Chapter I

FROM THE UMBRIAN HILLS

> *Between S. Anatolia and the Valley of the Nera extends a promontory, an ancient prehistoric fluvial terrace, first inhabited by the Umbrians and which then became a Roman colony. At the beginning of the 6th century, in the time of Theodoric, was formed the Eremo di S. Fede, a monastic and agricultural cell that grew up around an oratorio [...]. In the 12th century the agricultural colony gathered itself upon the height forming Castel San Felice, feudal domain of the Duke Corrado of Urslingen [...] and was by him ceded in 1198 to Innocent III.*
>
> Ansano Fabbi, *Storia dei Comuni della Valnerina* [1]

Poised upon a craggy rockbound spur elevated high above the level plain that traverses the Valnerina and the bed of the River Nera that rushes tumultuously below, on an isolated mountain pass overshadowed by mountains looming darkly above it, rises the tiny hill town of Castel San Felice di Narco, 8 km east of Spoleto. Typical of the rockbound fortresses built upon the summits of mountain passes, its origins date to a remote period of history that is long forgotten. Its name is derived from the monastic church on the edge of the river, coursing below the castle, which had existed long before the community was formed. The community was centered on the ancient church, which is no longer at its center but now lying a short distance down the mountainside beside the now sluggish River Nera.

In the 17th century, the population of this tiny community was dominated by two families, the Medei, descended from early bishops of the region, and the Campani. In such small rural communities, social importance was predicated upon the possession of real property, and both families were prominent land owners.[2]

It was this tiny rustic hamlet high in the barren Umbrian hills that witnessed the birth of five brothers of the Campani family, three of whom were to achieve

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[1] Ansano Fabbi, *Storia dei comuni della Valnerina*, vol. 1 (Abeto (Perugia): Presso l'autore, 1976), 341.

[2] Ibid., 1:351–53.

acknowledgment and recognition in the sciences in their time. The oldest, Matteo Campani, became pastor of a fashionable church in Rome. Pier Tommaso was a clockmaker who invented fascinating new types of clocks with automatons and found employment in the Vatican. Giuseppe, the youngest of the Campani brothers, was responsible not only for remarkable horological inventions but also for producing astronomical lenses and telescopes acknowledged to have been the finest of the century. The name of Campani already had been one of venerable age in the region of Spoleto and the adjoining little villages and hamlets in its environs. It was a family name frequently encountered in business records and notarial acts as early as 1556.[3]

The local importance of the two families is confirmed by the presence of their burial vaults with inscribed tombstones embedded in the aisle in front of the altar in the nave of the church of San Felice. There are no others. The earlier and smaller gravestone over the vault of the Medei is inscribed:

D. O. M.
DE MEDEIS BERNARDINI
EORVM AC HEREDIBVS
A. DNI 1610.

A short distance beyond is a larger stone, having a crack through its center, bearing the inscription:

D. O. M.
ANGELVS CAMPANVS
SIBI SVIS AC DESCENDENTIBVS
HOC SEPVLCHRVM EXTRVI CVRAVIT
ANNO DNI 1661.

The date marked upon the Campani tombstone does not designate the year of Angelo Campani's death, which actually was 1681. It was in 1661 that Angelo's son and executor, Giuseppe Campani, arranged with Church authorities, probably the Bishop of

[3] Giovanna Sapori, ed., *Giovanni Di Pietro: un pittore spagnolo tra Perugino e Raffaello* (Milano: Electa, 2004), 66.

Spoleto, to install or enlarge the tomb for the Campani family, following the death in that year of Angelo's second wife, Sebastiana.[4]

Marking the slopes of the ancient hamlet are ancient gnarled olive trees that appear to stagger with age against the steep inclines. Every structure in the hamlet is constructed of the same reddish stone, having been erected at some point in time immemorial, often attached to one another or joined by means of overhead stone archways. Occasionally visible behind and between some of the dwellings are hay mows and miniature vegetable gardens. The crops are few, only those required for immediate subsistence. In addition to the olive groves are sparse vineyards, and visible in the immediate distance are several open fields in which hay was cut for winter fodder or in which hemp was being grown.

Traditionally, the community's economy always was constituted of many small revenues called *entrate*, including the growing of hemp, production of olives, and the harvesting of truffles, which once were found in some abundance in the region. Whereas the white truffle occurs in quantity in the Piedmonte region, Umbria, the Papal Marches and Tuscany, the cherished black truffle (*Tuber melanosporum*) was to be found only in the immediate region of Spoleto and Norcia and the adjacent small communities, such as Castel San Felice. While the white truffle was said to grow sporadically, never in the same place and apparently without a definite manner, the black truffle is believed to have

[4] Late in World War II, as Allied troops were advancing rapidly into Italy in their march to Rome, German planes began hastily leaving the Eternal City. On their way out of the country, their route took them over Castel San Felice, as they came strafing and dropping bombs upon the countryside. Forewarned, the people of the tiny community were hurriedly herded down the hillside to seek shelter in the basement of the church. Therein the several smaller children were hastily hidden inside the Campani vault, which proved to be large enough to accommodate them. It may have been during this incident, in the haste of excitement and fear, that the large unwieldy Campani gravestone was accidentally dropped and cracked. During this Author's visit to Castel San Felice in 1990, the sexton of the church recalled being hidden inside the Campani tomb and frightened of the dark, yawning hole that had been opened in the church floor, and he still retained vivid memories of wooden coffins, some broken apart revealing bones and skulls.In addition to the family of Angelo Campani, there were other Campani families in the region at the same time, undoubtedly all related to some degree. Prominent in local affairs at the same time was Alessandro Campani, who may have been a brother or cousin of Angelo Campani. He frequently stood proxy in all litigations "said to be current, not possible nor foreseeable" occurring in Sant'Anatolia di Narco for a number of other residents of Castel San Felice, Scheggino, and the neighboring villages or hamlets of Borgiano, San Vito, and Ponte. ASS, "Scheggino", fol. 7, (February 19, 1666); "Ponte", fols. 10-11 (October 31, 1666); "Scheggino", fols. 25-26 (September 9, 1672); fols. 8-9 (February 13, 1667); fols. 5-6 (March 27, 1667); fols. 1-4 (October 28, 1668); fols. 16-17 (September 21, 1669); fol. 24 (November 7, 1672); fol. 27-28 (November 12, 1674); "San Vito", fol. 29 (December 23, 1674); and "Scheggino", fol. 18 (August 26, 1676). [Scientific Editor 1: References to these archival documents are not clear. I assumed that names now between "" are names of files. Is it correct?]

its own pit or quarry (*cave*) or “truffle ground” (*tartufare*). That is, they continued to grow in the same location year after year, with changing quantities depending on the nature of the season. Because of this characteristic of growing always in the same locations, the truffle was designated a “fruit” or product of that particular location and therefore was considered the absolute property of the owner of the land in which it grew; anyone else who collected it was committing a theft.

The commerce in black truffles in Spoleto and Norcia and environs eventually was considerable. Control of the truffle harvest was noted among the earliest accounting records of the community of Spoleto. A record of 1672 terminated with the words: “This fruit in all of Italy has been conceded to only a few communities of God and those of our mountains when they have reached maturity are the most odorous and tasteful of those of other communities.”[5]

Documentation of the control of truffle culture was to be found as early as 1296 in the *Statuti Comunali* of Spoleto. In 1600, license to excavate truffles in Spoleto was awarded only to tenants. It seems during that period, the ownership of the truffle mines or quarries was variously resolved because such tenants were many in that community, and it was concerned also with the rights of excavation on private property. This law derived from the extension of rights relating to the entire community in comparison with the more strict laws relating to rights of private property and pasture and cultivated lands where truffles were present. In 1620, the law prohibited anyone from digging truffles “in a poor manner or with porcine animals or in any other way in the ‘*tartufanare*’ existing in the territory of the Castel” except by those who rented, under pain of a fine of 5 *fiorini* for every such misdemeanor and for each porcine animal being used. Then, in 1630, a new edict prohibited the grazing of goats in any zone of the Castel. Conflicts relating to the harvesting of truffles in the region continued through the 19th century, and the exportation of truffles to the present remains one of the chief products of Spoleto and environs.[6]

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[5] Waverley Root, *Food : An Authorative and Visual History and Dictionary of the Foods of the World* (New York: Simon and Schuster, 1980), 526–31; Donald P. Rogers, ‘The Training of Truffle-Dogs’, *Journal of the New York Botanical Garden* 51, no. 606 (1950): 131–32.

[6] Mario Laureti, ‘Il tartufo nero e i suoi rapporti giuridici nello Spoletino e nel Nursino’, in *Atti del Congresso Internazionale sul Tartufo* (Congresso Internazionale sul Tartufo, Spoleto: [s.n.], 1968), 43–50, https://www.montagneaperte.it/wp-content/uploads/pubblicazioni/congresso-internazionale-tartufo/atto1.pdf.

A statute in 1652 had introduced a tax on beasts (goats and sheep) that grazed in the communal territory. In the course of the 18th century, the community of Castel San Felice also approved statutes that established rules for the ownership of sheep and goats, prescribing, respectively, a minimum and maximum owned.[7]

The cultivation of hemp was an additional occupation in which some in the community of Castel San Felice were engaged. The seed for this annual crop was sown early in the spring, usually broadcast by hand, and the field was then rolled. The crop was harvested about four months after seeding. Hemp was used locally for making rope and other commodities and also sold to merchants in Spoleto or in one of the other large towns in the region. There was an active market for hemp for the manufacture of various types of twine, shoe and harness thread, canvas, marlines, sails, and rope of superior quality, in particular.[8]

The fact that members of the Campani family were involved in cultivating hemp was recorded in various notarial acts filed in the state archives of Spoleto. In May 1668, for example, Giuseppe Durante, son of Gellio of Castel San Felice, had purchased a usufruct (the legal right to use and enjoy the fruits or profits of something belonging to another), which he then sold to Ursula Campani, for whom her father Angelo acted as proxy because she was living in Rome; the property consisted of a house and a parcel of land in the village of Castel San Felice.[9]

Other than truffle gathering, maintaining olive orchards, and engaging in hemp growing, there were few other means of employment in Castel San Felice. During the winter months, the only employment was wood cutting in the local forests. The wood that

[7] ASS, *Statuto Comunale di Castel San Felice*, 1564.

[8] 'Canapa', *Enciclopedia italiana di scienze, lettere ed arti* (Roma: Istituto Giovanni Trecanni, 1930).

[9] In October 1672, a notarial act related to some property in the local countryside owned by Fabiano Fedele; Veronica's mother, Sebastiana — said to be the daughter of the late Pietro Agostino Canetti (Carucci?) of Scheggino and wife of Campani — was here mentioned as having sold an usufruct of 2 *scudi* and 4 *giuli* to Luciano Morichello and Cecilio, son of the late Matteo of Scheggino, on January 23, 1653. In September 1679, Fabiano Campana, son of the late Giovanni Battista Campana and second husband of Veronica Campani, sold the usufruct of a parcel of land for the cultivation of hemp that he had owned in La Pieve in the territory of Sant'Anatolia di Narco. Fabiano sold the usufruct of 1 *scudo* a year to Antonio, Pietro, and Tommaso of Castel San Felice. In January 1683, Fabiano rented to Felice Benedetti a parcel of land for the cultivation of hemp. ASS, "Castel San Felice", fols. 19-23 (May 2, 1668); 58r-59v (December 23, 1671); and fols. 67-74 (October 27, 1672; April 22, 1687). [Scientific Editor 1: See comment to note 5].

was cut was hauled by ox cart over the perilous narrow, curving roads into the cities in the region.

Until the end of the 17^{th} century, Castel San Felice had been governed by a community statute established in 1564, which provided for administration of the community by a mayor (elected annually by the city of Spoleto); a vicar or curate (elected for six months by an assembly of the community); an administrator of the communal public revenue and taxation; three councilors; one notary designated by the vicar and the councilors; a public official responsible for making citations and relations in the civil cause and deaths, edicts, sequesters, and executions; a supervisor of the village roads and its territory; a captain to superintend the maintenance of military surveillance of the castle who also was responsible for its defense; two judges who decided the operation of the entire administration of the community; and a "custodian of secrets" who received statements sworn under oath and denounced to the curate and to the notary those persons who were swearing, those who had caused damage, strangers who had come and caused danger or who had cut wood in the territory of the castle and violated the statute, and persons who played games in a manner not conforming to the statute.

The statute established a fine of 10 *soldi* for whomever was discovered working on festive days, including the days of Christmas, Easter, Epiphany, Ascension, Corpus Domini, the feast days of the Virgin Mary, the feast days of the twelve apostles and of the evangelists, the feast days of Saint Felice, Saint Mauro, All Saints, Saints Lorenzo, Giuliana, Anatolia, Nicholas, Silvestro, Innocent, Catherine, Lucia, Angelo, the feast day of Santa Croce, and every Friday in March. The statute of 1564 also disciplined a game called "*ruzzola*" (*ludus rutuli*), which was very popular in the countryside and is still popular in various parts of Umbria.

The local system for land transfer was achieved by means of the *census* (a term now archaic), signifying income derived from the collection of lease contracts. The term *census* also was used to identify such lands as had been given as part of a dowry. Often, after having sold a tract of land, the original land owner continued to work the land, or hired someone else to do so, and paid rent for his former property. The individual who rented the land was required to fulfill a series of obligations concerning its maintenance. Payment of the *census* was generally due every six months.[10]

Although at one time Castel San Felice di Narco had been governed by its own mayor, in 1880 the little community was designated a hamlet, called a *frazione*, of the slightly larger nearby community of Sant'Anatolia di Narco, which was similarly perched upon the side of another nearby mountain. By archiepiscopal decree in 1860, the records of San Felice's parish were transferred to the archiepiscopal archives in Spoleto. When the community of Sant'Anatolia di Narco requested the records of Castel San Felice for the purpose of updating its own records, the Castel San Felice Archives subsequently lent them, and there they remained unclaimed in the town's archives for a number of years. During World War II, Sant'Anatolia di Narco's town hall and archives were destroyed by bombing from the passing German planes; consequently, all copies of these precious documents recording the births, marriages, and deaths of the population of Castel San Felice from its early history to World War II no longer exist, neither in Castel San Felice nor in Sant'Anatolia di Narco, and neither in the archiepiscopal archives of Spoleto nor in the Vatican's Vicariato in Rome.[11]

Castel San Felice is a community having few memories of its past, the earliest are those of the Syrian monks who founded it, as memorialized upon the frieze over the great church doorway. According to the historian Lascaris, in about 530 A.D. the castle had been erected upon an elevated hill by the people of the Valle and named San Felice. The priory passed to secular priests with a canonical title. A lesson book (*lezionario*) of 1194 documented the existence of a Benedictine monastery, and the church of San Felice remained the seat of a monastic priory until the 13th century. The origins of Castel San Felice di Narco are buried among the primitive local Christian traditions and are remembered only among the famous immigration of Christians from Syria. According to the 17th century local historian Ludovico Jacobilli, Saint Mauro was one of the 300 companions of Laodice and Cesarea of Syria who traveled to Italy, some of whom found their way to Rome and others settling particularly in the region of Spoleto. The migration

[10] Fabbi, *Storia dei comuni della Valnerina*, 1:319–36.

[11] A search for the parochial records of Castel San Felice was undertaken at this Author's request through the archiepiscopal archives of Spoleto and then directly in the office of the mayor of Sant'Anatolia di Narco, without resolution.

is said to have occurred between the 4th and 6th centuries, in the time of Theodoric the Great, and notice of which is found among the hagiographical legends derived from the *Acta Sociorum*.[12]

Among these Christian immigrants were Mauro, his son, Felice, and the son's nurse, who remained unnamed. Gentle people devoting their time to prayer and penitence, the newcomers retired to a grotto along the river Nera and there they made their home. Mauro, whose consort, Eufrasina, had remained in Syria, settled in Narco with his son and nurse, and there he built a small hermitage. Mauro's humble and peaceful way of life, in which he educated his son, led the valley dwellers to accept the newcomers. Legend has it that they begged Mauro to slay a pestiferous dragon that had slaughtered many men among them and had caused much mayhem in the region. Mauro was shown the direction of the dragon's lair, and as he and Felice prayed, an angel appeared to assure him that it was God's wish that he do as the people wished. Felice followed his father, walking upon the waters of the Nera, until they arrived at the grotto. There he killed the dragon with an iron, and thereupon God caused a great stone mass to fall upon the dragon's body. Mauro threw the carcass into the river, where its blood, flowing into the Nera, reached the Tiber and eventually the sea.

Felice converted this wild region from paganism but later, in 535 A.D., he and his nurse were put to death by Roman persecutors. Mauro, remaining alone, deposited their bodies in a chapel, creating an oratorio dedicated to Saint Felice, which subsequently became the church dedicated to Saint Felice. Thereafter, the community that was established around this church assumed his name. With the aid of other young men coming to the region, Mauro erected a monastery contiguous to the church, formerly extending along the right wall. He was elected the abbot of the religious community, and the monastery was administered by the Rules of Saint Benedict. Mauro died there in 555 A.D. and was buried in the same oratorio with his son. From this monastic cell arose the monastery that at first was a dependent of Farfa and later of San Pietro in Valle. In the

[12] Lodovico Jacobilli, *Biblioteca Umbriae : sive de scriptoribus provinciae Umbriae* (Bologna: A. Forni, 1973), 323.

12th century, it became a priory dependent of Sassovivo and once was frequented by many ancient black-robed monks of the Order of St. Benedict.[13]

In time the small agricultural community moved to higher land to form the village of Castel San Felice, an imperial feudal property of Duke Corrado d'Urslingen. Spoleto profited from the controversy that existed between the imperial and the papal factions by fortifying and occupying the castle. It was in 1194, during this period of fervid political and religious conflict, that the primitive chapel was replaced by the church of San Felice. In 1198, Corrado ceded it to Pope Innocent III.

Situated within a hidden hollow along the river Nera some distance from the roadside, the church is visible only from one side of the rugged village looming above it. The 12th century priorial church has survived almost intact through the centuries. Never having been remodeled or rebuilt, it remains a magnificent construction of chiseled local stone, with a Romanesque facade featuring a rose window. In times past, the actual campanile, or bell tower, served as the medieval defense tower.

The facade of the church is the product of Spoletan stonemasons working under the influence of "cosmeateschi" mosaicists. A sculptured band under the rose window reproduces the legend of Saint Felice, depicting the dragon emerging from its grotto as the saint, under guidance of an angel, strikes the beast with an axe. Felice is being followed by the angel who protects him and Saint Mauro, who implores celestial assistance. Under a pavilion, Saint Felice is depicted resurrected as an infant. On the third part, the elegant tympan is built upon small pensile arches adorned with mosaic, having bases sculptured with zoomorphic faces. The interior of the church is rich with paintings and contemporary sculpture.

[Figure 1.1]

At a later time, the remains of Saint Felice, as well as those of his father and his old nurse, were contained in a stone urn and placed in the crypt of the subterranean church below the main floor, which is reached by two series of stone steps. The crypt contains two altars upon which Mass is celebrated. These altars are situated one on either side of the tomb in which the remains of Mauro, Felice, and the nurse—now reduced to bones with their skulls intact—are displayed.

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[13] Ibid., 323.

The monastery was suppressed in the mid-13th century and given to the Capitolo of the Duomo of Spoleto. In 1536, the monastery was conceded to the Lauri family of Spoleto, who had obtained its patronage from Pope Clement VII. Until the time of Lascaris, it remained a possession of the Lauri family, who in 1712 elected D. Alessandro Paradisi of Giano. Upon the door of the parish house, ex-monastery, is featured the coat of arms of Lauretus Lauri di Giacomo, displaying the cross charged with ten lozenges containing the initials "L. L." Because of the popular worship of St. Rita and St. Benedict in the region, the roads to Cascia and Norcia did not remain as secluded and inaccessible as others in those sequestered valleys.[14]

The convent's rarest and oldest treasure is a carved polychromed wooden statue of the Madonna with Child. It was a work of the 13th century — of the period during which the church was built — which later was always maintained in the parish church. The figure displays great majesty as she is depicted wearing a crown and seated upon a *postergale*. Her mantle falls from her head, covers her shoulders, and drops to her knees. With her left hand, the Madonna sustains the Child seated, and in her right hand she holds a globe of the Earth. This same image, attributed to Roman and Abruzzesse influence, has been found to be repeated in a number of the parish churches of the Valnerina. **[Figure 1.2]**

In the years following the end of World War II, thieves began raiding isolated parish churches in Italy and stealing religious treasures. Organized in small groups or singly, they made lightning sweeps, generally on motorcycles, through the countryside. The statue of the Madonna and Child in the Church of San Felice had been among the few items remaining unguarded in the country churches of the region. In 1993, the little church came to the attention of the marauders as they ranged through the countryside, and one day the carving was snatched up in the unattended church by a thief on a motorcycle, who then drove off quickly before he could be intercepted. The aging pastor, the late Father Soloni, was still agile although already in his late years. He immediately commandeered a motorcycle from one of his young parishioners and, giving chase,

[14] Lodovico Jacobilli, *Vite de' santi e beati dell' Umbria: e di quelli, i corpi de' quali riposano in essa provincia ...*, vol. 1 (In Foligno: Appresso Agostino Alterij, 1647), 638; Fabbi, *Storia dei comuni della Valnerina*, 1:353.

succeeded in tracking down the culprit and recovering the statue. It is now preserved in the Pinacoteca Vescovile, Spoleto's archiepiscopal gallery.[15]

[Figure 1.3]

Today the little community of Castel San Felice, huddling like a homeless, abandoned elder upon the bleak mountainside, is drawing its last breath. No record of the size of its population in the 17th century survives; the earliest census was made in 1712 when 140 inhabitants lived there. In 1769, the population had diminished to 103, then rose surprisingly in 1871 to 322, and then dropped once more in 1930 to 118. The population remained at 118 until 1971, but it has now fallen to 114, consisting chiefly of the old and infirm and the older sons and family required by custom to care for them.[16]

The streets of the village are too narrow to allow for the passage of automobiles. The young people, inevitably sporting motorcycles, find doubtful leisure pursuits at the bar of the nearby hamlet of Piedipaterno and for excitement have to forage further afield in Terni, Scheggino, and Spoleto. There is a constant stillness over the community of Castel San Felice, and as one walks between the ancient stone dwellings on each side of the narrow streets, one might glimpse a tired old horse or mule noisily munching away at hay outside a stable. There are no children in view nor is there the sound of them, and residents appear to remain indoors. The village has the stillness of a slowly dying community that has struggled to survive after one and one-half millennia.

