serie Storica Specola XVII-XIX sec.', B36.16.6, letter from Johann H. Müller to Eustachio Manfredi, January 8, 1712.

[1262] Celani, "Il Carteggio di Eustachio Manfredi con Francesco Bianchini," 144–45: letter from Manfredi to Bianchini on May 10, 1712.

Hungary, he offered his services to Emperor Leopold. In 1683, he was taken prisoner and suffered as a slave of the Turks until his release in the following year.[1263]

Marsili then presented his great collection of the materials he had collected in England and Holland to the Senate of Bologna. He proceeded to make his mansion available to youths who wished to pursue his knowledge in experimental science. It soon became a center for those of his many friends and acquaintances who shared his scientific interests. These gatherings eventually developed into an academy of experimenters that became known as the Accademia degli Inquieti, founded in 1690 by a 16-years-old Eustachio Manfredi. In 1711, the Accademia degli Inquieti was transformed by Marsili into the Accademia delle Scienze dell'Istituto di Bologna. Marsili had long dreamed of providing his community with something comparable to the Academie Royale des Sciences in France, but the program he proposed was never entirely implemented. In 1690, he bequeathed his home and collections to the University of Bologna to be perpetuated as an Institute of Science. Conceived by him to be a research center for public instruction, with emphasis on teaching the practical sciences, it was equipped with a library, laboratory, and physical sciences cabinet, manned with a staff of five specialists.[1264]

In addition to his dominating interest in the natural sciences, Marsili also had a lifelong interest in astronomy, so that he wished that an astronomical observatory would be featured as well as part of the Institute he had founded. The observatory in due course was constructed above the granaries on Marsili's estate.

In 1701, when Marsili had been about to depart from Bologna on military assignment in the war for the Spanish Succession, he was faced with a dilemma. He anticipated that he would be absent from home for a long period; in fact he was not to return for the next 7 years. Unwilling to postpone his plan for the projected observatory, he appointed Eustachio Manfredi, a young lecturer at the University, to supervise its construction to the completion stage during his absence. Marsili planned to remain in contact with the project from his posting in Vienna, by sending Manfredi instructions from time to time as the project progressed.

Manfredi, then 28 years of age and self-taught, had been employed for the past 2 years at the University of Bologna as a lecturer in astronomy. He eagerly undertook Marsili's assignment, and as he later informed his mentor, Francesco Bianchini, Marsili had assigned to him also

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[1263] Cesare Preti and Giuseppe Gullino, "Luigi Ferdinando Marsili," *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 2008); Bedini, *Science and Instruments in Seventeenth-Century* Italy, 434.

[1264] Giuseppe Gaetano Bolletti, *Dell' origine e de' progressi dell' Instituto delle scienze di Bologna* (Bologna: Per Lelio dalla Volpe, 1763); *Notizie dell'origine, e progressi dell'Instituto delle scienze di Bologna e sue accademie: con la descrizione di tutto ciò, che nel medesimo conservasi : nuovamente compilate, ed in questa forma ridotte per ordine, e comandamento* (In Bologna: Nell'Instituto delle scienze, 1780); Enrica Baiada, Alessandro Braccesi, and Fabrizio Bònoli, *Museo della Specola: catalogo italiano-inglese* (Bologna: Bologna University Press, 1995), 39–80; Paolo Dorè, "Origini e funzioni dell'Istituto e dell'Accademia delle Scienze di Bologna," *L'Archiginnasio* 35 (1940): 192–214.

responsibility for his library and his collection of instruments for the new observatory. Manfredi immediately enlisted the assistance of his boyhood friend Vittorio Stancari. As youths unable to find a teacher in Bologna to further their interest in astronomy, both Manfredi and Stancari had become self-taught, spending their nights together making astronomical observations and learning as they studied from sources available to them.[1265]

Immediately prior to his departure from Bologna, Marsili initiated a number of arrangements for the purchase of new scientific equipment for the observatory. He already possessed several of Campani's optical instruments, which he highly prized. In addition to Campani microscopes, among them was a six-draw telescope having a focal length of 105 feet (32 m) that Marsili had received as a gift from his brother. It was with that instrument that Manfredi later was to make observations of the satellites of Jupiter. In describing the results to Bianchini, Manfredi wrote, "I used an extremely fine telescope of Sig. Campani which had a length of 10-1/2 feet (320.04 cm), which gave me the greatest satisfaction to the eye, whereupon I persuaded myself that in the determining the immersions it could be equal to longer telescopes which others have been using".[1266]

Determined that his observatory would have only the finest equipment, in January 1702, Marsili had written to Giuseppe Campani in Rome. He requested his advice and recommendations concerning the type and range of instrumentation that would be required to equip an observatory of the finest quality. He inquired also about the cost of the series of telescopes with which eventually it should be furnished.[1267]

Now having only limited time while remaining at home, Marsili waited with increasing impatience for a reply to his letter or for an explanation for the delay. After first 1 month had passed and then another without receiving a response, Marsili finally concluded that Campani either had retired permanently or perhaps had passed on. He thereupon lost no more time and sought other makers from whom to purchase equipment for his observatory. Furthermore, in the interim he had changed his mind somewhat and decided on different types of instruments.

Early in April, Manfredi informed Bianchini that Marsili had finally been convinced to commission all the instruments he required to be fabricated by a maker in Rome and had in fact already decided that they should be made by "a certain Usuerg, who is credited with being a fine

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[1265] Celani, "Il Carteggio di Eustachio Manfredi con Francesco Bianchini"; Ugo Baldini, "Manfredi, Eustachio," *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 2007).

[1266] Celani, "Il Carteggio di Eustachio Manfredi con Francesco Bianchini", 138: Biblioteca Vallicelliana, Fondo Mss., vol. U17, fol. 890, letter from Manfredi to Bianchini on August 26, 1702; Biblioteca Universitaria di Bologna, *Mss. Marsiliani* 80 A, letter from Manfredi to Marsili on January 10, 1702.

[1267] Monaco, "Un parere di Francesco Bianchini sui telescopi di Giuseppe Campani", 419, letter from Marsili to Campani on January 22, 1702. This letter has not been found but its content is deduced from Campani's reply: Museo Astronomico e Copernicano (Rome), Ms. V 1855, cart XI, letter from Giuseppe Campani to L. F. Marsili on April 29, 1702.

artisan".[1268] The reference was to Domenico Lusuerg (or Lusverg) who advertised himself as "Maker of Mathematical Instruments at the Collegio Romano." Although at this time Domenico's name was still little known, he had succeeded to that office previously held by his well-known uncle Giacomo Lusuerg, a talented maker of instruments.[1269]

Despite Marsili's impatience to obtain Campani's recommendations for his observatory, he was probably aware that the prices for iron and brass instruments for positional astronomy (for Marsili very important in order to reform geographical maps) from Lusuerg would be substantially less than those for which German ones had become noted. As a consequence, it was decided to commission Lusuerg to make two quadrants and a mural semicircle.[1270]

At just that time that Manfredi was negotiating with Lusuerg, Giacomo Filippo Maraldi happened to be in Rome engaged in making astronomical observations together with Bianchini. Manfredi asked Maraldi to provide him with the design of a quadrant with pendulum, which the latter sent him in February 1702. As Manfredi wrote to Bianchini, Marsili also had participated in designing the quadrant with pendulum and the General had suggested that a similar one be made in Rome in order to take advantage of the presence there of Maraldi and Bianchini. Marsili felt that the two astronomers could lend valuable advice to the instrument maker, thus contributing greatly to the perfection of the instrument. Manfredi accordingly arranged to have the remainder of the instrumentation required for the observatory to be made in Rome by Lusuerg.[1271]

Two months later, in May 1702, Manfredi wrote to Bianchini requesting that he negotiate with Lusuerg concerning the instruments, since he was in Rome. He asked Bianchini whether he "could arrange with Lusuerg to make a quadrant with pendulum for the sum of eighty *scudi*, twenty *scudi* of which he will receive now, and the remaining sixty he will receive as soon as the work is completed. As for the other two instruments, I am concerned primarily that we have from you the design and complete instructions before he leaves from Rome, and on which basis it is likely that he will explain more freely about the price, at least approximately. [. . .] This notice of the price is desired by me in order not to involve Count Marsili in an exorbitant expense because there is no

[1268] Celani, "Il Carteggio di Eustachio Manfredi con Francesco Bianchini."

[1269] Several generations of the Lusuerg family achieved great renown as makers of mathematical instruments in Rome into the second half of the eighteenth century. Giacomo Lusuerg had been working in Rome in 1695; Jacobus Lusuerg worked in Rome in 1673 and 1683 and for the Duke of Modena in 1674. Anita McConnell, "Instruments and Instrument-Makers, 1700-1850," in *The Oxford Handbook of the History of Physics*, ed. Jed Z. Buchwald (Oxford: Oxford University Press, 2013), 347.

[1270] Celani, "Il Carteggio di Eustachio Manfredi con Francesco Bianchini", 137: Biblioteca Vallicelliana, Ms. U17, fol. 874, letter from Manfredi to Bianchini on April 1, 1702. Baiada, Braccesi, and Bònoli, *Museo della Specola*, 45 and 58-59.

[1271] Celani, "Il Carteggio di Eustachio Manfredi con Francesco Bianchini", 136-137: Biblioteca Vallicelliana, Ms. U17, fol. 870, letter from Manfredi to Bianchini on March 11, 1702.

doubt that he would wish in every manner to have the instruments and I would not, however, wish to exceed the assignment [. . .]".[1272]

It was not until the end of April, 4 months after Marsili's letter had been sent, that Campani first saw or read the letter, upon his return to Rome after his absence from home of several months. He immediately responded to Marsili after having read the General's letter. In his reply Campani explained that he had been unexpectedly called away from Rome during the past several months. "I had been in Spoleto," he wrote:

where I was obliged to remain for some time attending to various domestic interests of mine, and it was not until I arrived in Rome upon my return that I discovered that the Abate Vespignani had left at my house your welcome letter of the past January 22nd, in which you honor me by seeking my advice concerning various points relating to the astronomical observatory you are having erected in Bologna. I have ventured to communicate your letter and your express wishes to Monsignor Bianchini, cameriere d'onore of our Holy Father, a great professor and who is very expert in these astronomical matters. I communicated it at the same time to Filippo Maraldi, nephew of *Signor* Cassini, both of whom are old patrons of mine, after having had several discussions with them on the subject. […]

As to Ustorian glasses, about which you have honored me to inquire, I must respond that they are not made here, because here they do not have the secret of liquidifying glass, as one does with metal, I can only offer to work on a glass that is manufactured in those parts of the sizes that would be required to be fused in the convex form […].

Concerning the tube [telescope] for observing the spots on the sun, I do not know at present the most secure method, whether to make [a direct] use of a telescpe (except that one must make use of a telescope with caution, however when one is observing with it directly into the sun, the lens near the eye must be to such an extent full of colors, so that one's sight does not suffer damage from the solar rays) or to receive from the same telescope the image of the sun in a white paper in a camera obscura. This is the little that, as a consequence of my weakness and ignorance, I can say and offer in service, and in obedience to Your Highness. If by means of *Sig. Dott.* Manfredi, Professor of Mathematics in Bologna, or of the Sig. *Abate* Vespignani, you would do me the favor of your command, I will seek to exceed myself for better serve you.[1273]

Campani had attached a document to his reply to Marsili that was handwritten by Bianchini but unsigned, in which the Monsignor analyzed the subject of aerial telescopes. He expressed approval of Campani's long focus telescopes but was opposed to those of Christiaan Huygens, he noted. Of particular interest in this document was Bianchini's attribution to Campani of the idea of attaching a small telescope on the tube close to the object lens for the purpose of identifying celestial bodies. He wrote:

[1272] Ibid., 137: Biblioteca Vallicelliana, Fondo Mss., letter from Manfredi to Bianchini in May 24, 1702.

[1273] Museo Astronomico e Copernicano (Rome), Ms. V 1855, cart XI, letter from Giuseppe Campani to L. F. Marsili on April 29, 1702; Monaco, "Un parere di Francesco Bianchini sui telescopi di Giuseppe Campani", 426-28. The abbot Giovanni Sebastiano Vespignani (1669–1746) was an eminent doctor of laws and for many years had been magistrate in Cesena, Foligno, then in the city of Trento and in Roveredo. He was the aulic counsel to the principal archbishop of Salisbury; Bologna wanted him as auditor in its Rota, then judge, and Genoa called him auditor of its Rota. He was the author of *De emptione, et venditione*. He published many of his legal decisions, in the compilation of which he was assisted by his son, who also was a noted Jurisconsult. He died at the age of 77 in Genoa where he was auditor of the criminal Rota. [Luigi Angeli, *Memorie biografiche di que' uomini illustri imolesi, le cui imagini sono locate in questa nostra iconoteca, che si distinsero in ogni ramo di scienze, e nelle belle arti* (Imola: I. Galeati, 1828), 72].

It has been requested by a personage intending to promote science to express my opinion concerning the furnishing of astronomical instruments for the astronomical observatory. I have informed myself on the versatile subject with those well versed in observations and especially with Sig. Filippo Maraldi, nephew of *Sig*. Cassini and the others of the Académie Royale des Sciences in Paris, from what they have responded, and from the reflections that I have made in connection that I have also availed myself of these instruments for that studio, which have some distinct purpose as follows.

For the eclipse of the moon and of the sun it is enough to have telescopes of long focus of from about 8 up to 15 Roman palms because up to this length they show all the disks of the planet in one opening of the tube.

For the eclipse of the satellites of Jupiter the most comfortable is to avail oneself of a tube about 25 Roman palms with which they can be observed sufficiently distinctly. Even a tube of 15 Roman palms would be adequate.

In order to observe the diameters and the disks of the planets, one of 50 palms made by a good maker and is available to demonstrate them sufficiently clearly. Recently, with one made by *Sig*. Campani, we have observed Venus a short time before the Synod with the Sun lightly curved. With the same one we have observed the ring of Saturn and in preceding years, the band of Jupiter and similar particulars of their bodies.

But to see clearly all the satellites of Saturn, I believe that a length less than 100 Roman palms is sufficient. *Sig*. Maraldi had told me that these have been discovered most recently by Cassini, with one of about that length that had been made by *Sig*. Campani. Although it appears at first sight difficult to manage a telescope of such a great length, however, Sig. Campani proved it some fourteen years ago in the garden of Sig. Prince Pamphili being able to raise one of 90 palms with the mechanism of his invention that succeeded most admirably, and with incredible ease and convenience, so much so that I estimate that one can equalize to that of M. Huygens, who showed a method of using the lenses without tubes. I have seen set up with this invention in Brescia by *Sig*. Cervaro in the year 1696 (while he was Captain for the Most Serene Republic of Venice in that city) a lens of 150 and possibly 200 palms (that at the beginning essentially I did not recall) that succeeded well. *Sig*. Campani in that year has proven that the other invention of *Sig*. Cassini of using lenses without tubes, to which *Sig*. Maraldi had referred, had similarly succeeded well. But upon reflecting upon the circumstances that close by, I would say that it seems that it would have been much easier to use the same lenses with the tube for the invention before *Sig*. Campani: and that in this there would have been a great advantage in order to see with distinction the celestial bodies over the method of using the lenses without tubes. Comparing the facility and the advantages, if earlier I had explained succinctly enough the manner of using the lenses without tubes already, since that the other method of using and managing with tubes still much longer, of 130 and 150 palms, are explained sufficiently in the brochure printed by Campani. [SKETCH].

M. Huygens placed the objective CD upon the staff BC. The staff is folded in A and at the same time in counterweight in such a manner as to by means of the weight E that with a string of silk EG makes it self obey in a long distance of 150 to 200 palms to take whichever direction the objective CD either [any] direction. At the end of the string G by means of another small mechanism similar are placed its glasses of equal measure with the tube, and for this invention is recovered an incredible distance. The advantage of using the lenses with the tube, one cannot believe who has not experimented, and I will compare with the other invention without tubes. The tube in this manner that still does not require towers and wooden structures. It is enough to have a plan upon which is erected an antenna in the manner described by *Sig*. Campani.

It would be inconvenient to transport the mechanism of *Sig*. Campani, when it would succeed in transporting the wooden structure of the observatory in Paris [Marly tower]. Neither the wind nor the weight gives disturbance to the tube in the invention of the said *Sig*. Campani, having been seen in practice that the cords of his retain the axis of the tube in a straight line, and does not permit it to be moved by the wind. Certainly the wind greatly inconveniences those who conserve the method of M. Huygens because the large cardboard that is attached to the object glass.

I would say, therefore, that the astronomical assortment capable of making whatever observation should be provided with

A telescope of 8 to 10 palms
One of l5, or of 20
One of 25 or 30
One of 50

One of 100 palms at least, or possibly
of 120 to 130, that would be better
and I would say that these ultimate telescopes should be used with a tube of the type invented by *Sig*. Campani, better than one of the two others of *Sig*. Huygens or of *Sig*. Cassini.[1274]

The superiority of telescopes utilizing tubes over the aerial telescope, according to Bianchini, remained without question, although the method developed by Campani did not totally eliminate the problems indicated. While the ropes held well taut could eliminate curving of the long tube, the difficulty of maintaining or keeping the instrument immobile, given its massive structure, was not entirely surpassed if the same Campani and Bianchini made use of the telescope without tubes in the years that followed. In 1713, in fact, Bianchini presented to the Académie in France a new method for transporting and maneuvering large aerial telescopes.[1275]

Marsili felt that in Bianchini he had the perfect channel by means of which to obtain on his own behalf equitable precision in his orders. The judgments expressed by the young astronomer in favor of Campani was not sufficient with every probability, however, to overcome the obstacle of the high cost of the instruments. It was necessary to consider also that the long tubes constructed of wood, proposed by Campani, would have created serious problems of space in their use and storage in Marsili's observatory. The larger telescopes certainly would have required that arrangements be made for their maintenance elsewhere.

The prices of Campani's clocks, lenses, and instruments were substantially higher when compared to those of others, and which was confirmed in a subsequent letter from Zambeccari to Stancari in Bologna. During his sojourn in Rome, Zambeccari wrote, he had called at Campani's shop with the intention of purchasing a small microscope, but he quickly had changed his mind after having been told the price. He added that Campani also had for sale hand telescopes [*da pugno*] that were truly excellent, but the prices for which also were extremely high. Displayed in the shop also for sale, he saw object lenses of long focus (most probably these four ones once sent ot Paris). These Campani offered only in groups of four at a price that Zambeccari considered to be greatly elevated. He saw that annexed to the set of lens was an invention for manipulating aerial telescopes with extreme facility. Zambeccari mentioned that at this point Campani had declared himself disposed to cede the four objectives together with the model of the machine to whomever was able to demonstrate he could make lenses superior to his own, or at least that were equal to them. Evidently the telescope maker felt quite secure in the unequaled quality of his work,

[1274] Monaco, "Un parere di Francesco Bianchini sui telescopi di Giuseppe Campani", 427-31.

[1275] M. de Reaumur, "Description d'une machine portative, propre à soutenir des verres de très-grands foyers, presentée à l'Academie par M. Bianchini," *Histoire de l'Académie Royale des Sciences* Année 1713 (1739): 299–306, 1 plate.

Zambeccari commented, or perhaps this may have been another maneuver to ensure that the best merchandise went to the appropriate person.[1276]

By the end of 1702, the quadrant that had been ordered from Lusuerg had been shipped to Bologna where it was received with great enthusiasm by Manfredi, which he expressed in a subsequent letter to Bianchini: "The quadrant has already arrived here; it is most noble and convenient and there is no doubt of the greatest pleasure it will provide. The [first] quadrant, however, resulted most notably defective. Meanwhile, the second one fortunately was not, analogical to the first, and the mural semicircle was constructed with major diligence by Lusuerg".[1277]

Bianchini responded that as concerned this second quadrant, he had paid Lusuerg the sum of 75 *scudi*, which the latter found acceptable for the total price. In the same letter, Bianchini asserted "as to what concerned the semicircle, Lusuerg had promised that by the following March, with that condition and direction that Your Excellency had prescribed, he would make that; he was obligated to make over from the beginning another instrument when the divisions were not come correct." The poor quality of workmanship of the first quadrant had induced Manfredi to promise himself a confrontation with Lusuerg, who, however, had worked the final two instruments with extreme precision. Bianchini made many valuable suggestions to Manfredi and provided assistance directly to Lusuerg in the construction of the instruments, and also was a valuable contributor to the preparation of the observatory.[1278]

The absence of any response to Campani's proposal in the correspondence in those years between Manfredi and Bianchini apparently led Marsili to assume that Campani, having been informed of the commission that had been assigned to Lusuerg, found no reason to communicate further.