The largest gatherings in the community are held on Sundays and holy days of worship, during which the people from the countryside dutifully flock down the hillside to attend services in the church. As it was then it is now, while the women and children occupy the pews intent on their rosaries and prayers, the men without exception stand stolidly inside against the inside wall in the rear of the church, from which they occasionally step silently out of doors for a quick smoke or a chat.

In the early 17th century Angelo Campani, a son of the late Proserpio Campani of Castel San Felice, owned a number of small tracts of land within the community of Castel San Felice and environs. Some of these parcels he had inherited, others he acquired as part of dowries of his two wives, and yet others he had purchased from time to time. He

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[15] This story was recounted to the Author in 1995 by parish priest the late Father Soloni.

[16] ASS, *Archivio Sordini*, fols. 7, 66; Luigi Fausti, 'Degli antichi ospedali di Spoleto', *Atti della Accademia Spoletina*, 1922, 85–86.

leased these tracts to tenant farmers, to whom he frequently also lent small sums of money for interest on short term.

Eventually, Angelo Campani and his wife Eufemia became parents of six children: five sons, Matteo, Carlo, Ignazio, Pier Tommaso, and Giuseppe, and a daughter, Ursula. They were a family of modest proportions for the place and time. In Castel San Felice, which was never a particularly prosperous community, relying as it did entirely on its agricultural pursuits, Angelo Campani was a relatively successful property owner. Despite his position in the tiny community, however, Angelo realized that there could be no future locally for his sons, and that it was inevitable that they would have to leave home to seek employment elsewhere. Perhaps one son might remain to help till the land, but as a small peasant proprietor, the relatively limited portion of land that Angelo cultivated sufficed only for one family's subsistence. He anticipated that his sons would find some sort of work in one of the larger communities in the region, such as Terni, Scheggino, or Norcia, or possibly even as distant as Rome.

In addition to his prominence as a land owner, Angelo Campani appears also to have been the local metal smith or blacksmith who made and repaired tools for the community. An inventory of his estate compiled after the death of his second wife described a room in Angelo's house that appeared to have been equipped as a shop for metalworking. It contained an anvil, two pairs of bellows, an iron vice, a forge with several irons or tools and three large augers, five assorted planes, five axes, and seven hatchets.

The death of his wife Eufemia in 1640 left Angelo Campani widowed with several young children. His single daughter, Ursula, was 14 years of age at the time and assumed the care of her younger brothers, Pier Tommaso, age 10, and Giuseppe, age 5. The oldest son, Matteo, was then 24 years of age and had completed studies for the priesthood at a seminary in Perugia. Angelo's other two older sons, Carlo and Ignazio, had made their way to Rome to find employment some time between 1642 and 1650. Four years or so later, Pier Tommaso, upon reaching the age of 14, made his way to Terni. There he found employment as an apprentice to a clockmaker.

Angelo soon was married again, in about 1642, to a young woman named Sebastiana, daughter of Pietro Agostino Canetti of nearby Scheggino, this union thus relieving Ursula of some of her responsibilities. In late 1644, Angelo and Sebastiana became parents to a daughter named Veronica.[17]

Despite Castel San Felice's distance from Rome, the Eternal City was the one offering most opportunities — in fact, Rome was the magnet that attracted ambitious young men from all parts of the Italian city states. Among those drawn there eventually were all of Angelo Campani's children from his first marriage.

Matteo, born in 1620, after completing his studies at a seminary in Spoleto, he went on for further studies in Perugia, possibly at the Jesuit college ,dedicated to the instruction of the young. After his ordination, Matteo's first assignment was the ancient tiny Church of San Sabino on Via G. Marcini in Spoleto. Matteo subsequently was assigned as vicar to another equally obscure parish church, San Tommaso, in the tiny hamlet of San Sabino some 4 km on the outskirts of Spoleto. Perched high upon the side of Colle San Tommaso, rising 360 meters above sea level, the 13th century church was constructed of the local stone. Until recent years, it was still possible to distinguish the scene in the single surviving remains of the Romanesque decorative fresco. Revealed were an angel and another figure in a recess in which edifices were recognizable, possibly the subject of an Annunciation.[18]

Although Matteo dutifully had taken holy orders, from his youth he retained a strong natural inclination toward the sciences and the mechanical arts. He endeavored to pursue these interests at every opportunity that was offered throughout his life, despite the priority of his parochial responsibilities. As pastor of his small church, Matteo must have found life almost intolerably dreary and limiting. On multiple visits to Rome during the next several years, possibly undertaken in connection with his pastoral studies or with acceptable excuses, he again met some former associates with whom he had been acquainted in the seminary, as he later reported. Notable among them were the Jesuit teachers Niccolò Cabeo and Francesco Eschinardi.

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[17] ASS, *Archivio Sordini*, fols. 7, 66; Fausti, 85–86; Bruno Toscano, *Spoleto in pietre : guida artistica della città* (Spoleto: Panetto et Petrelli, 1963), 49–50, 61; *Quando Spoleto era romanica : una mostra nella Rocca : antologia per un museo del Ducato : catalogo della mostra, Rocca Albornoziana, appartamento Piccolomini ; Duomo, Cappella della Reliquie, 30 giugno-29 luglio, 1984* (Roma: Multigrafica, 1984), 'S. Tommaso del Colle'.

[18] Toscano, *Spoleto in pietre*, 49, 51, 61, 62; *Quando Spoleto era romanica*, 'S. Tommaso del Colle'.

One day late in the year 1650, while Matteo happened to be in Spoleto, his attention was drawn to public notices posted outside the Duomo, one of which immediately aroused his interest. It announced a vacancy for a parish priest in Rome, for which there would be held a "Competitive Examination for the Parish of San Tommaso in Parione in Rome." Could this be a God-given opportunity that could take him out of the doldrums of Spoleto's outskirts and in to the Eternal City? He read on with mounting excitement:

> By order of the Most Eminent and Most Reverend Lord Cardinal Marzio Ginetti, Vicar of Rome, notification is made to one and all of those wishing to take the competitive examination for the Parochial Church of San Tommaso in Parione, made vacant by the death of the Very Reverend Cristoforo Bartocci, its last Rector and Possessor, that within the limit of ten days counted from the date of this present letter, they should, and each one of them should, make known to our undersigned secretary, their names, surnames, country, age, the [holy] orders received by them, their benefices, pensions, and other qualifications and degrees; and likewise they should show patent and dismissorial or testimonial letters and the customary oath that they are submitting to the examination, not with that mind or with that intention, that if they receive the mentioned Parochial Church, they will afterwards put it aside, but that they will fulfill its obligations and take up residence there [...].
>
> Given at Rome from our residence this 26th day of December, 1650.
>
> Ascanius Riccaldus, Vicar
>
> Joseph Palamolla, Secretary.[19]

Rome! A magical word about a magical world! How Matteo had always longed to be assigned there. Now at last there might be an opportunity to put his tiny rural parish of San Sabino behind him and finally have a parish not only of substantial size but one in Rome, the center of the Christian universe and the focus of scholarly activity! He was worried that he might not be of sufficient age for the appointment because he was only 30 years of age, and most priests in his time were not assigned a major pastorship until they were at least in their early forties. He was extremely anxious to advance his career,

[19] Survey of the premises undertaken March 16, 2001, personally by Rev. Giuseppe M. Cagni of the Padri Barnabiti, Rome, at the Author's request.

however, and to indulge in some of the extraneous studies he was not enabled to pursue because of his present responsibilities and distance from cultural centers.

Matteo lost no time in submitting his application, fulfilling all the requirements as specified. The days passed slowly before he received a response and further instructions a week later. The examination for the candidates was to be held "on the 23rd lunar day of the month of January, 1651, at 2:15 o'clock [...] in the presence of the Most Eminent and Most Reverend Cardinal Priest, Vicar of Rome." Enclosed with the notice was a list of the names of the competitors who had applied, and he noted that his name, "Matteo Campana [sic.] of the Diocese of Spoleto" appeared in the nineteenth place. It promised to be a tough competition, particularly if, as expected, there were to be many applicants from within the city itself.

Matteo immediately applied to his local superiors in Spoleto for permission to make the journey, which was granted. When time came to leave, he made his way to Rome on mule-back, the customary local means of travel, appearing before the examining board at the appointed time. After having taken the examination, he remained in Rome for several days while he waited anxiously for publication of the results. At last a list was published identifying the candidates who had been selected. Upon completion of the examination by the candidates, it said:

> and when those things had been seen which should be seen, and those things had been considered which should be considered, the Most Eminent and Most Reverend Lord Cardinal Ginetti, Vicar of Rome, selected, judged, and declared from all the above-mentioned examined and approved candidates, those most suitable, to obtain the Parochial Church of San Tommaso in Parione, namely, the Reverend Matteo Campana [sic] of the Diocese of Spoleto, V[icario] in S. Thoma.[20]

Matteo's relief and pleasure knew no bounds, and he impatiently hurried on his return journey to bring the good news to his bishop in Spoleto as well as to his family. He thought of the tiny hamlet in which he had been born and the even smaller community of

[20] The statutes of the sodality were approved by Pius IV in 1561 and renewed with the approval of Pope Alexander VII in 1662, in the period that Matteo was pastor of San Tommaso. Originally, the organization had included as members the cardboard makers (*cartai*) and the miniaturist artists who, because of discord arising with representatives of other arts, left the sodality in 1616. Massimo Petrocchi, *Roma nel Seicento* (Bologna: Cappelli, 1976), 188–89.

his parish, and his mind boggled as he compared them with the opportunities that would be available to him in the great city of Rome.

Before having left Rome, Matteo had taken the time to visit the Church of San Tommaso in Via Parione to familiarize himself with his new vicarage and its neighborhood. He found it to be a church of the second level, a very small church when compared to many other churches in Rome of this time. It was an ancient church with an interesting history, however, having been consecrated in 1139 by Pope Innocent II. In 1449, Pope Nicholas V conceded the church to the Company of Writers and Copyists with a *Motu Proprio* subsequently confirmed by Pope Julius III who enlarged the privilege. In 1517, Pope Leo X elevated it to the status of a titular church of a cardinal deacon.[21]

The church was distinguished by the fact that it had been in this church that, after having achieved all the required sacred orders, Saint Filippo Neri had accepted its deaconate. In 1582, the church's aging structure was restored, largely reconstructed by Mario and Camillo Cerrini of the Roman nobility, based upon the design of Francesco da Volterra. In a survey published in 1971 of the churches existing in Rome in the 17th century, San Tommaso in Parione then was listed as having had in the past a parish of 240 houses or families, one bishop, 28 priests, 6 nuns, and 766 communicants.[22]

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[21] Cecilia Pericoli Ridolfini, *Rione VI : Parione*, vol. pt. 1, Guide rionali di Roma 6 (Roma: Palombi, 1973), 91–94; Antonio Federico Caiola et al., *Roma sacra : guida alle chiese della città eterna* (Pozzuoli (Napoli): De Rosa, 1997), 9–11.

[22] Petrocchi, *Roma nel Seicento*, 188–89; Pericoli Ridolfini, *Rione VI : Parione*, pt. 1:91–94; Mariano Armellini, Carlo Cecchelli, and Pietro Tacchi Venturi, *Le chiese di Roma dal secolo IV al XIX* (Roma: Edizioni R.O.R.E. di N. Ruffolo, 1942), 23.

Chapter II

AVE ROMA IMMORTALIS

(1651–1655)

Go thou to Rome—at once the paradise,
The grave, the city, and the wilderness;
And where its wrecks like shattered mountains rise,
And flowering weeds, and fragrant copses dress
The bones of desolation's nakedness.

Percy Bysshe Shelley, *Adonais* (1821).

By the mid-17th century, at the time that Matteo Campani arrived in Rome, the population of the Eternal City consisted of some 120,000 inhabitants. They lived for the most part within the inner core of the city, in homes jammed closely together along the ancient dark and narrow winding streets. The encirclement by the seven hills of Rome created topographical problems that made a formal classical street plan impossible. Divided into fourteen wards known as *rioni*, the city did not enable even the classical outline of a Roman camp. All of the main avenues, paralleled by the Tiber River, appeared to continue routes that had been taken by pilgrims from antiquity as they traveled to Rome to worship at its seven basilicas. The unpaved streets made walking a difficulty and generally were constantly buried under mud.

Among the major squares, there were the Campo dei Fiori and the Piazza Farnese, and the Piazza Navona, which featured the new Church of Sant'Agnese, still was under construction. Other squares punctuated areas here and there, usually resulting from the widening of sections of streets to accommodate the market stands of vendors. The frequency of gridlocks often made streets virtually impassable as coaches, litters, and an occasional rider vied with carts and mules and porters for passage. The already narrowed streets were made more hazardous for travel by masses of abandoned refuse that littered them. In addition to being covered with the silt of centuries, those streets that the waters of the Tiber could reach were in the worst condition of all, as they were regularly flooded, with each inundation bringing new deposits of mud that remained. There was a time that the Via Lata was so narrow that a horse had difficulty passing through it.[23]

Pavements were rarely penetrated by sunlight because the houses lining the crooked, narrow streets were clustered so closely together. Ranging in height from one story to as many as four, the buildings were entirely inconsistent in structure, some having projecting balconies and exterior staircases, their fronts often recessed from the street, while others projected beyond the limits of the street, appearing grotesque instead of picturesque. The wealthy often managed to avoid these problems, having homes high up in the city's seven hills, while dwellings of the poor occupied the low areas along the river front as well as in the Jewish ghetto and the Trastevere. Miscellaneous dwelling arrangements beyond the city walls accommodated the homeless.

Some 5,500 shops were estimated to have been in operation in Rome during this period, the nature of the contents being sold apparently responsible for the manner in which they were organized, at least to some degree. Traditionally, specific areas of the city were allocated to particular occupations. The older part of the city abounded with markets and an endless number of stalls that filled every available space and obstructed traffic. These stalls were occupied by fishmongers and dealers in olive oil and farm produce, all noisily vying for space. The favorite location for booksellers was around the Piazza of Pasquino, for example, while second-hand bookstalls and scrap-iron dealers could be found at the Piazza Navona, in the vicinity of which the various building trades also were situated. The Piazza di Monte Giordano featured rag pickers, and oil was sold in the Piazza Capranica. In accordance with its name, vendors of rosaries and religious objects lined the Via dei Coronari. The Forum, then known as *Campo Vaccino* (which literally meant "cow-field"), was the marketplace where cattle, sheep, hogs, and chickens were bought and sold.[24]

Although the newly elected pontiff Alexander VII discovered early in his reign that it was virtually impossible to cut new streets through the city, nonetheless he made a heroic effort soon after his election in 1655 to improve traffic. He proposed to do so by undertaking a program of straightening the streets. Accordingly, drastic measures had to

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[23] Giuseppe Baracconi, *I rioni di Roma* (Rome: Edizioni del Pasquino, 1979), 9–14; H. V. Morton, *A Traveller in Rome : With Photographs and Endpaper Maps* (New York: Dodd, Mead, 1957), 8–39.

[24] Pietro Romano, *Roma nelle sue strade e nelle sue piazze* (Roma: Palombi, 1949) passim.

be applied, in an effort to remove as many as possible of the countless outdoor stairs and stoops that protruded into streets and squares, as well as vendors' stalls. It became necessary even to order fronts to be cut away of some of the houses that projected too prominently into the streets.[25]

Like every newcomer, during his first days in the city after his arrival, Matteo attempted to absorb every aspect of the city as he encountered it, delighting in all that was new to him. He had visited Rome several years earlier, so that the city was not altogether strange to him. Immediately upon arrival, he had made his way to Via Parione to his new assignment, the little Church of San Tommaso, where he was to spend the remainder of his life. In his past visits to Rome, he had not been aware of this particular church that was ideally situated in Via Parione, which at that time was one of the most fashionable sections of the city. Now he looked at it with admiration as he compared it with the two little churches in the rural parishes in which he had served.

Although unfamiliar with architectural details, Matteo saw that the facade was of two architectural orders, the inferior tripartite of pilasters with a portal of triangular pediment joined by means of volutes with the one above, in which there was a square window. At the right side of the church was the rectory, containing a large open room that served as the mortuary chamber in which bodies of deceased parishioners were placed while awaiting funeral preparations. Inside the church, he saw that the interior was divided into three naves, each with eight pilasters with attached Ionic fascia. A stairway in the rear led to three upper floors, which opened into six rooms. There also was a chapel, or a room for the recital of the divine office of the canonical hours. Bells rang in the campanile for sacred functions.

Unquestionably it was Matteo's move to Rome that hastened the arrival of other members of Angelo Campani's family to the Eternal City, although two of them already had preceded him. His brothers Carlo and Ignazio already were in Rome when he arrived. Virtually nothing is known of their occupations or activities while in Rome. His sister Ursula is believed to have come to Rome with Matteo to serve as his housekeeper in the rectory. Carlo Campani, who was two years younger than Matteo, died in Rome on July 26, 1651, six months after Matteo had taken over his parish. With his brother Matteo

[25] Georgina Masson, *The Companion Guide to Rome* (London: Collins, 1965), 212–14.

officiating, Carlo was buried in the Church of San Tommaso in Parione.[26] His brother Ignazio also became a member of Matteo's parish. No reference to the two brothers is made in any of Matteo's later communications, nor in those of his two younger brothers, Pier Tommaso and Giuseppe, who next followed him to Rome.

In the summer of 1651, upon the death of his son Carlo, Angelo Campani journeyed to Rome to make arrangements with the Church authorities to reserve space within his son's church stated to be "for his own burial and that of his descendants"—that is, all members of the Campani family who died in Rome. By this time, Angelo had realized that in the future his entire family would be domiciled in Rome and could no longer be expected to return for permanent residence to Castel San Felice. For that reason, he indicated that he too planned to be buried in the Church of San Tommaso. As his son Matteo later recorded the arrangement in the church's "Book of Deaths, the site for burial within the church "was chosen by our father, Angelo Campani, for himself and his descendants who die in Rome, in front of the high altar on the right hand side between two burial stones near the lamp of the same altar." The tomb for the Campani family was on the side of the Gospel (*Vangelo*). In the liturgy that continued until Vatican Council II, when facing the altar, the side of the Gospel was on the left side, while the right side was the side of the Epistle.[27]

The burial chamber as such containing deceased members of the Campani family no longer exists because in the latest restoration of the church all of the flooring or pavement was replaced by modern marble of a grey color. There is no longer evidence of the trap doors or apertures through which cadavers of the deceased were passed into the tomb; the entire floor is now uniform, and no trace remains of the opening. Inasmuch as in Italy today the dead no longer may be buried inside the churches, the restorers apparently preferred to make the flooring of the presbytery in a uniform manner, without reference to the tombs that were no longer serviceable.

In 1666, when his brother Ignazio died, Matteo made a note elsewhere in the same volume of church records that his brother had been buried "in the particular place before

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[26] ASVR, *San Tommaso in Parione, morti,* (1651-1708), noted on July 26, 1651, the death of Carlo Campani, followed on November 15, 1665, in the death notice of an infant son of Pier Tommaso Campani, named Francesco Aloigi (Aloysius) Matteo Campani.

[27] Ibid.

the high altar between the two lamps on the gospel side." During the course of the next four decades, at least eleven members of the Campani family who had died in Rome eventually were buried in the space selected in the Church of San Tommaso in Parione. These included the first two wives of Pier Tommaso (Giacoba Giuditta Heroldi and Rita Vittorini), five of Pier Tommaso's children, the two brothers Ignazio and Carlo Campani, and the sister Ursula Campani, in addition to the rector himself, Matteo Campani.[28]

Pier Tommaso, who became a clockmaker, was the fourth son of Angelo Campani. Born in 1630, he had left Castel San Felice at the customary age of about 14 to seek an apprenticeship with a clockmaker in the town of Terni, situated some 70 km from Rome. The ancient town, traditionally said to have been founded in 672 B.C., was an episcopal see of Umbria. No local clockmaker was identified as having been established in Terni during that period, and Pier Tommaso probably was apprenticed to a German craftsman working there after having traveled into Italy seeking employment. Many were forced to seek work elsewhere after the conclusion of the Thirty Years War, which had brought with it such dire devastation to the great tradition of mathematical and horological instrumentation that had existed in Germany and the Low Countries. In Italy, some succeeded in finding employment at the princely courts in major cities.

Following traditional practice, by 1651 Pier Tommaso had completed his apprenticeship and may have continued to work as a journeyman for his former master for the next year or two before going to Rome. In the interim, he also may have traveled around the region gaining experience in the nearby communities of Scheggino, Spoleto, or Narni. Two years later, having reached the age of 23, Pier Tommaso obtained his father's permission to move to Rome. He was accompanied by his younger brother Giuseppe, whom, in accordance with his father's instructions, had been training in clockmaking as well. It appears to have been a practice in that time and place that a son required the father's permission before making a change in venue or occupation.

Matteo readily furnished lodgings for his two younger brothers in the spacious rectory. He already had been making a practice of renting some of the rooms in the rectory and elsewhere on the church premises, possibly following the practice of his predecessor. Rental was at 1 *scudo* per room a month. Meanwhile, he maintained his own

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[28] Ibid.

private domicile in the tower section of the church at the left of the main structure. Presumably, it was accepted practice among pastors to rent church space to generate funds for the parish or perhaps to supplement their salaries.[29]

At the time of the arrival in Rome of Pier Tommaso and Giuseppe, there were very few clockmakers and mathematical instrument makers at work in Rome. In addition to the living quarters that Pier Tommaso shared with Giuseppe, the space Matteo provided his brothers included sufficient room for Pier Tommaso to use as a workshop until he could venture to establish his own shop. With financial assistance from his father, Pier Tommaso next purchased the shop equipment he required, including a lathe, clockmakers' tools, and requisite stock materials. It was soon apparent that Pier Tommaso had considerable talent and was particularly skillful and ingenious, capable of producing timepieces of significant complication in addition to ingenious automata.

Upon his arrival in Rome, Pier Tommaso may have applied for temporary employment with one of the few local clockmakers, intending to work for a brief period in order to make himself and his work known in the city. The fates favored him, however, and soon examples of his work provided evidence of his talents and ingenuity, succeeding in attracting wealthy patrons. As noted, he already had come to the attention of Cardinal Fabio Chigi (later to become Pope Alexander VII) even before his election to the papal throne. There is no doubt, however, that by the time the newly elected pontiff took office in 1655, Pier Tommaso had become well-established as a clockmaker in Rome and already had found employment at the Apostolic Palace.

In 1655 Pier Tommaso was mentioned in public notices: he was described in the *Avvisi*,[30] Rome's occasional gossip sheet and forerunner of the newspaper, as "a

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[29] The *scudo*, a 3.34 gr golden coin (plural: *scudi*), was the currency of the Papal States until 1866, when it was replaced by the Italian *lira*. See: Silvana Balbi de Caro and Luigi Londei, *Moneta Pontificia: Da Innocenzo XI a Gregorio XVI* (Roma: Edizioni Quasar, 1984).