From time to time, Campani applied himself with equal passion to pursuits other than horology or astronomy, such as mechanical problems, as was confirmed in Zambeccari's letter relating his visit to Campani's shop in the autumn of 1705. He wrote that while in the shop the artisan demonstrated to him a system he had invented for raising heavy columns. The scheme, Zambeccari reported, was a true and real problem of applied mechanics. The system consisted of a series of pulleys with which it was possible to raise columns of whatever weight, because they were

[1276] AABo, 'Serie Storica Specola XVII-XIX sec.', B37.9, letter from Francesco Zambeccari to Stancari on September 12, 1705. Vittorio Francesco Stancari (1678–1709) of Bologna, astronomer and companion of Eustachio Manfredi, suffered a respiratory ailment from which he died at the age of 31. In his work *Schedismatae Mathematicae* (Bologna: Barbiroli, 1713), Manfredi published a number of Stancari's unpublished papers. Stancari was also the first secretary of the Accademia delle Scienze.

[1277] Celani, "Il Carteggio di Eustachio Manfredi con Francesco Bianchini", 138: Biblioteca Vallicelliana, fondo Mss., letter from Manfredi to Bianchini, December 20, 1702.

[1278] Biblioteca Vallicelliana, fondo Mss., vol. U20, fols. 38–39, letter from Bianchini directed to Manfredi on October 6, 1703.

disposed by means of ropes of whatever length. It seems, however, that this system did not satisfy all that the pontiff desired to employ to raise an obelisk and considered assigning the project to “a Dutchman”.[1279]

While Zambeccari was visiting in the little hill town of Albano above Rome in the autumn of 1705, he took the time to write to Stancari, eager to tell him about what he had seen in Rome. He described a visit he had made to the piazza di Montecitorio, where he witnessed the removal of the column of Antoninus Pius (138–161 A.D.), which was in the process of being extricated in separate pieces from among the houses in the piazza. He was aware that it was for the removal of this column that Campani had devised his *trochlea* or pulley. As Zambeccari had been idly observing the activity at the site, he noticed several gossips standing nearby who had been exerting themselves in efforts to obtain a better view of the column. As a consequence of which, in doing so one of them managed to injure a leg seriously.[1280]

The column of Antoninus Pius had a checkered history, and it is interesting to note Campani’s association with it. When Hadrian died, Titus Aurelius Antoninus succeeded to the principate as the first emperor from Gaul. Because of his filial devotion, he was successful in achieving deification for Hadrian, despite many senatorial protests, and he was called Pius.

Following the death of Antoninus Pius in the year 161 A.D., his two adopted sons, Marcus Aurelius and Lucius Verus, erected in his memory a gigantic column of oriental granite supported upon a base of Italian marble. An inscription in bronze was inlaid upon the face of this base and on its opposite side was sculpted the apotheosis of Antoninus and his wife Annia Galeria Faustina. The top of the column featured a statue of Antoninus. It was erected less than 100 meters from the sundial-obelisk erected by Augustus in 10 B.C.

The obelisk in the Piazza Montecitorio originally had been made in Egypt for the Pharaoh Psametik II (595 BC – 589 B.C.). Augustus had it transported to Rome together with another obelisk. The one erected in Campo Marzio was made to serve as a sundial. When in 1084, the Norman adventurer Robert Guiscard captured Rome in order to free Pope Gregory VII from Emperor Henry IV. The city of Rome was set on fire and the houses around the column of Antoninus Pius were destroyed.

The column of Antoninus Pius in the Campo Marzio was damaged by fire and eventually it had fallen and remained buried in the rubble. Due to occasional flooding of the Tiber during the passage of the years, the granite shaft had become covered more and more with the earth and silt being brought in by the tides. Eventually the original purpose of the monument, as a memorial to

[1279] AABo, ‘Serie Storica Specola XVII-XIX sec.’, B37.9, letter from Francesco Zambeccari to Stancari in autumn 1705.

[1280] Ibid., letter from Francesco Zambeccari to Stancari in October 1705.

Antoninus, was totally forgotten because its identifying base had remained underground and had become entirely obscured. In time, the column, which had never become completely covered and parts of which had remained visible, became erroneously attributed to the memory of Marcus Aurelius.

Pope Sixtus V in 1587 ordered the architect Domenico Fontana to recover the blocks of the column, but the architect claimed that the blocks already had become so greatly damaged by fire that had devastated Rome in 1084 that he counseled the Pontiff not to proceed with the project. More than 70 years passed, before the same idea to restore the column also occurred to Pope Alexander VII. In July 1666, he assigned Athanasius Kircher to study the problem in order to devise a practical means for digging out the granite blocks. If the probing he had arranged to have done in the area proved to be accurate, Kircher claimed that he could recover the pieces and raise the column. In fact, he suggested that the Pontiff should have it erected in front of the Church of Santa Maria degli Angeli at the Termine and dedicate it to the Immaculate Virgin. The pope did not follow his counsel, however, and the colum continued to remain buried and forgotten.

It was not until the final decade of the seventeenth century that the monumental column of Antoninus Pius was again discovered in the garden of the Casa della Missione, arousing the interest of Pope Innocent XII. He arranged to have some of its granite removed and used to restore another obelisk, the one that had been erected by Augustus as a sundial nearby in the Campus Martius. Accordingly, the granite column was broken up and selected parts of it were used to mend the obelisk in the Piazza Montecitorio.

Several years later, in 1703, the decision was made by Pope Clement XI to unearth and restore the column after all. It was in that year that it finally was identified accurately and described by the Abate Francesco Valesio in his diary. It was inevitable since now the column had been correctly identified at last, that the Pontiff became eager to have it restored, despite the advice of his architects, who warned him of the considerable difficulties that would be involved.[1281]

It is likely that it was at this time that Pope Alexander VII, or a member of his staff, recalled the recent publicity relating to Campani's successful telescope-elevating apparatus and realized its potential for raising the column. On the other hand, Campani himself, upon being informed of the column's recovery, may have volunteered to devise an apparatus for the project. In any case, he proceeded to design a *trochlea*, which was illustrated and described in the *Acta Eruditorum* published in Leipzig in July 1707:

[1281] L. Vogel, *The Column of Antoninus Pius*, Loeb Classical Monographs (Cambridge, MA: Cambridge University Press, 1973); Rodolfo Lanciani, *Ancient Rome in the Light of Recent Discoveries* (Boston: Houghton Mifflin Co., 1889), 157; Augustus John Cuthbert Hare, *Walks in Rome*, vol. 2 (Philadelphia: David McKay, 1890), 292.

The other figure is worthy of consideration, which shows Campani's mechanism suitable for erecting and removing enormous columns or any other kind of heavy object, in which "A" denotes the column that is to be erected, "BC" the transverse beam with 22 sets of blocks and pulleys, "D" 20 other sets of blocks and pulleys, "E" the axis with a toothed wheel and perpetual spiral. And we are not able—not up to this time—to advise whether Giuseppe Campani, who has achieved very great repute from the year 1664, on account of his immense skill in producing telescope lenses with great exactness, states for certain that he has found a new technique for freeing telescopes from the great undertaking of the optical tube, which we remember from Huygens in 1684, p. 363 et seq., was entirely different and so easy and simple that one person can easily move all the apparatus required up to this point from place to place, no matter how large the lenses are. Nay, rather, he asserts that he very distinctly saw the hand of a clock from a distance of fifteen Italian thousand-paces through a thirty foot telescope with the aid of this device; a cupboard in a bathing room lighted by sunlight from a distance of almost eighteen Italian thousand-paces through a one hundred foot telescope. But this finding was not to be published, unless a certain sum of money was paid by the Prince. The Illustrious Dr. Tschirnhausen, in our Acta for the year 1699, p. 147, has claimed that a similar device was known to him for a long time. And it is to be hoped, that each man will share his findings with the public, so that we no longer lack something so useful: and after it is done it will become apparent how much difference lies between the two inventions.[1282]

[Figure]

A model of Campani's *trochlea* was displayed and preserved in the Museo Kircheriano at the Collegio Romano in Rome at the time and was described and illustrated by Filippo Bonanni in the catalogue of the Museo that he compiled in 1709. After defining the nature and purpose and uses of the wedge, cochlea and of other machines, examples of which also were on display in the Museum, Bonanni went on to describe various exhibits of these five implements in the Museum, noting that diverse modifications of *trochlea* were to be observed:

these can move huge weights with little labor and, generally speaking, the more little wheels that are duly placed in the *trochlea*, the less force is required in moving the loads. Now this is done, not by each wheel bearing the whole weight but by each wheel bearing a portion of the burden in a certain ratio. Because of this characteristic, the famous Don Giuseppe Campani cleverly devised one of these little machines at Rome in order to raise out of the hole where they had lain for years the cylinders of the column that Antoninus Pius had erected so that the people of Rome could worship his deified form. These cylinders of the columns had lain buried among the rubble of the Roman ruins near the hill that they call Citorium. He attached 20 little wheels to the parallel cross beam and reinforced it firmly. He then added 19 little wheels on the other cross beams and so arranged them [*ut inversae superiores respicerent*] so that when it was turned over, the wheels faced those on the higher ones. He inserted a rope through them all so that it ran up and down. The ends of the rope protruded from either end of the series of wheels along the upper beam, where those who were to operate the machine were stationed. After all this, a huge weight was attached to the lower beam which was easily lifted when the ends of the rope were pulled. Less effort was required when they pulled with the aid of screws [*vitis*] than was required by the Archimedean or "perpetual pulley". We have sketched this machine as it is in the Museum in illustration No. 67 in the following plate. The machine aptly illustrates the inventor's genius. Some, however, frown upon it, objecting mainly to the danger to which the load is exposed, for it would be ruined if the single rope which lifts the weight should break, which often happens even in the case of thicker ropes, due to the heat generated by friction or inferior construction of the rope. For this reason the experts disparage this method of raising objects.

[1282] "Lettres de G. Desnoues etc., i.e. G. Desnoues, anatom. et chirur. profess. in Academia Bononiensi, ac Dn. Guglielmini, medicina & mathemat. Profess. Pataviensis atque Societ. Reg. Scientiarum parisiens. Membri, aliorunque eruditorum epistolae de variis inventis novis," *Acta eruditorum* Anno 1707, no. Septembris (1707): 417–20, fig. 3 a and 3 b. Count Ehrenfried Walter von Tschirnhaus (1651–1708) was a German mathematician, physicist, and philosopher. Between 1651 and 1708, he erected three glassworks and a mill near Gorlitz for grinding and burning glasses. He also made discoveries in the production of porcelain.

Quite a number of students of mechanics and art have wracked their brains on the problem of finding a method as safe as it is easy to lift these columns off their bases, raise them to the surface of the earth under which they lie, and lay them flat until they again are erected elsewhere. There is no need to have to recount all the clever and detailed ideas that have been mulled over and published in public papers, such as the various methods of Pope Sixtus V for raising and transporting that immense mass of stone [the obelisk] that we admire today in front of the Vatican Basilica crowned with the Cross.

At the time that I was collecting models for the Museum to illustrate the principles of mechanics which I had gleaned from various places, I tried to invent some machine by means of which any weight could be lifted safely and easily moved without the danger of being ruined. For I observed that in many instances of this type of work the ropes by means of which the load was suspended and moved often break. Furthermore, the strength of those who pulled the ropes was ineffectively used and the cross beams to which the *trochlea* was bound, slipped from place to place and yielded under the strain. Therefore I was eager to correct all these things in a manner that I shall demonstrate below.[1283]

[Figure (*trochlea*)]

Whatever efforts made to raise the granite pillar during the next several decades may have been, they proved to be unsuccessful and went un-noted. It was not until almost 70 years later, in 1748, that Pope Benedict XIV ordered the talented Vatican *sampietrino* Nicola Zabaglia to begin excavating the remaining five blocks of the foundation. Zabaglia was a famous self-taught technician in his time and invented a simple machine for raising the pieces. The work resulted in great cost, however, and in due course the project was abandoned one more time, and the column remained broken and buried.

The original pedestal that had been made for the column of Emperor Antoninus Pius, was for a period erected in the Piazza Montecitorio, but was later moved to the Gardens of Vatican, where it may readily be seen today. Among the reliefs depicted on the pedestal is one of a winged genius guiding Emperor Antoninus Pius and his profligate wife Faustina to Mount Olympus.[1284]

The pace of Campani's activities did not seem to abate with his increasing years, although despite the continued success of his work, his most recent years had been filled with frustration and concern. This was primarily due to the disobedience of both of his sons, upon whom he had relied to carry on his work. From the time that each of them had been about 14 years of age, he had been employed in his father's shop to assist first with minor chores, then to learn his techniques by observing him as he worked. Giuseppe had arranged, meanwhile, to have them provided with the necessary schooling as well as special instruction such as was available in the technical background required as a basis for his work, including a study of the theory of optics. Then, little by little, he enabled them to advance and engage in his techniques for grinding and polishing lenses and completing instruments.

Each of the boys worked with Campani in his shop for 10 years or more. His older son, Carlo Sigismondo, remained at home and continued to work with his father until 1697. Then, at the

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[1283] Buonanni, *Musæum* Kircherianum, 303, plate 313, fig. 67.
[1284] Klaute, *Diarium Italicum*, 159.

age of 28, he abruptly left home without explanation. He had become well trained in the work by that time, and his departure proved to be a great loss to the father. Attempts to find him were unsuccessful.

Then, several months later, on April 13 of that year, Carlo Sigismondo unexpectedly returned home and asked his father for funds. What explanation he may have given for his action nor for his request is not known, but he made it clear that he had no intention to return home under any circumstances. After long discussions, which undoubtedly must have grown heated, to say the least, and unsuccessful pleading on Campani's part, Giuseppe capitulated and gave Carlo Sigismondo the sum of 610 *scudi*. This was a most substantial amount at that time, and Campani made the condition that Carlo would agree to surrender all future claim to an inheritance. Carlo agreed willingly to the stipulation, then taking the money, he departed, never to be heard from again by his family.[1285]

Carlo Sigismondo had become well trained in the work of the shop and Giuseppe mourned not only the loss of his son but also the lack of his assistance. At the same time, he also was concerned about his well-being, and unsuccessfully attempted to learn news of him. During the next 2 years, Campani attempted to resign himself with the presence of his second son, Michel Angelo, who continued to work with him in his shop.

Then, in 1699, suddenly without notice, Michel Angelo, then 27, also ran off without any explanation to his parents. He also had recently completed an apprenticeship with his father. Campani searched for him in vain throughout Rome and environs, inquired from everyone he knew for news of him, but to no avail. As he had with Carlo, Campani utilized every means possible to learn about Michel Angelo's whereabouts and circumstances. He called upon friends, patrons, and others for assistance, without success. Finally, he was informed that Michel Angelo had made his way to Germany to join a German army. Later he was told by another source that Michel Angelo was in Augsburg and had landed in jail. The departure of both sons was a great blow for the aging instrument maker, and with the passage of time he felt the loss increasingly. As well as can be determined, neither of the sons was married at the time.

It is to be noted that each of the sons left home at just the age when customarily male youth of the times would be contemplating marriage and having a family of their own. With each undoubtedly came the realization any disruption of the work in their father's shop would face his stern objections.[1286]

[1285] ASR, Notary Olivieri Ferrei, Apost. Camera Card. Vicario, Off. 30, (April 13, 1697); document not found; Notary Giuseppe Perugino, vols. 5782-5786, cc. 646-650, 683-686, 745-747, 751-762, 771-782, 786, 788.

[1286] Communication with Dr. Juergen Hamel, Archenhold-Sternwarte, Berlin (July 19, 2002).

Several months later Giuseppe was informed that Landgrave Karl of Hesse had arrived in Rome for a visit and, as he anticipated, eventually the German nobleman sought out Campani to purchase instruments for his observatory in Kassel. He paid his first visit to Campani's shop or observatory on the Gianicolo on February 5, 1700. The visit was recorded by the Landgrave's secretary, who accompanied him on his travels. As he wrote in the Landgrave's travel diary, shortly after their arrival in Rome:

We rode over the Ponte Sisto towards the mountain Giancolo to the famous optical inventor, Giuseppe Campani, of whom I have already given mention, with whom his Most Serene Highness transacted business, purchasing the following tubes and perspectives:

Hingefahren nemlich einer langen tubum (a telescope)	*fur 30 doppien*
Ein Microscopium (a microscope)	*fur 8*
Ein Camera Obscura	*fur 6 1/2*
Una altera per la notte (another [clock] for the night)	*fur1 1/2*
	fur 46 doppien.[1287]

The precise location of Campani's shop or observatory on the Janiculum [Gianicolo] can no longer be established with certainty, but the diary related how after the Landgrave had visited his shop, he and his secretary walked around the neighborhood. The diary noted that they had seen the sober and dignified façade of the nearby Church of San Pietro in Montorio that had been built in 1481 for King Ferdinand and Queen Isabella of Spain. In one of its chapels they particularly noted a fresco depicting the Flagellation by Sebastiano del Piombo. They followed down a steep path with flights of steps that terminated on the terrace just in front of the church. Beside it, in the cloister of the Franciscan monastery, they discovered the famed architectural creation Bramante's celebrated small circular *Tempietto*, framed in the shadowy arch of the cloister. It marked the spot once believed to have been the site of St. Peter's crucifixion. A much older church had formerly existed on the site.

From the terrace in front of the church, the German visitors looked down into the streets and houses of the Trastevere far below and were afforded one of the most celebrated views of the Eternal City. The Palatine and Aventine and their green oases were visible across the red tiled roofs of the Trastevere, while in the far distance they had a glimpse of the portico of St. John Lateran. The Landgrave and his party wandered further along, turning right on the hill beyond San Pietro in Montorio, moving up until they came to the monumental Fontanone dell'Acqua Paola. It had been commissioned by Pope Paul V and built in 1612 to the designs of Giovanni Fontana with stone that had been taken from the Forum of Nerva.

The Landgrave and his traveling companions remained in Italy from December 1699 until April 1700. During that period, the Landgrave visited Campani's shop several times and made

[1287] Klaute, *Diarium Italicum*, 159.

additional purchases. On one of the Landgrave's visits, Campani related to him the story of his younger son's dereliction and asked him to use his influence to try to obtain information in Augsburg about him. The Landgrave made every effort to do so but without success, and so reported to the boy's father. The Landgrave's secretary recorded in his travel diary:

> This renowned Virtuoso complained to me how his only remaining son, who in lens grinding and optical science had already made good progress, one year ago was corrupted by other wretched young men and became a soldier in Augsburg. Since the calf skin or drum did not suit him, however, and he, as one had instructed him, ran therefrom. Should he the good for nothing in that very place in part have become. Since I now had friends in Augsburg, the good old one implored me to inquire of the certainty (reliable information) and notify him of the state of affairs. In order for me to keep such in my memory, he made me a gift, of an although small but very accurate perspective [glass]. I have thereupon written to Augsburg on his behalf, but from an answer received that at no time a soldier of this name had in there stood, early in the century very few were hanged because of having committed desertion, which information the old father himself let serve as consolation.[1288]

A search made in recent times of the military records in the state archives of Augsburg and related published literature has failed to bring to light any mention of young Campani. The possibility exists that he may have joined the army under an assumed name.[1289]

Among the Landgrave's papers related to his visit to Campani's shop during his sojourn in Italy was to be found a unique copy of Campani's printed price list for his optical instruments, the only example that has come to light. On a sheet of paper was printed the measure of a Roman palm. The remainder of the text in Italian is translated as follows:

> Prices for Telescopes having four lenses of various lengths made by Giuseppe Campani in Rome, which he claims to be the most perfect that have been produced until now by any other Maker.

From 1-1/2 up to 2-1/2 palms valued at *scudi*	– 20
From 3 palms up to 4-1/2 palms	– 24
Of 6.37 palms	– 30
Of 8 and 10 palms	– 35
Of 12 and 13 palms	– 45
Of 15 palms	– 55
Of 20 palms	– 75
Of 25 palms	– 90
Of 30 palms	– 120
Of 40 palms	– 180
Of 60 palms	– 300
Of 100 palms	– 500
Of 150 palms	– 800
Of 200 palms	–1,000
Small Hand telescopes	– 3

> Other hand Telescopes that provide a wide field of view where little light is available and particularly useful at night in the Theatres:

The longest	– 6
Of Medium size	– 4

> The Microscope of the Newest Invention that serves for observing
> every types of object, be they transparent, opaque, solid or fluid,

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[1288] Ibid., 159.