[30] Although there had existed in Rome since 1640 a printed newspaper, the *Gazzetta Ordinaria* (or *Pubblica*), it lacked the popularity of the *Avvisi*. The publication and distribution of these news sheets were arranged by several of the leading Italian political powers, probably through their ambassadors to the Holy See, who sent copies of them home at regular intervals. These news sheets first came into being in Rome and Venice, and because those from Rome were written for and about court circles, they were far more popular and interesting, being considerably more libelous and critical. Reporting local events and activities of the pontiff and the cardinals, they also gleefully provided court gossip and featured scandals among the prelates and the nobility. The pontiffs frequently fulminated against the *menanti*, as the journalists were called, but to no avail because the writers were too clever and essential to their employers. The *menanti* frequented the Parione region instead of aristocratic quarters, and papal attempts to censor them were

clockmaker most famous in this city" and noted that he had "singular virtue".[31] His success was further made evident by the fact that within a year or two after his arrival in the city, on not only one but on at least two recorded occasions, Pier Tommaso had been sought out by Cardinal Fabio Chigi to execute special commissions for him, possibly on the recommendation of the architect and sculptor Gian Lorenzo Bernini.

As Pier Tommaso described his work several years later, "I began my first work with a manner of thinking that was not simple, but capricious and outside of the ordinary, and my spirit was never tranquil if not toiling at my clock." These characteristics are reflected in contemporary descriptions of his clocks and are visibly evident in almost every one of the known surviving examples of his work.[32]

Giuseppe Campani, the youngest of the brothers, arrived in Rome together with Pier Tommaso. Ever since his childhood, Giuseppe had demonstrated a particular love and a remarkable talent for mechanics, and accordingly, with his father's support and Pier Tommaso's agreement, it had been arranged that the latter would train him as an informal apprentice in the art of clockmaking. Giuseppe had been 16 years of age when Matteo left Castel San Felice for Rome and was no more than 18 at the time that he arrived in Rome and joined him.

Giuseppe's first impressions of the fabled Eternal City were filled with excitement and yet bewildering at the same time because of Rome's sharp contrast with the quiet, easygoing tenor of the small Umbrian hill town he had left behind. There was so much new for him to see, so much more to be learned and remembered, and at first he spent his leisure hours wandering the streets, familiarizing himself with the region. Gazing about him as he walked around, staring with awe up at the monumental palaces squeezed next to ordinary dwellings, entering countless churches, and seeking out ancient

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consistently unsuccessful. Maria Luisa Ambrosini and Mary Willis, *The Secret Archives of the Vatican* (Boston: Barnes & Noble, 1996), 164–68.

[31] ASV, *Avvisi*, vol. 24, Rome (October 23, 1655).

[32] Pier Tommaso Campani, *Lettera di Pier Tommaso Campani, ad vn suo amico, nella quale le dimostra l'origine, e l'artificio dell'oriolo da lui fabricato l'anno 1656. con la sfera dei pianeti, ...* (In Roma: per Giacomo Dragondelli, 1660), 4–5; Silvio A. Bedini, 'Introduzione', in *Discorso intorno a' suoi muti oriuoli con Lettera di Pier Tommaso Campani nella quale dimostra l'origine e l'artificio dell'oriolo(1660)*, by Pier Tommaso Campani, Edizione a cura di Silvio A. Bedini (Milano: Il Polifilo, 1983); Matteo Campani, Giuseppe Campani, and Pier Tommaso Campani, *Opera varia horologica @ microscopica, 1660-1705: raccolta commentata di opere a stampa, manoscritti e lettere autografe*, ed. Anatolio Egidi (Spoleto: Nuova eliografica, 2012).

ruins, Giuseppe was searching for their remnants of history and absorbing all the color and excitement of this new way of life.[33]

Every building had its memories, he knew, and every street had its history. Giuseppe noticed that some of the palaces he passed had facades and entrances upon two streets back and front, often opening inward upon two courtyards. Someone explained to him that the lower floors generally were occupied by stables, a coach house, kitchens, and other domestic offices. A half story above these, he was told, was a mezzanine housing the unmarried sons of the house and their tutors. Above was the *piano nobile*, or state apartments, in which the princely family dwelled, with dining and reception rooms. Peering through the entranceways into the great halls, he often noticed displays of family arms embroidered in bright colors and great staircases rising from street level wide enough for a horse to ascend. Occasionally he observed important personages ride up and down the staircases on muleback and was informed that as many as 100 persons lived in these establishments. Most impressive of all he found to be Saint Peter's Basilica, with its majestic size.

Walking about the city, he searched for and found occasional reflections of the Rome of the Caesars to the east and south past the Quirinal hill as far down as the Piazza Venezia, which featured the dusky and forbidding Palazzo Venezia, the earliest Renaissance palace in Rome. Beyond it was visible the Campidoglio rising with the ancient bronze statue of Marcus Aurelius poised upon his horse, and a few steps farther forward, the Forum came into view. There he saw ruins lying half buried in the earth, was surprised by the *Campo Vaccino* and how it was pockmarked with excavations. As he watched, herds of sheep, oxen, and buffalo roamed and drank from fountains shaded by towering oak trees against the backdrop of the Colosseum. Houses lining both sides of the quadrangle that formed the Forum added to the rural ambience of the scene, where he could briefly experience a pastoral peace reminding him of the open sloping fields of Castel San Felice. Although from time to time his thoughts returned to his early days in the Umbrian hills, his mind was too preoccupied and filled with all the wonders and people in his new life.

[33] About life in Baroque Rome: Pietro Romano, *Due secoli di vita romana: aneddoti - documenti - curiosità* (Roma: A.R.S. Anonima Romana Stampa, 1941).

From time to time in the course of his wanderings, Giuseppe found himself following along beside the sluggish silt-colored Tiber as it snaked its way through Rome and noticing marble ruins scattered about in thickened clusters along the way. On some days, when he ventured into the Piazza Navona near his brother's rectory, he found himself part of large groups of spectators observing acrobats and mountebanks who frequently used the piazza as their showplace. Commonplace was the occasional presence of barbers and tooth-pullers carrying on their trades in the open air, and he learned to ignore the beggars who were annoyingly prevalent everywhere. In the summertime, special festivals were featured in the Piazza Navona, such as one called the *naumachia*, during which the piazza was flooded to enable water jousts and mock sea battles to take place. It was a place where astrologers wandered about among the visitors, seeking to tell their fortunes.

Feast days and religious festivals were so numerous in the great city that it seemed to Giuseppe as though almost every other day was a holiday; by the late seventeenth century, the city recognized some 150 religious festivals. To these were added periodic special pageants such as the great procession following the election of each new Pope. For variety from time to time there were seasonal incursions such as the advent of the peasants who traveled annually in great droves from the Abruzzi region. They flocked to Rome every December, clad in sheepskin coats and paraded through the Roman streets from shrine to shrine playing bagpipes.[34]

Giuseppe visited churches beyond measure; there were more than 300 of them, he was told. On the feast day of Saint Peter, the great basilica that bore his name was illuminated by means made possible by the Vatican's 365 agile acrobat-like *Sampietrini* who flew about through the air swinging on ropes above the congregation with 6,000 lighted paper lanterns and lamps flaring with fire.[35]

By 1621, Rome's population of 118,356 residents was almost outnumbered by visiting pilgrims and tourists who swarmed into the city. In 1653, when Giuseppe first

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[34] Francesco Cancellieri, *Storia de' solenni possessi de' sommi pontefici detti anticamente processi o processioni dopo la loro coronazione dalla Basilica Vaticana alla Lateranense dedicata alla Santità di N.S. Pio 7. P.O.M. da Francesco Cancellieri* (In Roma: Presso Luigi Lazzarini stampatore della R.C.A., 1802), 256–75.

[35] Francesco Buranelli, *Habemus papam: le elezioni pontificie da San Pietro a Benedetto XVI* (Roma: De Luca, 2006), 158.

ventured along the Corso, he undoubtedly encountered wealthy residents parading in their ornate carriages, while on the Quirinal hill he could observe the rich as they strolled leisurely about their gardens. He walked along the torturous, poorly paved streets of Campo Marzio, where grand palaces loomed over tiny houses squeezed into vacant lots. Balconies sometimes projected from low buildings on either side and some also had exterior staircases, all clustered closely together.

Except for the homes of personages of particular importance, it was not until 1744 that house numbers were first assigned in Rome. Consequently, the only means of identifying an address in Rome in Giuseppe's time was to relate it to a recognizable landmark, such as the nearest church or a monument. When the plague first swept the city, however, Giuseppe had observed that, at first, houses containing the sick were marked, but the practice was soon abandoned. The situation was not improved until long after his time, by the turn of the nineteenth century, at which time marble slabs were erected as indicators of the *rione* or district boundaries.[36]

The streets were rarely cleaned, except in advance of an official announcement that a special procession or visitation was about to occur. Most of the time, the streets were overlaid with dust from the silt of centuries and the filth discarded by a careless population. In winter those areas that were within reach of the Tiber were in even worse condition because the river flooded regularly. Mud clogged the streets, often several feet deep, while in summer the same streets were choked with dust that rose above them with every disturbance. The population relied heavily on rain showers to lay the dust, but it was never adequate. Ineffective attempts were made, frequently in the evenings after sundown, by trundling several carts along the streets. The laborer following each cart swung a leather tube connected to a water barrel on the cart from side to side as he progressed along the street in an attempt to dampen the dust.

There were favorite haunts that Giuseppe undoubtedly enjoyed exploring in the remote corners of the fabled Trastevere. He probably ventured into its darkened and cramped alleyways seeking the full range of Roman life, for it was there that was to be found every trade represented by a shop sign bearing its painted icon hanging over their

[36] Ellen B. Wells, 'The Plague of Rome of 1656' (McGill University, 1973); Cardinale Sforza-Pallavicino, *Vita di Alessandro VII sommo pontefice. Libri cinque* (Milano: Per Giovanni Silvestri, 1843), 101.

entrances above the street level. They ranged from the barber's shaving plate to the fattened hog of the butcher. The smoking pipe designated the shop of the tobacconist, the opened scissors denoted the tailor's shop, and the bleeding arm could be only the sign of the surgeon. He would have looked in vain for shop signs of clockmakers, for the few that existed were to be found only among the shops of goldsmiths, silversmiths, and pewterers along the Via dei Pellegrini.

Elsewhere in the city, the coffee sellers could be readily identified by the sense of smell because of the odor of their roasted beans at the column of Marcus Aurelius in Piazza Colonna. This was the only place in Rome in which they were allowed to roast the beans because the smell of coffee was considered offensive. In the evenings, the piazza where vendors sold fruit drinks was illuminated by lamps, and a strong smell of wood smoke pervaded the region. The shops of the cabinetmakers and wood workers, for the most part, were situated between the Piazza Campitelli and Via Arenula. The stalls of the booksellers generally were in the vicinity of the Chiesa Nuova; almost every craft and trade had a particular area where they were habitually to be found. A number of the streets were identified by the tradesmen who maintained their shops on them by describing their wares: the hat makers, for example, were in the Via dei Cappellari, the dealers and makers of rosaries frequented the Via dei Coronari, and the habitat of Rome's locksmiths was the Via dei Chiavari.[37]

In addition to the many new sights and sounds of the city that Giuseppe as a country boy found strange at first, but to which he was becoming accustomed, was the experience of seeing and meeting men, women, and children of many other races and nationalities, in a great variety of dress, from the Jews in the Trastevere to the pilgrims coming from all parts of Europe who flocked through the city streets eager to visit all of Rome's seven basilicas.

Little by little Giuseppe familiarized himself with the habits and customs of city living. He had been surprised at first, for example, to discover that in Rome food generally was prepared outdoors because of fear of fire. Many of the shopkeepers and artisans pursued their activities and crafts out in the open too. The family washing was hung to dry out of windows, often on ropes stretched from one to another, even at the

[37] Luigi Huetter, 'Le corporazioni d'arti e mestieri in Roma', *Capitolivm*, 1926, 689–98.

Vatican. Rubbish was everywhere, piled against the walls of the buildings awaiting the attention of refuse collectors who rarely seemed to make their rounds. Sanitary practices were of the most primitive, for there were no pissoirs, and all classes from the richest to the poorest relieved themselves shamelessly in public against any convenient wall or staircase.

Despite these unfavorable aspects of the Eternal City, Giuseppe was surprised by the easy pace of life in the city and the general cheerfulness that abounded, and he soon adopted the proverb by means of which the people in Rome lived, that “Those who are content will enjoy” (*Chi si contenta gode*).[38] Occasional vistas that Giuseppe glimpsed through the city probably reminded him of the countryside, for he saw cows and sheep wandering about some of the moss-covered ruins, and from time to time he encountered peasants hurrying in from the countryside with baskets or handcarts filled with farm produce, all of which combined to create a comfortable pastoral feeling, reminding him of the little hamlet from which he had come.

Time was measured in the traditional Roman style, on a 24-hour dial from sunset. If the sun set at five o’clock, then the first hour of the day was six, the second seven, and so on through the 24 hours. Clocks and watches were set by the sound of the Ave Maria bell that tolled one-half hour after sunset, and standard time was taken from what was called “the Clock of the Roman People,” a timepiece situated above the round window at the left of the main door of the Church of Santa Maria in Aracoeli. Eventually, the practice was changed to taking standard time from the ringing of the bell in the campanile on Capitoline hill.[39]

Tradition decreed that a rest at noon time was essential to enduring Rome’s summer temperatures. The siesta was a practice to which the Campani brothers were not accustomed, and as naturally active country-bred individuals, they had difficulty in accommodating themselves. The hours of the siesta were long, during which—according to the popular saying of the Romans—only dogs, lunatics, and Frenchmen would be out in the streets. The several hundred workshops of smiths, masons, engravers, potters, painters, and other crafts and trades throughout the city were frequently closed and

[38] Scientific Editor’s note: “Enough is as good as a feast.”

[39] Maurice Andrieux, *Daily Life in Papal Rome in the Eighteenth Century* (New York: Macmillan, 1969), 81–82.

shuttered, occasionally even before the beginning of the siesta. During the torrid summer months, the Romans resigned themselves to this sacrifice with sinful pleasure, and when winter came, they patiently suffered the extremely cold spells that occurred from time to time.[40]

There were countless diversions to be found and enjoyed in Rome. As already mentioned, on occasion one witnessed the periodic travel of the Pontiff riding in his carriage from the Quirinal Palace surrounded by innumerable mounted attendants on his way to inspect various sites or to participate in ecclesiastical activities in designated parts of the city. On May 29, 1655, for example, the Campani brothers must have been among the crowds that observed an elephant being made to perform publicly, according to the *Avvisi*, "that with its trunk made many antics, and it was most curious to see, bringing out the entire city, and left shortly thereafter to tour other places in Italy".[41]

Because clockmaking was not among the major crafts in Italy at this time, the number of craftsmen thus engaged was limited and there were no Italian craft guilds or fraternal associations for clockmakers such as existed in the Netherlands, France, and Germany, probably because there were not enough members to form them. For the most part, clockmakers might be found employed at the princely courts of the city-states, surviving on the patronage of princes, prelates, and wealthy merchants. Although Rome with its papal court would appear to have been a particularly lucrative center for clockmakers, such does not appear to have been the case.

The Campani brothers managed to achieve success and even fame almost immediately, partly because there was so little competition for them at the time that they began working in Rome and partly because their work invariably was innovative. Pier Tommaso's elaborate timepieces, frequently equipped with automata, with which he was particularly skilled, were conversation pieces and found a ready market in the palaces of Roman nobility, in embassies to the Holy See, and with members of the papal court. In due course, Giuseppe in turn produced one horological invention or innovation after another, some of which substantially advanced the science of horology and made his name known even beyond the confines of Rome. Matteo, although neither a clockmaker

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[40] Cindy Sherman, ed., *The Rome Studio* (Providence, R.I.: Brown University, 1993), 9.
[41] ASV, *Avvisi*, vol. 24, Rome (May 29, 1655).

nor an instrument maker, nonetheless published on the subject of the Torricellian tube and conceived several ingenious timekeepers, although they were not successful in practice.

The city of Rome's primary source of income derived from the Church in one form or another. Each Holy Year brought between half a million and a million pilgrims to Rome. The city's commerce consisted primarily of the importation of commodities such as food, fuel, wood, and metals that were delivered in small boats to the port areas of the Via Ripetta. Traffic was the constant major problem, then as now. Then it was attributable largely to the great numbers of vendors of foodstuffs and fuel who came from the countryside into the city to offer their wares, establishing themselves on particular locations they chose on specific streets and squares. This commerce was supervised by the papal government, which established price control for purposes of taxation. Because the prices of flour and bread were of considerable concern to the poor, their costs were subsidized by the government because a great number of religious organizations supported charitable institutions, ranging from monasteries and religious hospital orders to confraternities or brotherhoods.

The Pontiff was the secular as well as spiritual head of the government of the city of Rome. Next came the College of Cardinals, to which the Curia (the central governing body of the Church) reported. The College of Cardinals consisted of a series of congregations, some established by the Pope and others by the Curia. These congregations, headed by cardinals, included representatives from other groups as required. They functioned as legislative and civil service departments and were concerned with matters of doctrine and other specific problems. They were tribunals that fulfilled the judicial functions of spiritual as well as secular government. The Chancery and the Datary, which were responsible for civil service, were administered by four Palatine secretaries. Much of the temporal power resided in the Apostolic Chamber, which served also as the treasury and administered the congregations. Separate administrative staffs for Rome and the outlying Papal States were appointed by the Pontiff, and they reported to the Apostolic Chamber.[42]

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[42] Morton, *Traveller in Rome*, 19–21; 301–21; Francis Marion Crawford, *Ave Roma Immortalis! : Studies from the Chronicles of Rome. In Two Volumes*, vol. 2 (New York: Macmillan & Comp., 1898),

By tradition, the great families of Rome were closely associated with the Church, their long-established incomes supporting their ostentatious living and enabling them to subsidize artists and a wide range of artisans. The election of each new pontiff inevitably brought many artists from all parts of Italy scurrying to Rome seeking commissions. Preferable commissions were those orders derived from members of the Church hierarchy who now would be seeking to implement the splendor of not only their residence but also of their titular church and the church they had selected for their own burial. The artist often was provided with lodgings in the patron's palace and a monthly stipend during his stay. A market price generally was negotiated for each work that had been commissioned and that the artist completed. Not all artists were favored with a permanent patron, and others had to maintain their own studios and accept commissions from any source.[43]

One of the most popular artists of the period was Carlo Maratta, whose work also was reputed to be among the most costly. He was paid 1,590 *scudi* for a full-length portrait, for example, while Gaulli, his closest rival, was paid only 100 *scudi*. Both of these artists were among those who produced dial paintings for the night clocks subsequently produced by both Pier Tommaso and Giuseppe Campani.[44]

Because of their growing monopoly of wealth, the papal families inevitably dictated fashion and were the leaders in the arts. At the time of Matteo Campani's arrival in Rome, the papal throne was occupied by Innocent X, scion of the Pamphilij family that had been established in Rome for over a century. His predecessor, the Barberini Pope Urban VIII, had been noted for his patronage of the arts, making his exceedingly long

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245–48 (pilgrimages); *Ave Roma Immortalis! : Studies from the Chronicles of Rome. In Two Volumes*, vol. 1 (New York: Macmillan & Comp., 1898), 297–318 (Parione), and 260–65 (nineteenth century Italian life).

[43] If a painting was intended for a private gallery, the practice generally was to specify the measurements, the subject matter, and often the number of full-size human figures to be included. Additional cost might be requested if research was required by the artist for subjects depicting scenes or incidents from the Old Testament or popular secular subjects in the event that it might be necessary to consult a scholar for information or advice. During the second half of the seventeenth century, a patron might require the price in advance as well as a preliminary drawing or a sketch in oils and might specify a time limit for completion.

[44] Carlo Maratta (1625–1713) was an Italian artist who produced many commissions for Pope Alexander VII and was created painter in ordinary by King Louis XIV. The popular artist and architect Giovanni Battista Gaulli (1639–1709), known as "*Il Baciccio*," was established in Rome and became protégé of Gian Lorenzo Bernini. [Robert Enggas, 'Giovanni Battista Gaulli', ed. Jane Turner, *The Dictionary of Art* (London: Macmillan Ltd., 1996), 197–203.]

reign a period of luxury and enterprise. The election of Innocent X in 1644 brought about substantial change, however, creating a virtual revolution in the Eternal City.

The election of each new pontiff inevitably brought large numbers of his relatives and friends to Rome, seeking to share in the family riches and to seize the most lucrative posts. The patron families with their new riches, constantly competing with one another, built new palaces and filled them with great collections of art that they had been accumulating. Often a reversal occurred, however, upon the demise of each pontiff, caused by the diminishing or termination of the income of his family and supporters.

Following the death of Innocent X, sixty-six cardinals entered the conclave on January 20, 1655, for the purpose of selecting a successor from amongst themselves. The selection would be of considerable importance because at this point in the history of the Holy See, the next occupant of the papal throne must be able to combine spiritual depth with moral integrity and also have had diplomatic experience. Few of the cardinals had all these qualifications, but it was obvious that at this time it was the political qualifications that were of utmost importance. Although the cardinals that Pope Innocent X had created maintained a neutrality, the new papal selection faced two factions that were critical: an imperial party of the Spanish and a French group strongly influenced by Cardinal Mazarin.

As the two foreign factions vied with each other to obtain control over the next several weeks, there was much fruitless scrutiny. The cardinals meanwhile were impatiently experiencing increasing discomfort as a consequence of being forced to remain locked up within the stifling, limited space of the Sistine Chapel. They complained constantly of the foul air of the enclosure, and several became ill and were forced to leave the conclave. In fact, one of them, Cardinal Carafa, died during the conclave.

A name that kept emerging again and again in the voting with increasing frequency was that of Cardinal Fabio Chigi. Scion of a wealthy banking family of Siena, he had been a popular cardinal in Rome. He was considered by his contemporaries to be capable, pious, and well-intentioned. He had a definite advantage in being supported by a group of powerful cardinals that he inherited from the preceding pontiffs and which included among them members of both the Barberini and Pamphilij families.

Finally, on April 7, 1655, after 85 days of voting, the election was resolved with the selection of Cardinal Chigi, who took the name of Alexander VII. On the day that his coronation was celebrated, April 18, a blustering north wind came raging through the city in a violent storm, bringing endless rain and hail, causing much damage, particularly to the vineyards in the environs of Rome. Many considered that it was an omen, an event that did not auger well for the new incumbent.[45]

The newly elected Pontiff was determined from the very beginning to maintain the greatest simplicity. This began with the arrangements being made for the preliminary possessional ceremony. Traditionally, the route to be followed involved a substantial distance, from the Church of Santa Maria Maggiore to the Basilica of Saint John Lateran. The Pontiff announced that he planned to walk the distance barefoot, accompanied by the entire clergy. He would do so for good reason, he stated, stipulating that the money saved in this manner was to be given to the poor.

The dire prospect of such unaccustomed exercise so greatly alarmed the clergy, that they finally succeeded in prevailing upon him to follow the customary procedure. Desperate for reasons to make him change his mind, they pointed out how otherwise the people of Rome would be greatly disappointed and deprived, for the festive decorations that would be erected throughout the city along the traditional route would have provided work for countless craftsmen and artists. Furthermore, the poor would benefit because of the cost of many of the expensive costumes that would be worn later would be given to impoverished members of the nobility. It was with considerable reluctance that the pontiff finally capitulated.

As a cardinal, the new Pontiff had earned general respect for his wisdom and modesty. His integrity was greatly admired, and the people entertained high hopes as they joyously greeted the selection of the new Pope. He was relatively young for the position, only 56 years of age, and a long and vigorous pontificate was anticipated. Since his youth, however, Fabio Chigi had suffered from kidney problems, leaving him with a threatening legacy of frail health during the remainder of his life. While studying in Siena in his youth, the Pontiff had been greatly inspired by Celso Cittadini, from whom he

[45] John Bargrave, *Pope Alexander the Seventh and the College of Cardinals*, Works of the Camden Society 92 (New York: AMS Press, 1968), 7.

inherited his love of history and literature.[46] He had studied Euclid and geometry, was particularly interested in architecture, and had read Vitruvius. He enjoyed drawing and was interested in painting. He appeared to have a particular affection for timepieces, said to have often made carvings of various gnomonic figures, cylindrical, boxed, concave, convex, and all types of timepieces (sundials), including wall dials.[47]

The new Pontiff had chosen the name of Alexander VII in memory of Pope Alexander III who had fought Emperor Frederic I to preserve the Church's independence.[48] The two themes Alexander VII chose for his coat of arms were the eight-pointed star in combination with the six mountains. Concerned that his formal coat of arms might not survive the hazards of history, he had artistic decorations made that featured these themes in the belief that art always would be respected. These themes were repeated many times as adornments, not only on buildings he had erected but also on others only slightly restored, and on numerous minor works. The star sometimes appeared independently used on his personal possessions and became identified solely with Alexander VII and his reign. For example, on clocks he commissioned from Giuseppe Campani, the eight-pointed star was featured as the pendulum bob.

The election of Pope Alexander VII augured a new era for Rome, which lived up to its promise as a period of remarkable artistic activity that would continue for almost a century. It was generated to a great degree by his architect, Gian Lorenzo Bernini, and sustained by Bernini long after Alexander's reign. It was as Cardinal Fabio Chigi that he had met Bernini, shortly after his first arrival in Rome in November 1651 to assume the office of the Vatican's secretary of state, and a mutual deep and lasting friendship immediately developed between them.

Alexander VII was greatly concerned and unhappy to have been selected for the papacy, however, for he was sincerely convinced that he was unworthy of the position. Night after night he lay awake, increasingly troubled with insomnia, as he was reviewing in his mind the heavy burden of his many new responsibilities. Having been bitterly

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[46] Mario Rosa, 'Alessandro VII', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1960).

[47] Giovanni Incisa della Rocchetta, *Gli appunti autobiografici d'Alessandro VII nell'Archivio Chigi* ([Città del Vaticano]: Biblioteca Vaticana, 1964), 442 and 449; 'Alexander VII', *The Catholic Encyclopedia* (New York: Appleton, 1907), 294.

[48] Scientific editor's note: Alexander III was from Siena too.

opposed to the traditionally corrupt government of his predecessors, at first he was determined to establish a new pattern. Recalling how the considerable excesses of Urban VIII and Innocent X had evoked such extreme criticism of their reigns among the public, Alexander VII publicly announced his firm decision to wait for at least a full year before he would consider providing any potential benefits to his relatives.

At a time when the deplorable moral and financial consequences of nepotism in the papacy were being realized by churchmen, coupled with the need for a pontiff who would reign without the aid of relatives, the election of Alexander VII was considered to have been providential. It was confidently assumed, therefore, that the new pontiff would fulfill his promise and avoid nepotism. His own sanctity of life, severe morals, and demonstrated aversion to luxury, all confirmed his virtues and talents.[49]

As each month passed, however, there seemed to be increasingly strong reasons for which the pontiff found it necessary to do otherwise than he had promised. Despite his sincere opposition to nepotism, in due course he realized that he had no choice because he was experiencing an urgent need to have about him those he could trust without question. He sorely required his family's support, and it was with considerable reluctance, therefore, that by the following month of May, he allowed several of his relatives to come to Rome.

The first to arrive was his elder brother Mario, then Mario's son Flavio. Following was the very young Agostino, son of the Pope's deceased third brother, Augusto. In addition to other duties, to Mario the Pope assigned command of the militia, governor of Borgo, and made him prefect of the municipal food supply (the papal *annona*). In May 1656, Agostino, who was designated to continue the family line, was named Keeper of Castel Sant'Angelo, governor of the communities of Benevento and Civitavecchia, and commander of the fortresses of Perugia, Ancona and Ascoli.

To Mario, the Pontiff assigned command of the papal militia and the surveillance of the Leonine Borgo, and he designated him prefect of the papal *annona* or municipal food supply as well. He had arranged for his nephew Flavio first to study with the Jesuits

[49] Gregorio Leti, *Il Nipotismo di Roma, or, The History of the Popes Nephews from the Time of Sixtus the IV. to the Death of the Last Pope Alexander the VII. In Two Parts. Written Originally in Italian, in the Year 1667. and Englished by W.A.*, trans. William Aglionby (London: printed for John Starkey, at the Miter near Temple-Bar in Fleet-street, 1669).

in preparation for his ordination, and in June Flavio took the priesthood. On April 9, 1657, his uncle raised him to the cardinalate with Santa Maria del Popolo assigned as his titular church. Flavio Chigi achieved the rank of *cardinale padrone,* and in subsequent years, he gained more titles and honors, including being named prefect of the Biblioteca Apostolica Vaticana.

Cardinal Flavio Chigi was described as a gentle young man of 25 upon his arrival in Rome, distinguished by a round face with dark curly hair. Well balanced and cultivated, according to contemporary accounts, he was courteous and without superfluous mannerisms. Over the years, he proved to be a competent diplomat and an efficient administrator. Interested chiefly in philosophy and science, Flavio also enjoyed drama, hunting, and the pleasures of the table. His morals were irreproachable, and although no scandals attached to his name, contemporaries spoke of his sensuality because in his palace at Ariccia he had assembled a collection of portraits of the most beautiful ladies of the time.

In Rome, Cardinal Flavio acquired a villa situated on the great thoroughfare leading from the Church of Santa Maria Maggiore to the Pincio, at the point where today Via Nazionale crosses Via De Pretis. Although his collection of antiquities was displayed mainly in his palace adjacent to the Church of the Santi Apostoli, he had a great garden developed around his villa's casino in which he housed a museum. Its range of unusual items included oriental costumes, the horn of a unicorn, and Egyptian mummies and featured a number of the sculptures that had been recovered from ruins in Rome and surroundings, which he had purchased. His collection was famed as one of the foremost of its kind in Rome; in the eighteenth century, it was purchased and removed to Dresden.[50]

In subsequent years, Alexander provided even greater benefits to his relatives. He continued by providing Agostino, who was designated to continue the family line, with a principality. He allow Agostino to marry Maria Virginia Borghese; the marriage was celebrated in July 1658 at the Vatican. At the time of Agostino's marriage, which the Pope officiated, he made it possible for his nephew to acquire the principality of Farnese

[50] Pio Paschini, *I Chigi* (Roma: R. Istituto di studi Romani, 1946), 36–42; Enrico Stumpo, 'Chigi, Flavio', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1980), 747–51.

together with the communities of Ariccia and Campagnano, in addition to the palace formerly owned by Aldo Brandini in the Piazza Colonna. As an expression of courtesy to the new Pontiff, Emperor Leopold I designated Agostino a prince of the Holy Roman Empire. With his uncle's help, the young Agostino then acquired the title of Count of Campagnano. In 1659, Mario and Agostino purchased the palace of the Princess of Rossano, which subsequently became the Palazzo Chigi on the Corso near the column of Marcus Aurelius. As a consequence of Agostino's marriage into the Borghese family, the Chigi family formally became citizens of Rome. Agostino and his wife subsequently became the parents of 17 children.[51]

Sigismondo, brother of Agostino, who was only 6 years of age when his uncle ascended the papal throne, had shown signs of great talent at an early age. The pope eventually assigned him the priory of the Knights of Malta in Rome, and later, in December 1667, in gratuity toward the Chigi family, Pope Clement XI gave Sigismondo the cardinalate at the age of 19 with the deaconal title of S. Maria in Domnica. This pallid youth was not long-lived, however, and died 10 years later, on April 30, 1678.[52]

The Campani brothers, still fresh from the countryside, absorbed the excitement of the times with the initiation of a new papal reign. Not the least of the important events marking it was the forthcoming arrival in Rome of Queen Christina of Sweden, several months after Alexander VII had ascended the papal throne. One of the most notable women in history, Queen Christina pursued a multitude of interests and by one means or another had amassed great collections ranging from fine art, books, and manuscripts to numismatics, with which she filled her palaces. She also had a lifelong preoccupation with the sciences of mathematics and experimental physics as well as astrology and alchemy. Less known was her consuming interest in astronomy and what was to be her unfulfilled plan to establish her own astronomical observatory.

When, in 1655, Queen Christina had abdicated the Swedish throne and converted to Catholicism, Alexander VII foresaw in her conversion an event of major importance,

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[51] Enrico Stumpo, 'Chigi, Agostino', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1980); Pio Pagliucchi, *I castellani del Castel S. Angelo di Roma: con documenti inediti relativi alla storia della Mole Adriana tolti dall'archivio segreto vaticano e da altri archivi* (Roma: Polizzi & Valentini, 1909), 84; Ludwig Pastor, *Storia dei Papi dalla fine del Medio Evo* (Roma: Desclée, 1944), 327 et seq.

[52] *"Atti di Famiglia"*, fasc. 232, fol. 2v, Archivio Chigi, BAV; Paschini, *I Chigi*, 36–42.

one that would permanently memorialize his pontificate in the pages of Vatican history. After his royal convert had agreeably accepted his invitation to make her permanent residence in Rome, the pontiff began to be troubled by rumors of the reputation that now was preceding her arrival. She traveled through Europe with a cavalcade of 200 personages. After a month-long journey through Italy, she reached Rome in mid-December, her progress marked by frequent notices in the news sheets of the times in which she was occasionally referred to as "the Queen of the Vandals."[53]

The Queen undertook her journey to Rome in late autumn, reaching the final stage on December 20, 1655. On the Via Cassia, a few kilometers north of Rome, she was met at the Villa Olgiata by two papal legates, Cardinals Gian Carlo de' Medici and Frederick of Hesse, one of her distant relatives. She was conducted into Rome in one of the Pope's own carriages and taken directly to the Apostolic Palace, arriving after darkness had fallen. Girolamo Farnese, Archbishop of Patras and Majordomo of the Apostolic Palace,[54] led her through the staircases and galleries of the Palace to the Pope's apartment, where the Pontiff received her in a brief private audience.

Inasmuch as no arrangements had been finalized for a permanent royal residence for the Queen, and since she would be a guest of the Vatican for the next several days, it was decided that the Queen was to occupy an apartment that had been fitted for her in the Tower of the Winds, the observatory that rose above the Cortile del Belvedere adjacent to the Vatican library and secret archives. It was in the observatory's Meridian Room that in 1582 Pope Gregory XIII had met with scholars to observe a demonstration that had initiated the system of calendar reform that bears his name.

The several rooms of the tower had been specially decorated in anticipation and hastily prepared for the royal presence, and finally all was in readiness. The rooms were provided with a blazing fire and a silver bed warmer. Then, at the very last moment, a potential problem was discovered that gave cause to great consternation. The mural painting on one wall depicting the allegory of the North Wind bore a caption reading *ab Aquilone pandetur omne malum*: "All the evils spread from the North". The words were

[53] [Scientific Editor 2: this was actually part of her proper Latin title as Queen of Sweden: *Regina Suecorum, Gothorum et Vandalorum*. With the ancient name of "Vandals" were called the Wends, the Slavonic people settled along the Southern coast of the Baltic Sea under the control of the Swedish Crown].

[54] [Scientific Editor 2:: chief steward of the household of the Pope].

hastily painted over to avoid the possibility that the Queen might assume they referred to herself be offended.[55]

The Queen's state entrance into Rome occurred on December 23rd, arriving in a cortege of dazzling splendor the likes of which had not been seen in that century. It was raining in the morning as she rode in one of the papal carriages to historic Ponte Milvio. There she was formally received by the assembled senators of Rome accompanied by all of Rome's nobility. With a cavalry escort and trumpeters, the cavalcade next progressed to the villa of Julius III on the Via Flaminia, where she was served a light collation as the company waited for the rain to diminish. Despite the inclement weather, the Queen decided to continue into Rome, where a public holiday had been declared and the entire populace had turned out to gape and cheer.

Representatives of the Sacred College, led by Cardinals Francesco Barberini and Giulio Sacchetti and followed by 24 other cardinals, all mounted upon mules, welcomed the Queen at the Porta del Popolo, the traditional entrance into Rome. The gate on the inner side of the Porta had been decorated for the occasion by drawings made by Bernini and featured a welcome composed by the Pontiff, "FELICI FAUSTOQUE INGRESSUI ANNO 1655".

The cortège wove its way slowly along the Corso until it reached Castel Sant'Angelo. There a thundering salute from the fort's cannon greeted the Queen, setting off the ringing of church bells throughout the city, an endless chorus that contrasted with the clamor from the throngs. Monsignor Farnese had offered her a saddled horse, which she rode side saddle; the horse was draped in blue velvet embroidered with decorative *putti* and featuring the sheaves of Vasa, her family coat of arms. She wore a simple grey dress sparsely embroidered in gold, and a black shawl was thrown over her shoulders. She also wore a man's wig, very heavy and piled up in front, and a simple black plumed hat, but no jewelry. Her shortness of stature was noted and commented upon, as was her deformed shoulder.

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[55] Fabrizio Mancinelli and Juan Casanovas, *La torre dei venti in Vaticano* (Citta del Vaticano: Libreria editrice vaticana, 1980), 28–32; Roberto Buonanno, *Il cielo sopra Roma: i luoghi dell'astronomia* (Milano: Springer-Verlag, 2008), 75; Deoclecio Redig de Campos, *I palazzi vaticani* (Bologna: Cappelli, 1967), 178; Florio Banfi, 'Christina di Svezia e Stefano Gradi di Ragusa', *Archivio Storico per la Dalmatia* XXVI, no. 154 (1939): 363–69; Georgina Masson, *Queen Christina* (New York: Farrar, Straus & Giroux, 1969), 247–53.

The Queen's appearance contrasted sharply with those of the elegant ladies of the Roman nobility who came wearing velvets and covered with gems. Surrounded by cardinals and followed by a train of glittering carriages, the cavalcade slowly wended its way to the basilica of St. Peter. The continuing thundering of cannon from Castel Sant'Angelo and the cheers of the clamoring populace heralded its progress as the procession slowly advanced through the city toward the Vatican.[56]

Arriving at the piazza in front of Saint Peter's basilica, the Queen paused to listen to the *Te Deum* that was being sung by the finest voices assembled from all over Rome. After she prayed before the altar, she was led to the Scala Regia and then taken to the pontiff who received her in a public consistory. The Duke of Parma had invited the Queen and her entourage to occupy his residence at the Palazzo Farnese as a temporary residence. That evening, she was conducted there by torchlight in a cavalcade, and there she remained for the next seven months. In order to accommodate her, the Duke of Parma had evicted Cardinal Frederick of Hesse-Darmstadt, the former occupant of the Palace.

The Pontiff, meanwhile, lavished the Queen with countless costly gifts, among which was an elaborate carriage designed by Bernini. Particularly noteworthy among the gifts for the royal guest was a horological creation by the clockmaker Pier Tommaso Campani, a recent newcomer to Rome. It was the second of the horological commissions he was to produce for the new Pontiff. It already had attracted much public attention and praise in October 1655 in connection with plans being made in the city for the anticipated arrival of the Queen. It was reported in a manuscript record dated October 23, 1655, among the Barberini papers in the Vatican Library: "His Holiness is preparing great *galanteries* for the arrival in Rome of Queen Christina of Sweden. He has already purchased a clock for 1,500 *doble*[57] an object extremely curious and bizarre because every time that it strikes the hours it creates the most beautiful effects and various figures appear".[58]

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[56] Georgina Masson, 'Papal Gifts and Roman Entertainments in Honour of Queen Christina's Arrival', in *Queen Christina of Sweden*, ed. Magnus von Platen, 1966, 244–61; *Queen Christina*, 255–66.

[57] [Scientific Editor 2: a *dobla* or *doppia* was a golden coin of 6.7 grams, equal to a double *scudo*: Girolamo Andrea Martignoni, *Nuovo metodo per la lingua italiana la piu scelta, estensivo a tutte le lingue: col qual si possono agevolmente ricercare, e rinvenire ordiantamente i vocaboli ... cavati dal vocabolario de' Signori Accademici della Crusca* (Milano: Malatesta, 1750)].

[58] BAV, *Manuscript Barb, Lat. 6367*, , ff. 704r-v. [Scientific Editor's note: also the *Avvisi* mentioned this clock: ASV, *Avvisi*, vol. 24, Rome (October 23, 1655)].

The clock generated considerable public interest, and two weeks later it also was singled out for comment in the *Avvisi*: "Among the other gifts prepared by His Holiness for the Queen of Sweden, His Holiness has also resolved to present her with a clock, of admirable artifice, made by Signor Pier Tommaso Campani of Spoleto, a clockmaker most famous in this city and in regard to the singular virtue of whom His Holiness has also honored the clockmaker's brother, pastor of San Tommaso in Parione with a *Scudierato*".[59]

This comment was an invaluable advertisement for the young clockmaker recently arrived in Rome, and he took every advantage of it. His "singular virtue" was not surprising, for later Pier Tommaso wrote, with scarce modesty "I will say first of all to Your Lordship that my ingenuity [*genio*] has brought me always to invention, or to imitation, or to the perfecting of beautiful works, and particularly of clocks and of automata".[60]

The *Scudierato* bestowed upon Matteo Campani was an esquireship, an honorary title appointing an esquire in the papal household. His duties consisted merely of attending on the pontiff from time to time at table or on horseback. There is no evidence that Matteo fulfilled the honor. If he had done so, he would have noted it to correspondents.[61]

There can be no doubt that all three of the Campani brothers were among the spectators observing the Queen's triumphal arrival. To have been mentioned twice in public accounts within such a short time, and being the only clockmaker in the city having been so honored in the press at the time, was valuable publicity that Pier Tommaso appreciated and cherished, for the accolade brought him to the attention of prospective clients.

During the next several months, the series of magnificent entertainments that had been prepared for the Queen, which had been sponsored by Rome's nobility and the ecclesiastical community and that the visiting monarch enjoyed, continued even through the carnival season. Members of the Barberini family outdid all others by hosting three

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[59] ASV, *Avvisi*, vol. 24, Rome (November 13, 1655).

[60] Campani, *Lettera di Pier Tommaso Campani*, 4–5.

[61] Gaetano Moroni, *Dizionario di erudizione storico-ecclesiastico da S. Pietro ai nostri giorni*, vol. Scudierato (Venezia: Tipografia Emiliana, 1840).

operas and a joust with carriages that took place at the Barberini Palace at the Four Fountains.[62]

Queen Christina, who in old age described herself in her memoirs as an "*esprit versatile*," was indeed a nervous, flighty individual who sought to involve herself with scholars in every field of endeavor. Small of stature, slightly stunted in growth, with masculine lineaments, an aquiline nose, and short hair, her strong, sonorous voice resembled more that of a man than of a woman. She was neither beautiful nor even handsome, yet she made a strong, if strange, memorable impression upon those who met her for the first time. She was a woman of many contrasts, with a fiery nature ranging from violence to piety, from good to bad, from superstition to accepted sciences. Nonetheless, her virtues greatly exceeded her defects and earned her the title of the "Minerva of the North", assuring her a permanent place in the history of the cultural life of Rome.[63]

The pontifical reign of the newly elected Pope unfortunately was marked from the very beginning by extremely bad weather that prevailed throughout Italy. Failed harvests were reported from every region as storms with heavy hail wrought great damage to crops in the region around Rome. As a consequence, grain was in short supply, but to avoid raising the price of bread, in Rome and surroundings, the weight of each loaf was reduced from 8 to 6 *once*.[64] This proved to be a most unpopular measure, and to overcome the problem, the Pontiff then had money set aside for the Camera Apostolica to be used to import grain from Sicily, Sardinia, Holland, Dalmatia, and Provence; inevitably, however, the price of bread had to be raised.[65]

In May 1656, the Pontiff had just moved out of sweltering Rome to his summer residence at Castel Gandolfo high over the city, which he much enjoyed, when he received very disturbing news. He was informed that the first cases of bubonic plague,

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[62] Masson, 'Papal Gifts and Roman Entertainments in Honour of Queen Christina's Arrival' esp. pp. 251, 258, and 259.

[63] Henry Woodhead, *Memoirs of Christina, Queen of Sweden*, vol. 2 (London: Hurst and Blackett, 1863), 29; Per Bjurström, ed., *Christina, Queen of Sweden - a Personality of European Civilisation, Etc.: Eleventh Exhibition of the Council of Europe*, trans. Patrick Hort and Roger Tanner, Nationalmusei Utställningskatalog. No. 305. (Stockholm: Stockholm, 1966), 53.

[64] Scientific Editor's note: the English for *oncia* (pl. once) is "ounce", and 12 *once* made a Roman pound (Italian: *libbra*).