[1289] Communication from Dr. Wolfram Baer, director, Stadtarchiv, Augsburg (March 31, 1981).

valued at – *scudi* 24

The Microscope of a single Lens, or for *linea lavorata*, that serves for observing transparent objects, and fluids, miraculously enlarging with clarity, valued at – *scudi* 10[1290]

Several of the Campani instruments that the Landgrave had purchased during that visit have survived and presently are preserved in the Museum für Astronomie und Technikgeschichte in Kassel. Among the Landgrave's purchases while in Rome was a Campani screw-barrel microscope and a *perspektiv* or terrestrial telescope. Surviving is the large wooden telescope made by Campani in 1699, which the Landgrave had purchased during his visit to Campani's shop and which he brought back to Kassel personally with him upon his return. Regrettably, its original mounting was destroyed during the bombing of Kassel in World War II.[1291]

Half a century later, Zacharias Conrad von Uffenbach, while touring through lower Saxony, Hesse, the Netherlands, and England, visited Kassel. There, on November 20, 1752, he was shown the Landgrave's scientific collection by Professor Zumbach von Koesfeld. Uffenbach wrote an account of the visit, noting that: "After seeing some things that Zumbach had displayed for us, he shows us an 'uncomparable' object lens made by the most famous and finest glass cutter [sic, lens maker] whose name was inscribed on the periphery of the lens, '*Giuseppe Campani in Roma 1684 Palmi 145*'. It took 100 pistols of money because he—Campani—is very expensive and stubborn with his work", concerning which Zumbach had this following story: "The Academie Royale des Science in Paris", he recounted, "purchased such a lens from Campani but the lens was broken during transit and the Academie offered to pay him only half the price he asked. Campani did not agree and requested instead that the pieces of the lens be returned to him. My conjecture is that 'the good Campani' did not trust the Academie in Paris and suspected that the lens had not in fact been broken but that they were attempting to acquire the lens for a lesser price".[1292]

The story of this lens was told by an eyewitness, the French astronomer Joseph Jérôme Lefrançois de Lalande in an account of his travels in Italy in 1765 and 1766, during which he visited Bologna. While there he was taken by the curator, Ercole Lelli, on tour of the Institute of the Sciences. Lalande wrote, "M. Hercule Lelli, who exhibited them [the instruments in the Cabinet of Physics] showed me also an object-lens for a telescope having a focal length of 205 palms [141 French feet] the work of the celebrated Joseph Campani: it had been made by order of M. Colbert; but upon the death of this great Minister, which occurred in 1683, the lens was sent back to Rome: it had been broken into two pieces, but M. Campani rejoined the two pieces in such a manner that

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1290 Klaute, *Diarium Italicum*, 129.

1291 Photograph taken in c. 1990 of the long telescope made by Campani in 1684 and purchased by the Landgrave Karl of Hesse on his tour of Italy. From Mackensen, *Naturwissenschaftlich-technische Sammlung,* 76.

1292 Zacharias Conrad von Uffenbach, *Diary*, entry for November 10, 1751; from Dr. Juergen Hamel, Archenbold Sternwarte, Alt-Treptow, Berlin (August 13, 2002).

one could actually use it as if it were still whole, and this is the most beautiful telescope glass that exists in the world".[1293]

[Figure]

As Campani entered his seventies, the burden of his advancing years had become more and more apparent to him. Despite his anxious efforts to obtain news about his sons, he received no further news about Carlo nor any word from or about his second son Michel Angelo. After the brief visit made by his older son, Carlo, he also was never heard of again. His wife Theopista, meanwhile, had become a house-born invalid and could no longer manage the household as before and relied for assistance on their two unmarried daughters, Teresa and Maria Vittoria, who had remained at home.

Having waited impatiently year after year with hopes for the return of one or both of his sons to the family hearth, Campani gradually became resigned and more and more embittered. He recalled the countless months and years he had spent patiently training first Carlo and then Michel Angelo in the techniques of lens grinding and polishing and the pleasure he had taken as he observed the growing application of their skills. Then to have it all cast away first by one and then by the other became a source of great sorrow. At the same time, he constantly worried also about their well-being. He wondered how they fared among strangers, out in the world by themselves, and from day to day he expected there might be some word; even unpleasant news would be better than none at all.

Finally arriving at the conclusion that he could no longer count upon the return of either of his two sons, and determined that his work should be carried on after his demise, Campani had no alternative but to turn to the two unmarried daughters still at home. He set to work to train them both at the same time in his techniques and in the use of his lathes and other shop equipment. The young women went out of their way to please their unhappy father and spent long hours working with him in his shop in addition to attending to their household chores.

Both of them proved to be not only amenable but also surprisingly capable. Teresa, the older daughter, in particular, readily mastered the technical aspects of laboratory work, while Maria Vittoria demonstrated useful business skills and ability to deal with clients, so he felt reassured that working together they would be able to manage successfully. The question remains whether

[1293] Joseph Jérôme Le Français de Lalande, *Voyage en Italie: contenant l'histoire & les anecdotes les plus singulieres de l'Italie, & sa description ; les usages, le gouvernement ... ; avec des jugemens sur les ouvrages de peinture, sculpture & architecture, & les plans des toutes les grandes villes d'Italie* (Venise: Desaint, 1769), 37; Tabarroni, "La lente spezzata del Campani conservata nell'Istituto di Fisica dell'Università di Studi di Bologna", 433–42; Giorgio Dragoni, "La ricostituzione del Museo dell'Istituto di Fisica dell'Università di Bologna," in *Gli strumenti nella storia e nella filosofia della scienza*, ed. Gino Tarozzi (Bologna: Istituto per i beni artistici, culturali, naturali della Regione Emilia Romagna, 1984), 40–45. The lens is presently preserved in the Museo di Fisica of the University of Bologna – Musei di Palazzo Poggi.

Campani considered the wishes of the young women and whether they were satisfied with their new role. Had they had a desire to marry, perhaps, or to join a religious order? If so, there is no doubt that parental obedience took precedence and prevailed as they resolved themselves to a spinster future.

And so life went on in the Campani household, and Giuseppe took pleasure from the commissions for instruments he continued to receive. In May 1705, when he was then 70 years of age, Campani wrote to Grand Duke Gian Gastone in Florence in a letter copied by a scribe concerning his latest invention in optical instrumentation—telescopes measuring more than several hundred palms in length, an account of which the Grand Duke had requested. "Having experimented many times", Campani wrote, "which Your Highness deigned to acknowledge, as well as my most humble servitude and also the dioptric works of telescopes and microscopes that to my great honor I was commanded to transmit for your service, and which, as ultimately I was assured by *Sig*. Count Fede, your most respected agent, has met the approbation that the telescope lenses which I made. I also submit for your generous appreciation the notice of a rare invention, much desired by mathematicians, concerning the use of the telescopes that extend an extraordinary distance of several hundred palms. The narrative of this discovery of mine has been requested by a foreigner who wished to put in light in a publication, but knowing the propensity of Your Highness relating to the noble inclination of your House to be always a glorious protector of the sciences, I have esteemed it to be my debt to send it to Your Highness first of all before any other with the annexed copy, so that before anyone else you will be informed personally by the author of the invention itself, rather than to have to seek another source".[1294]

Several years later, Campani offered one of his lenses of great focal length to the Jesuit priest Antoine-François Laval, hydrographer to the French king, who already had become well known as an astronomer. Upon receiving the offer, Laval wrote about it to Cassini: "Sr. Campani has asked me one hundred Roman *eçus* for an object-lens of 20 to 25 feet, and he informed me that he is letting me have it at a bargain price, because he wished to give me pleasure, and hopes that I make note during the observations that it is by means of his objective that I will be served". It is not known whether Laval purchased the lens being offered.[1295]

[1294] BNCF, *Gal.* vol. 284 c. 80, letter from Giuseppe Campani to Grand Duke Gian Gastone on May 9, 1705, with enclosure.

[1295] Bibliothèque de l'Observatoire de Paris, letter from Antoine-François Laval to Jean Dominique Cassini on February 20, 1710. Laval (1664–1728) was born at Lyon, entered the Jesuit order at the age of 16, taught grammar and rhetoric, and was named professor of hydrography at Marseille in 1697, then at Toulon in 1718, where he ended his career. A great part of his astronomical observations was published in the *Mèmoires de Trévoux* and in the publications of the Academie des Sciences. A copy of his journal produced by order of Delisle is in the archives of the Observatoire de Paris and contains all his observations to 1724. [Suzanne Dèbarbat and Simone Dumont, "Antoine-François Laval (1664–1728) hydrographe du roi, jésuite et astronome," in *Actes du 115e Congrès National des Sociétes Savantes* (Congrès National des Sociétes Savantes, Avignon: Editions du C.T.H.S., 1990), 17–26, *vide* p. 20 ; Bibliothèque de

Among the instruments owned by Bianchini and which he had continued to use until late in his life was a telescope 50 palms (11.17 meters) in length which Campani had provided to him and with which it was possible to discern a star of the first size even in full daylight. In 1725, Bianchini observed the spots of Venus from the Platine, in a locality much adaptable for his use without disturbance, using a telescope of 90 palms (20.10 meters). By means of observations he made with aerial telescopes of 25 and 35 feet, made by Campani, Bianchini concluded that Venus rotates upon an axis inclined at approximately 75 degrees to the plane of its orbit in slightly more than 24 days. This conclusion was quite in variance with the one obtained by Cassini. A critical comparison between the two sets of observations were made with telescopes of 82 and 114 feet focus, but they were unable to see any permanent markings on the disk.[1296]

Campani no longer was able to work during the last several years of his life, and from the correspondence between Bianchini and Maraldi, it was apparent that it had become well known that lenses for telescopes now were available not from Campani but from his daughters.[1297]

Bianchini had continued to maintain contact with Campani even after his retirement. In a letter written in 1713, Marchese Paride Maria Salvago wrote to Bianchini: "I have heard with pleasure what you have said about *Signor* Campani, who does not wish to deprive the world of his secret method of working lenses. Having, as I am told, instructed his daughters, we shall have to see if they will know how to serve as has the father, and if they are furnished with the same ability and dexterity of hand. He had shown good judgment in leaving on earth an art that would not serve for the sky where he will be".[1298]

In the same year, the Campani sisters furnished a telescope of 94 palms (21 meters) to the Count d'Osembray at the same time that they were busily involved with providing lenses and instruments that had been commissioned from their father for João V de Braganza, King of Portugal.[1299]

Giuseppe Campani died on July 28, 1715, at the age of 80 years. He was buried on the following day in his parish church of Santa Maria in Monterone. His death was noted in the records of the church preserved in the Vicariatio di Roma:

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l'Observatoire de Paris, letter from A. F. Laval to Cassini on February 20, 1710.

[1296] Armando Schiavo, *La meridiana di S. Maria degli Angeli* (Roma: Istituto poligrafico e Zecca dello Stato, Libreria dello Stato, 1993), 32, 46–49; Bianchini, *Hesperi et phosphori nova phaenomena*, 22; Jaques Cassini, *Memoires Académie des Sciences* (Paris), p. 197 (1732).

[1297] Schiavo, *Meridiana*, 63; Cornelio Desimoni, "Notizie di Paris Maria Salvago e del suo Osservatorio Astronomico in Carbonara, con appendice di tavole cronologiche," *Giornale ligustico di Archeologia, Storia e Belle Arti*, no. III (1876): vol 2, 465–86, vol. 3, 41-65; Riccardo Balestrieri, "Un progetto per la storia dell'astronomia in Liguria," in *Atti del Convegno Nazionale di Storia della Fisica e dell'Astronomia. Centro Volta, Villa Olmo, Como, 24-25 maggio 1996*, ed. P. Tucci (Como, 1996).

[1298] Schiavo, *Meridiana*, 62; letter from the Marchese Paride Maria Salvago to Francesco Bianchini on November 25, 1713.

[1299] Ibid., 62-63.

Die 28 Julij 1715. D. Joseph Campana vir eximius in sua professione matematice filius quondam Angeli e Castro S. Felicis Diecesis Spoletane etatis sue annorum octaginta circiter, recepto tantum sacramento estreme unctionis, non vero Penitentie et Sanctissimi Viatici, quia non erat mentis compos in communione S. Matris Ecclesie animam Deo reddidit, et eius cadaver die sequenti sepultum fuit in hac Parochiali Ecclesia.[1300]

Bianchini received his first news of Campani's death from the Marchese Salvago in a letter written from Genoa:

I have learned with great sadness of the loss that has occurred of Campani, who despite his advanced age continued to promise great things from his hands in any manner he had great merit with the public, who will mourn him for a long time not having him still alive, and while his daughters will be able to maintain his memory still alive, in any case I do not know whether he has been able to leave heirs having the felicity of his hand in giving form and polish to lenses of long vision. I have pleasure in understanding at the same time that you are the executor of his estate. It is an obvious sign of the esteem he held of your goodness and valor, to whom he has confided all that he held most precious, assembled in such a long period of time. There must be among his papers practical notes that will provide light to those who are not ignorant of optics, and if he will have noted completed objectives and their lenses, of their size and prices, it would be possible to cooperate in their disposition. It is certain that until his death no other artisan has surpassed him in the production of lenses of excessive and not ordinary size.[1301]

Having anticipated in his final years his approaching demise, on January 7, 1711, Giuseppe had prepared his last will and testament and it was made public the day after his death, on July 29, 1715. In it he specified a number of strict provisions. First of all, he asked that following his death he was to be buried "in the venerable church of the parish where I would follow my mother". In addition to the number of masses that his heirs planned to have said for his salvation, he "ordered and commanded" that they have celebrated in whatever manner suited them another 200 low masses, and that they distributed 15 *scudi* as a charity to the poor, during the next 3 years.

To his beloved wife, Theopista Santori, he bequeathed, in addition to the furnishings she considered necessary, the sum of 38 *scudi* to be paid semi-annually for the remainder of her natural life, funds to be derived partly from the rents from properties he owned, and the other part from the fruits of exchange of a principal of 351 *scudi* of which he was *testore* against Angelo Antonio Bianchini of Castel di Martignano, which was a district of Castel San Felice, and from Lorenzo Medei of Castel San Felice, according to contracts made on May 2, 1701, October 3, 1702, and March 15, 1710, for a total of 308-1/2 *scudi* annually.

In a preferential legacy [*prelegato*] to his surviving daughters Teresa and Maria Vittoria he had left equal shares of:

all instruments, lathes, and devices [*linie* and *ordegni*] of every type possible, which served for my profession of optical instrument maker, or for making instruments, from then to repair, make the cases, a box of spectacles and large telescopes together with the benches, tables, shelves, cabinets and materials of every sort, and especially that serve my profession with everything, individual products, lenses, telescopes, and all

[1300] Ibid. p. 63; ASVR, *S. Maria in Monterone*, *morti,* 1636-1719, f. 95.
[1301] Ibid. Biblioteca Vallicelliana, fondo Mss. (Rome), vol. U18, cc. 1607–1608.

other worked glasses and worked for any distances, lengths, widths, and forms, that remain and which in any manner would serve them and which at the time of my death may be found in Rome as well as elsewhere, such instruments and tools I wish to go to my children Teresa and Maria Victoria, immediately upon my death, making it possible for them to take possession with proper authority without they be given to them neither by any justice or other heirs.[1302]

Based upon the wording of the will, it was apparent that it was expected that Campani's wife, Theopista, who had become infirm, would continue in that condition. He declared that he had four surviving children, two sons, Carlo and Michel Angelo, and the two daughters all by the same wife. The two sons having departed from Rome from 16 to 18 years before, of Michel Angelo he had received no further news, although he had used every possible means to discover where he was, and Carlo had returned once and had received from his father 610 *scudi* against his future inheritance, and thereupon left Rome once more and nothing more was known of him, despite every effort that Campani made and had commissioned to be made by many friends and patrons to determine what happened to him. He was willing to pardon "all offences and disobedience and disgusting acts" and would abolish and annul his agreement made with Carlo if he returned. The amount already paid him, however, was to be a share of future inheritance notwithstanding.

Campani named the four children, two sons and two daughters, as his rightful and proprietary heirs. In the event that neither of his sons were located by the time of his death, his daughters were to share equally as his heirs and they had the right to sell, immediately upon his death, and whenever it pleased them, those furnishings which were not needed by them and their mother and, if within a year after his death his male heirs were not found, everything went to the surviving daughters. As his executors he named Monsignor el Vico, *Votante di Segnatura*, and Monsignor Francesco Bianchini.[1303]

Campani's house in which he died was situated in the Piazza della Valle, formerly known as the Piazza dei Quatracci. It was adjacent to the Church of San Andrea della Valle and fronted upon the main doors of the convent of Sant'Andrea della Valle, which was attached at the left side of the church. Campani's house was a free-standing building next to the church in the area now usurped by the Corso Vittorio Emanuele. He was a member of the parish of the nearby church of Santa Maria in Monterone, and it was for that reason that he was subsequently buried there.

Since Campani's time, the parish church has been completely remodeled several times, first in 1682 and again in 1754, when the paving inside the building had to be raised because of flooding from the Tiber. The process of laying new paving required removal of numerous inscribed tombstones in the process, including any memorial there may have been to Giuseppe Campani. In

[1302] ASCRC, Notary Giuseppe Perugino, Camera del Vicario, sez. XLIV, vol. 135. ASR, Notary Giuseppe Perugino, vols. 5782-5786, cc. 646-650, 683-686, 745-747, 751-762, 771-782, 786, 788.

[1303] Ibid., fols. 647r-v–650r-v.

1728, the church was assigned by Pope Benedict XIII to the Mercedari brotherhood, of the Order of the Blessed Mary Virgin of the Mercede. The Order was founded in 1218 in Barcelona and became a mendicant order in 1690. In 1815, Pope Pius VII re-assigned the church to the Padri Redentoristi, the order that occupies it at present.[1304]

Campani also owned a house in the castle town of Albano, high above Rome. Originally the Santori home of his wife's family, it was a substantial establishment. Presently it is unidentified, but it is unlikely that it was the building presently known in the community as "Palazzo Campano", which has become a pizzeria in modern times. That edifice appears to have been the palace that had been built in 1465 for Archbishop Gianantonio Campano. Giuseppe Campani also owned a vineyard.

In the inventory of Giuseppe Campani's estate, seven timepieces or parts thereof are listed. None are identified by maker, and one or more may have been his work, although none appears to represent one of his own inventions:

> A clock with case and urn of ebonized pearwood having capitals and other ornaments of gilt metal copper in front, painted with various pictures. 40
>
> A clock mounted atop a pillar having a walnut case and brass dial plate. 75
>
> A clock of round shape with its counterweights and a black frame............. 15
>
> A clock in a gilt copper case, having small figurines and two silver chapter rings for minutes. Said clock with its bell, was supported upon a base of ebonized pearwood that contains a small drawer.. 8
>
> A pocket watch with strike with pierced silver case. 9
>
> Clock case of engraved copper and with gilded figures................................ 3
>
> A frame for a clock of ebonized pearwood, and two other clock cases that no longer are serviceable. .... 50[1305]

[1304] Letter from Rev. Salza, Padri Redentoristi, Via Monterone 75, Rome, on February 14, 1952; Cecilia Pericoli Ridolfini, *Rione VIII : S. Eustachio, parte III*, Guide rionali di Roma (Roma: Palombi, 1984), 117–22.

[1305] ASR, Notary Giuseppe Perugino, vols. 5782-5786, cc. 646-650, 683-686, 745-747, 751-762, 771-782, 786, 788.

Chapter XXIII

GIUSEPPE'S DAUGHTERS

(1715–1763)

I have heard with pleasure what you have said about Signor Campani, who does not wish to deprive the world of his secret method of working lenses. Having, as I am told, instructed his daughters, we shall have to see if they will know how to serve as has the father, and if they are furnished with the same ability and dexterity of hand.

Marchese Paride Maria Salvago[1306]

At the time of Giuseppe Campani's death in 1715, his daughter Teresa was in her 34th year of age and Maria Vittoria was 29. During their father's final illness, they had already been working together, operating his shop for several years in accordance with his instructions. After his death, they continued to live at home, caring for their mother and maintaining his shop as before because it was already fully equipped and its location well known to his prospective clientele. For them it was not a matter of earning an income, because their late father's substantial estate had left them wealthy, but because it had been a promise to him to continue his work that they were obligated to fulfill.