[65] Cardinale Sforza-Pallavicino, *Vita di Alessandro VII sommo pontefice. Libri cinque*, 311–16.

which had been raging in Naples, were reported in Rome. The Pope immediately returned to the city, and working together with his brother Don Mario, he initiated a series of emergency measures to limit the spread of the epidemic. His first action was to cut off all communication between Rome and southern Italy, then he closed all but eight of the city gates, and all travelers were kept in quarantine upon arrival. Holy water no longer was allowed in the churches, and he ordered cancellation of all events that attracted large gatherings, such as the *Quarantore*, the Forty Hours of Prayer.[66]

Pope Alexander lost no time in establishing a *lazzaretto*, a special plague hospital, on the Isola Tiberina, the island in the midst of the Tiber. Those whose homes had been sealed following a case of the plague therein were given temporary lodgings at San Eusebio in the Monti district, and those discharged from the hospital were sent to Porta San Pancrazio. Edicts regulating the reporting of sickness, transport of the sick, and control of entry and exit from Rome all had been promulgated. The Pope constantly visited the various parts of the city in person, often traveling on foot and careless of the risk of infection. As a consequence, chiefly through the efforts of the Pontiff and his brother, the epidemic was held in check; of Rome's population of 120,000, a total of only 15,000 deaths was reported. It was part of the last great pandemic of plague to cross Europe. It did not account for as many deaths and social disruption, probably because of the level of institutionalization of the responses. It was one of the best documented medical events of the century, resulting in many manuscripts and published and graphic materials. By 1657, the plague was over, but it was immediately succeeded by an epidemic of influenza, the most severe to occur since 1580.[67]

In Rome, Matteo Campani was already on familiar ground, for he had made occasional visits to spent time in the Eternal City some five years earlier. No details of the nature of the visit in 1646 are known except that prior to that time he had become acquainted and friends with a young Jesuit, Francesco Eschinardi, who may have been a student at the Collegio Romano. Two years later, in 1648, Matteo had participated in

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[66] Giuseppe Balestra, *Gli accidenti più gravi del mal contagioso osservati nel lazzaretto all'Isola, con la specialità de' medicamenti profittevoli, esperimentati per lo spatio di sette mesi ...* (Roma: Francesco Moneta, 1657).

[67] Ellen B. Wells, "Prints Commemorating the Rome, 1656 Plague Epidemic," *Annali dell'Istituto e Museo di Storia della Scienza di Firenze* 10, no. 1 (1985): 15–21.

Eschinardi's experiments with the development of a hydraulic clock at the Collegio Germanico in Rome.

The Collegio Germanico was a Jesuit seminary established in 1552 by Saint Ignatius of Loyola and Cardinal Giovanni Morone for the purpose of engendering love of the Roman Catholic Church among clerics who emigrated from Germany and German-speaking aliens from Bohemia, Poland, and Hungary, especially those inclined toward Lutheranism. Based upon the same organization and plan of study of the Collegio Romano, the Collegio Germanico was first housed in a building near the Collegio Romano, and later it was moved to the Church of Saint Apollinare, which had been assigned to the Collegio Germanico in 1573. Today it is located on the Via San Nicola da Tolentino near the Piazza Barberini.[68]

Matteo Campani was constantly consumed by his interest in the sciences and mechanics and an eagerness to become involved with them. It was an interest that had been fueled by some of his early teachers in the seminary. Matteo later wrote that Niccolò Cabeo "had been my master and teacher, and in 1644 it was he who showed me the first hydraulic clock I ever saw."[69] Matteo later mentioned that he had made use of the commentary on meteors published in Rome in 1646 by Niccolò Cabeo: *In quatuor libros meteorologicorum Aristotelis commentaria*. It was in this work that Cabeo expressed bitter hostility to Galileo.

Cabeo may have been one of the teachers at the seminary that Matteo attended, and in all likelihood they probably met again on one of the several occasions that Cabeo visited Rome in 1645 and 1646, at the same time that Matteo also was visiting the Eternal City. Matteo's preoccupation later in his life with magnetism and perpetual motion undoubtedly had been generated by Cabeo's influence during their early association.

Francesco Eschinardi was three years younger than his friend Matteo, having been born in 1623 in Rome. He had entered the Jesuit order in 1637 at the age of 14 and subsequently joined the faculty of the Collegio Romano, teaching rhetoric and philosophy for some time, logic in 1659, physics in 1660, and metaphysics in 1661. Traveling extensively, he taught at various Jesuit seminaries and Italian universities. He became

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[68] Gaetano Moroni, *Dizionario di erudizione storico-ecclesiastico da S. Pietro ai nostri giorni*, vol. LXIV (Venezia: Tipografia Emiliana, 1840), 16–23.

[69] Matteo Campani, *Horologium solo naturae motu* (Roma: Ignazio de Lazares, 1677), 6.

professor of mathematics in Florence and at Perugia, then from 1665 he was again teaching at the Collegio Romano in Rome, where he held the chair of *Mathesis*, *cum Geometria et Astronomia*. While functioning as professor of mathematics, he was also charged with revising the plans for the buildings of the *Compagnia di Gesù*, all of which then were sent for review to Rome to the Father Superior. That Eschinardi was an enthusiast of the sciences was made well-known in his time by his numerous publications. Dominant among his interests was horology, about various aspects of which he published original material as well as commentaries on the accomplishments of others.[70]

Eschinardi's treatise on the hydraulic clock (*Appendix ad Exodium de Tympano*), printed in Rome in 1648, was his first published work and appeared as an adjunct to a volume by Mario Bettini.[71] Although the clock was unsuccessful as a timekeeper, the concept of the invention was to play a significant role several years later in the story of the Campani silent night clock. In 1658, Eschinardi produced a treatise on Aristotelian cosmogony (*Microcosmi Physico mathematici*, *seu Compendi*, *in quo clare et breviter tractantur praecipuae mundi partes*, *Coelum*, *Aer*, *Aqua*, *Terra*, *eorumque accidentia*), published in Perugia, and then a philosophical summary in 1661 (*Simulacrum ex Chisiis montibus*), which he dedicated to Cardinal Flavio Chigi.

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[70] Francesco Eschinardi-(1623–1700) was one of the great Jesuit experimentalists of the latter half of the Seventeenth century. He joined the Jesuit order in 1637 and held teaching posts at Florence and Perugia and from 1658 to 1665 was member of the faculty of the Collegio Romano in Rome. He was concerned with a great number of scientific projects, ranging from the physics of sound to perpetual motion, and he also was involved with attempting to graduate thermometers on a scientific principle. He often collaborated with his fellow Jesuit Athanasius Kircher. [See Riccardo G Villoslada, *Storia del Collegio romano dal suo inizio (1551) alla soppressione della Compagnia di Gesú (1773)* (Romae: Apud universitatis gregorianae, 1954), 187, 327, 330–32, 335; and Jean Michel Gardair, *Le Giornale de' letterati de Rome (1668-1681)* (Firenze: Olschki, 1984), 125–30.] Maria Mucillo, 'Eschinardi, Francesco', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1993).

[71] Francesco Eschinardi, 'Appendix Ad Exodium de Tympano', in *Apiaria vniversæ philosophiæ mathematicæ, in qvibvs paradoxa, et noua pleraque machinamenta ad vsus eximios traducta, et facillimis demonstrationibus confirmata. Opvs non modo philosophis mathematicis, sed & physicis, anatomicis, militaribus viris, machinariæ, musicæ, poëticæ, agrariæ, architecturæ, mercaturæ professoribus, &c., vtilissimum ... Accessit ad finem secvndi tomi Evclides applicatvs, et condítus ex Apiarijs, indicatis vsibus eximijs præcipuarum propositionum in prioribus sex libris Euclideorum Elementorum*, ed. Mario Bettini, vol. 2, 3 vols (Bononiæ: Typis I.B. Ferroniij, 1650). Bettini's work was reprinted in 1650 and 1654, and the appendix was reprinted in Rome in 1672 by Eschinardi in *Schiaro de' Letterati*. It was reprinted in several editions within the next few years. Bettini's appendix of his timepiece also was published separately as a small quarto book of 9 pages. Consequently, copies were readily available. [Granville H. Baillie, *Clocks and Watches: An Historical Bibliography* (London: N.A.G. Press, 1951), 47–49.]

Having a naturally gregarious personality, Matteo Campani lost no time in enlarging his acquaintanceship with men of science then living in or visiting Rome. His former association with Eschinardi enabled him to meet and become familiar with other members of the Jesuit faculty of the Collegio Romano, notably Urbano Davisi, Giovanni Battista Giattini, Athanasius Kircher, and Daniello Bartoli.[72]

Matteo readily made friends outside ecclesiastical circles as well, including the optical instrument maker Eustachio Divini, whom he probably had met during one of his earlier visits to Rome. Divini was to become a key figure who would dominate the lives of Matteo and his brother Giuseppe first as a close friend, then as a dedicated competitor, and finally in a most unpleasant manner as a deadly rival.

Born in 1610, Divini was the youngest of the three sons of Tardozzo and Virginia Divini of San Severino Marche in the province of Ancona. Tardozzo was descended from Domenico (d. 1502) and Nicola Indivini (later called Divini), wood-carvers and inlay makers, some examples of which are still to be found in the church of San Francesco in Assisi.[73] Young Eustachio was only four years of age in 1614 when his mother died, and only eleven in 1621 when he and his two brothers were orphaned by the death of their father. In the next few years the three orphans experienced great poverty. It is not known which member of his family assumed responsibility for the youngest boy until he reached maturity, but presumably he lived with an aunt or uncle in the community.

The two older sons had managed to advance their educations and subsequently migrated to Rome; eventually, both achieved recognition in the arts and letters. Cipriano Divini, seven years older than Eustachio, became known as a poet and writer, while Vincenzo was a physician who also worked as an artist. Surviving is a map of the town of San Severino Marche produced by Vincenzo. Eustachio was educated in the local schools, but he was restless and little interested in humanistic studies, having an inclination toward the sciences. His limited circumstances finally led him to a military career, and at the age of 17 he left San Severino Marche to join the pontifical army (one

[72] Mentioned in a letter from Matteo Campani to Eschinardi, which was later quoted by Eschinardi in printed work. See: Francesco Eschinardi, ‘Appendix quinta: de horologio hydraulico’, in *Cursus physico-mathematicus ... pars prima, de cosmographia. Tomus primus, continens duplicem tractatum, primum de sphæra; secundum de astronomia, etc.* (Romae, 1689), 362.

[73] Patrizia Peron, ‘Domenico, Indivini’, *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 2004).

source stated it was the imperial army). It is not certain how long he remained under arms, but apparently he saw action in the field. Illness eventually hospitalized him at the town of Cento in northern Italy and led to his medical discharge.[74]

Urged by his brother Cipriano to join him in Rome, Eustachio did so after his release from military hospitalization, and there he recovered his health while looking for a new career. Eustachio favored the sciences of mathematics and astronomy and, with assistance from his brother Vincenzo who frequented the city's scientific and cultural circles, Eustachio made new acquaintances. Among them was one of Galileo's disciples, Benedetto Castelli, a Benedectine monk who occupied the chair of mathematics at the university La Sapienza in Rome. Among Castelli's other students with whom young Divini presumably became acquainted were Bonaventura Cavalieri and Michelangelo Ricci, who were to become major figures in the sciences in Rome during the next several decades.[75]

Divini began studies with Castelli, who taught him new theories in physics and engaged him in studies of Euclidean geometry and astronomy. These studies provided a solid theoretical basis for his subsequent career. Castelli's classes were frequented by such well-known men of science as Evangelista Torricelli and Giovanni Alfonso Borelli, whose presence provided inspiration to the students. It was during this period that Divini and Torricelli became acquainted, sharing mutual interests in physics, mathematics, and astronomy.

It was Torricelli's preoccupation with timekeeping and lens making that directed Divini's interests into the same directions. Although undocumented, almost certainly it was Torricelli who taught Divini the techniques of lens grinding and telescope making, possibly during sojourns in Florence, for there was no one else at work in these skills in

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[74] Letter from Alfiere Giulio Gentili in Cento to Eustachio's brother Francesco Divini on August 6, 1629, Filippo Rossi, *Programma di associazione alla Vita di S. Pacifico Divini da Sanseverino-Marche sacerdote della più stretta osservanza nell'Ordine Serafico preceduta e seguita da interessanti notizie storico-patrie pel sacerde Filippo Rossi Sanseverinate terziario francescano* (San Severino Marche: [s.n.], 1888), 424.

[75] Benedetto Castelli (1577–1643) was born in Brescia, entered the Benedictine order, taught mathematics at Pisa and Rome, and was considered probably the greatest of Galileo's pupils. His publication *Delle misure dell'acque correnti* (In Roma: Nella stamparia camerale, 1628) led him to be considered to be the founder of the Italian hydraulics school. Francesco Bonaventura Cavalieri, S.J. (1598–1647), a disciple of Galileo, was a professor of mathematics at the University of Bologna.

that period in Rome. After acquiring at least a basic knowledge of optics and dioptrics, by about 1640, Divini began producing lenses for telescopes.

As Divini continued to further his work with the refracting telescope, he found that it aroused interest among patrons and emerging practitioners of the sciences. The lenses he produced were of improved quality, and he began to experiment with producing telescopes having tubes of greater diameter and length than any heretofore produced by others, with increasing success.[76]

There is no record that Divini ever married; thus, it appears that he remained a lifelong bachelor, totally dedicated to his work. Several contemporary references mention Divini as a clockmaker, which may have been a skill he had learned in the army. He may in fact have been employed for a time by a clockmaker in Rome, or he may even have worked as a repairer of clocks.[77]

If so, Divini's career in clockmaking was of short duration, a fact that was confirmed not only in the writings of Matteo Campani but also in those of Evangelista Torricelli. In a letter to Michelangelo Ricci in Rome, Torricelli had written in early 1646: "*Signor* Eustachio [Divini] clockmaker is my friend and a person of great zest, speech and judgment and I have no doubt that he will do well, but that he will achieve the level at which I have arrived, I do not believe".[78] By this time, Divini had just begun to produce lenses and telescopes commercially. In his published letter to Count Carlo Antonio Manzini of 1663, Divini confirmed that he already had been working with optical lenses for the past 17 years, indicating that he had entered the field in 1646.[79]

Having mastered the techniques of lens grinding and polishing, Divini began experimenting with the construction of optical instruments and began producing telescopes for sale. Two years later, he ventured into another form of optical instrumentation and constructed a compound microscope based on Proposition 37 of

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[76] Gualberto Piangatelli, 'Eustachio Divini ottico e sperimentore (1610–1685)', in *I.T.I.S. Eustachio Divini - S. Severino MXXV della Fondazione, Cronache e contributi* (Macerata: [s.n.], 1985), 41–64.

[77] Ibid.

[78] Letter from Evangelista Torricelli to Michelangelo Ricci, February 10, 1646, in Paolo Galluzzi, *Le opere dei discepoli di Galileo Galilei*, vol. 1 (Firenze: Giunti Barbèra, 1975), 276–77.

[79] Eustachio Divini, *Lettera di Eustachio Diuini all'ill.mo sig. conte Carl'Antonio Manzini. Si ragguaglia di vn nuouo lauoro, e componimento di lenti, che seruono à occhialoni, ò semplici, ò composti* (In Roma: Per Giacomo Dragondelli, 1663), 22.

Kepler's *Dioptrics*. This first example of an improved lens made by Divini for a microscope consisted of two plano-convex lenses with the plane faces placed externally. This new invention of a doublet lens made by Divini was noted in the same year in the *Philosophical Transactions*.[80]

In the course of the next few years, Divini produced instruments of increasing sizes and power. As yet he had few competitors in his field, and his instruments were eagerly sought by astronomers and men of science not only in Italy but also elsewhere in Europe. It was through his association with Torricelli that Divini met and became friends with Vincenzo Viviani, who became the Medici court mathematician in Florence. They apparently discussed experiments with glass and lens making and compared results. Their association was confirmed in a letter written in 1656 by Viviani to the mathematician André Tacquet at Anvers, noting that Divini was "my particular friend, whose knowledge, diligence and accuracy has always served me in making all the aforesaid experiments [with the characteristics of glass]," and he described some of Divini's experiments with lens making.[81]

In 1668, the Abbé Emanuele Maignan of the Order of Minims, in the preface of his work *Perspectiva Horaria, sive de Horographia Gnomonica*, acknowledged Divini and included him as an equal in the august company of the pioneering Galileo and Torricelli in Florence and Fontana in Naples. Maignan wrote:

> Like most things, the marvelous art of making that wonderful instrument called the telescope began slowly before reaching the perfect state, that as we see, it has reached nowadays. In fact, it first appeared in the Netherlands [*in Belgio*], then it was developed by Galileo in Florence and by Fontana in Naples; it was afterward cultivated in Florence one more time by Torricelli, and is now worshipped in Rome by Eustachio Divini with, if

[80] Johannes Kepler, *Ioannis Kepleri ... Dioptrice seu Demonstratio eorum quae visui & visibilibus propter conspicilla non ita pridem inventa accidunt : Praemissae Epistolae Galilaei de iis, quae post editionem Nuncii siderii ope Perspicilli, nova & admiranda in coelo deprehensa sunt. Item Examen praefationis Ioannis Penae Galli in Optica Euclidis, de usu Optices in philosophia* (Augustae Vindelicorum: typis Davidis Franci, 1611), 13; 'Another Extract out of the Italian Journal, Being a Description of a 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 (1668): 842: on Eustachio Divini.

[81] BNCF, Gal. 244, cc. 34r–41r. Letter from Viviani to André Tacquet on May 22, 1656. André Tacquet (1612–1660) was a Belgian mathematician and native of Anvers who entered the Jesuit order in 1646. He experimented with the measurement of solids of various bodies and was the author of several works in his field [Paolo Galluzzi, *Le opere dei discepoli di Galileo Galilei*, vol. 2 (Firenze: Giunti Barbèra, 1975), 338, 342.]

it is legitimate to say, a divine hand. It has never happened to me, however, to meet some one that was expert in this art who was willing to share with me even a bit of his own experiences in this field or his thoughts about it.[82]

Not long after his arrival in Rome, Matteo Campani sought out scientific circles and became interested in one scientific endeavor after another, even though Rome was by no means a center of important scientific activity in this period. The range of his scientific enthusiasms seemed limitless, however, and brought him into contact with other men of science in Rome, notably the abovementioned Athanasius Kircher, Michelangelo Ricci, Giovanni Alfonso Borelli, and Stefano Gradi, among others.

Pier Tommaso, meanwhile, also had made himself acquainted in his new surroundings. Among his early connections in the city were Adam Heroldt (active c. 1615–1649), who was known to the community by the Latinized version of his name "Heroldi." A talented maker of mathematical instruments, Heroldt had emigrated from Germany early in the seventeenth century and become well-established in Rome. He may have been employed at the Vatican, and if not, he nonetheless produced works for the incumbent pontiffs. Among the few of his instruments known to have survived is a quadrant and compass of his own invention dated 1622 and inscribed with a dedication to Pope Gregory XV.[83]

As Pier Tommaso and Heroldt became better acquainted, the latter probably was responsible for introducing the young Umbrian clockmaker into the small circle of skilled craftsmen employed at the Vatican, where Pier Tommaso subsequently found employment. It was a limited group, each member protective of his own prerogatives in

[82] Emmanuel Maignan, *Perspectiva horaria, sive, De horographia gnomonica tum theoretica tum practica libri quatuor* (Rome: Typis, & Sumptibus Fratrum de Rubeis, 1725), 687. In this work, Maignan described three curious lathes, constructed with massive timbers, for turning spherical mirrors; he also described the convex tools for grinding them [689–700, three plates and text; 687–705: he deal with grinding and polishing lenses for dials and telescopes, illustrating the related machinery in three fine copper plates].

[83] Also surviving are two armillary spheres dated 1648 and 1649 in the Science Museum in London and the Osservatorio Astronomico in Rome as well as a quadrant in the collection of Fausto Casi [Edward Luther Stevenson, *Terrestrial and Celestial Globes: Their History and Construction* (New Haven: Published for the Hispanic Society of America by the Yale University Press, 1921), 64–65; Matteo Fiorini, *Sfere terrestri e celesti di autore italiano oppure fatte e conservate in Italia* (Roma: presso la Società geografica italiana, 1899), 301; Surveyors' Institution, *Five Centuries of Maps & Map-Making: An Exhibition at 12 Great George Street, Westminster S.W.1* (London: Royal Institution of Chartered Surveyors, 1953), 68; Fausto Casi, *Strumenti scientifici dal 1500 al 1800: scienziati aretini dal '400 al '700* (Arezzo: Centro Affari e Promozioni, 1994), 99.]

such a selective place of occupation. The only other clockmaker of record on the Vatican rolls at this time was Mattia Ertel (sometimes Ertell), also a German craftsman, who had succeeded his father Andrea Ertel in the position.[84]

During the period that Pier Tommaso was employed at the Vatican, papal commissions for the production of special timepieces were awarded both to clockmakers employed in the Palace as well as to independent clockmakers in the city. In the Vatican's records of payment, Pier Tommaso Campani was generally designated "clockmaker of the Palace" as was Mattia Ertel, whereas other clockmakers appearing in the records were not so designated. In June 1655, for example, Francesco Arrigoni, identified merely as a clockmaker (hence not on the Palace staff) was commissioned to produce a time glass to be consigned to the *monsignor guardarobba*–i.e. the official in charge of the papal furnishings.[85]

Later, however, in an entry for February 26, 1657, Pier Tommaso was identified only as a clockmaker, confirmation that by this time he had left the papal service and established a shop of his own, meanwhile continuing to receive commissions for clockwork from the Pontiff.[86]

It was the practice of the Vatican treasury to pay a salary to craftsmen on the Vatican rolls who provided services—such as harness makers and clockmakers, for example—and furnished them with an allotment for rental of their dwellings in the city. In addition, separate payment was made to individuals for each project commissioned by the Pontiff. Confirmation that free rent was a perquisite of clockmakers employed at the Apostolic Palace occurred in the record of payment made on October 6, 1648, to Andrea Ertel, "clockmaker in the Palace," for 15 *scudi*, "which are for the rental of the house he inhabits and this is for an anticipated six months." Five days earlier, on October 1, 1648,

[84] Mattia Ertel, clockmaker at the Vatican, succeeded his father in the position as early as in 1659. Several more generations of the Ertel family subsequently worked at the Vatican or in Rome. In 1660, Mattia Ertel produced a clock for the Pontiff with an alarm that lighted a candle, and he was paid 5 *scudi* and 30 *bol*. on September 27, 1670, for "the balance of diverse accounts of work done by him for servicing the clock of Our Holy Father." Mattia Ertel died March 24, 1675, and was buried in the cemetery of Santa Maria wherein he was registered as a German: Antonino Bertolotti, *Artisti belgi ed olandesi a Roma nei secoli XVI e XVII : notizie e documenti raccolti negli archivi romani* (Roma: Arnaldo Forni editore, 1880), 317.

[85] Leandro Ozzola, "L'arte alla corte di Alessandro VII," *Archivio della R. Società Romana di storia patria* XXXI (1908), 79.

[86] Ibid, 80.

he was paid the sum of 12 *scudi* for his three-months salary: "for his *trium mensium ordinaria provvisione*".[87]

During the period of his employment in the Apostolic Palace, Pier Tommaso was paid at the same rate as Ertel, and on August 26, 1656, the Pontiff ordered the Vatican treasurer to make payment to Pier Tommaso Campani, "clockmaker of the Palace, of 15 *scudi* for rental of his house for six months ending next April 1st, including the entire month of September, in the usual manner".[88]

It was before the summer of 1655 that Pier Tommaso produced a timepiece he described as the "Clock of Death" [*oriolo della morte*],[89] the first private commission that he had undertaken for Pope Alexander VII. It also had been made before he had been commissioned to produce the clock with automata for Queen Christina that he completed by October of the same year. In fact, the Pontiff had commissioned this morbid timepiece while he was still Cardinal Fabio Chigi, before his election to the papal throne or shortly thereafter. It was a bracket clock with striking mechanism and it was placed in the papal bedchamber. Enclosed within the clock case would have been a brass clockwork movement having time and strike trains, using a crown wheel and verge escapement regulated by a circular or bar balance, the pendulum regulator not yet having been invented. It was by no means a silent timepiece, and as was common in clocks of that period, a loud ticking resulted from the beating to and fro of the insidious balance. At night, when the Pontiff retired, the clock was illuminated by means of a small oil lamp situated in front of the dial.

The Clock of Death apparently may have remained on Vatican premises, at the Apostolic Palace or at the Quirinal, for more than a century. In a June 1, 1770, inventory of the Servizio della Floreria listing properties in the Quirinale at that time, mention was made of a monumental timepiece exceeding two meters in height in the room contiguous to the short passage [*Passetto*] of the Quirinal Palace. It was described as:

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[87] Bertolotti, *Artisti belgi ed olandesi a Roma nei secoli XVI e XVII*, 317.

[88] ASV, Sacro Palazzo Apostolico, *Registro di ordini a Monsignor Tesoriero*, *sezione "Varia"*, vol. 770, p. 13; *Regist. Mandati*. On page 12 of the roll of the "family" of Alexander VII, Mattia Ertel is listed as a clockmaker, whereas Pier Tommaso is listed but without identifying his craft. [*Rolo della famiglia di Nostro Sigre Papa Alessandro VII aggiunto sotto il primo marzo 1663*, *Bibl. Vitt. Eman. Mss. Ges*., LIII (1664); Leandro Ozzola, 'L'arte alla corte di Alessandro VII', *Archivio della R. Società Romana di storia patria* XXXI (1908): 8 n.]

[89] Campani, *Lettera di Pier Tommaso Campani*, 9.

A dial of a large clock called of Death [*orologio grande detto della morte*] made of ebony, by Campana [sic] on the face in front alternating with lapis lazuli and other fine stones [*pietre dure*], with six figures or statuettes of gilt copper and six small columns of alabaster having capitals and bases of gilt brass, with diverse ornaments and similar instruments of gilt copper, with its pedestal of sandalwood, and pearwood however made in the form of a small cabinet with two doors 10 palms high, in two parts ...[90]

This timepiece, a large bracket clock forming the upper part of a cabinet with twin doors situated on a pedestal, is no longer in the Quirinal Palace.[91] As happened with many of the elaborately decorated Campani night clocks over the course of the years, it may have lost its decorative elements of *pietre dure*. It is probable that during the turbulent events of 1870, when the Quirinal Palace was confiscated by the Italian government to become the royal residence, the clock subsequently may have been transferred to Castel Porciano, another royal [and now presidential] property...

The fact that the Pontiff commissioned Pier Tommaso to make a Clock of Death for him at the time of his election to the papal throne, or before, is not surprising inasmuch as the Pope's obsessive longing for death and his special penchant for *memento mori* imagery had become widely known and publicly commented upon, especially among his Palace associates. As a cardinal, it was said he was in the habit of drinking from a silver goblet having the image of a skull engraved on its bottom, and on his desk he always kept at hand a decorative "Death's head": a skull carved from marble that the Palace architect Gian Lorenzo Bernini had made for him immediately after his election. He also had ordered Bernini to arrange to have a coffin of cypress and lead fabricated for

[90] ASV, Servizio della Floreria Apostolica, *Inventario delle Robe della Floreria Apostolica*, *Palazzo Quirinale* (June 1, 1770); Enrico Morpurgo, 'Gli orologi del Campani in Vaticano', in *L'orologio e il pendolo* (Roma: La Clessidra, 1957), 66–67.

[91] In appearance, it seems to have resembled the cabinet style known as a *Prunkschrank*, of which Pier Tommaso later produced another timepiece. As late as 1957, a clock of similar dimensions and description as the morbid timepiece was reported by the staff clockmaker of the Quirinal Palace to be in the hunting lodge maintained by the president of Italy at Castel Porziano. He described the timepiece as a clock of the type made by the Campani brothers, approximately two meters in height, and featured on the dial was the traditional image of Death—usually represented as Chronos or Father Time or a skeleton with a scythe. It almost certainly was the same timepiece recorded in the 1770 inventory of the Quirinal Palace, the Clock of Death that Pier Tommaso had produced for Pope Alexander VII in 1655. [Scientific Editor's note: Among Silvio Bedini's papers there is a substantial file containing his correspondence written between 1952 and 2007 on his Campani project. Among these letters one may find the source for this piece of information].

him. The pontiff kept the coffin in his room, where it aroused considerable interest and speculation among his contemporaries.

This morbid preoccupation was mentioned in nearly all the French scurrilous pamphlets published against Alexander VII and in biographical accounts. Gregorio Leti, for example, wrote that at the time that Cardinal Fabio Chigi had ascended the papal throne, he had been totally dedicated to an evangelical life, and that in order to keep death fresh before his eyes, he held audiences with ambassadors in a room full of human skulls and with his lead coffin visible in full view in his bedroom. The Pontiff slept on straw with a stone for a pillow. Abominating pomp and riches, he replaced his silver dishes with others of earthenware decorated with skulls on which he took his meals, seasoned with ashes![92]

From an early age, Alexander VII suffered from kidney illness that continued to plague him most of his life. His condition deteriorated to such a degree during the summer of 1666 that he had difficulty carrying out his responsibilities. His constant physical suffering was responsible for his failure to rule as firmly as had been anticipated. Despite his early promise, Alexander VII had not become popular in Rome because, although he spent much of his time with poets and scholars and his achievements in the world of culture and art certainly matched those of Urban VIII, the realistically inclined common people blamed him for not improving food supplies or reducing taxes. His spectacular effectiveness during the plague that had raged through Rome was soon forgotten, and people never forgave him for assisting his relatives to riches.

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[92] Ludwig Pastor, *Storia dei Papi dalla fine del Medio Evo*, vol. XIV. Storia dei papi nel periodo dell'assolutismo dall'elezione di Innocenzo X sino alla morte di Innocenzo IX, 1644-1700 (Roma: Desclée, 1943), 16, n. 4; Maurizio Fagiolo dell'Arco and Marcello Fagiolo, *Bernini: una introduzione al gran teatro del barocco.* (Roma: M. Bulzoni, 1967) no. 209; Maurizio Faggiolo Dell'Arco and Silvia Carandini, *L'effimero barocco: strutture della festa nella Roma del 600* (Roma: Bulzoni, 1977), 161; Cardinale Sforza-Pallavicino, *Istoria del concilio di Trento*, vol. III (Milano: Pirotto, 1843), 269; Charles Gérin, *Louis XIV et le Saint-Siège*, vol. 2 (Paris: Lecoffre, 1894), 157; Leti, *Il Nipotismo di Roma*, 94 and 166 (1667) and 40-42 (1668); ASF, attributed to G. Riccardi (April 8, 1655): "He ordered Bernini to make for him a coffin [*cassa da morte*] and to deliver it to keep in his bedchamber *e chi prima non gli darà udienza*"; ASV, *Avvisi*, Rome (April 10, 1655); The English traveler John Bargrave also wrote about Alexander VII in a similar vein: "In the first months of his elevation to the Popedom, he had so taken upon him the profession of an evangelical life that he was wont to season his meat with ashes, to sleep on a hard couch, to hate riches, glory, and pomp, taking a great pleasure to give audience to ambassadors in a chamber full of dead men's sculls, and in the sight of his coffin, which stood there to put him in mind of his death." Bargrave, *Pope Alexander the Seventh and the College of Cardinals*, 7.

Thus was the time when the Campani brothers first ventured into clockmaking; it was on the eve of the invention of the pendulum regulator, as Giuseppe Campani independently discovered the pendulum regulator for clockwork without knowledge of the achievements of Galileo or Huygens. Giuseppe's inventions incorporating the pendulum regulator were to be rewarded by a papal patent.[93]

[93] Christiaan Huygens, *Christiani Hugenii ... Horologium oscillatorium: sive, De motu pendulorum ad horologia aptato demonstrationes geometricæ.* (Parisiis: Apud F. Muguet, 1673); Christian Huygens, *Christiaan Huygens' the Pendulum Clock, Or, Geometrical Demonstrations Concerning the Motion of Pendula as Applied to Clocks*, trans. Richard J. Blackwell (Ames: Iowa State University Press, 1986). Christiaan Huygens (1629–1695), Dutch mathematician and astronomer, was one of the foremost scientific figures of his time. A founding member of the Académie Royale des Sciences, appointed by King Louis XIV in 1666, he remained there until early 1680, and he also was a foreign member of the Royal Society of London. He was the son of Constantijn Huygens Sr. (1596–1687), a senior diplomat of the Dutch Republic with great interest in the arts and sciences. Constantijn Huygens Jr. (1628–1697) was his brother and a diplomat in the Dutch Republic who went to England with William of Orange in 1688.

Chapter III

A PATENT FROM THE PONTIFF

(1655–1656)

> *Thus I greatly admire the genius of the Campani brothers, upon whom Nature has bestowed so much intelligence and manual dexterity, two characteristics that seldom go together, so much so that I wonder what to praise the most in their inventions, either their cleverness or their precision.*
>
> Francesco Eschinardi, S.J., *Microcosmi Physicomathematici* ... (1658).

It was in the course of Pier Tommaso's employment as a clockmaker in the Vatican that fate provided the three Campani brothers with an opportunity that would dramatically change the course of their lives. It occurred in the month of October 1655, just after the papal household had returned to the Apostolic Palace of the Vatican from the Quirinal Palace where it had spent the summer months in an effort to avoid the intense seasonal heat and closeness of the air in the lower part of the city.[94]

Pier Tommaso provided an account of the occurrence in a publication that appeared several years after the event. He wrote how "one day, when I had gone to the [Apostolic] Palace to wind the Clock of Death which I had made earlier, it so happened that a Prelate who was passing through the room in which I was working, told me that His Holiness desired to have a clock, that indicated the hour of the night, and without having the light glaring in his eyes, or that impeded the obscurity of the room. I replied that I would make every effort to satisfy the desire of His Holiness, and I then resolved to make my silent clock as I had designed it, with that addition furthermore, desired by His Holiness."[95]

[94] Traditionally, during the period 1650 to 1700, each year in April the papal household moved from the Apostolic Palace on Vatican Hill to the Quirinal Palace because it was situated on a higher elevation. There it remained until late October, at which time it returned to the Apostolic Palace at the Vatican to spend the winter months. ASV, *Avvisi*, vol. 24, Rome (October, 1655).

[95] Campani, *Lettera di Pier Tommaso Campani*, 9–10.

The prelate with whom Pier Tommaso's conversation took place was the Majordomo (and Prefect) of the Apostolic Palace, Girolamo Farnese, Archbishop of Patras.[96] The Majordomo reported how one morning the Pontiff had whimsically commented to him about his insomnia, complaining of the countless sleepless nights he had spent since his election. He related how he lay awake, wondering what the time might be and how many hours remained before the coming of dawn, and he expressed his annoyance because he was unable to see the clock dial from his bed. Then, grumbled His Holiness, for the remainder of the night he would be kept awake by the loud erratic clicking and ticking of the clock's balance wheel. "How desirable it would be", he added, "if someone could invent a clock that would display the time distinctly at night, made constantly visible", the Pope added, "perhaps by means of a concealed lucerna or lamp that would illuminate the dial from within without offending the eyes, and without the necessity of having to strike a light when one wished to know the time! A clock", he went on, "that was silent so that one was not kept awake for the rest of the night by the sound of its churning and turning wheels!".[97]

Pier Tommaso was intrigued by the Prefect's account of the Pontiff's ruminations. Casual night thoughts they might have been, but they presented a challenge and an opportunity that Pier Tommaso could not overlook. As a clockmaker with a talent for

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[96] As a matter of record, at this time Girolamo Farnese was a archbishop and had not been elected a cardinal until some time later, although he had been appointed Majordomo of the Apostolic Palace. It had been claimed in some quarters that Girolamo Farnese had spent a wild and inconstant youth, yet at the age of 16 he had published a scholarly *Dialectica* at Parma. In 1639, Pope Urban VIII made him archbishop of Patras and sent him as papal nuncio to Switzerland. Although his stay in Switzerland proved to be have been fraught with conflicts during which he experienced grave personal danger, Farnese nonetheless had managed his assignment with considerable diplomatic skill and tact. A decade later, Farnese was appointed governor of the city of Rome. Pope Alexander VII, appointed Farnese Majordomo of the Apostolic Palace and placed him in charge of the *Maestre pie*, the network of schools established throughout Rome that the Pontiff supported. On April 7, 1657, Farnese was made a cardinal, with the titular Church of Santa Agnese fuori le Mura [St. Agnes Outside the Walls], but it was not until a year later that his appointment was publicly announced. Later the Pope sent him as papal legate to Bologna, where again he distinguished himself by exercise of his good judgment. Stefano Andretta, 'Farnese, Girolamo', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1995), 95–98.

[97] Sientific Editor 2: I was not able to find in any historical document the quoted passages in this paragraph. It seems that Bedini has here turned the passages coming from the abovementioned writers, into a more charming theatrical version. Bedini had previously published this passage in his article 'L'orologio notturno: un'invenzione italiana del XVII secolo', in *La misura del tempo: l'antico splendore dell'orologeria italiana dal XV al XVIII secolo*, ed. Giuseppe Brusa (Trento: Castello del Buonconsiglio. Monumenti e collezioni provinciali, 2005), 189–219.

invention, he felt inspired by the possibilities for innovation that the situation appeared to offer. That evening, he wrote, he reported his conversation to his older brother Matteo at the rectory. Both Matteo and his younger brother Giuseppe, who also was present, had many questions. Had the Pontiff really been serious about his suggestion? Had such a timepiece ever been made? How was it possible to make a clock silent? Obviously it could not be an ordinary clock with wheels and gears, they were certain, if it had to be silent. It did not really matter, they finally agreed, for it provided a challenging project and would be a great coup if they could achieve it. With mutual agreement that it might be possible to construct such a timepiece, they spent their free time during the days that followed reviewing the state of the clockmaker's art and contemplating where and how to begin. They spent countless hours reviewing the types of clocks they had seen and discussing the various possibilities. Finally, exhausting the subject, they agreed that it did not seem impossible to meet all the requirements.

On Pier Tommaso's next encounter with Monsignor Farnese, whom he met frequently in the Palace, he mentioned that he and his brothers had discussed the matter and were confident that they would be able to design and produce a clock such as the Pontiff had visualized, one in which the dial would be readily visible at night while the movement operated without sound. Not entirely convinced by Pier Tommaso's confidence, Farnese nonetheless was aware of the young clockmaker's reported horological skills, which had already become known in the press. He suggested that the brothers provide him with some sort of a design of what they proposed. Pier Tommaso agreed, and the brothers set about the task, collecting inspiration from a variety of sources and discussing the project among themselves in the rectory in their spare time.

Giuseppe Campani, who had been involved with the project from the very beginning, was the first to publish an account of the event, and he presented a somewhat different recollection of the encounter. Giuseppe's account suggested that a second discussion with Farnese occurred, after his first encounter with Pier Tommaso, and that this time all three of the brothers had been present. At the beginning of his published *Discorso* on silent clocks, Giuseppe wrote:

> In the year 1655 in the month of October this or a similar problem was proposed by the Most Eminent Cardinal Farnese then Majordomo of His Holiness, that is, that it was desired to

have for the service of His Holiness a clock for the night that displayed the hours well and distinctly, but in such a manner that the light of the lucerna or lamp did not offend the eyes of whoever was looking at it. This was heard by me, and by two other brothers of mine, who only a short time before had promised His Eminence to make a clock that was noiseless from the sound of the balance, that set all three of us to speculate on a solution of the problem.[98]

Because Pier Tommaso was responsible for the regular maintenance of the clock he had produced for the Pontiff, his responsibility also included keeping all of the clocks of the Apostolic Palace wound, enabling him to have daily access to the papal premises. This maintenance provided him with opportunities to seek out and observe the various timepieces maintained both in the Apostolic Palace and the Palazzo Quirinale as well as those that were in storage. He recalled that among those he had seen was a hydraulic clock that had been invented more than a half century earlier by Attilio Parisio, a Venetian doctor of laws. Apparently, the timepiece had operated successfully, and in the 1590s, Parisio had arranged to have it presented to Pope Clement VIII through the good offices of Giovanni Dolfin, ambassador of the Venetian Republic to the Holy See. The mechanism of the Parisio clock consisted of a single wheel and was powered by water. It incorporated an ingenious dial indicating daylight and night hours. Parisio may have been inspired by earlier inventions of Giovanni Fontana.[99]

After having produced his clock, Parisio had published a small tract in 1598 describing his invention without, however, revealing any useful details about its construction. The clock is known to have survived in the Apostolic Palace as late as 1681, so that it was unquestionably on the premises during Pier Tommaso's term of employment. Although the clock functioned silently with water, it did not fulfill the Pontiff's other requirements in that it was not illuminated and presumably its dial was not satisfactorily visible. In fact, even though the clock was on the premises, it may no longer have been operable and may have been discarded and forgotten. As the brothers went about their undertaking, Pier Tommaso was reminded of the Parisio clock and probably described it to them, and it is even more likely that he took them into the Palace to see it.

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[98] Giuseppe Campani, *Discorso di Giuseppe Campani intorno a' suoi muti oriuoli, alle nuove sfere Archimedee, e ad un' altra ... inventione ...* (Roma: Per F. Moneta, 1660), 1–2.

[99] Marshall Clagett, 'The Life and Works of Giovanni Fontana', *Annali dell'Istituto e Museo di storia della scienza di Firenze* 1, no. 1 (1976): 5–28; Frank D. Prager and Giovanni Fontana, 'Fontana on Fountains: Venetian Hydraulics of 1418', *Physis* 13, no. 4 (1971): 341–60.

If Matteo sought out a copy of the book describing it, however, he would have learned nothing of its construction from what Parisio had written.[100]

The Campani brothers were able to draw greater inspiration from a description of a hydraulic clock proposed by Matteo's acquaintance Francesco Eschinardi. The timepiece was in fact based upon the principle of the Parisio invention, and a detailed description in Latin with drawings had been published as an appendix to Mario Bettini's *Apiaria universae philosophiae mathematicae*, which first appeared in 1648.

Furthermore, as a consequence of Matteo's friendship and subsequent frequent association with Eschinardi, Matteo may already have been fully aware of the latter's hydraulic clock and its published description, as well as of its shortcomings. Although Eschinardi made no reference to Parisio's earlier timepiece in his publication, it is likely that Eschinardi had known of it either from the published work or from having seen the timepiece itself at the Vatican

As the Campani brothers continued their efforts, they were frustrated by one problem after another that were generated in their early attempts to design a silent night clock. Nonetheless, they persisted, for the opportunity that had offered itself was too special not to be pursued. Neither Parisio's clock invention nor the one described by Eschinardi fulfilled the primary requirement of operating silently, and in fact, there was no known precedent for a timepiece that operated silently while simultaneously making the time visible at night. In that period, clock movements commonly incorporated a crown wheel and verge escapement regulated by a noisy circular or bar balance. A few so-called "night clocks" had been made in the form of a monstrance with a light source placed in front of it, but they failed to fulfill any of the Pontiff's requirements.

In actuality, the requirement to illuminate the clock dial at night without the need to strike a flint and steel proved to be a relatively simple matter. As the Campani brothers contemplated their options, they agreed that the timepiece could not be illuminated from the exterior of the dial, by means of a lamp or candle stand, because not only would it not

[100] Attilio Parisio, *Discorso dell'eccell. D. di leggi, il Sr Attilio Parisio, sopra la sua nuova inventione d'horologi con una sola ruota. Nel quale di dimostra la real essentia lora, la qualita, I moti, & effetti maraviglioso, insieme, con le resolutioni di quante oppositioni gli potessero esser fatte* (In Venetia: G. Angelieri, 1598); Silvio A. Bedini, 'The Compartmented Cylindrical Clepsydra', *Technology and Culture* 3, no. 2 (1962): 115–41. Parisio's clock was described in considerable detail in a privately owned manuscript of 48 pages titled 'Horologio d'acqua: inventione dell Ecc.mo Sigr. Attilio Parisio', probably by Parisio dated from Treviso on February 18, 1626, some 28 years after the publication of Parisio's book.

satisfy requirements, because it would have provided continual illumination of the entire room, but it also presented a potential fire hazard. Matteo claimed for himself the solution to the illumination problem, which he based upon the principle of the newly invented magic lantern, with which Matteo was familiar. His suggestion proved to yield a ready resolution to the problem of a light source. A miniature lamp or lucerna fueled by oil could be designed of a sufficiently small size and shape to be enclosed within the clock case; the light would be confined within the interior of the case, with light rays permitted to be emitted only through perforations made in the hour disks of the clock dial.

As Matteo later reported, he had been inspired by a lantern he recalled having observed that had been maintained by the Reverend Pietro Gravita in the Oratory of Saint Francis Saverio, called "the Oratory of Caravita."[101] When the faithful arrived at the Oratory for devotions and to partake in the customary discipline, they entered a dark chamber. The only illumination visible in the darkness was a small red cross that was projected by means of a magic lantern in such a manner that none of the lantern's light was being shed through the Oratory. Matteo proposed to adopt the same principle by installing a small lamp inside the clock case so that the only light visible would be that emitted through the openings of the clock dial's perforated hour numerals.[102]

The brothers proceeded to construct a miniature lucerna, the common type of oil lamp, which they hammered out of a sheet of iron that had been tinned to prevent rust and provided with a wick. They attached it to the back panel of the interior of a mock-up clock case, positioned directly opposite the dial opening. The support they made for the lamp consisted of a small bracket, also made of tinned iron, devised so that the lucerna could be adjusted more precisely by moving it the short distance required forward or backward. An opening was provided in the top of the clock case, concealed by a

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[101] Campani, *Horologium solo naturae motu*, 9.