After Theopista's demise, the date of which is not recorded, the Campani sisters sold both their father's former residence and his shop and moved to the more fashionable business district at the Quattro Fontane, which had been built for Pope Sixtus V (Felice Peretti 1585–1590), situated at the crossing between two main streets, Strada Felice and Strada Pia leading to the Quirinal palace. Nearby were several palaces including the imposing Palazzo of Cardinal Alessandro Albani. At first they maintained a home a short distance away on the nearby Strada Felice, one of the five large arteries radiating from Santa Maria Maggiore. Strada Felice (also called Via Felice) was a street that had been opened by Pope Sixtus V and named for him and corresponds to the actual Via Sistina-Quattro Fontane, Agostino Depretis, etc., that extends from the Church of Trinità dei Monti and terminates at the Church of Santa Maria Maggiore. In the early eighteenth century, the Strada

[1306] Schiavo, *Meridiana*, 62; letter from the Marchese Paride Maria Salvago to Francesco Bianchini on November 25, 1713.

continued through vineyards and gardens with which that part of the city was then filled and which had not yet been urbanized.[1307]

The street, after 1870, was re-named Via Sistina and ran between Piazza Barberini and the Church of Trinità dei Monti. The four fountains from which the region of Quattro Fontane derived its name had been constructed in 1587 at the point of the summit of the Quirinal hill, where the Via Felice formed a cross-roads with Via Pia (now Via XX Settembre), and which thereafter gave the name to the street from Piazza Barberini toward Via Nazionale. More recently, the section between Via Nazionale and Santa Maria Maggiore has been given the name of Via Agostino Depretis.[1308]

At about the same time that they moved their home and shop, the sisters also transferred from their family's parish Santa Maria in Monterone and joined the parish of San Nicola in Via in Arcione, which was close by the Largo Tritone. This small church, which had existed since the end of the tenth century, had been rebuilt in their time when the sisters began to worship there, but it finally was demolished in 1907.

Later the sisters found it convenient to move once more, and they purchased a home, described as a house of modest size, adjacent to Palazzo Galloppi, on Via Quirinale 21 in the immediate vicinity of the Church of San Carlo alle Quattro Fontane, locally known as "San Carlino". It was the church of the Spanish Congregation of the Discalced Trinitarians. It was designed and built by Francesco Borromini with limited funds and in limited space in the early eighteenth century, after he had first completed the small monastery of the Order with a tiny cloister and an adjacent monastic yard. The church had been only recently completed when the sisters moved there.

Although both Teresa and Maria Vittoria had been trained in the art of lens-grinding and optical instrument making by their father during his final years, the sisters now in their own shop divided their responsibilities to their best advantage. Teresa, the older and the more manually skilled and experienced, became the active artisan working in the private regions of the shop, grinding and polishing lenses and assembling the instruments. The younger Maria Vittoria, meanwhile, proved to be more socially oriented and maintained the public part of the shop. She was responsible for the displays of merchandise, accounting, and record keeping, and she was the more adept at dealing with clients.

Campani's former clients undoubtedly were frequenters of the fashionable region of the Quattro Fontane and readily found their way to the shop of his daughters, and soon it was often visited also by prospective new clients. The French astronomer Joseph Jérôme Le Français de Lalande, in the account of his voyage in Italy during 1765 and 1766 written some years later, wrote

[1307] Masson, *The Companion Guide to Rome*, Strada Felice, Via Sistina, and Via Pia.
[1308] Communication from Carlo Pietrangeli (March 26, 1991).

that he had been told by an unnamed informant of a visit the latter had made to the shop during the period while it was still being maintained by the sisters. The informant said he had come primarily out of curiosity and not to purchase and noted that the two daughters of Campani "successfully continued his commerce in Rome, and they have been still by the Quattro Fontane for thirty-five years".[1309] They maintained their clientele more due to the fame of their father, selling *lunettes d'approche* and other optical works; while the other never showed herself and presumably kept herself occupied in working in the laboratory, the one reluctantly responded to the public; they sold much more expensively than others, but the name of their father still sustained their reputation. Meanwhile, however, the great invention of achromatic lenses began to make those of Campani negligible and of the most competent optical workers who had them.

If, as de LaLande's informant had reported, Campani's daughter Maria Vittoria appeared to be reluctant and responded to the public with much difficulty, it may have been due to increasing poor health as she entered her later years. The shop of Campani's daughters remained modestly successful for more than 30 years. In addition to their father's shop and tools, the sisters had inherited a substantial stock of lenses and instruments, some already completed, others in progress, and a stock of materials, all of which the sisters made good use. In addition to these were new lenses and instruments that Teresa produced in the shop's back room, or laboratory. All seemed to be going moderately well for the spinster sisters, until Teresia became ill and finally was no longer able to work in the shop. According to the church census taken in 1741, the household of the Campani sisters then included, in addition to themselves, a man named Filippo Corbeta (aged 45), not identified, who may have been an artisan employed by the sisters to assist them in the shop or may have been one of their father's former employees.[1310]

Teresa lingered on, unable to work and having to be cared for at home. Finally, on December 26, 1741, she died, at the age of 60, and was buried in her parish church, San Nicola in Arcione. Maria Vittoria, who now had reached the age of 55, had been left to operate the shop alone.[1311] She managed to carry on, possibly with a hired assistant. She continued to sell lenses and telescopes as long as a demand existed but, eventually, by the time she was 60, sales had diminished substantially, as indeed had the extra stock. Since Maria Vittoria had not been engaged in producing new lenses during the past few years, after Teresa's death she had to rely on selling the remaining stock on hand. This consisted of work that had been completed by her sister and some

[1309] Lalande, *Voyage en Italie*, vol. 2, Chap. 3, 39-41. Joseph Jérome Le Français de La Lande (1732–1807) was a French astronomer who improved the planetary tables of Edmund Halley and others; in 1751, the Academie Royale sent him to determine the moon's parallax. He became director of the Paris observatory in 1768. He is the author of *Traite de l'Astronomie* (1764) and *Histoire Celeste Francaise* (1801).

[1310] ASVR, *S. Nicola in Arcione, anime,* (1741-1742).

[1311] ASVR, *S. Nicola in Arcione*, *morti,* vol. 35, fol. 73v (1729–1749).

that had remained from the stock inherited from her father. Little by little in the course of time, these quantities also diminished.

Now finding herself alone in the world, Maria Vittoria's age and the burden of having sole responsibility for the shop began to weigh on her. She arrived at the realization that she no longer could continue alone. It was a difficult decision as she reluctantly concluded she must sell the shop and its trade. As De LaLande had foretold, the new invention of achromatic lenses had been increasingly overshadowing the fame of Campani lenses and instruments, causing their sales to diminish substantially by this time. Maria Vittoria attempted vainly to find a purchaser for the shop and its contents, but without success. With no prospect of a purchaser, she then concentrated on selling as much as possible of her stock on hand, thus managing to continue the business for the next several years. She faced a grim future as her prospects appeared to be diminishing with each passing day.

Then, from fortuitous contacts at the nearby papal palace of the Quirinal, Maria Vittoria happened to be informed how in recent years the incumbent Pontiff, Benedict XIV, had been generously supporting an institute of the sciences in his native Bologna, repeatedly making gifts of art and scientific programs. She informed herself as much as possible of the institute's history and of the Pontiff's plans for its future expansion.

Maria Vittoria thereupon exercised every means at her command and utilized her contacts connected with the Church in order to communicate with someone in the Pontiff's retinue. She was anxious to do so particularly during the months that he remained in residence at the nearby Quirinal palace, before he returned to Vatican hill for the winter. It is clear, from the wording of the subsequent Chirograph, that it was by means of Maria Vittoria's dogged persistence that she managed to bring her offer to the personal attention of the Pontiff. It is even possible that a meeting with him had been arranged for her, during which she transacted the sale. The Pontiff was extremely pleased to have negotiated such an important acquisition, and he proceeded to arrange for its purchase without delay. The earliest record of the accomplished transaction is a Chirograph, an autograph papal decree, of May 6, 1746. The next Chirograph, dated December 30, 1746, and signed by Pope Benedict XIV, was directed to Cardinal Silvio Valenti, the Vatican's Secretary of State:

It has been represented to us by Maria Vittoria Campana [sic] that, having her father Giuseppe Campana died in the year 1715, he left in his estate various object-lenses and other optical instruments, of which, as heir, although she had with diligence continually tried to sell it [the workshop] in this period of time, she was unable to obtain a suitable offer, and thinking about it, she finally, with repeated supplications to us, offered the collection for whatever price we wished to offer. And we accepted on your behalf a similar offer and for the fulfillment and execution of the same, we have exhibited the one time payment of three hundred *scudi* and the payment of twelve *scudi* a month during the rest of her natural life; these conditions were agreed by Maria Vittoria to be equitable, and for the most of a great length and means until now found, she accepted for an act of our Father's clemency. She begged for the completion of a contract with which the present

Chirograph we express the precise quality, quantity, and value of the objects and other optical instruments, and any other item which are necessary to be expressed, of our *Motu Proprio* [...] habilitating we Maria Vittoria to have [this transaction] done by herself, without the intervention and consent of her closest relatives with a decree from a judge, and without the serving of the prescribed solemnity of the laws or statutes of this our city and their reforms, we order that in our name, for us at our liberty to make disposition to purchase and acquire from her thirteen object-lenses of various focal lengths from fifty to two hundred palms, and all individual lathes, plates [molds], and any other mathematical instruments related to working telescopes, that is, of optics inherited from the noted Giuseppe Campana her father, for the price and name of the price that is three hundred *scudi* in currency, which according to the stipulation in the contract you will pay from money existing in our general depository in a separate account at your disposition, and the payment of twelve *scudi* a month to the seller Maria Vittoria during the remainder of her natural life, you will do and constitute [...] over the rents of our Chancellery and [...] applied after the death of the Rev.^{mo} Cardinal Ottoboni to our Camera [Chambers], and, in case they might not be sufficient, in general through the incomes and rents of the same Camera of ours; and in that case, as a guarantee, we raise on those incomes and rents a mortgage, so that You, in our name, will be able to secure in favor of the aforesaid Seller the regular payment of the above-mentioned twelve *scudi* during her natural life only, and in this form you will draw up the necessary Contract of sale, with the usual clauses, granting you the right to receive the aforesaid lenses, and the other aforesaid Instruments of Optics, and to issue for that the required receipt, and also to designate any person you wish in order to fulfill the mentioned matters, since that is our decision and our precise will. We therefore order and decree our present Chirograph, even if not admitted and not registered in the Camera, to be valid and always to have its full effect, execution and validity by means of our simple signing only, even if Monsignor the Administrator of our Camera and the closest relatives of the aforesaid Maria Vittoria have not been called, summoned or consulted, notwithstanding the Constitutions of our predecessors [...] To all those (regulations) having here expressed the conditions in clear words, to make a special and specific exception for this time only and only for the aforesaid purpose.

Given in our Apostolic Palace of the Quirinale on the 30th of December 1746.

Benedictus P. P. XIV.

We the undersigned designate the Abbot Antonio Cosimi as our Procurator so that he can carry out in our name all the dispositions cited in the above-mentioned Chirograph having all the necessary and appropriate powers granted us by the same Chirograph.

From our Residence in the Palace of the Quirinal, 30th December, 1746,

S. Cardinal Valenti.[1312]

Constantly surrounded by many men of learning of his time and corresponding with as many others, the Pontiff ‘s interest in the sciences and in history was reflected again and again in his many gifts to museums and academies, some of which he had founded. He also established chairs for chemistry, mathematics, and the various arts in numerous schools.

Pope Benedict XIV maintained a particularly lively interest in the Institute of the Sciences in his native city, which was acquiring esteem and honor in the scholarly world by means of publications produced by its faculty. Inspired by the examples of his predecessors, the pontiffs Clement XI and Clement XII, Benedict XIV was led to imitate them by benefitting the Institute by donations made from his personal funds to fulfill its immediate needs and for the acquisition of desirable collections useful to the faculty.[1313]

1312 Benedict XIV, *Lettere, brevi, chirografi, bolle, ed appostoliche determinazioni prese dalla Santità di Nostro Signore Papa Benedetto XIV nel suo pontificato per la città di Bologna sua patria*, vol. 2 (Bologna: presso il Longhi stampatore arcivescovile, 1751), 334–44.

1313 Bolletti, *Dell' origine e de' progressi dell' Instituto delle scienze di Bologna*; Bolletti, Angelelli, and Angelelli, *Notizie dell'origine, e progressi dell'Instituto delle scienze di Bologna e sue accademie.*

The purchase of the Campani collection was announced in a *Motu Proprio* dated November 28, 1747, in which the Pope stated that the collection would be added to the Institute of the Sciences in Bologna. This administrative act of the Holy See was drawn up, signed, and issued by the Pontiff, evidently of his own accord without the advice of others, expressing his desire to assist the development of the Institute.

The *Motu Proprio* also noted the lack of adequate materials and studies on anatomy at the Institute, for which he proposed the establishment of an annual lecture series with suitable exhibits. Accordingly, he commissioned the artist Ercole Lelli to create eight statues in wax, to be accompanied by explanatory tables, to demonstrate the study of muscles and of bones. A room in the Institute was to be set aside to accommodate the statues in individual wall niches. Lelli was appointed curator and exhibitor of this special hall for the remainder of his lifetime. Upon his demise, a successor was to be appointed by the state's *Reggimento*, which would initiate the practice of naming a professor to be in charge of each of the Institute's departments or halls. If and when Lelli were to be absent, or when the position became vacant, the Institute's *Assunteria* would submit the vacancy to the custodianship of the *Reggimento*, and that body would select the successor.[1314]

The selection of Ercole Lelli having been made personally by the Pontiff for such an important position in the Institute was not surprising. Lelli already had achieved considerable renown in his native city and was recognized as one of Italy's foremost painters, sculptors, and engravers of his time. Lelli worked in many materials, and in 1734, he produced two wax ecorchés for the anatomical school of the University of Bologna. He also had been commissioned by Count Niccolò Aldrovandi to create several anatomical figures in wax, but the patron died before they were completed.

The Pontiff, while still Cardinal Prospero Lambertini, Archbishop of Bologna, had conceived the idea of adding eight figures to the uncompleted series in the Institute's Hall of Anatomy. When he was elected pope in 1740, Benedict XIV proceeded to commission Lelli to continue the project at the Pontiff's personal expense, to be completed within the next 6 years. The completed figures brought Lelli great additional prestige and resulted in his election to the Accademia Clementina. These eight statues were the primary reason for the issuance of the *Motu Proprio*, which provided for their installation in the Institute.[1315]

[1314] Benedict XIV, *Lettere, brevi, ...*, 2:334–44. The *Reggimento* was the city government; the *Assunteria* were the appointed officials.

[1315] Ibid., 334-344 ; Ercole Lelli (1702–1766), anatomist and sculptor, worked at first as a gunsmith in his father's workshop in Strada San Donato, together with his brother Antonio, and like him was licensed as an expert by the Holy Office. He was a painter, sculptor, engraver, and optical worker. He was a memebr of the Accademia Clementino from 1746. He died in March 1766 at Bologna. He was an engraver at the papal mint at Bologna from 1734

The same *Motu Proprio* then proceeded to announce the purchase of the contents of Giuseppe Campani's shop, which was to be maintained under Lelli's custody, inasmuch as he already possessed sufficient theoretical knowledge of the science of optics and had practiced the construction of dioptric glasses. To reassure himself, the *Motu* continued, the Pontiff had summoned Lelli to Rome, where Lelli had satisfactorily demonstrated evidence of his ability to use Campani's tools and instruments, and even had produced works by means of them. Within a brief period, he in fact had constructed a telescope having a focal length of 29 Roman palms, which not only met with the pope's satisfaction but brought approbation from others well-versed in the subject. As a consequence, Lelli was appointed custodian and demonstrator of not only the anatomical statues and the Campani optical workshop equipment, but also of a collection of lathes previously donated to the Institute by its founder, Count Ferdinando Marsili.

The *Motu Proprio* further delineated certain specifications for exhibiting the equipment of Campani's workshop, in addition to Lelli's responsibilities concerning it. A suitable room was to be assigned for the equipment's use and which was to have facilities adaptable for its preservation. Included were to be wooden cabinets, bookshelves, tables, and other furniture that might be required, all to be obtained at the Pontiff's expense. The document further specified:

> in this room, furthermore, there shall be placed and preserved all such items as Lelli might make anew in lenses, instruments, machines and similar items, reserving those which might be of service in other rooms, which by the foregoing order should be consigned to the *Assunteria*. If new discoveries or equipment are made elsewhere in the profession, the Assunteria should attempt to obtain them for Lelli's use, and it should be Lelli's responsibility to acquire them, but at no profit to himself.

Lelli was not to produce any work for an individual professor's private use, and all requests made to him had to be in writing. The Pontiff expressed the wish that Lelli was to have free use of all the Campani equipment in order to perfect himself in dioptrics and was to produce whatever work for profit or gain, including the Marsili lathes, which should not be left idle. The Cardinal Legate, the Archbishop pro tempore, the *Reggimento* and the *Assunteria* of the Institute were thereupon designated overseers.[1316]

Finally, in September 1747, the Campani workshop equipment, including the lathes and other machines, shop tools, and completed and incomplete instruments, were assembled in Rome, presumably on Maria Vittoria's premises. Then, each item appeared to have been carefully inventoried individually before it was packed for shipment by the Abbot Uti, a member of the Vatican curia. The collection was then officially transferred by Uti to Luigi Wood.[1317]

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to 1766 and his signature "E.L." appeared on a *scudo d'oro* of Clement XII in 1736. Susanna Falabella, "Lelli, Ercole," *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 2005).

[1316] Benedict XIV, *Lettere, brevi, ...*, 2:334–44.

[1317] ASB, Assunteria d'Isituto, Diversorum 11, n. 15: Luigi Wood, *"Inventario delli Strumenti*, *e Lavori*

On September 28, 1747, Luigi Wood in Rome consigned the Campani collection directly to Lelli, as the designated curator, who had come to Rome and who then personally took the collection to the Institute in Bologna. The inventory of its collection, identified as the "Compendium of the Items Donated By Our Father Pope Benedict XIV to the Institute if the Sciences of Bologna" listed the following:

> 14 metal molds for fashioning lenses and reducing them to convexity;
> 58 molds and wheels of diverse metals for fashioning concave glasses;
> 66 metal holders of various sizes for holding the glasses being fashioned;
> 46 small brass plates together with other brass equipment, the use of which is indicated thereon;
> l Machine of ingenious invention for fashioning concave glasses;
> l Bench of particular construction for fashioning the crystals [lenses] with the utmost perfection;
> 6 turning Lathes, two of which are of considerable size, all of brass and worked with the greatest perfection; of the remaining four one is of wood and brass and the other three are partly of iron and partly of brass; all six being for special dioptrical use, in addition to various wooden beams and bronzes for the construction of a great machine for working metallic forms of whatever proportions of a sphere, capable of achieving a sphere of 700 palms and greater;
> 5 Machines for using object lenses of 100 and more palms without the need of tubes, being Campani's devices for supporting aerial telescopes;
> 13 items, including object lenses of various focal length from 36 palms to 203 palms.
> There are also other works and other equipment, all of the utmost perfection and particulars. In summary, they consist of the total capital that served the famous Campani for the construction of his famous telescopes, microscopes, and other works which made him famous throughout the world, and furthermore there was communicated to Lelli by order of the Pope the method of using each piece of equipment indicated by the daughter of the above-mentioned Campani, who was excellent in her own right in dioptrical work.[1318]

It is to be noted that, in his *Motu Proprio*, the Pontiff specified that the purchase was to be limited specifically to Campani's shop tools and equipment and finished and unfinished work relating to optical instruments, namely, lenses, telescopes, and microscopes. Not to be included were Campani's tools for clockmaking, models and unfinished timepieces, or other projects. This may have been due to the pope's lack of awareness of Giuseppe Campani's earlier horological activities. It is probable that by this time not many clockmaking items remained in his shop, and there is no record of disposition made of such materials by the Campani sisters.