[102] *Oratorio di San Francesco Saverio detto del Caravita* is a church that originated in 1602 when the Jesuits instituted the "urban mission" proposed by Rev. P. Nicolò Promontorio who, by going about preaching in the public squares, gave life to the "*Communioni generali*." In 1618, he was succeeded by Rev. Pietro Gravita who was authorized to construct an oratory on the right side of the ancient cortile of the Collegio Romano. In 1630, however, Gravita arranged to exchange the site with that of the Church of S. Nicola, also owned by the Jesuits, and there the construction of an oratory was completed three years later. In the years after Gravita's death in 1658, his name was corrupted to "Caravita." A restoration of the oratory was undertaken between 1859 and 1875 [Carlo Pietrangeli, *Rione IX: Pigna, parte III*, Guide rionali di Roma (Roma: Palombi, 1980), 36–38; Giovanni B. Memmi, *Notizie istoriche dell'origine e progressi dell'Oratorio della SS. Comunione generale, e degli Uomini illustri, che in esso fiorirono* (In Roma: nella stamperia del Bernabò, 1730).]

decorative pediment, into it was inserted a tinned iron funnel-like chimney that enabled heat, smoke, and oil fumes to escape from within the clock case.

When it came to developing a system for exhibiting the hours, Pier Tommaso in his turn borrowed some elements from Eschinardi's unsuccessful hydraulic clock and experimented with the principle of a planispherical dial plate having a single opening in its circumference through which the character of the current hour would appear as it revolved underneath the arch of a larger circle by means of serrated teeth. In this manner, the hours and quarters would be demonstrated perfectly and distinctly.

The project did not proceed as smoothly as might have been anticipated, however. Pier Tommaso, as a professional clockmaker, and as the one with whom Monsignor Farnese had discussed the Pontiff's desires, assumed naturally that he was in charge of the project. Matteo, on the other hand, as the senior brother and because he was a priest, felt that he had the right to manage and direct. Young Giuseppe wisely kept his silence, followed instructions when he was addressed, and made suggestions only when the climate appeared to favor his participation.

After the brothers finally had reached an agreement on the elements to be utilized and the proposed manner of their production, Pier Tommaso set to work to construct an operative model made of brass. He incorporated the suggested light source and the dial with movable hour disks. They contracted with the cabinetmaker who produced the clock cases for Pier Tommaso's clocks and provided him with specifications for housing the silent night clock. They installed the components they had devised within the case, and Pier Tommaso brought it to the Palace later in October to demonstrate it to Majordomo Farnese. The Major Domo expressed approval of the projected timepiece, Giuseppe reported as did also several "conspicuous Princes" who were present and to whom it was shown. The clock must be now also entirely silent in operation.[103]

The Campani brothers had not overlooked this requirement but had postponed dealing with it for the time being because it presented the greatest difficulty, hoping to find a solution. Matteo later wrote that in addition to the Eschinardi *Appendix*, he also had consulted a published work by the Jesuit scholar, Niccolò Cabeo, whom, Matteo noted, "had been my master and teacher, and in 1644 it was he who had shown me the

[103] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 4.

first hydraulic clock I ever saw. Two things struck me in their writings: (1) the advantage of silence; (2) the method of the hours proceeding one by one in procession and running along a band which had been curved to form a semi-circle and designating the entire course of the hour in the space of the band. To achieve this I thought first of using quicksilver; but seeing that it would not work, I turned to the careful construction of a mechanism, which among other interesting things, seemed to be a reconstruction of an ancient device of *Archimedes*. When completed I offered it through the good offices of His Eminence Cardinal Farnese to the Sovereign Pontiff Alexander VII."[104]

Matteo's account does not indicate whether the hydraulic clock that Cabeo had brought to his attention might have been an account of Parisio's clock, an early version of Eschinardi's hydraulic clock, or yet an entirely different invention. The "mechanism" to which Matteo referred that he had constructed was later revealed to have been the "material sphere" that the Campani brothers also presented to the Pontiff and was not part of the clock.

In a brief work published in December 1660, eight months after the appearance of his brother Giuseppe's *Discorso* and five years after the silent night clock had been completed, Pier Tommaso, presented his version of the invention, an account which he claimed to be more accurate than the circumstances described by his brother Giuseppe in his *Discorso*. Pier Tommaso reported that he had once seen a hydraulic clock that was noiseless. It was motivated by means of water enclosed within a container, the interior of which was divided into compartments. He noted that he did not recall the number of the container's divisions but assumed that the mercury, also called quicksilver, would be most successful if its container had four compartments so that the liquid metal could flow freely from one compartment to another through a small opening in each of them. He concluded that a round receptacle would be most successful shape and planned that the mercury container would serve as the clock's regulator, replacing a balance wheel.[105]

Pier Tommaso reported that he had proposed this to Matteo as a means of making an operating clock that was silent. He made apparent his position as the master craftsman among the brothers and stressed the point that Giuseppe was his apprentice, noting "here

[104] Campani, *Horologium solo naturae motu*, 6-7.
[105] Campani, *Lettera di Pier Tommaso Campani*, 5-6.

I speak of the older brother inasmuch as the younger one was yet not capable of these matters."[106] Matteo did not agree immediately with Pier Tommaso's proposal, objecting that if the openings in the compartments were too small, the mercury could not flow through with sufficient freedom because of the fluid metal's density, and if the openings were too large, the mercury would drop from one to another too suddenly, thus making the idea useless.

Pier Tommaso later recorded how he had not been discouraged, however. He wrote about how one day while working alone at the rectory he took a cylindrical drinking glass and divided its interior into two compartments by inserting tightly fitted dividers made of strips of brass. He bored a tiny hole in each of the strips then, enclosing a small quantity of mercury within the glass, he placed it upon an inclined plane. He watched as it slowly descended, made mobile by the changing weight as the mercury moved from one compartment to the other. The brothers then immediately proceeded to develop Pier Tommaso's experiment with a small round metal container into which they inserted a quantity of mercury. Its interior was divided into four compartments, each with a tiny opening enabling the mercury to move from one compartment to the next in such a manner that the container, upon being given an initial slight impulse by hand, continued to revolve as a consequence of the displacement of the mercury. They concluded that, in principle, it would serve as the regulator for their night clock because it operated in silence.[107]

In practice, however, the brothers soon encountered grave difficulties that remained unsolved, causing much frustration and considerable wasted effort and delay. The first of the difficulties that arose related to the dial, which, as Giuseppe said, he "often had indicated to my brothers, could not succeed in these clocks which had always a constant [or equal] and uniform motion, in contrast to those operated with water [instead of mercury], which moved with interrupted and unequal motion."[108] In order not to abandon completely the appearance of the model they had developed and already had exhibited at the Vatican, Giuseppe thereupon ventured the suggestion that it might be possible to make a similar dial "having two openings diametrically spaced from each

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[106] Ibid., 7.
[107] Ibid., 6-9.
[108] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 5–6.

other."[109] When put into practice, the suggestion proved to resolve the problem, with the consequence that thereafter they experimented with dials having two and even more openings.

The most successful version of the dial plate, the one they finally selected, was suggested by Matteo. Pier Tommaso wrote that he had proposed using the planispherical dial of the successive hours such as had been designed for the hydraulic clock "which would display the character for the hour and which would run in a mobile opening, and that the artifice should consist of a pentagon. My senior brother [Matteo] indicated that if instead it were based upon a decagon it would be possible to have two openings diametrically opposite each other, in one of which would be observed the nascent hour and in the other the passing hour of the night and also the half, quarter and half-quarter hours."[110] They traced the characters upon translucent material. Believing that it was possible to illuminate these hour characters by enclosing the small lucerna they had made within the clock case in the manner that Matteo had observed in the Seminario Romano "in order to make it possible to read some words in the air, the demonstrator wrote them upon a semi-transparent corpus and placing it behind a lamp and all of the foregoing succeeded."[111] Not one to dispense credit generously, Pier Tommaso claimed for himself the incorporation of the compartmented cylindrical clepsydra and suggested that the other elements were already common and well-known.[112]

Having now solved the problems that had occurred with the major aspects of the project, the brothers presented a revised working model to Majordomo Farnese. Farnese encouraged them to continue, reminding them once more of the necessity to eliminate all sound of clockwork operation, as they had promised. He pointed out that although not as noisy as wheeled clockwork, their mercury escapement still required improvement, for it was not entirely soundless, particularly in the stillness of the night. When the compartmented container of mercury was tested in operation outside the clock case, it had seemed to require only the slightest impulse to place it in motion. When enclosed,

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[109] Ibid., 6.
[110] Campani, *Lettera di Pier Tommaso Campani*, 10-11.
[111] Ibid., 11-12.
[112] Ibid., 13-16.

however, it moved only briefly or not at all, its motion generally irregular and therefore unacceptable for regulating the clock.[113]

Finally, after several more weeks of long contemplation, experimentation, and frustration had passed, and after having tested and constructed a wide variety of forms and diverse types of interiors of many such containers, the brothers arrived at last at one having such a disposition of the interior space that enabled the cylinder to move successfully and continuously with uniform motion. This interior was incorporated in a completed model and shown to Farnese as promised. The selection of the container's intended material was the next decision to be made. It was beyond their capability to produce a container made of glass that fitted the clock's requirements, and most metals were unacceptable because they would experience corrosion upon contact with the mercury in the course of time. After much trial and error, they found a successful solution in a container made of ivory. They contracted to have such a cylinder produced to their specifications by an ivory turner in the city.

Because this timepiece was to serve in the silence of the night, at first they had spoken of it as a "night clock" [*orologio notturno*]. Because it could be used equally well in the daytime, however, to distinguish it from other types of domestic clocks, and because of its unusual feature, they named it instead a "silent clock" or "mute" [*orologio muto*]. Now that the movement and dial arrangement had been satisfactorily completed and tested, the question of the appearance of the clock case remained to be resolved. The final decision concerned with the clock case required some study because it had to be in keeping with the religious surroundings of the papal bedroom, in which their invention would be permanently used and displayed. Uncertain how to proceed, they probably sought advice from Majordomo Farnese, who may in turn have asked for suggestions from the Pope's architect, Gian Lorenzo Bernini, inasmuch as it was a matter relating to furniture in the papal chambers.

It was concluded that the most appropriate style for the clock case was that of the "edicola reliquario" (or *aedicola reliquorum* in Latin), a relatively small but elaborate private altar or shrine. Generally black in appearance, constructed from solid or veneered ebony or other rare woods, and occasionally decorated with colorful inlays of *pietre dure*,

[113] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 6–8.

the *aedicola*, or private family shrine, was an item of furniture frequently found in homes of the wealthy and palaces of the nobility. The altar-shaped structure terminated in a pediment flanked by volutes. Its main feature was the central panel, usually consisting of a miniature religious painting on a wooden panel or one of sheet copper. In rare instances, the central panel consisted of a slab of polished decorative semi-precious stone, such as amethyst matrix, upon which a religious allegory in oils had been painted. Occasionally, the panel was surrounded by a cornice made of rare marbles, under several of which may have been imbedded religious relics. This panel often was framed on each side by decorative columns inlaid with colorful marbles and having gilt or silver bases and capitals; occasionally, gilt statuettes and other adornments were added as well.

The *aedicola* was an item of domestic furniture that became particularly popular during the sixteenth and seventeenth centuries in Rome and was frequently listed in contemporary inventories of furnishings in Rome's palatial dwellings. Such an inventory made in 1666 of the furnishings of the Palazzo Pamphilij in Piazza Navona, for example, included a tabernacle of black ebony bordered with silver in perspective with two columns made of jasper interspersed with lapis lazuli, with at its center a panel of jasper upon on which had been painted Saint Anthony of Padua holding the Christ Child.[114]

The fashion for veneered furniture had become so popular in Rome during the Baroque period that it brought a number of cabinetmakers from the Low Countries, Germany, and northern Italy to work there. Among those known to have produced *aedicola*, in addition to the talented German Jacob Hermann (also known as "Hermann Muller" or "Giacomo Ermanno"), other craftsmen similarly engaged included Raniero Bruc, Giovanni Cheller, and Remigio Chilazzi. In Rome, Gaspare Mola and Raniero Bruc were distinguished workers in *pietre dure*. In 1631, Mola made a testament bequeathing to his nephew his entire shop in which four framed works in *pietre dure* had been committed. Bruc received payment in 1613 for two reliquaries of ebony, which he had produced "for the service of Our Holy Father." Another well-known worker in *pietre dure* in Rome was Francesco Botaciolo, who produced for Pope Urban VIII a large

[114] Anna Maria Giusti, ed., *Splendori di pietre dure: l'arte di corte nella Firenze dei granduchi* (Firenze: Giunti, 1988), 144.

square and frontispiece all with *pietre dure* and having two large silver angels, for which he received payment on December 28, 1633.[115]

The *aedicola* provided the Campani brothers with an obvious solution, and its design proved to be so convenient for night clocks for use in the bedroom that it was adopted by both Pier Tommaso and Giuseppe Campani for the cases of all of their night clocks thereafter. Subsequently, like the *aedicola*, the night clock became the purview of the wealthy and took the established form with more or less decoration and elaboration, depending upon the taste and the purse of the owner for whom it was being made. As a consequence of modeling the clock case of the Italian night clock after the *aedicola*, the style proved not only to be appropriate but also satisfyingly tasteful. It prevailed as other Italian makers of night clocks thereafter followed suit, and the style became the accepted standard form. It perfectly reflected the *fasto Romano* for which the second half of the seventeenth century became known. The night clock soon became a prime example of the sumptuous splendor of the Baroque style as expressed in Roman furniture, its frequent excess of decoration demonstrating the opulence and luxury of the times, occasionally venturing beyond magnificence into pomposity. The example of an Italian night clock that undoubtedly signifies the ultimate of *fasto Romano* might be the night clock made in 1683 by Pier Tommaso Campani, now in the British Museum, formerly in the collection of the late Courtenay Adrian Ilbert.[116]

The more elaborate examples of the *aedicola* required the combined skills of a specialist in ebony veneering (in Italian, an *ebanista*), a lapidarist, a painter, and a goldsmith, all working in cooperation. Veneered ebony furniture became particularly popular in Rome during that period, the art of veneering in ebony having been a specialty brought to the Eternal City after the end of the Thirty Years War by skilled German and Flemish craftsmen.

The overall dimensions of the clock's housing were determined by the size required for the dial plate, which had to be of sufficient size so that when it was placed

[115] In addition to Jacob Hermann, other early craftsmen deserving mention were Jan van Santen, Giovanni Vasanzio, and Flaminio Ponzio. In comparison with carved furniture, which was more sculptural and elaborate in nature, ebonized furniture was more severe and austere in appearance, with simple lines in an architectonic form and more appropriate for their purpose [Antonino Bertolotti, *Artisti lombardi a Roma nei secoli XV, XVI e XVII: studi e ricerche negli archivi romani*, vol. 2 (Sala Bolognese: Forni, 1985), 196, 205, 211, 217, 255.]

[116] Hugh Tait, *Clocks and Watches* (Cambridge: British Museum, 1983), 54, no. 63.

upon a table at a short distance from his bed in the papal bedroom, it would readily be seen from the Pontiff's bedside. Accordingly, the clock case they designed was not less than two feet and not more than three feet in height. The Campani brothers also may have been inspired to some degree by the drawing of the clock case for Eschinardi’s hydraulic clock, which in turn was based upon the clock case of Parisio’s timepiece, both in the general form of the *aedicola*. The Campani brothers arrived at the convenient arrangement to design the clock case so that the facade consisted of a large hinged door. The dial plate with the clock movement was attached to its reverse side, in somewhat the same manner as the arrangement of the Parisio and Eschinardi clocks.

The Campani brothers mutually agreed that the only appropriate color for the clock case was black, favored for most of the *aedicola*, and in all probability the wood selected for the case was ebony or ebonized pearwood or walnut. Having no capability to make the clock case themselves, the Campani brothers contracted with an *ebanista*, probably the one that Pier Tommaso had been employing to make his previous clock cases, to produce a clock case to their specifications. It may have been Jacob Hermann, who subsequently constructed a number of the clock cases for the timepieces produced by both Pier Tommaso and Giuseppe Campani. The wooden or copper dial plate may have been painted with decorative themes by one of their artistic associates.

At last, in March 1656, all was in readiness, and the brothers formally delivered the completed silent night clock to the papal Majordomo Girolamo Farnese. When the Pontiff saw the timepiece, he was extremely pleased, and after several days of trial in the Apostolic Palace, the clock was declared to be an eminent success. News of the unusual new invention spread quickly throughout the papal court and from there to the embassies to the Holy See and to the Roman nobility.

Thus was born the first Italian silent night clock, an entirely new concept in timekeeping, never before seen, invented by the Campani brothers and designed primarily for an ecclesiastical setting and imbued with a permanent austere and sumptuous appearance. It resembled an architectonic structure based upon that of an *aedicola* having a painted dial plate. The case was designed to be placed upon an item of large furniture such as on a large shelf or console in a large hall or salon in large buildings such as mansions or palaces.

"The novelty of the silent clock so pleased important princes that in a short time they were in great favor," later wrote Giuseppe, "and many important personages, some of whom are still living [in 1660], purchased them at great price and made gifts of them to others, including the King and the Queen of Spain, the King of Poland, and the Grand Duke of Tuscany."[117]

Confirmation that the Campani brothers had in fact produced a clock for King Felipe IV (1605–1665) of Spain and his Queen similar to the one they had made for the Pontiff was noted in a royal Spanish commission executed in 1658, as reported by the Spanish horological historian, *conservadora-delegada del Tesoro Artistico*, Paulina Junquera. She wrote: "In 1656, the brothers Giuseppe and Pier Tommaso Campani or Campanus, constructed an alarm [sic] clock for Pope Alexander VII. The clock, of their invention, became very famous in its time, and Felipe IV commissioned another similar. The commission was completed in 1658, although this piece no longer exists, nor is it listed in any royal inventory."[118]

On June 20, 1656, payment was made by the Vatican treasurer to Pier Tommaso Campani "clockmaker of the Palace" for 500 *scudi*,"as the price for a clock contained within a cabinet [*studiolo*] of ebony with *pietre dure* of agate, gilt bronze capitals and with similar statuettes, presented by him for the service of His Holiness." This was the payment for the mercury escapement clock made by the combined efforts of the three brothers and probably including the cost of the clock case and decorations.[119]

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[117] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 11. See also: Alvar González-Palacios, *Fasto romano : dipinti, sculture, arredi dai palazzi di Roma* (Roma; De Luca: Leonardo, 1991), 23–28, Tav. xxxiii; Stefanie Walker and Frederick Hammond, eds., *Life and Arts in the Baroque Palaces of Rome: Ambiente Barocco* (New Haven: Yale University Press, 1999), 196–98.

[118] Paulina Junquera, *Relojería palatina: antología de la Colección Real Española* (Madrid: Roberto Carbonell Blasco, 1956), 24. Two clocks by Giuseppe Campani, nevertheless, were included in the inventory of the properties of Don Fernando de Valenzuela, compiled by José Matheo, clockmaker in the employ of Queen Doña Mariana. They were evaluated 2,500 and 3,300 *reales de vellón*. [Scientific Editor 2: 2 *reales de vellon* = 1 *real de plata* or silver *real*. Junquera added that it was not impossible that one of those had been a gift from the Queen Mother Mariana to her minister Don Fernando. After a few years of barren successes, the reign of Felipe IV had become a long story of political and military decay and disaster. A fine hunter and horseman and lover of art, the King left the administration of the country to favorites with disastrous results. Archivo de Palacio, Madrid, Leg. 16, fol. 413v; *Inventario y tasación de los bienes de don Fernando de Valenzuela*. [Scientific Editor 2: see chap. VI of this book: *Oscillating Bars: The Crank Lever Escapement (1657–1659)*.

[119] This papal invoice confirmed that the first silent night clock had been made as part of a cabinet or *studiolo* and had been decorated with *pietre dure* inlay with columns having bronze capitals and bases and statuettes, a style duplicated later in other examples; Ozzola, 'L'arte alla corte di Alessandro VII', 79; González-Palacios, *Fasto romano*, 151.

This first Campani silent night clock incorporated three separate inventions: a silent escapement to achieve what was the first mechanical silent clock with wheelwork as distinguished from other timepieces such as sundials and clepsydras; it had a dial without an index or hand, displaying only one hour character at a time; and, finally, it had illumination provided from within the clock case behind the dial instead of in front of it, such as already existed in timepieces of the Renaissance, as exemplified by the Dutch and German examples and the Spanish clocks of Hans de Evalo.[120]

The concept of a hydraulic clock had been one of long standing, attempted again and again in the early seventeenth century. Although the Campani invention inevitably bore some similarity to Parisio's hydraulic clock, the latter was not a night clock, although it displayed the hours in a related manner. As noted, some elements had been borrowed from the description of Eschinardi's unsuccessful hydraulic clock that he had intended to present to Cardinal Francesco Barberini, which also was likely based upon Parisio's prior invention. It is to be noted that Eschinardi did not make any reference to Parisio's clock in his description of his own invention, nor later in his endorsement in the *Iudicium* of the Campani invention, nor in his other works. Nor was the Parisio clock ever mentioned by the Campani brothers in their writings.[121]

In actuality, the principle utilized by Parisio, Eschinardi, and the Campani brothers had a much earlier history and can be identified in the *Libros del Saber* of the Spanish King Alfonso X of Castile, which described a clock having a compartmented cylindrical clepsydra divided into twelve compartments and that used mercury for the

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[120] Mathieu Planchon, *L'horloge: son histoire rétrospective, pittoresque et artistique* (Paris: H. Laurens, 1898), 84, 110, 165–67.