News of the acquisition of Campani's optical shop equipment by the Institute excited considerable interest in the scientific world, not only in Italy but also in France. In Paris, particularly, the excellence of Campani's lenses and instruments had long been very well known and acknowledged and envied not only at the Royal Observatory but among members of the Academie Royale des Sciences as well. When, in 1763, it became known at the Academie that one of its members, the 31-year-old Fougeroux de Bondaroy, was about to leave France for a visit to Italy, he was officially commissioned by the Academie to visit Bologna. Although he was a

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diotrici del fu Giuseppe Campani e che sono stati consegnati dal Sig.re Abb.e Uti a Ercole Lelli per spedirli a Bologna, ed ivi consegnarli all'Istituto delle Scienze a tenore degli ordini di N.ro Signore Papa Benedetto XIV", September 28, 1747, cc. 10; neither the Abate Uti nor Luigi Wood have been further identified.

1318 Ibid.

botanist, archeologist, and geologist, nevertheless, the fact that he was visiting Italy would provide an opportunity for him to attempt to discover, if possible, details of Campani's methods for fashioning lenses, the secret of which was believed to be hidden in his workshop equipment.[1319]

Upon arrival at Bologna, the eager Bondaroy had an opportunity to study the Campani shop contents and equipment and to discuss it at great length with Lelli. In the course of their meetings, Lelli mentioned that he was then on the verge of publishing the results of his own studies of Campani's equipment and techniques based upon his own experiments with the equipment, assuring Bondaroy that he would be informed. Lelli's untimely death in 1766, however, occurred before the studies he had mentioned could be published. A thorough search made of libraries and archives of Bologna has failed to bring to light any trace of Lelli's notes or manuscripts relating to the Campani equipment, if in fact he had prepared any during the 19 years that he had been custodian of the Campani workshop equipment. In time, there has been reason to doubt that he had done so, and furthermore, that he had deliberately misinformed Bondaroy only in order to evade providing more detailed information.

Upon his return to Paris, Bondaroy prepared a comprehensive report of his examination of the Campani equipment at the Institute in Bologna. On January 28, 1764, it was read before the members of the Academie and subsequently was included in the Academie's *Mémoires* for the same year, published in 1788.[1320]

According to his observations, Bondaroy stated in his report, there were several elements that combined to result in the perfection of Campani's lenses. These, Bondaroy explained, were Campani's choice of glass, the inventor's different and improved methods of cutting the lenses, together with minute details of his workmanship. He commented that it was believed in Bologna that Campani utilized only glass obtained from Venice for his object lenses. He noted that although this glass frequently was filled with bubbles of air, in general it appeared to be clearer and smoother, more durable and less streaked, than any glass then being produced or available in France.

Bondaroy ventured his opinion that the secret of Campani's success more probably may have derived from his use of the numerous metal molds of all sizes that formed part of his shop collection. It was generally believed that Campani made use of many different molds in the course

[1319] Auguste-Denis Fougeroux de Bondaroy (1732–1789), botanist, geologist, archeologist, and member of the Academie Royale des Sciences, was born in Paris, the nephew of Duhamel du Monceau. He was adjoint botanist in 1758 replacing Guettard; in 1759, he replaced Louis Guillaume Le Monnier, and he became director in 1787. Eulogy by Condorcet was read November 12, 1791. Institute de France, *Index biographique des membres et correspondants de l'Académie des Sciences, du 22 décembre 1666 au 15 novembre 1954* (Paris: Gauthier-Villars, 1954), 195–96.

[1320] Auguste-Denis Fougeroux de Bondaroy, "Mémoires sur les objectives," in *Mémoires de l'Académie des sciences, contenant les ouvrages adoptés par cette Academie avant son renouvellement en 1699*, ed. W. J. Gravesande (Paris, 1767), 251–61.

of producing each lens, progressively changing to molds of increasing fineness. Confirmation of this is found in the fact that in the original inventory for each measurement there were three types: those marked with the letter F for fine, those larger marked with the letter G for *grosso* [rough] and reported in couples under the statement “Molds for working convex lenses with *smeriglio* [emery] and *Tripoli*”. Campani had yet another category of mold with the notation “Molds that serve to reduce [*sgrossare*] convex lenses with arena [sand]”. On the basis of these three types of molds, it may be concluded that there were three phases in the processing of a lens. The first was to rough hew or reduce the surface, achieved with sand, then the smoothing with emery and *tripoli*, and finally, the polishing with paper or cloth using extremely fine *tripoli*. This last phase required particularly careful handling due to the curvature of the *imprimerie* [moulds] being so close to the superficial plane that the rough hewing was not necessary and probably even would be damaging because tiny grains of sand might leave scratches on the surface of the lens. The major portion of Campani’s metallic molds, about 70%, were used for working convex lenses while the remainder were used for concave lenses.[1321]

During these operations, the piece of glass to be converted into a lens was attached to a muller by means of a special mastic. Such a mastic found among the Campani shop materials consisted of black resin [*colophony*] and turpentine of Venice. The polish imparted to an object lens, Bondaroy went on, was the most difficult part of the process because the more that the glass was polished, the more deformed it tended to become. It seemed probable that Campani did the polishing by hand, a practice which did not appear to have any advantage over any other later methods except that he was enabled to change molds more easily. From the great number of molds that Campani had available, it was possible for him to select the ones that fitted most perfectly with the form that the glass had taken, in such a manner that if the mold selected did not satisfy him, he could quickly change to another again and again until the glass bore its entire surface upon the mold or basin.

It was believed that Campani did the final stages of the polishing of a lens with paper. He attached his paper to the mold with a liquid gum, according to Bondaroy, which produced the least thickness and inequality of surface. It was believed that the paper Campani used to cover his molds had been personally manufactured by him in his own shop. It was clear, at least, that the paper he used was made expressly for this purpose and differed from any other, since a large stock of it had been found in his workshop and had been transferred to the Institute. Apparently, its potential importance was not realized, and consequently no samples were preserved.

[1321] ASB, Assunteria d’Isituto, Diversorum 11, n. 15: Luigi Wood, *“Inventario delli Strumenti e Lavori diotrici del fù Giuseppe Campani...”* cc. 10.

Based upon what he had been told by Lelli, Bondaroy indicated that Campani had no means of working lenses other than the methods he had enumerated in the foregoing, which differed little from the methods generally in use in eighteenth century France. However, Bondaroy noted, Campani did have a machine or lathe that he used for shaping the molds. He claimed that although that particular machine had been hidden from him during his visit at Bologna, he had managed to obtain a drawing of it, and which, since he had not been sworn to secrecy, he attached to his report to the Academie. Bondaroy immediately assumed that the sketch he had found was of the machine that Lelli had concealed from him. The fact that he did not doubt his discovery suggests that while he was at Bologna, Lelli deliberately had sent him on a false scent, since the Campani machine was so different from that which he proposed.[1322] **[Figure]**

The lathe depicted in Bondaroy's drawing appeared in fact to be no more than a very simple lathe in common use by other optical artisans in that period. The principle of Maignan's lathe was the same, for example, and the scheme of this machine was very similar also to the horizontal lathe described by Cherubin d'Orleans in his *Dioptrica Oculaire* published in 1671.[1323]

In an account in which he described De LaLande's visit to Italy in 1765 and 1766, Sebastiano Canterzani reported that Bondaroy had not obtained his design of the Campani lathe in Bologna, as he had claimed, but at a later date during a visit he had made to Rome, although it was not known from whom he had acquired it. The truth of the matter appears to have been that while Bondaroy was in Bologna, he had not in fact seen Campani's actual machine because Lelli had not wished to demonstrate it to him, claiming that he planned to publish about it himself. Thus, Campani's actual lathe had been kept hidden from the French visitor in 1763, and it is likely that it already may have been disassembled and stored. It was not illustrated until 20 years later, in 1783, by Canterzani.[1324] **[Figure]**

Throughout his professional career, Giuseppe Campani had maintained as his closest secret his techniques for grinding and polishing lenses. Particularly he assiduously guarded details of the lathe he claimed he had made for the purpose. If such a tool actually existed, probably it was not seen by anyone other than members of his immediate family and perhaps his brother Matteo. Giuseppe had trained two of his sons and later two of his daughters in his techniques and it is likely that he instilled in them the same need for maintaining secrecy about details of its construction.

The optical lathe that Giuseppe had maintained so jealously in secrecy during his lifetime remained a mystery even after his death. When the Campani collection was acquired by the Institute

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[1322] Ibid. Table: *Machine a travalleir les bassins pour faire des objectifs suivant Campani*.

[1323] Cherubin d'Orléans, *La dioptrique oculaire, ou la théorique, la positive, et la mechanique de l'oculaire en toutes ses espèces* (Paris: Thomas Joly & S. Bernard, 1671), fig. III, page 3.

[1324] BUB, *Canterzani*, Capsula 4176, fasc. 8.

in 1747, the machine arrived dismantled and conveyed into Lelli's hands in pieces, not in the operable form in which he had seen it in Rome. It was readily identifiable in the inventory inasmuch as the separate parts were listed—including two large pieces of wood having iron rings at their extremities, followed by a list of the parts necessary for its assembly.

It seemed apparent that Lelli fully understood the importance to Campani's work of that particular lathe. According to Canterzani's statement and confirmed by Giuseppe Bruni, at some date in 1748–1749, the senators had instructed Lelli to reassemble the separate parts of the lathe so that he would be able to construct a small operative model of it for demonstration purposes. At the same time, he was to assemble the Campani lathe itself into functioning condition once more for the purpose of using it to construct an example of a mold with it.

At the same time, Giovanni Bacialli, the secretary of the Institute, was assigned the task of drawing up a draft or a brief containing a clear description of the model. Although this description subsequently was found, none of Lelli's writings on the subject ever came to light. Furthermore, it has not been possible to verify even whether some lenses or molds had then been effectively produced with the lathe. It is certain that after the commission ordered by the senators had been executed, the machine was once again dismantled. Its various parts were stored in separate places, apparently in a deliberate effort to ensure that no one should be able to assemble it again to its original structure. However, when, in 1751, the historian Giuseppe Gaetano Bolletti compiled a brief account of the Institute's history and of its most notable instruments, Campani's lathe was included.[1325]

Efforts to preserve Campani's secret about his lathe continued at Bologna. Both the miniature model of the Campani lathe that Lelli had made as well as its written description were stored in a small strongbox, which was kept locked and the key to which was given to Bacialli for safekeeping. Consequently, in 1763, when Bondaroy arrived in Bologna, the operable machine had been dismantled and therefore was unrecognizable. Also completely concealed from Bondaroy was the existence of the little model and its description by Bacialli.

It seems probable that it was in order to forestall Bondaroy's requests that Lelli, as noted, told him that he was on the verge of publishing an account of the machine. Evidently the secrecy that surrounded the lathe, which had been preserved with such concern by Campani himself, continued to be a subject of "mystery and arcane" long after Campani's death, as Giuseppe Bruni later stated.[1326]

[1325] Bolletti, *Dell' origine e de' progressi dell' Instituto delle scienze di Bologna,* 176-177.

[1326] BUB, fondo Canterzani Capsula 4151, fasc. 5/6, Sebastiano Canterzani, "Delle invenzioni del Sig. Giuseppe Campani circa alla maniera di tornire le piattaforme, e di lavorare in esse gli obbiettivi . . . E dei metodi intorno allo stesso particolare dal sig. Giuseppe Bruni praticati", cc. 14 (Of the Inventions of Sig. Giuseppe Campani Concerning the Manner of Turning the Moulds, and of Working Objectives in these, . . . and of the method relating to

Lelli's unexpected death at the age of 64, on February 7, 1766, left a major gap in the Institute's faculty, and the *Reggimento* experienced considerable difficulty during the next 2 years in selecting a capable replacement. Finally, on May 6, 1768, the Senate appointed Giuseppe Bruni to the position of custodian of the Hall of Dioptrics, to serve for a period of 5 years. A native of Ravenna, Bruni had moved to Bologna in 1748 as a young man and there he eventually married a young Bolognese girl and established himself as a mechanician in the city. Twenty years later, when Bruni was appointed to the position of custodian of the Hall of Dioptrics, he already had been in the employment of the Institute as a mechanician. Upon assuming his new position, Bruni arranged to lease space within the Institute building to accommodate a small shop in which he could work on personal projects. It was an unusual arrangement, but nonetheless, for the next year and a half Bruni appears to have fulfilled his several Institute responsibilities satisfactorily. These included also working in the Institute's astronomical observatory without apparent conflict with his personal interests.

There the matter rested until, in 1771, when the senators in the Assunteria of the Institute instructed Bruni to reassemble Campani's lathe once more and to restore it to a functioning condition. It was then that Sebastiano Canterzani, secretary of the Institute, entrusted to Bruni to be used as a guide the little model and description made by Lelli. After studying the material consigned to him, Bruni advanced the hypothesis that, judging from Lelli's model, the previous curator had never really understood the operation of Campani's lathe, because, in the manner in which it had been represented by the model, it could not have functioned at all satisfactorily.

Canterzani was aware of Bruni's opinion, and after he reported it to Senator Giovanni Fantuzzi, it was resolved to consign the original Campani lathe to Bruni so that he could restore it to correct functioning condition. After this had been achieved by Bruni, he then was informed that he was to operate the lathe, in the presence of all the senators, in order to produce a mold of 18 feet of Bologna (approximately 38 cm).[1327]

Bruni managed to operate the Campani lathe successfully, producing an acceptable mold in less than 2 hours. Then, in the course of the next 2 days, he used the mold he had made on the lathe in the polishing process of an object lens. After the lens had been tested by the senators in the Institute's astronomical observatory, they reported that it confirmed the favorable opinion that they already had of the excellence of Campani's lathe.

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the same particulars of Sig. Giuseppe Bruni). Biblioteca Universitaria di Bologna, fondo Canterzani, Capsula 4176, fasc. 8.

[1327] Biblioteca Universitaria di Bologna, fondo Canterzani Capsula 4151, fasc. 5/b, Sebastiano Canterzani, "Delle invenzioni del Sig. Giuseppe Campani circa alla maniera di tornire le piattaforme, e di lavorare in esse gli obbiettivi . . . E dei metodi intorno allo stesso particolare dal sig. Giuseppe Bruni praticati", cc. 14.

At this point, in order to generate public interest in the lathe and finally to dispel the mystery that had surrounded it, the Institute's secretary Canterzani was assigned to write and publish a dissertation describing the lathe and the manner in which it was to be used. At the same time, Bruni was given the task of executing a series of suitable designs of the lathe and of its details to accompany the publication. The drawings were superbly executed and eventually were published with Canterzani's description in volume VI of the *Commentarii* of 1783.[1328]

[Figures]

Unfortunately Bologna's university presses, like the mills of the gods, ground slowly, and it was not until 14 long years after the project had been assigned to Canterzani that his description and Bruni's drawings of the lathe finally appeared in the *Commentarii*. This delay was not the fault of either Canterzani nor Bruni but due to the fact that after the preceding volume of the *Commentarii* had been issued in 1769, there had been no other publication scheduled for the series until the end of 1783, the year in which volume VI was printed.

It has not been possible to find the manuscript that Canterzani is reported to have produced in 1771 that was intended as a manual for informing technicians in using Campani's equipment. It was reported that in it he had included even the description of a lathe that had been constructed by Bruni several years earlier. The self-same Bruni recounted that he had constructed the lathe for the purpose of demonstrating it to a particular person, whom he did not identify. This unidentified person had boasted that he possessed Campani's secret, stating that in reality it was a simple matter to construct a machine to produce molds for object lenses of long focus. In actuality, Bruni's lathe proved to be considerably inferior to that of Campani, for it could produce molds only for lenses of short and medium focus [*raggi*], and none for lenses of greater focus.[1329]

Of particular interest in Bruni's rendition of the lathe, however, was the mechanism for "the advancement of the point" [*avanzamento della punta*] achieved by means of an ingenious combination of two toothed wheels having their axes competing 90 degrees. It can be compared with Campani's rudimentary device (Figures 1 and 2 in Appendices).[1330]

Meanwhile, the Campani collection in the Institute had been unified with the collection of Marsili's German lathes that already existed in the Institute. All of the Campani shop equipment, including the lathe, remained in the Institute's Hall of Dioptrics as late as 1780. The senators, who prepared a report on the origin and the progress of the Institute, characterized it together with that of

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[1328] Sebastiano Canterzani, "De machinis duabus ad metallicas formas, quibus vitreae lentes conficiuntur, construendas inventis," *De Bononiensi Scientiarum et Artium Instituto atque Academia Commentarii* 6 (1783): 93-95-391.

[1329] BUB, *Canterzani*, Capsula 4176, fasc. 8: "Macchina per costruire le Piattaforme di metallo che sieno proporzione di una sfera di qualunque raggio".

[1330] Canterzani, "De machinis."

Bruni. In fact, on page 177 of this account was expressly noted: "There are in fact two machines that were used to construct molds [*piattaforme*] of whatever portion of a sphere was required, one of which was the greatly celebrated aforementioned machine of Campani, and the other has been found, and has been executed by Sig. Giuseppe Bruni, the present operator of optics, and custodian of the said hall of the Institute".[1331]

Later, when a modification of the contents of the Institute was achieved by combining the Halls of Dioptrics and the Hall of Lathes, it resulted in relegating these machines to storage once more as items of lesser interest, inasmuch as their use already had become minimal. In fact, with the advent of improvement of telescopes by Newton and Dollond, optical lathes no longer were useful; as a consequence thereafter there no longer was need for mystification in the treatment reserved for them.

In his inventory of the Hall of Optics that Silvestro Gherardi compiled in 1835, he included mention of the small model of the Campani lathe that had been preserved in the small locked chest, concluding that it had been dispersed. There no longer was to be found any trace of the optical lathes, and this was the situation also with the model. All that remained were Canterzani's published dissertation and the splendid drawings made by Bruni together with his manuscript description of the machine.[1332]

In retrospect, a question still remains concerning the lathe that Campani devised and with which he claimed to have ground and polished lenses without the use of molds. Campani had written in his *Ragguaglio*: "I applied all my spirit [*anima*] and [the result of] all of my studies to the invention of a lathe having the greatest precision for working lenses without any other use of molds, and it proved to be a success".[1333]

Campani's affirmation had aroused considerable skepticism among his contemporaries at that time, primarily concerning his ability to work with the glass matrix directly upon the lathe, without the use of molds. Huygens and Auzout, who at the time were the most authoritative contemporaries, both expressed opinions on the subject. In a letter to Huygens in 1664, Auzout wrote: "I do not know any better than you how Campani can work his glasses upon a lathe and without molds, and as for myself, I believe he has used the same forms".[1334]

Hooke confessed to have imagined such a lathe for working lenses without molds, and noted that he had mentioned it in the preface to his *Micrographia*, published 3 years later, in 1667. An

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[1331] Bolletti, *Dell' origine e de' progressi dell' Instituto delle scienze di Bologna*, 62–63, 177.

[1332] BUB, bb. 97-112, fascc. 361-497: Silvestro Gherardi, *Catalogo del Gabinetto di Fisica della Pontificia Università di Bologna chiuso in Agosto 1835 colla aggiunte degli anni consecutivi*, p. xviii, pp. iii, xviii; *Canterzani*, Capsula 4151 5/6.

[1333] Campani, *Ragguaglio di due nuoue osseruazioni,* 8.

[1334] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 6, 145, n. 1273: letter from Auzout to Huygens November 1664.

extensive intercourse on the subject between Auzout and Hooke resulted in which Auzout was convinced of the impossibility of working lenses with Hooke's machine, which in fact proved to have been only a concept and had never been produced.[1335]

As noted, Auzout reported that a lathe similar to the one claimed by Campani had been invented by a French artisan named de Méru, but in practice it was useful only for producing small lenses. Auzout contended that with his lathe de Méru was able to work directly on the glass on plates fixed directly to the axis of the lathe, without the use of molds. However, the historian Maurice Daumas doubted that the machine had ever been produced.[1336]

Undoubtedly, Campani later had transmitted to his daughters this same determination to conceal the details of his working methods. It is true that even after Campani's death, the secret of his lathe, if in fact a secret actually existed, still had not been revealed. If there was actually a secret aspect to the lathe, then Lelli, after having been completely informed by Maria Vittoria on Campani's working techniques, would have been very much inclined to boast that he finally had learned the great secret that had preoccupied the optical world.

In retrospect, the secret may have been simply that which Campani wished to make others believe, namely, the fiction that he had constructed a very ingenious machine with which, with little effort, he could construct molds of every sphericity with optimum results. In fact it was from the correctness of these molds that he then depended in great part for the successful result of his lenses. Divini recalled a phrase made by Matteo Campani to someone who took pleasure in making lenses, sustaining that "No other person could make well the lenses, than those who worked normally with ironwork, clocks, and similar things because they make and can work by themselves the molds, as does Sig. Divini, and my brother, who do not use contrivances that ill treat the craft".[1337]

The construction of molds or basins for shaping object lenses was not unique to Campani, for others also employed them. Campani shaped his molds from both brass and ductile copper, first casting them, then molding them, and finally rendering them into the precise shape they were to have by means of the lathe just mentioned. As noted, in his work *Dioptrique oculaire* published in 1671, Cherubin d'Orleans illustrated and described a machine having much in common with Campani's lathe for fashioning lenses, although the latter was undoubtedly of greater accuracy and enabled the operator to adjust the length of the tool to the finest degree of accuracy.

The comprehensive treatise by Cherubin d'Orleans was one of the most useful works on lens making produced in the seventeenth century. It covered the subject of glues for attaching lenses

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[1335] Auzout, *Lettre à M. l'abbé Charles sur le "Ragguaglio di due nuove osservationi, etc.", da Giuseppe Campani*; Hooke, *Micrographia*.

[1336] Ibid., 2-3. See chapter IX in this book: The *"Ragguaglio"*.

[1337] Divini, *Lettera intorno alle macchie di Giove*, 71.

to mullers, abrasives for grinding and polishing, directions for the construction of molds and patterns, and it also described and illustrated a variety of lathes used for grinding and polishing. In addition to a machine having alternating rotary motion and specialized apparatus for producing patterns and molds, Cherubin described a lathe quite similar to that made by Campani but that operated on a vertical plane, and also a horizontal lathe to which the pressure of the lens blank or workpiece against the tool was achieved by a system of counterweights. There is great doubt, however, that any of these lathes were actually made and used, and they may have been only conceptions of the author.[1338]

In actuality, upon review, Bondaroy's report on Campani's techniques presented nothing new or interesting. He maintained that Campani had deliberately created the assumption of secrecy around his own work in order to divert attention from the details of his grinding and polishing techniques, presumably in his efforts to clothe the excellent results of his lenses with a mysterious air. Bondaroy concluded that there had been no secret in Campani's techniques and that the fine quality of his object lenses was derived entirely from the scrupulous and minute attention that he dedicated to them in the course of working them. He admitted that in addition to which apparently Campani had unusual manual skills. Furthermore, Bondaroy noted, Campani had equipped himself with a considerable number of well-worked forms or molds so that he could change them frequently in the course of his work, always selecting the best of the glass available, and fitting his molds together perfectly with the spherical superficies of the lens.

Summarizing the abovementioned report by Bondaroy, the Frenchman stated that in his view the perfection of Campani's lenses was due to the following factors: the quality and perfection of his molds; the careful selection of the finest glass from Venice, the Venetian *tripoli*, and the paper he used for polishing the lenses; and finally to the numerous little attentions he devoted to his work. It was these minute details of technique that Campani kept from the knowledge of others with such great care during his lifetime, which were not to be found in his workshop equipment.

As one example of these minute details, Bondaroy reported that it was believed in Bologna that Campani went as far in his scrupulous attention to detail as to attempt to select those days for finishing his lenses during which the temperature remained absolutely constant. There may be some basis for this conclusion. It was possible, of course, that an exaggerated opinion of Campani's knowledgability might have been derived just from the superiority of his products.

Bondaroy also believed that Campani, being extremely jealous of his reputation, after having completing each piece of work, discarded those lenses that were not absolutely perfect. Accordingly, he would sell only those having no defects. As a consequence, his prices had to be

[1338] Cherubin d'Orléans, *Dioptrique oculaire*.

elevated to compensate for the loss of time spent on the products that proved to be imperfect and were discarded. Bondaroy stated he was made doubly aware of the effort expended by Campani on the production of lenses by one of his object lenses, already noted, having a focal length of 205 Roman palms (141 feet or 45.79 m) that Campani had made for the Paris Observatory. This was the lens that had been broken, and when it had been returned to him, Campani, being aware of the great amount of work that would be required to duplicate it, went to considerable effort to join the two parts of the broken lens. He succeeded so well that it could be used as if it never had been broken.[1339]

The importance of Bondaroy's report cannot be overestimated, for it was only in this document that Campani's methods of workmanship, as known and related to Bondaroy by Lelli, have been recorded and preserved. Pope Benedict's *Motu Proprio* had specified that the custodian of the workshop collection, namely Lelli, was to be instructed by Campani's daughter in the use of each piece of Campani's equipment at the time the collection was purchased. It was confirmed that Lelli had indeed received such instruction from Maria Vittoria, although the notes he had taken on the use of the equipment have never been found.

By the end of that period, some time following upon Bondaroy's visit, serious trouble was discovered at the Institute. An account of the problem, dated December 28, 1769, survives in a manuscript from the Assunteria dell'Istituto, a board which presided over the Institute. Addressed "to the illustrious auditor of the Torrone" , it began with the statement that it had been discovered that Giuseppe Bruni was guilty of a number of serious misdemeanors, which apparently had taken place over a period of time. At some previous date, Bruni had appropriated two telescopes from their place in the observatory. One was a Newtonian telescope and the other was one made "according to the invention of Dolon [sic, Dollond]". Both instruments were decorated with silver ornamentation. The Newtonian instrument was eventually returned to its repository, but it was later discovered that its silver mountings, including ornamentation and the cartouche bearing the maker's name, had been replaced with others made of silver-plated brass. It subsequently came to light that Bruni had stripped and used the original silver for making other works to his own advantage.[1340]

These activities of Bruni's had discovered and reported by Giuseppe Paganucci, a youth who was working as an assistant in Bruni's personal workshop at the Institute. As the consequence of the insistence of several professors of the observatory, the second missing telescope also was subsequently restored to the observatory. A further dereliction that had been brought to the attention

[1339] Bondaroy, "Mémoires sur les objectives," 260. The lens is now preserved at the Museo di Fisica of the University of Bologna: Tabarroni, "La lente spezzata del Campani conservata nell'Istituto di Fisica dell'Università di Studi di Bologna", 433-41.

[1340] Franca Arduini, *I laboratori storici e i musei dell'Università di Bologna* (Milano: Silvana Editoriale, 1988), 43; ASB, Assunteria d'Isituto, Diversorum, busta 15, n. 36 fasc. Bruni, cc. 1, 9.

of the Assunteria was the removal by Bruni of much of the leading around the observatory's windows. An accounting of the missing leading was demanded, but Bruni did not include it in the inventory that he submitted of projects executed or in progress. According to this inventory, the cost of work completed by Bruni to that date totaled 337.18 *zecchini*.[1341]

The Assunteria suspected, furthermore, that some of the molds or patterns that Campani had used for producing his lenses were now missing from the collection in the Hall of Dioptrics. The suspicion was that Bruni probably had sold them for their metal content. The report noted also that it had been discovered that on one of Campani's turning lathes, the one made of red wood, the brass ornamentation and fittings now were missing, believed to have been taken to be sold also for the metal content and that then they had been shipped out of the city. It was suspected that Bruni had hidden them in a shop somewhere in the city. Accordingly, it was ordered that a search be made for the missing fittings.

The Assunteria thereupon ordered that any further evidence of Bruni's misconduct was to be brought immediately to the attention of the auditor. Meanwhile, the Assunteria requested that criminal proceedings be instituted against Bruni, inasmuch as that governing body was anxious to take every precaution for the future preservation of Campani's workshop equipment, which it considered to be part of Bologna's most precious patrimony.[1342]

The next record relating to Bruni's defection was dated 2 weeks later, on January 15, 1770, and was a directive addressed to the Assunteria that had been issued by the auditor of the Torrone. It was a formal notice to the members of the Assunteria, meeting in congress at the Institute, that inasmuch as Bruni had committed various defections that had been brought to the attention of the Assunteria, under whose jurisdiction he was employed, it had become their responsibility to ensure that Bruni repaired whatever damage he had done and that every precaution be taken thereafter to prevent further like damage.

In accordance with the acts and processes formed at the first Scabello [office] of the tribunal of the Torrone, the Curia Criminale of Bologna was ordered to proceed to apprehend Bruni and collect the evidence necessary to obtain his confession. Specified in the instructions of the Conventions established in 1715 by Marsili and confirmed by the apostolic act of Pope Clement XI "it will always be the liberty or privilege of the Senate to remove from the Institute whichever Subject has become unworthy". Bruni meanwhile had been apprehended and imprisoned and had confessed his crime, and a judgment was obtained against him after he had confessed.[1343]

[1341] The *zecchino* was a 3.545 gr. golden coin. ASB, Assunteria d'Isituto, Diversorum, busta 15, n 36 fasc. Bruni, c. 8.

[1342] Ibid. c. 8.

[1343] Ibid., cc. 1-2, January 15, 1770.

Desirous to follow the wishes of the public in the present situation, the Assunteria placed the matter of Bruni's dismissal to a vote. It was at this point in the proceedings that a mystery developed. Even before a vote was taken, it appeared to be a foregone conclusion that Bruni would not be dismissed but would be restored to his position and allowed to continue as custodian. The minutes of the Assunteria's meeting reported: "Without entering into a discussion of the past relating to said Bruni, the Assunteria does not wish to assert itself other than to beg the distinguished gentlemen [of the tribunal of the Torrone] that their vote shall order that the aforesaid Bruni continue in his employment. If further defection by Bruni becomes apparent, however, it will then be within the jurisdiction of the Assunteria to dismiss him immediately from his office without further recourse".[1344]

In order to obtain a plurality of votes, however, the Assunteria's members were requested to declare their opinions in the matter. If the vote proved to be affirmative, Bruni was to continue as custodian of the Hall of Dioptrics with the express provision that if he should commit new defections, that the Assunteria would have full authority to dismiss him immediately and permanently without recourse to the Senate. If the vote was negative, then Bruni would be dismissed immediately. As it already had been anticipated, the Assunteria voted to have Bruni resume his duties despite the fact that he had made a formal confession of his thefts.[1345]

It seems incredible that political pressure could have been exerted to such a considerable degree in the face of such blatant publicized criminal action and that the public would permit such judicial negligence to occur. Unquestionably, Bruni had strong influential political connections, for there can be no other explanation for such gross miscarriage of justice. This situation probably was made possible because of the curious political conditions that existed then in Bologna, as a consequence of the dual authority under which the city was governed. The *Reggimento* of Bologna had battled the papal court in Rome for centuries for the maintenance and the re-vindication of ancient prerogatives of sovereignty. There is no doubt that Bruni had at least one or several influential friends or sponsors but whose identity was not revealed at the time, nor could it be determined thereafter, since the files relating to his criminal judgment were sealed and are not available to the public.[1346]

Within the next 2 weeks after the voting, the Assunteria attempted to pick up the pieces and restore some order once more in the Institute. A document filed on January 27, 1770, contained a listing compiled of all the items that Bruni had removed from the Institute's premises without permission, which eventually had been restored and consigned to Giacomo Conti, who was

[1344] Ibid.
[1345] Ibid.
[1346] [Scientific Editor 2: I was not able to find where Bedini has taken this information from].

designated as custodian of the Institute's properties, and which now were preserved in the Institute's storehouse under Conti's care. Included were:

> 182 round irons from the wickets of the great windows of the observatory;
> 61 other round irons from the lunettes of the aforesaid observatory windows;
> 15 bolts with plate [?] (i.e., *Cattenazzi con cartella*);
> 7 window catches (*Marlette*);
> 1 *Fellaro* (grid?) of iron from one of the windows over the cupola of the observatory.[1347]

Other items that were recovered from Bruni as a result of the judgment but which no longer were in a condition to be useful were sold to tradesmen by order of the Assunteria and payment credited to that body. Included were:

> 51 *oncie* (12 *oncie* are equivalent to 0.7984 pounds) of broken glass sold to the furnace . . . Z[ecchini]. 2-2-6;
> 60 *oncie* of lead melted into two forms, estimated at 51 *oncie* and 15 *oncie*, sold to Signor Zarrini, glazier, at a rate of 16 Zecchini per hundredweight . . . Z. 10-12-6;
> 7 *oncie* of bent sheet brass at a rate of 12 *soldi*, sold to Signor Silvetti, brazier, according to his estimate, for the amount of . . . Z. 4-4-0;
> making a total remuneration of *Zecchini* 16-19-0.[1348]

This tally was supplemented with a list of stolen items that had not been recovered, and consisted of:

> 1. The original silver ornamentation of the Newtonian telescope, including the ornamental hinges, the band, the name-plate with the name of the maker. [It was noted that the instrument was made of wood and that Bruni's replacement of the original silver ornamentation was of silver plated brass.];
> 2. The molds or plates [*piatti*] of the Campani collection, which had been sold by Bruni and taken out of the city of Bologna.
> 3. The brass fittings of Campani's lathe with red wood frame. The brass had been melted down in a shop in Bologna;
> 4. The leadings of the windows of the observatory, which had been employed for actual use [i.e., which had been put to legitimate use], but for which remuneration had not been made to the Institute. [The statement indicated that Bruni had stripped and removed the leadings from the windows with the full knowledge and assent of the Assunteria but that he had neglected to make remuneration for it.];
> 5. The telescope of "Dolon" [i.e., Dollond], which had silver decorations and had been kept in the observatory;
> 6. There is some suspicion that the rod of gold was missing in a machine for measuring the dilation of heat, a [machine] which had been donated, it is believed, by Monsieur Leprotti;
> 7. The lathes of Campani have suffered considerably because they have been used around iron.[1349]

Bruni was released from prison and apparently returned directly to his duties at the Institute, quietly resuming work, and for the next several years continuing to work without further defection. The final chapter in the saga of Bruni's career occurred almost a decade later at a joint meeting held on January 30, 1779, of the administrators of the Institute and the Boards of Munitions and Militia,

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[1347] ASB, Assunteria d'Isituto, Diversorum, busta 15, n 36 fasc. Bruni, cc. 10-11.

[1348] Ibid.
[1349] Ibid., c. 4

when a petition from Bruni was presented and read. In it he requested that he be provided with an assistant or coadjutor for his office to work as a mechanician in the Hall of Physics. One of the members present, Senator Lambertini, suggested, perhaps ironically, that Bruni probably would have no difficulty in obtaining approval at this time even if he requested a pension and the additional favor of being allowed to continue working in his own shop on the Institute's premises!

Incredibly, it was in fact thereupon unanimously voted to award a pension to Bruni, and to grant him permission to conduct his own shop thereafter on the Institute's premises! Further discussion revealed, however, that if Bruni's shop was permitted to remain in its present location, it would be to the Institute's detriment, nature unspecified. Accordingly, two members of the board, Senators Aldrovandi and Savioli, were delegated to seek and recommend another suitable location elsewhere on the premises for Bruni's shop.[1350]

At a subsequent meeting of the Institute officials held a month later, the two Senators presented their report. They suggested that Bruni's shop should be removed from its present apartment, and furthermore, that he should be returned at the first opportunity to his lodgings, which had an entrance under the Institute's portico. Part of the house next door, which had been partially destroyed by creating the courtyard of the printing office, would be made available to him and he could establish his forge in the shop under the portico, with which he could have communication or passage from within without detriment to the anvils.[1351]

Meanwhile, as a consequence of the passage of time, and assisted by Bruni's depredations, Giuseppe Campani's shop equipment slowly was being reduced item by item until only a very small portion of it remains. The surviving collection and its allocation in the Institute was reported in a little volume published in 1780, the year following Bruni's retirement:

> after climbing the last two landings of the grand staircase and turning to the right, we find collected in one room all the tools of the celebrated deceased Giuseppe Campani for use in optics and dioptrics, which Pope Benedict XIV had acquired from the former's heirs, and for which he had constructed entirely at his own expense the cabinets in which they were conserved; these consisted of a series of metal plate molds duplicated for the construction of whatever length of telescope from 200 Roman palms to all of the shorter measures. Furthermore, there were reposing in a cabinet thirteen object-lenses, of all focal lengths; among others was one of 213 palms, which was the one with which the famous Cassini had discovered the satellites of Saturn.
>
> There were also two machines, which served for the construction of plate molds of every portion of a sphere of which there could be need; one was the noted machine of the said Campana [sic] and the other had been found and executed by Giuseppe Bruni, the present optical worker and custodian of the said Hall of the Institute.
>
> In other rooms can be seen all of the lathes which served that department, and also all of the others which were brought from Germany by General Marsili.[1352]

[1350] Ibid. c. 3.
[1351] Ibid. c. 4.
[1352] Bolletti, *Dell' origine e de' progressi dell' Instituto delle scienze di Bologna*, 62-63, 177.

In the original inventory that accompanied the donation, a distinction had been made between the metal forms or molds and their handles or hafts [*manubri*] that served to hold the crystal [glass] firmly while it was being worked and formed into convex lenses. These hafts did not require any accurate work. Listed in the original inventory under the category "Brass handles or hafts that serve to hold the crystal to shape convex lenses",[1353] the lens would be attached to the haft with tar and mastic. Several of the items listed in the original Campani inventory that have long been lost and not later mentioned by those who had been assigned custody of the collection, were:

> No. 2 Designs made by water color which demonstrate the means of using the objectives of long vision [aerial telescopes], whether by day or by night, without tubes;
>
> A small manuscript book by Giuseppe Campani in which he recorded the proportions the object lenses were required to have in relation to the oculars;[1354]
>
> Another small book by Campani printed in the year 1664 dedicated to the Most Serene Prince Mattia of Tuscany.[1355]

This last one was Campani's own copy of his *Ragguaglio* containing revisions in his own handwriting.[1356] Contained in a miscellany of short anonymous manuscripts relating to astronomy that is filed in the Biblioteca Universitaria di Bologna, is a short treatise in Italian consisting of only four half-pages describing the construction of octagonal telescope tubes, in the handwriting of Giuseppe Campani. The nature of the other items in the same file of Ms. 1496 strengthens this attribution, for they consist of a drawing relating to the design of lenses, another on the erection of Giuseppe Campani's long telescopes, his drawing of the satellites of Jupiter, which had been included as an illustration in the *Ragguaglio*, and an Italian translation from the Latin description of Giuseppe Campani's lens grinding machine written by Matteo Campani and published in his *Horologium solo naturae motu*; this was a translation probably made by or for Ercole Lelli. Attached is a page, in what appears to be the same handwriting as the translation, of sketches and notes relating to lens design. The numbering of the pages of the translation of Matteo's description of the machine and of the short treatise on making telescope tubes, added at a later time, is continuous, indicating that they had originated in the same source or volume. It appears almost with certainty that this file had been part of the collection that Pope Benedict XIV had acquired and donated to the Istituto delle Scienze. Following is a translation of the treatise on constructing octagonal telescope tubes:

[1353] ASB, Assunteria d'Isituto, Diversorum 11, n. 15: Luigi Wood, *"Inventario delli Strumenti e Lavori diotrici del fù Giuseppe Campani..."*, c. 10.

[1354] Ibid., where is mentioned: *"Un libretto Manoscritto di Giuseppe Campana delle proporzioni*, *che devano avere gli oggetti agli'oculari"*.

[1355] Ibid.

[1356] It was discovered in recent years in the collections of the Biblioteca Universitaria, where it is presently preserved.

The tube should be made in an octagonal shape, of wood that is light and strong, here [in Rome?] there have been made these large ones of wood of Albuccio [*Populus alba* or Silver Poplar] which have been most successful. The tube can consist of twelve pieces which enter one into another as do the small telescopes made of cardboard, and each piece can be made of a length of 20 Roman palms. The largest can be made a palm longer than the others so that there will be room for the casing into which the object lens is placed, with the caution to the master that this should be cut perfectly square so that the objective will be placed with exactitude and so that it will not incline to any side. If the casing becomes too loose, the tube must be filled up again on a lathe, so that the object lens rests in the center, and is straight. At the ends on the outside of this larger tube one attaches with glue a ribbon of string wound around a number of times to increase the strength, and these bands should be placed at a distance one from another of about three palms because the tube on the outside, which tends to suffer more than the others, will not become unglued; as for the other tubes which sit one inside the other, one can reinforce only the ends, and another glued girdle of ribbon about half a palm distance from the first so that one may conveniently apply pressure with the hands in order to extend all the tubes completely. At the ends of each of the tubes that fit into one another, one must adjust and shape an aperture large enough so that there will be one ounce of wood for each turn and thus these apertures can be well glued to the openings of each of the tubes. Each of the tubes must be painted black on the inside, and also the ocular tube which contains the three glasses, or, that is to say, lenses. There are to be attached to the inside of the octagonal tube eight little pallets of equal thickness as spacers which are necessary so that the ocular tube will rest in the center of the tube for the length of the telescope. Examine [check] the length of the telescope to make certain that it will be exact to the sight. Experience will show, because one cannot provide a certain or exact measure which will depend on the vision of the persons who will look through the instrument, depending on the distances of the objects, some are longer and others are shorter.

One must be cautioned that in such cases as when the air trembles or puddles [becomes misty?], it is better to make use of the small, when, however, the air is clear and quiet, then the larger will have admirable results.

It is necessary to caution also that in dismantling the tube it is well to remove first the casing which contains the object lens as well as the ocular tube in which are the three lenses so that in the course of dismantling the air will not cause them to fall away.[1357]

The manuscript with instructions for making octagonal telescope tubes, although unsigned, unquestionably was the work of Campani. Definitive further evidence confirming the authorship is derived from a comparison of the handwriting of the manuscript with that of letters written by Campani to the Medici princes and to Viviani; they reveal a consistent similarity. Furthermore, the name “Giuseppe”, which was written and then crossed out on the manuscript’s end paper is unquestionably in Campani’s hand. It is entirely plausible that the little treatise was part of a larger manuscript intended as a shop manual describing various aspects of shop practice that Campani had prepared for the guidance and instruction of his apprentices, namely, his sons or daughters.

Few instrument makers were producing large telescopes for astronomical observation in the seventeenth century; among them were Evangelista Torricelli, Vincenzo Viviani, Jacopo Mariani, called in Florence, and Giovani Borelli, who achieved note for their work with this instrument.[1358] They constructed very few, however, on an occasional experimental basis, never professionally. The most prominent professional makers of telescopes were, of course, Eustachio Divini and Giuseppe Campani in Rome, Stefano Coveri in Livorno, and Giuseppe Moschino in Genoa.

1357 Biblioteca Universitaria di Bologna, *Canterzani*, Capsula 1496, busta II, parte 3.
1358 Bedini, “On Making Telescope Tubes”, 110-16.

Of the makers mentioned, Divini and Campani are known to have constructed octagonal wooden telescopes, examples of which survive. The wooden tubes were relatively light in weight when compared with telescopes made of other materials by the same makers. It is unlikely that Divini and Campani produced octagonal wooden telescopes in some numbers, and only several by each of them have survived. A curious fact is that the two instrument makers did not produce octagonal wooden telescopes at the same time. Divini already was making wooden octagonal tubes in the 1660s and continued to use octagonal wooden tubes for his instruments until his later years. One such telescope made by Divini, signed and dated 1663, is in the Museo Copernicano of the Osservatorio Astronomico di Roma and two others are in the Istituto e Museo di Storia della Scienza in Florence. One of the telescopes, in seven sections with three lenses, is dated 1664 and another also of seven sections, is dated 1674.[1359]

Based upon surviving examples, Campani did not begin to make telescopes with octagonal wooden tubes until after 1680. Of his four surviving octagonal telescopes, one formerly in the collection of the late Dr. Fritz Rathschuler in Genoa and now in the Luxotica Collection, has a main tube with five reinforcing bands on the body, in addition to five wooden draw tubes with similar bands at each end and on the exposed ends of each draw tube. The lens is signed and dated 1682. Another large Campani instrument having six draw tubes that he made for Landgrave Karl of Hesse is in the Hessisches Landesmuseum in Kassel, the objective of which is signed and dated 1700. The instrument measures 1.70 meters when closed, with a diameter of 12 cm. In addition to the reinforcing bands attached to the ends, another band was added at the center of the large tube. A third octagonal telescope by Campani is in the Museo Copernicano of the Osservatorio Astronomico di Roma. Campani's fourth octagonal telescope, made of cypress and red fir, was part of the donation made by Cardinal Sebastiano Antonio Tanari at the inauguration in 1714 of the Astronomical Room of the Institute of the Sciences in Bologna. It measures 820 cm in length when closed and 13.5 cm in diameter. This 22-foot telescope tube is equipped with four lenses. There are seven octagonal draw tubes. Missing are the mounts for the ocular and object lenses, which are signed "*Giuseppe Campani in Roma*". Another octagonal telescope by Campani, in superb condition, is in the collection of Loumann.[1360]

Among the miscellany of papers and previously noted is an Italian translation from the Latin of the description of Giuseppe Campani's lens grinding and polishing lathe written by his brother Matteo and published in Latin as part of his work *Horologium solo naturae motu*. This translation into Italian probably had been rendered by or for Ercole Lelli; as one of the conditions of his

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[1359] Ibid.

[1360] Ibid., and Silvio A. Bedini, "The Optical Workshop Equipment of Giuseppe Campani," *Journal of the History of Medicine and Applied Sciences* 16, no. 1 (1961): 18–38.

donation of the collection, Pope Benedict XIV had stipulated that Lelli was to be instructed by Campani's daughter in the operation of the lens grinding and polishing lathes that formed part of the workshop collection. The numbering of the pages of the translation of Matteo's Campani's work and of the treatise on making telescope tubes is continuous, indicating that its previous owner had included them together.

Of particular interest is a page that was attached, written apparently in the same handwriting as the translation of sketches and notes related to lens design. While Fougeroux de Bondaroy was visiting Bologna in 1764 for the express purpose of studying the Campani equipment, he reported that Lelli had informed him that he had compiled notes describing the use and operation of the Campani equipment; this page may have been part of Lelli's notes.[1361]

[1361] BUB, *Canterzani*, Capsula 1496, busta II, parte 3.

Chapter XXIV

ERA'S END

(1750–1850)

Yea, from the very soil of silent Rome
You shall grow wise; and walking, live again
The lives of buried peoples, and become
A child by right of that eternal home,
Cradle and grave of empires, on whose walls
The sun himself subdued to reverence falls.

John Addington Symonds[1362]

Even before Campani's last surviving daughter, Maria Vittoria, had sold the contents of her father's workshop equipment to Pope Benedict XIV in 1747, she had closed her own shop and retired. After the sale, for a few years she continued to live alone in her house next door to the Palazzo Galloppi; opposite was the monastery of the Trinitarian Order and the Church of San Carlino alle Quattro Fontane. Then, with increasing of infirmities with advancing years, she faced the fact that she no longer could live alone even with having assistance at home.

In the intervening years she undoubtedly had become a familiar figure to the personnel in the nearby small monastery of the Trinitarian Order of Discalced adjoining Church of San Carlino. Now finding herself alone in the world, having no immediate family, she ultimately may have made the decision to join the sisterhood of the Order. Or, more likely, she had been offered and received care as she had need, and realized it to be a welcome solution to her problems to do so. After the sale of her father's shop contents, she lived on for 16 more years to the age of 77 and died on February 8, 1763.[1363]

Maria Vittoria was buried in the church of San Carlo, wherein her death was recorded in the church's records as follows:

Signora Donna Maria Vittoria Campanni [sic] Santoro, a sister of our Sacred Order and a great benefactress of the Order, died in this beloved city on the day of 8 of February, 1763, at the hour of twelve midnight by Italian reckoning, the day sacred to the veneration of Our Patriarch, Saint John of Matha, doctor of [the University of] Paris. When day came, her body immediately was brought directly to our venerated church where we conducted her funeral service. She was buried in the lower Church in vault No. 2. beneath the cross affixed to the street wall, wherefrom the bones of Brother Bernardo de Santa Maria were removed and brought to the cemetery.

[1362] John Addington Symonds, "Southward Bound" *Many Many Moods* (1878).
[1363] ASVR, *S. Nicola in Arcione*, *morti,* vol. 37, 1761-1770, fols. 17 and 184.

The remains of the said lady were placed in a wooden coffin; the body was dressed in our sacred habit with a long white veil and wimple, and the face covered with a handkerchief; a rosary entwined in the hands; at her feet was placed a garland of fresh flowers in token of her virginity preserved from girlhood throughout her life.

She was an excellent professor of the art of making microscopes, lenses, and telescopes, as became a disciple and the daughter of the great Campani, her father, famous for his excellence in this art. She possessed in equal degree knowledge of mathematics and optics, and—what is of more importance—the practice of mystical theology. She was a virgin of high virtue and rare patience in suffering, as was seen after her death. Finally, in testimony of her great devotion toward Jesus of Nazareth, she left an endowment for the celebration of that feast day with music; this is recorded upon a plaque, which is to be placed in the sacristy.[1364]

The plaque reported that imbedded upon a wall of the old refectory is an inscribed marble plaque which appeared and is translated as follows:

TO GOD THE GREATEST
Maria Vittoria Campani,
most esteemed virgin, a Roman,
in her will in the Records of Maccari Notary Public
disclosed 8 February 1763
wished it to be stipulated that with funds that she provided
there should annually in perpetuity be solemnly celebrated in
the Church of San Carlo alle Quattro Fontane
The Feast of Jesus of Nazareth
with Mass and Second Vespers
accompanied by music
and that at the same time
the Most Divine Sacrament
should be publicly exposed
for veneration
upon a day not determined
Likewise, that for the purification of her soul
and (of the souls) of her (dear) deceased
A lamp before the image of Jesus of Nazareth
which is most devoutly revered in (this) Church,
should be kept burning by night.

Father Michele di San Francesco di Paola
Procurator General, and the fathers, heirs,
had this monument erected.[1365]

[1364] Archivio Conventuale di San Carlo alle Quattro Fontane, "Libro dove sono annotati i defunti che sono sepolti nella chiesa di San Carlo alle Quattro Fontane di Roma, tanto di religiosi che di secolari", fol. 14.

[1365] *D[eo] O[ptimo] M[aximo] / Maria Victoria Campani / spectatissima Romana virgo / in suo testam per acta Maccarii N. C. / die VIII Februarii MDCCLXIII Resignato / cautum voluit ut perpetuo Ex aere suo / in ecclesia S. Caroli ad quatuor fontes / Festum Iesu Nazareni / cum missa et secundis vesperis cum musica / publiceque insimul venerationi / Esposito divinissimo sacramento / quotannis die iam statuto / solemniter celebretur / necnan ut in expiatione animae suae / Defunciarumque suarum / Noctu ante imaginem Iesu Nazareni / Quae in ecclesia religiosissimi colitur / Lampas non extinguator / P. Michael a S. Francesco de Paula / Procurator generalis et minister / PP. Que Haeredes / Hoc Monumentum posuere.* The Plaque may not be not readily visible to a visitorto the church. This writerfound it only after insisting on personally removing a large armoire that had been installed in front of it.

In the last will and testament of Maria Vittoria, she had specified that modest gifts of money were to be made to her three surviving nephews and a niece, and the remainder of her estate she bequeathed to the convent of the Trinitarian Order of the Church of San Carlo. The protocol of the convent, in the Spanish language, stated:

The *Signorina* Maria Campani

No. 1. Roman citizen, daughter of the latter Giuseppe Campani and of the latter Cleoperta [sic] Santori, in her last will and testament published by Maccari, Notary of the Chapter, on 8 February 1763, made our convent general legatee of all and only her stable property with obligation of celebrating in our church the Feast of Jesus of Nazareth, with Mass and second vespers with music, with the exposition of the Blessed Sacrament on the eve, of having always at night the lamp burning before the image of Jesus of Nazareth, and of placing in the sacristy a stone tablet with the description of other obligations. Finally, she left as legacy 50 *scudi* for each of her three [grand] nephews and a niece named Pier Tommaso, Giovanni Francesco, Ferdinando, and Lucia Campani, and these for one time only, which should be paid in the period of six years, which should be counted from the day of her death, with the condition that in case some one of the others should die within the said period, the mentioned legacy which was allowed to him would fall to the favor of the convent. Also, she left to the convent the trust of a benefice in Forlimpopoli. But this is to be appraised as nothing, because a certain family of Forlimpopoli having brought a lawsuit, she abandoned it by not continuing the suit.

2º. The convent accepted the landed property […] consisting of two halves houses: one facing the Four Fountains of Rome, bordering on the Galloppi palace, as is found described in this [document] on page 279, and the other in the city of Albano, as stated in this on page 286. It took possession of both buildings by decree of the collateral of the Campidoglio of 27 February 1763.

3º. The convent having entered into possession of the mentioned properties, the expenses of the funeral and other indebtedness of the deceased had, on which the convent paid 223-047 *scudi*, the most illustrious Signor Alfonso Galloppi, attempted to dispossess us of half the house, facing the Four Fountains, of which he was the immediate closer owner producing in court the document of investitures in which was found the clause of not being able to pass the other house into our hands without his permission, the convent maintained its possession with felicitous outcome of the suit, obtaining a favorable judgment [...] rendered on 14 August 1764, which was confirmed by two notarial decisions before Monsignor Marmelli on 10 December 1764 and the other on 19 April 1769, with which an end was put to the suit, the convent remaining in peaceful possession.

4º . Our convent having been declared landlord of the useful command of the house, with the Marquis Guidi owner of the remainder of the house, it went on to recognize as immediate owner of the entire house, to the illustrious Lady Teresa Catenaces Fruglieredera of the latter Raimondo Galloppi, to whom the ownership of the entire house belongs, as is clear from the document executed before Mariotti, Secretary of the Chamber on 5 October 1767 […]. The papers pertaining to another property are to be found in our archives at Nº. 27. A chest of papers are [sic] preserved also in our other archives, which are considered not to treat on anything in particular, but it will be fitting to be attentive, in case the convent, because it is the general legatee, acquires henceforth some building, inasmuch as the Santori house in Albano is rich. […].[1366]

It is to be noted that the family name "Campani" was stated to have been that of Maria Vittoria's three nephews and a niece, suggesting that at some time in her late years she had been in contact with one or the other of her two brothers, and in this manner recognized their children.

Of particular interest and concern is the reference to "A chest of papers are [sic] preserved also in our other archives, which are considered not to treat on anything in particular [...]". Extremely few of Giuseppe Campani's personal papers, including personal and business correspondence and records, have come to light. Such of his papers that are known generally have

[1366] Archivio Conventuale di San Carlo alle Quattro Fontane, "Protocolo del Convento de San Carlino", f. III.

been found filed among papers of his correspondents, consisting of clients among whom were a great number of notables including pontiffs, princes, and prelates. Some of his correspondence with clients, including the several Medici princes, Cassini, Minister Colbert, and other notables, have survived in the related archives of the recipients, in addition to papers at the Biblioteca Universitaria di Bologna, relating to Campani's workshop, and in the Vatican concerning to the papal patents he was granted.

There can be no doubt that Campani would have carefully preserved a considerable part of the correspondence he received in his lifetime from his eminent clientele, and presumably it would have been inherited by his heirs, namely, Teresa and Maria Vittoria, yet it has never come to light. Inasmuch as Maria Vittoria was Giuseppe Campani's final heir and his last survivor, it is almost certain that it was she and her older sister who would have received her father's papers. After her sister's death, the papers would have come permanently to Maria Vittoria she would have been preserved in her lifetime. It is no great stretch of the imagination to assume that the chest of papers that she had preserved, and which was noted in her last will and deposited in the monastery's archives, contained the family and business papers of her late father, Giuseppe Campani.

Repeated efforts to seek the chest of papers in the archives of the Trinitarian Order and of the church all have been met with rebuttals, but without confirmation that it no longer existed. One might be led to speculate concerning the appreciation of the Trinitarian Order for Maria Vittoria's handsome gift of money and property to the mission she had joined. When the present author visited the Church of San Carlino alle Quattro Fontane several times during 1996 seeking references to Maria Vittoria, however, he was greeted with total ignorance. No one on the premises had knowledge of the substantial gift she had made nor of its donor. When the present author insisted on personally searching the premises to find the memorial tablet in her memory, mentioned in her records, the incumbent staff of the church, including the archivist of the Order, proved to be totally unaware of it and disclaimed any knowledge. The present author, nonetheless suspecting that such a memorial tablet existed and that probably it had been installed in the rectory, insisted on having the staff move a large *credenza* that had been placed against a wall. There, behind it the tablet was found. Apparently the tablet had been installed at the time of Maria Vittoria's death and had remained obscured by the *credenza* long before the memory of the present personnel.

All efforts subsequently made over a period of months to have a search made for the chest of Campani papers brought the response that a search had been made and that the chest no longer existed. Perhaps some day others may prevail in investigating the presence or lack of it of this chest of Campani papers, for it has been confirmed that it had existed and would be a valuable resource.[1367]

Meanwhile, the grandiose scheme to create a great center of learning in the Institute of Science of the University of Bologna, as had been conceived by General Marsili and dreamed of by Pope Benedict XIV and other wealthy donors, waned and gradually diminished by the beginning of the nineteenth century. Considerable confusion had been created at the Institute in 1803 in attempting to establish a definition of its primary function. It passed officially to the newly organized *Università* Nazionale, which undertook the teaching of experimental science with a modern science faculty. In the reorganization mandated by Emperor Napoleon, the Institute's library, as well as its archeological and scientific collections, were annexed to the *Università*.[1368]

As a consequence, the Institute was deprived of almost all of its scientific activities, which thereafter little by little were gradually absorbed into the University. The application of a new study program at this time brought grave consequences to the Institute, and the subsequent redisposition of the science collections undoubtedly resulted in creating even more harm. The great scientific collections had been assembled over a period of time, reflecting the munificence of local nobility, cardinals, and senators, to which had been added those that had been donated by Pope Benedict XIV.

Despite the fact that there had been great objection and strong resistance to the division, grave damage to the collections resulted nonetheless. This became particularly apparent with the fate of the contents of Campani's workshop equipment. Many of its items were lost, some were stolen, others were misplaced. In this period, some of the instruments in the Institute's collections even found their way to France. Since the misconduct of Bruni, and later during the transfer made in Napoleonic time, those items now missing were lost or displaced.[1369]

Interest, meanwhile, had been turning from the now historical Campani equipment in the Institute to important new developments being made in optical instrumentation, which tended to lessen the importance of Campani's techniques for current use. An inventory of the instruments in the Cabinet of Physics compiled in 1835 by the noted physicist Silvestro Gherardi once more attempted to direct particular attention to the Campani equipment. It was a collection, the

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[1367] *Un libretto Manoscritto di Giuseppe Campana delle proporzioni*, *che devano avere gli oggetti* agli'oculari, ASB, Assunteria d'Isituto, Diversorum 11, n. 15: Luigi Wood, *"Inventario delli Strumenti e Lavori diotrici del fù Giuseppe Campani..."*, c. 10.

[1368] Dorè, "Origini e funzioni dell'Istituto e dell'Accademia delle Scienze di Bologna".

[1369] BUB, bb. 97-112, fascc. 361-497: Silvestro Gherardi, *Catalogo del Gabinetto di Fisica della Pontificia Università di Bologna chiuso in Agosto 1835 colla aggiunte degli anni consecutivi*, p. xviii. Enrica Baiada and Alessandro Braccesi, "Lo sviluppo della strumentazione astronomica dell'Osservatorio marsiliano e della Specola dell'Istituto delle Scienze di Bologna dal 1702 al 1815", in *Gli strumenti nella storia e nella filosofia della scienza*, ed. Gino Tarozzi, vol. 1, 2 vols., Ricerche dell'Istituto per i beni artistici, culturali e naturali della Regione Emilia-Romagna 10 (Bologna: Istituto per i beni artistici, culturali, naturali della Regione Emilia Romagna, stampa, 1983), 77–126; Dragoni, "La ricostituzione del Museo dell'Istituto di Fisica dell'Università di Bologna".

possession of which he considered to be "a unique item in the world, to be preserved with prideful relish such a monument of merited pride of illustrious and excellent art".[1370]

The Cabinet had undergone little reconstruction or reorganization, Gherardi commented in his inventory of the Hall of Optics, and that the exhibits of the instruments now were in accordance with the principle of featuring the most attractive appearance instead of those that had the most scientific merit. He added "the plate molds, the lenses of Campani, because of the restriction of space in the Cabinet, were massed together and poorly displayed, and were distributed and arranged in two wardrobes [*armadi a giorno*], instead of being crowded together like other objects of much less importance".[1371]

Despite the devoted attention to the Campani collection that had been exercised by Gherardi, the same care was missing in succeeding years. Nicodemo Jadanza, in his history of the telescope published in 1896, reported his dismay upon visiting the Institute. He noted that despite having made an exhaustive search at the Institute, he had been unable to find virtually anything there relating to Campani. "Just barely in that astronomical observatory, abandoned in one corner of the tower, we recognized a telescope by Campani, the tube, the greater part of which had been eroded by wood worms! The lenses were covered by a streak of dust and by a great cobweb! Nothing was found that had been donated by Benedict XIV!".[1372]

Yet, other items now missing as well in the Campani shop collection were noted more than half a century later in the updated publication *Catalogo con Aggiornamenti*, published in 1952 by the Istituto e Museo di Storia della Scienze in Florence.[1373] This was an annotated inventory of scientific instrumentation then existing in Italian public collections. It was produced to commemorate the first national exposition on the history of science, which was being held in Italy from May to October in 1929. The entries for the items then surviving in the Campani collection at the University of Bologna included seven bronze molds, six lens worked by Campani, and two bundles of gauges for working the lenses. Listed also as existing at that time and of considerable interest was a manuscript of "two tables or reference schedules for the calculation of lenses [*Due tavole per il calcolo delle lenti*]".[1374] Exhaustive searches undertaken of the collections in the University of Bologna's astronomical observatory, the libraries, and the Istituto di Fisica "A. Righi" of the University of Bologna, have failed to bring to light the two tables that have been missing as recently as since 1952. Perhaps this was the item that had been listed as part of the original

[1370] BUB, bb. 97-112, fascc. 361-497: Silvestro Gherardi, *Catalogo del Gabinetto di Fisica della Pontificia Università di Bologna chiuso in Agosto 1835 colla aggiunte degli anni consecutivi*, p. xviii
[1371] Ibid.
[1372] Jadanza, "Per la storia del cannocchiale", *vide* 28.
[1373] [Scientific Editor 2: today called Museo Galileo].
[1374] Istituto e museo di storia della scienza, *1a esposizione nazionale di storia delle scienze: (Firenze, maggio-ottobre 1929) Catalogo con aggiornamenti* (Firenze: L.S. Olschki, 1952).

collection, namely, “The manuscript book of Giuseppe Campani of the proportions that are required for the objectives in relation to the oculars”.[1375]

The metal molds have remained in the Institute of Physics “A. Righi” (called “Museo di Fisica” after 2012), while the majority of the lenses and astronomical items presently are preserved in the University’s Institute of Astronomy (called “Museo della Specola” after 2012).[1376] For a period of time in the eighteenth century, some of the Campani object lenses there had been put to use for making observations, while others remained in storage. Of the 13 object lenses that had formed part of the papal donation, only 7 remain at Bologna University, six at the Museo di Fisica, and 1 at the Museo della Specola. Already missing within two decades after the acquisition of the papal donation was the smallest object lens of 36 palms, which was unquestionably more useful than the larger lenses.[1377]

The surviving identifiable items that in modern times are preserved at the Museo di Fisica of the University of Bologna, are the following:

1. Object lens in cardboard frame, marked 223 mm (which is equivalent to 1 palm), with a marginal spacer of about 5 mm. Bound around the edge with fine cardboard laced in red by a spacer of about 1 mm. Inscribed just inside the rim of the glass is “*Giuseppe Campani in Roma Palmi 194*” (which corresponds to 43.3 meters).
2. Object lens, the glass of which has a diameter of 209.3 mm. With a marginal spacer of 4.3 mm. Missing the original border, of which traces remain; on the span of this the glass shows two scratches of triangular form on the face opposite to that on which the inscription appears and which reads “*Giuseppe Campani in Roma Palmi 138*” (equivalent to 30.8 meters) The rim of the lens is inscribed in the same hand with the number “138” indicating that it was to be covered by the frame.

[1375] ASB, Assunteria d’Isituto, Diversorum 11, n. 15: Luigi Wood, *“Inventario delli Strumenti e Lavori diotrici del fù Giuseppe Campani...”*, c. 10.

[1376] [Scientific Editor 2: In 2012, these institutions had undergone an important transformation: they were merged into the Dipartimento di Fisica e di Astronomia (DIFA) of the University of Bologna. The museums that are in charge of Campani’s instruments are now called “Museo di Fisica”, which owes the metal moulds and some lenses, and “Museo della Specola”, which preserves Campani’s telescopes and a lens. They are a part of the Musei di Palazzo Poggi dell’Università di Bologna].

[1377] In the inventory of the Campani instruments, compiled between March 10 and 14, 1769, presumably by Canterzani who was then secretary of the Institute, only two objectives were missing of all those given by the Pontiff. In subsequent years, the objectives that had remained for a long time had numbered 12. When Gherardi listed them in 1835, he had omitted the broken objective of 205 palms. After that date no mention was found concerning it. Furthermore, today only 9 remain. Another Campani objective of 36 palms was found but not the one in the papal donation, which already was missing in 1769. This other Campani objective belonged to a telescope that Cardinal Tanari had presented to the Institute in 1714. Baiada and Braccesi, “Lo sviluppo della strumentazione astronomica dell’Osservatorio marsiliano e della Specola dell’Istituto delle Scienze di Bologna dal 1702 al 1815,” 88; Dragoni, “La ricostituzione del Museo dell’Istituto di Fisica dell’Università di Bologna,” 40–45. The lens is presently preserved in the Museo di Fisica of the University of Bologna – Musei di Palazzo Poggi.

3. Object lens measuring 208 mm, including the frame with a spacer of about 4 mm, with the original frame inscribed "*Giuseppe Campani in Roma Palmi 142*". A more recent inscription on the red border is the number "35.7 m".
4. Another object lens within a cardboard frame measuring 198 mm. Including the frame with a spacer of about 4 mm with the original border slightly damaged. An opening in the center of the lens has a diameter of 23 mm. With two scratches near the opening on the opposite face. A marginal crack spreads from the border about 12 mm. The lens is inscribed on the edge "*Giuseppe Campani in Roma Palmi 120*" (i.e., 26.8 mm).
5. Object lens with a diameter of 197 mm including the frame and a spacer of about 4 mm. With the original border incised in the glass "*Giuseppe Campani in Roma Palmi 140*" (equivalent to 31.3 mm).
6. Object lens of 137.5 mm in diameter, corresponding to about 3/5 Palms. There is a spacer of 5.5 mm, with traces of the original border on the larger space on which may be observed small scratches. The focal length of this lens appears to be less than that of other Campani lenses in the collection. It is inscribed "*Giuseppe Campani in Roma*" without designation of its focal length.

As noted, another part of the collection that has survived consists of seven large bronze molds as well as five smaller flat plate molds, for fashioning lenses. Preserved also are two bundles of modules, or contour patterns, cut from thin sheet brass, each stamped or marked in ink with specification and identification of its particular purpose. One marked "P 50" for example, served as a contour pattern for a lens having a focal length of 50 palms. Others served as measures for telescope sections, for diameters and lengths of the tubes, and were marked with the measurement of each.[1378]

At the Museo della Specola, beside the 33-foot bject lens (56 palms of focal length, i.e.1210 cm) signed *"Giuseppe Campani in Roma"*,[1379] perhaps part of Benedict XIV's donation, one can find three telescopes by Campani and a machine for mounting his object lenses:

1. Marsili's 10.5 feet telescope made by Campani arount the year 1700 and used by Manfredi in his observations: extensible wooden tube covered in stamped paper and

[1378] Dragoni, "La ricostituzione del Museo dell'Istituto di Fisica dell'Università di Bologna," 40–63; Arduini, *I laboratori storici e i musei dell'Università di Bologna*, 87–88.
[1379] Baiada, Braccesi, and Bònoli, *Museo della Specola*, 124, Inv. MdS-26.

skin,[1380] object lens (focal length 410 cm, diameter 7,5 cm),[1381] erector eye-piece (diameter 4,7 cm);[1382]

2. Cardinal Tanari's telescope donated to the Instituto delle Scienze di Bologna in 1714: extensible octagonal wooden tube in cypress and red fir (22 feet)[1383] object lens of 36 palms (820 cm)[1384] signed *"Giuseppe Campani in Roma"*. Mounted on Lelli's machine together with an eye-piece of 10 cm. It was considered better than the long telescope by Dollond;[1385]
3. a 1.5-foot anonymous telescope (object lens and eye-piece missing) attributed to Giuseppe Campani but not mentioned in the papal donation;[1386]
4. Instrument or Machine for the object lenses of Giuseppe Campani by Ercole Lelli– length from 720 to 980 cm.[1387]

Of the numerous other items now missing from the collection of the Campani materials, some undoubtedly had been disposed of by Bruni, their loss having been undetected at the time. Other items may still exist, lacking identification, scattered throughout various collections in the University of Bologna or in other repositories within the city. It is ironic that the Campani shop collection has been so badly mismanaged within such a short period of time since its acquisition, despite Campani's fabled own lifelong concern for privacy about his working methods and his tools and the stringent precautions prescribed by Pope Benedict XIV for the safeguarding and preservation of the collection, supplemented by the Senate of Bologna's restrictions requiring written authorization of the Assunteria to borrow any of the items.

Reflecting upon the achievements of Giuseppe Campani and his consequent role in the scientific world of seventeenth century Rome during a life that spanned eight decades, he emerges as a ground-breaking pioneer, first in the field of horology and then in that of scientific optics as well as of astronomical observation. The accomplishments of Giuseppe Campani were innovative, useful, and significant during the century in which he lived. It was an era that was ending just as major changes were taking place in many of the areas with which he had been involved. As a consequence, in the early decades of the eighteenth century, one by one his achievements became obsolete and gave way to advancements in each of the fields of his endeavors that replaced them with the change in time and fashion and in scientific progress.

[1380] Ibid., 122-23, Inv. MdS-82.
[1381] Ibid., Inv. MdS-27.
[1382] Ibid., Inv. MdS-35.
[1383] Ibid., 124-25, Inv. MdS-193.
[1384] Ibid., Inv. MdS-28.
[1385] Ibid., 124.
[1386] Ibid., 122, inv. MdS-130.
[1387] Ibid., 125.

Giuseppe Campani and two of his brothers, working together, had invented and produced a new type of clock, the first of its kind, designed for use at night as well as daytime that not only provided light but also visible indication of the time but without the annoyance of sound. The silent night clock was a convenience that had not existed previously and that achieved great popularity throughout the second half of the seventeenth century, although limited to a certain level of society first in Italy and then to a lesser degree in England and elsewhere in Europe. The first version, utilizing a mercury escapement, was soon replaced by Giuseppe Campani's invention of the crank lever escapement, regulating the clockwork movement providing silent operation. The night clock, silent or otherwise, had not existed prior to the time of Pope Alexander VII and his expression of his complaints and desires. Prior to that time primitive forms of timekeepers for use after the hours of darkness, in addition to candles and oil lamps, were limited to monstrance-like devices having a clock dial illuminated by a flame placed in front or supported behind it. The Pontiff's plaintive wish, to be able to tell the time after dark by means of an illuminated clock dial that did not require illumination of the bedroom, but one that was free of the incessant toiling sound of wheels and gears, formulated a new concept to which the Campani brothers responded with a successful innovative timekeeper that fulfilled not only the desires of the wakeful Pope Alexander VII but also of many of the privileged who sought to acquire it.

The night clock made time-telling after darkness a convenience, and Giuseppe's invention of the silent escapements that followed made it also a pleasure. The difficulties that were inherent with the use of mercury were overcome by Giuseppe, who while working alone invented the crank lever escapement that functioned with a wheelwork clock movement that operated in total silence and with total accuracy. The silent night clock, in most of its forms, required a clock case that was designed only for spacious rooms of palatial dwellings and were limited to the tastes of the privileged, who were the only ones who could afford them. The ornate clock cases decorated with colorful rare marbles in *pietre dure* inlays, gilt bronzes, and other decorations, made to the tastes of the privileged of the period, were excessive in size and decor. Despite the considerable degree of accuracy of Giuseppe's crank lever escapement, however, it appears to have presented difficulties to clock repairers who dispensed with the invention and replaced it with the new invention of the anchor escapement and the dead beat escapement. In the course of time, the large overly decorated clock cases proved to be too cumbersome and space-stealing for many residences and were replaced by timepieces of a more practical size. Yet, within the period that Giuseppe Campani lived and worked, the silent night clock enjoyed its greatest period of popularity in Italy and to some degree elsewhere well into the early eighteenth century, diminishing by Campani's final years with the anchor escapement and dead beat escapement becoming common for all timekeepers thereafter.

Besides being granted by the papal authority with inventor privileges for the night clock (together with the brother Pier Tommaso) and for the crank lever escapement, Giuseppe obtained another privilege for a projection night clock. Meanwhile, his brother Pier Tommaso was awarded with an other inventor privilege for a fan-automaton clock. Matteo and Giuseppe Campani also engaged independently (but without success) into the field of navigation-clocks in order to determining longitude.

Giuseppe Campani's greatest achievement was the production of optical lenses for astronomical observation that surpassed in quality those of any of his contemporaries. His lenses and telescopes made possible the important celestial discoveries made by Cassini and other astronomers of his time. His invention of the screw-barrel microscope advanced microscopy and the medical and botanical sciences.

The end of the seventeenth century opened up a new era in the development of optical workshop practice. By now the pioneering work had been completed, and optical workers in France and England in particular had made great strides in improving apparatus and techniques for producing lenses of greater purity and accuracy. In England, a number of spectacle makers had now turned their attention to the making of lenses for optical observational instruments. Among them were Christopher Cock, Edward Scarlett, Richard Reeves, John Marshall, John Yarwell, and others. Of these, Marshall proved to be the outstanding craftsman and the first to be approved by the Royal Society. By 1688, he had developed a method of simultaneously figuring several lens blanks on a tool, based upon the principle of the machine Hooke described in the *Micrographia.*[1388]

Two major developments achieved in the eighteenth century changed the history of optical science in relation to astronomical observation; these were the improvement of the reflecting telescope and the production of achromatic lenses. Despite these revolutionary advances in the science of astronomical optics, however, optical workshop practice changed only gradually. Equipment for grinding and polishing lenses improved but slowly and, in fact, the techniques and procedures remained virtually the same until well into the nineteenth century.

Decades after Campani's death, his telescopes still brought high praise from all quarters.

During the eighteenth and nineteenth centuries, the achievements of Giuseppe Campani occasionally were erroneously attributed in whole or in part to his brother Matteo Campani. One reason for this error that has occurred to the present author is that, in French writings, Giuseppe Campani was often frequently referred to in the common form as "Monsieur Campani", and rendered in published form as "M. Campani." Although the "M." was originally intended to be "Monsieur", it was often misinterpreted to be "Matteo".

[1388] King, *The History of the Telescope*, 62.

An even more likely explanation is that in fact the error was first made by the Abbé de Fontenay in his *Dictionnaire des Artistes*, published in 1726, and that the error proliferated therefrom. He outrageously identified Matteo Campani as a priest in Rome and mechanician who had invented the silent night clock based upon the invention of the magic lantern and also invented the pendulum regulator for clocks. He stated that Campani, still speaking of Matteo Campani, had become famous for the lenses and telescopes that he produced, which were used by Gian Domenico Cassini and which he made to the order of King Louis XIV. Fontenay went on to add, "He had a brother, Joseph Campani, who was his pupil and who executed what Matteo imagined [designed]. The one and the other were still alive in 1678".[1389] To these sources of confusion must be added that of Matteo's deliberate attempts to steal the credit for Giuseppe's inventions, even in published form.

No exaggeration is required while comparing the achievements of Giuseppe Campani with his contemporary Christiaan Huygens. Although they grew up worlds widely apart, their interests and achievements yet coincided during their adult lives. Huygens was born in the Netherlands into a privileged social class and provided with an excellent academic education and a privileged life, while Campani emerged as an uneducated country boy from a remote tiny hamlet in an agricultural community; the extent of his education is unknown but presumed to have been a minimum secondary education from the parish priest followed presumably by studies at university La Sapienza or elsewhere in Rome. Huygens had the advantage of promotion and recognition as a consequence of his father's station in royal diplomatic service and by his appointment by King Louis XIV to the Paris observatory. As a scion of a patrician Dutch family, he did not lack for financial resources needed for study or for experimentation, while Campani lacked both. Yet both became engaged in relatively the same scientific endeavors, first the inventing of clockwork, in attempts to develop a timepiece for the determination of longitude at sea, then the production and development of astronomical lenses and telescopes, engaging in astronomical observations, and finally contributing to the evolution of the microscope.

Campani, however, had only the support of his brother, who dedicated much of his adult life to Giuseppe's promotion. Other than the academicians and the professional scientists, Giuseppe Campani must be numbered among those whom Hall designated the "*virtuosi* and *curiosi*",[1390] individuals of culture, passionate for the sciences, who may have had political power or influence in

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[1389] Louis Abel de Fontenay, *Dictionnaire des artistes, ou notice historique et raisonée des architectes, peintres, graveurs, sculpteurs, musiciens, acteurs & danseurs; imprimeurs, horlogers & méchaniciens* (Paris: Vincent, 1776).

[1390] Alfred Rupert Hall, *The Rise of Modern Science: From Galileo to Newton, 1630-1720* (New York: Harper, 1963), 28.

their profession. It is in fact to these *curiosi* and it is from those passionate of the sciences that we have the foundation of the first scientific publications, *Philosophical Transactions* (1665), *Journal des Sçavans* (1665), *Giornale de' Letterati* (1668) and the *Acta Eruditorum* (1684), which were private publications and independent at first, sustained by the passion and financing of the virtuosi who used them to publish their own writings.

The great importance attributed during the seventeenth century to experimental instrumentation was reflected by the many artisans engaged in optical instrumentation. These men of science (both scientists and technicians) worked for personal interest as well as because of scientific passion and, in that sense, often collaborated with astronomers, participating in their observations and constructing instruments of required scope. The best example is the *Philosophical Transactions*, which reflects the perfect collaboration between the technician and the scientist. The artisans, in seeking perfection of their instruments, constructed a notable stimulus to the sciences.

The self-induced mystery that had prevailed during Campani's working life concerning his claimed technique of producing his lenses by applying the raw glass directly to the lathe without the use of molds had mystified and intrigued his competitors and supporters alike during much of his lifetime. There was much serious questioning of the claim by artisans engaged in the same endeavors, but always with remaining doubt, because his lenses were invariably of the finest quality to be achieved in that period. There was universal agreement that his lenses were far superior in quality to those of any of his competitors so that the reason for this excellence was a matter of considerable concern to his competitors, although perhaps merely of academic interest to those who used them.

Studies that were made of Campani's workshop equipment after it had been acquired by the Institute of the Sciences of Bologna, with particular attention to Campani's lathes, first by Ercole Lelli and subsequently by Giuseppe Bruni and the vain efforts of Fougeroux de Bondaroy, all failed to reveal any remarkable technique by means of which Campani had achieved and been able to maintain the superiority of his work. That Campani did not in fact have or use a lathe capable of working lenses without molds is belied by the considerable number of molds of various sizes and shapes and associated equipment that formed an integral part of his workshop. The secret of his success, if one exists, must be sought elsewhere. Bondaroy may have found the answer in his conclusion that Campani deliberately mentioned his use of the lathe without molds to divert attention from the fact that in actuality there was none and to distract attention from his manner of working.

No portraits of Giuseppe Campani or other members of his family are known, and no collection of his personal papers has yet come to light, though logic insists that they existed. His adult lifetime was spent in the service of pontiffs, prelates, kings and princes, and records of the work he produced for them exists in their archives. Therein occasional communications from Campani are to be found, but not more than half a dozen letters are known. Logic suggests that he preserved princely correspondence, notes he compiled relating to his work, shop manuals, receipts of payments received, etc. A chest of papers, as mentioned previously, owned by his last surviving daughter, Maria Vittoria, long forgotten and overlooked, may still be preserved in the archives of the monastery at the Church of San Carlino alle Quattro Fontane.

Never was there a better example to illustrate the ancient phrase *Sic transit gloria mundi* than in the termination of an account of the life and work of Giuseppe Campani.[1391] The acknowledgment his achievements had received in his lifetime eventually were forgotten as, with the passage of the years, they were replaced one after another by innovations in the evolution of the sciences to which he had contributed.

[1391] The phrase has an ancient tradition in the history of the Roman Catholic Church. In translation it means: "Thus passes the glory of the World". Traditionally, during papal coronations, a barefoot monk marchesa long and interrupts the procession three times, holding aloft a burning tow and after it is extinguished, calling out: *"Pater Sancte* [Holy Father]*, sic transit gloria mundi!"* to remind the newly elected pontiff that despite the grand procession, he remaines a mortal man.