[121] Mario Bettini, *Aerarium philosophiae mathematicae, in quo elementa philosophiae geometricae de planis, curuis, & solidis figuris applicata, et ornata ... methodo iucundiore, ac breuiore in tres tomos distributa sunt. Intercessere ingeniosae inuentionis exodia horaria*, vol. 1 (Bononiae: Typis I.B. Ferronij, 1648). The addition to vol. 2, Epinomis post partem II tomi II Aerarij philosophiae mathematicae, in qua gnomonicae, machinariae philosophiae exodia sunt horaria, sandalium, cithara, microcosmus, arcus, tympanum, 45–60, contains the first published description of Eschinardi's hydraulic clock, which also was included in the 1650 and 1654 editions of Bettini's work, as well as in the *Schiaro de' Letterati di Roma* in 1672. See Pietro Riccardi, *Biblioteca matematica italiana: dalla origine della stampa ai primi anni del secolo XIX* (Modena: Tipografia dell'erede Soliani, 1870), 125. Eschinardi also published it separately twice, as *Horologium hydraulicum ex Aerario P. Marii Bettini,... cum appendice P. Francisci Eschinardi ...*, Secunda editio (S. l.: s.n., 1648), and; Francesco Eschinardi and Mario Bettini, *Appendix Ad Exodium de Tympano* (Bononiæ: Typis I.B. Ferroniij, 1650).

motive force as did the Campani night clock. However, it is extremely doubtful that the Campani brothers were aware of it.[122]

The wheelwork of the Campani clock did not vary considerably from that of common clocks of the period except that the assembly of the crown wheel and verge escapement with balance wheel regulator was replaced by the ivory compartmented cylinder containing a limited amount of mercury, which rotated in a vertical plane and silently regulated the motion of the dial. The passage of the hour characters was observed through a star-shaped opening appearing in a sector-shaped aperture in the upper part of the dial, which was graduated in hours, quarters, and half-quarters. The hour characters were perforated on small metal disks strung together in a chain and hung around a wooden frame in the shape of a decagon placed behind the main dial plate so that the disks changed epicyclically as the main disk was turned. No example of the Campani mercury escapement night clock is known to have survived,[123] nor is any representation of it.

Neither Pier Tommaso nor Giuseppe had knowledge of Latin and were incapable of reading or writing it, and such infrequent use of it as Giuseppe later made of the language in his writings were undoubtedly with Matteo's assistance. Pier Tommaso, in his *Lettera*, also commented on the difficulty he experienced in writing about his work even in his native tongue. It was easier for him, he wrote, to construct the work itself than

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[122] Enrico Narducci, *Intorno ad una traduzione italiana fatta nell'anno 1341: di una compilazione astronomica di Alfonso X, Re di Castiglia* (Roma: Tipografia delle Scienze Matematiche e Fisiche, 1865), 14; Bedini, 'The Compartmented Cylindrical Clepsydra'.

[123] In about 1970, however, at a time when few dealers and collectors outside Italy were as yet familiar with Italian night clocks, one was offered to Italian collectors in Milan by a dealer based in Bergamo named Gabrieli. The account states that from time to time Gabrieli's brother who lived in southern France provided him with a variety of merchandise to be sold in Italy, including clocks collected from that region as well as, undoubtedly, contraband. Among the items Gabrieli had recently received was a clock housed in a black case having simple lines. The movement and the clock case had been severely damaged, and the timepiece was incomplete and in poor condition. The movement appeared to have consisted of a large brass barrel to contain a spring and under it could be seen a painted copper dial plate having a small window opening to which was attached a somewhat schematic cylinder made of ivory or bone. This cylinder also was badly damaged. The clock collector to whom it was offered refused it because of its condition. Later, after thinking about it and having changed his mind, his attempts to reach Gabrieli through other dealers and clockmakers were unsuccessful. The timepiece is said to have been sold eventually in Venice, the identity of the purchaser unknown. The damaged timepiece may have been an original Campani night clock with mercury escapement, or possibly an attempt to reconstruct the silent night clock from the description provided by Pier Tommaso Campani in his *Lettera*. Communication from Dr. Giancarlo Del Vecchio (September 22, 1985). [Scientific Editor's note: In this letter, however, Del Vecchio, considers this piece of news not reliable].

to describe it in writing. “Inasmuch as it is the greatest obligation that I profess to you does not allow me to negate any item, that is in my power, I cannot fail to satisfy your curiosity in describing the manner with which I make the silent clocks, and the sphere or the exhibit of the Planets, that moves without being wound. I assure Your Highness that it would be much easier for me to make them, than to describe them, and as much mastery as I pretend to have as a clockmaker, I confess as much ignorance as a composer of letters; I have better success with the file than with the pen, and I have greater pleasure in completing a fine piece of work than to stretch my head to put together a fine discourse.”[124]

At the same time that the Campani brothers delivered the completed silent night clock to Pope Alexander VII, at the last moment they took the opportunity to present him also with a working model of another of their inventions, which apparently they had been developing. They described it as “a material sphere” of the planets without the necessity for winding.The word “material” [*materiale*] defined the instrument as being a tangible object and not a theoretical concept. The instrument does not survive, and the few contemporary accounts of it are at most mere mentions and fail to provide an adequate description of the device.

According to the writings of the Campani brothers and of others who had seen the “material sphere,” it was in fact a preliminary working model for a planetarium that was designed to display the rotation of the planets then known. The instrument was constructed in the form of a sphere, its mechanism made of brass enclosed within two clear glass hemispheres through which representations of models of the planets and their movements were to be clearly visible. The instrument was powered neither by a falling weight nor by a wound spring; the Campani brothers claimed that it was powered by means of an internal arrangement, the identity of which was never revealed. Its inventors claimed that its motive force could be provided by attaching the device to the silent night clock, which could then make it operative, or it could operate separately merely by providing it with an initial impetus.

Although it was only a preliminary model, the material sphere apparently pleased Alexander VII quite as much as had the silent night clock. Encouraged by the clock’s

[124] Campani, *Lettera di Pier Tommaso Campani*, 3–4 (1660).

favorable papal reception, the Campani brothers soon discovered that the Vatican's patronage helped to create an enthusiastic market for their new timepiece.

The brothers became concerned that their success inevitably would attract competition from other clockmakers who undoubtedly would immediately attempt to copy their invention for commercial gain. There must be some way to protect their inventions, they worried, and it probably was Matteo who researched the matter and conceived of a solution—a papal letter patent! Traditionally, over the centuries Popes had issued papal patents in the form of *privilegi*[125] or exclusive rights for inventions, processes, and other enterprises from which commercial gain could be derived. As well as can be determined, however, through a search of the records, documentation can be found of only a single papal patent that had been issued for a horological invention prior to the time of the Campani brothers. It was, in fact, for the invention of the hydraulic clock by Parisio, which was still in the Vatican Palace at that time and with which the Campani brothers undoubtedly were familiar. Matteo probably had found a copy of Parisio's tract, which described that 58 years earlier, in 1598, just such a privilege had been granted to Parisio by Pope Clement VIII for the invention of his hydraulic clock.[126]

Although there is no evidence of other such *privilegi* or papal patents having been issued for inventions by the papacy in recent history, such an award as was granted to Parisio was rare although not unique. The earliest similar patent issued by the papacy of which record can be found had been granted by Pope Pius V in 1567 to Janello Torriani of Cremona, also known as Juanelo Turriano, an Italian-born mechanician, engineer, and clockmaker, while he was working in Spain. The patent, which was in the form of a

[125] [Scientific Editor's note: in historiography these Early Modern patents are usually referred to as "privileges for invention" or "inventor's privileges"].

[126] Regesti Parisio patent. Parisio, *Discorso dell'eccell. D. di leggi, il Sr Attilio Parisio, sopra la sua nuova inventione d'horologi con una sola ruota. Nel quale di dimostra la real essentia lora, la qualita, I moti, & effetti maraviglioso, insieme, con le resolutioni di quante oppositioni gli potessero esser fatte*; Bedini, 'The Compartmented Cylindrical Clepsydra'. [Scientific Editor's note: On the court clockmaker to Emperor Charles V and to King Philip II of Spain Janello Torriani/Juanelo Turriano, which Enrico Morpurgo described in 1950 as "*the most popular among clockmakers*" has been recently published momographs and articles. One for all, see: Cristiano Zanetti, *Janello Torriani and the Spanish Empire: A Vitruvian Artisan at the Dawn of the Scientific Revolution* (Leiden: Brill, 2017); Enrico Morpurgo, ed., *Dizionario degli orologiai italiani: 1300-1800* (Roma: La clessidra, 1950).

chirògrafo, or papal written document, was awarded for the invention of hydraulic devices for raising water.[127]

Seizing upon the existence of such a convenient precedent, Matteo lost no time in arranging to submit an application on behalf of his brothers. He was excluded from the application inasmuch as his position in the Church did not permit commercial gain, as well as the fact that his role in the production of the invention had been primarily advisory. He assisted Pier Tommaso and Giuseppe in drafting the text of the application in their names. Although in fact it was composed mostly by Matteo, it was submitted in the handwriting of Pier Tommaso. Directed to Pope Alexander VII and dated March 5, 1657, the application was signed "Pier Tommaso Campani Clockmaker to His Holiness," and stated:

> Pier Tommaso and Giuseppe Campani, most humble and obliging servants of Your Holiness, with due deference declare that they having with considerable study, effort, and expenses discovered two inventions, that is, a method of making a material sphere representing the motions of the planets without having to be wound, and a method of making silent clocks, that is, without sound, which have a new method of indicating the hours; these things being at liberty for any one to manufacture, a state which would be greatly to the prejudice of the inventors; we beg therefore with the greatest humility that Your Holiness deign to grant a privilege ordinarily conceded by the Holy See to inventors, that is, for ten or fifteen years so that no others in the Holy State may make or sell any such items, in whole or in part, without the permission of the inventors. This concession would be received with special gratitude from the munificence of Your Holiness to whom may God concede a long life and every desirable prosperity and continued felicity.[128]

The application was favorably received, and two days later the request was rendered by the Vatican office into a formal edict in the Italian language dated March 7, 1657, that specified the content. An appendix in Latin signed by one G. Gualterius granted the privilege for a period of ten years. Several months were required for processing the patent through administrative channels before it was announced publicly in the form of a printed edict for distribution, a delay that caused considerable frustration to the anxious brothers for they delayed their production of more clocks until they were assured of the patent's protection.

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[127] ASV, *Minutae origin*, *Ab anno 1523 ad anno 1599*, n. 13419; Felice Zanoni, 'Un brevetto pontificio d'invenzioni del 500: Janello Torriano e un documento dell'Archivio segreto vaticano', *Bollettino Storico Cremonese* X, no. settembre-dicembre (1940): 145–53.

[128] ASV, *Sec. Brev. 1166*, 37r-v, 38r–39v.

The privilege was subsequently published in the form of a large broadside, the size of which could vary from approximately 10 by 18 inches to 15 by 20 inches; they were produced at the press of the Most Reverend *Camera Apostolica* in a great number of copies. Appearing in a footnote on the edict was the statement, "On April 11, 1657, the above edict was affixed and published to the door of the Curia, and in the Campo di Fiori and in other usual and proper places of Rome [*in alijs locis solitis et consuetis Urbis et moris est*] by me, Antonio Bertarellum, papal messenger." Copies of the printed broadside were then distributed widely and posted in all public places in Rome and other cities within the realm of the Holy See.

The edict followed the standard form used for papal edicts and featured three sets of arms under the main heading. First was the Holy See's crossed keys under the papal umbrella, the arms of the reigning Pope at the center, followed by those of the *camerlengo* or papal chamberlain. The text was printed in two parts, the upper half in the Italian language, which was duplicated in Latin in the lower section, explaining the nature of the invention or process for which the privilege was issued, the penalties to violators, etc. The patent was granted on March 7, 1657, and read as follows:

Pope Alexander VII

For the future record of the matter. Recently our beloved sons Pier Tommaso and Giuseppe De Campanis [sic], clockmakers in this City [Rome] brought to our attention that they discovered, through their own ingenuity, a manner of making material spheres [globes] with the movements of the planets without tension, and also silent clocks, that is, without the noise of the movement, and having a new method of showing the hours successively. They fear, however, lest others, desirous of gain from someone else's work and industry, make spheres and clocks of this type to the detriment and prejudice of Pier Tommaso and Giuseppe. The above-mentioned Pier Tommaso and Giuseppe, therefore, have humbly asked that we deign to provide opportunely from our Apostolic benignity for them in the above-mentioned matters as [described] below. We, therefore, wishing to favor the same Pier Tommaso and Giuseppe with [our] special favors and graces, and absolving [them] from any sentences of excommunication, suspension, and interdict and any other ecclesiastical censures and penalties inflicted by the law itself or by a judge on any occasion or for any cause, if they happen to become involved in any way whatsoever in these [censures] for the effect of these present Briefs to the extent that they follow, and considering that they will be absolved, moved by this petition, we grant and concede, by our Apostolic authority and by the contents of the present Briefs, to the same Pier Tommaso and Giuseppe, that for the next ten years no one can make material spheres and silent clocks of this kind either in the City [Rome] or in the rest of the ecclesiastical state, mediately or immediately subject to us, or if they are made elsewhere, to put them up for sale or sell them without the express permission of the same Pier Tommaso and Giuseppe.

Restraining therefore all Christians of both sexes, especially makers and sellers of material spheres or timepieces, under the penalties of 500 gold [pieces] *de camera*[129] and the loss of timepieces of this kind, for one [third part] to our Apostolic Camera, and for another [third part] to the same Giuseppe [and Pier Tommaso], and for the remaining [third part] to the accuser and judge prosecuting [the one] unpardonably devoting himself, and by that very fact incurring [the penalties] without any declaration, lest within the mentioned ten-year period they dare or presume in any manner whatsoever to make material spheres or silent clocks of this kind, even by the pretext of adding to them, or [by the pretext] of any change of them, without the aforesaid permission, both in the City [Rome] and in the rest of the ecclesiastical state, or to be put up for sale and sell them, though made elsewhere. Commanding also that our beloved sons and legatees *de latere* of the Apostolic See, and their vicars, presidents, governors, *praetors*, and ministers of justice of the above-mentioned City [Rome] and the provinces, cities, lands, and places of our ecclesiastical state, that, assisting by the protection of an efficacious defense, the same Pier Tommaso and Giuseppe in the above-mentioned matters, whenever they are asked by the same Pier Tommaso and Giuseppe and by either of them, they execute the above-mentioned penalties against any [persons] unpardonably disobeying, notwithstanding the Apostolic constitutions and ordinances, and any statutes whatsoever, and [or] customs even by oath with the Apostolic confirmation, or privileges strengthened by any other enforcement whatsoever, even indults and Apostolic Briefs to the contrary of the above-mentioned, no matter how conceded, confirmed, and [or] innovated, and all other things to the contrary notwithstanding. We wish, however, that the same faith be given to reprints of these present Briefs, signed by some public notary and marked with the seal of some person of ecclesiastical dignity [station], in court and outside it, the same as if these present Briefs were brought forth or shown. Given at Rome at St. Peter's [under] the ring of the Fisherman, the seventh day of March 1657, the second year of our Pontificate.

G. Gualterius[130]

It was a remarkable document, and the first of record to be so extensive and conclusive in content. Naturally, the brothers were delighted and reassured that they had protected the exclusivity of their invention. Not only did these papal edicts serve as deterrents to the unlawful, but they also had the unparalleled advantage of providing free advertisement for the inventions they protected not only in Rome but over a wide region, elsewhere in Italy. This was achieved by the addition at the bottom of the printed edict of the address at which such inventions could be obtained, stating "The above-named clockmakers live at [the Church of] S. Tommaso in Parione in the Rectory."[131]

In the years that followed, both Pier Tommaso and Giuseppe Campani succeeded in being granted several other papal privileges not only in Rome but elsewhere in Italy. It is to be noted that there is no record of similar privileges being granted by reigning pontiffs to other clockmakers or makers of mathematical instruments during the period

[129] Scientific Editor's note: the golden *scudo di camera* had a minor value compared to the papal golden *scudo*.

[130] ASV, Miscellanea, Armadio IV: Bandi, vol. 27, fol. 454.

[131] Ibid.

covered from 1570 to 1670, except to Attilio Parisio and Pier Tommaso and Giuseppe Campani.

Although three years later Giuseppe provided a description after a fashion of the material sphere in his *Discorso*, the text presented it in such a manner as deliberately to obfuscate details of its construction or identification of its components. His purpose was to protect an invention in progress, which had not yet been completed. His discussion of the sphere took the form of a dialogue between an articulate and well-informed ingenious and experienced individual he named Servio and a skilled clockmaker named Britio. Undoubtedly, this form of exposition, possibly inspired by dialogues in Galileo's works, was suggested by Matteo, to whom Giuseppe attributes the fisrt idea of the material sphere and this dialogue itself.[132] It enabled the participants to discuss the invention at length yet revealing few if any specifics of its appearance and none of its construction, thus assuring priority of invention while protecting its details from potential rivals.

In Giuseppe's *Discorso*, Britio noted that while he had been in Spoleto in late 1655, he had received a brief explanation of the device, described as a certain sphere that demonstrated the motions of the planets and operated without the necessity of winding. He did not identify the source of his information, but obviously Giuseppe the author was referring to himself. Servio's preliminary description, given in Latin, stated:

> We can build a sphere [which] eternally follows the circular movement of the sky during the twenty-four hours of the day and even for a longer time (not by itself but by means of an external agent) and also it can do this for as long as we wish without making a single mistake not even in a thousand years. This sphere will show us the years, the months, the days, the hours, the course of the sun and the moon (whose course, however, would be better and more appropriately demonstrated in a separate sphere) and of each planet, as well as the daily and natural movements of the five errant planets, the true movements as well as the mean ones, together with their stops, retrograde and direct motions. All the above-mentioned things can be shown endlessly by the sphere in such an exact and pleasant way, free from any error, so that by means of it we can know them all better and more precisely than from the heavens themselves.[133]

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[132] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 32–33.

[133] "*Possumus construere sphaeram, perpetuo secundum cursum aetheris singulis viginti cumdum cursum semel circumrotabilem (Intellige non per se se, sed ab agente externo) aut toties amplius, quoties nobis visum fuerit, ita ut nec mille annis semel fallat, ostendentem nobis annos, menses, dies, horas, cursum solis, lunae (cuius tamen motum melius et commodius erit in sphaera separata exhibere) omniumque planetarum, seu quinque erronum motus diurnos et naturales, tam veros, quam medios, stationes, retrocessiones, et directiones praedictaque omnia ita exacte, et iucunde citra notabilem errorem exhiberi semper possint; ut ex ea magis exacte, meliusque, quam e Caelo ipso habituri simus*": Ibid., 36-37.

This statement made clear that Giuseppe was describing an invention that was projected or being planned and not yet constructed and was not referring to the preliminary model that he and his brothers already had produced. He then went on to describe the similarity of the device to the Archimedean sphere, "enclosed within two hemispheres of glass, *dispares stellarum cursus* (as Lattanzio Firmiano referred), *dum verteretur*, *exhiberet*."[134] He demonstrated a small sphere, which could be movable, attached to an axis from a nearby clock that caused it to revolve in 24 hours, and had it been possible to be exhibited when separated from the clock, it would have demonstrated the movements of all the planets that it displayed when connected with the clock.[135]

Britio, questioned how the sphere could operate without being wound, claiming that it must receive its circular movement from some external agent, which most likely would have been a winding device or something equivalent to it, such as the human hand or an inclined plane. So, with the application of the same device, they could have made another sphere to demonstrate it, which contained all the planets and their movements, without it being necessarily attached to any clock.[136]

In 1658, Matteo Campani, had provided a second description of the planetarium in a manuscript in the following words:

> The material sphere, that is, made from brass or any other suitable metal or other material, is enclosed with glass (as is said about the Archimedean sphere). In its interior are closed the planets or planetary rings. They complete their daily, natural, and real movements as the heavens do; they complete their orbits perfectly, moved by no force or outer instrument or tension but by its own secret driving spirit (and this is the secret and an the invention) in circular motion in the space of 24 hours [...] by means of an external clock or other instrument acting outside the sphere, set stationary within it and on the outer glass. And without the movement coming from [this] *primum mobile*; that moving spirit enclosed within the sphere, that bears the functions of the assisting Intelligenses, will show all the remaining movements forever.[137]

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[134] [Scientific Editor's note: translation of the Latin passage : Then rotating, it will show the unqual motion of the stars] Ibid., 40.

[135] Ibid., 42.

[136] Ibid., 42-44.

[137] BAV, Ms. Ott. Lat. 1886; Matteo Campani, *Dell'Horologio Muto cioè senza lo strepito del tempo e della sfera materiale con li moti delle pianeti senza caricatura. Inventioni di Pier Tommaso e di Giuseppe Campani. Discorso di Matteo Campani al Signor Eustachio Divini in risposta a un suo Memoriale ed ad un'Epistola dell'Ill.^{mo} e R.^{mo} Monsig. Caramuele scritta pur ad istanza del Medesimo Divini contra le opere e gli autori sopradetti*, (1658), 93.

Servio subsequently commented that the main properties and principal characteristics of the projected planetarium, of which the planetary device was a preliminary model, were twelve in number:

I. This sphere will contain all the planets, except the moon, which we mean to put in a separate sphere in order that the sphere does not turn out to be too large, expensive, and difficult [to manage].

II. It will not be more than two Roman feet in diameter and will be elegantly divided into the distances required and the geometric dimensions of all the orbits of the planets.

III. Each planet will move on its eccentric precisely, periodically, and exactly, that is, without notable error.

IV. It will display all the planets, their real as well as average movements, with their retrocessions, positions, and directions.

V. In all of these inner movements of the planets, because of their inner motive source, it will be inalterable and will always proceed in one direction.

VI. For every outer revolution, each planet will always make the movement it must make in twenty-four hours and to every part of the outer revolution it will correspond the movements of all the planets in the proportion required.

VII. If the revolutions or turnings of the sphere are from the east to the west, the sphere will show the future movements (and because we can move it around very quickly without any danger of confusion; in a very short time we can show the movement of many years in the future); if we then make the revolutions in the opposite direction, that is, from west to east, the sphere will show the movements of many years past, as many as we would want, as has just now been said of future movements. Here I would like to have it noted that following, as is our duty, the common opinion of the Holy Fathers and of the Holy Bible, which (as you can see in the commentaries of Father Giacomo Tirini on Chapter 20 of the *Fourth Book of Kings*) demand that all the heavens and stars along with the *primum mobile* stop, for at the command of Joshua the sun stopped; and that they all go back beyond the time when a longer life was declared unto Ezekial by the prophet with the retrocession of the Sun in the heavens and the shadow on the clock (because otherwise, say Abulense and S. Dionysius) the entire celestial machine would be confused and disordered. Art cannot make a model more exact and more perfect than our sphere, particularly if what the learned Caierano and other scholars have affirmed and written is true (speaking of the above-mentioned case of Ezekial): Suddenly, almost in a moment or at least swifter than the usual movement, the sun retroceded.

VIII. [The sphere] need not be attached to any clock but may be kept in a room or studio as are armillary spheres and other globes. Each one can show perpetually the movements of the planets by simply turning it once a day. Or, with more ease and greater wonder, it can be adjusted or turned so that on one of the poles of the axis of the same sphere there is a little cord or chain a palm or two in length with a weight tied to it (these things can be easily hidden) the whole sphere by the force of the weight will turn perpetually for 24 hours without the need of another clock, provided that the said weight is pulled up once a week or once a month or once a year depending upon how long or how short the cord is and how far it is from the instrument, also without a weight, etc. He who has not seen the artifice will hold it in great esteem and will admire it very much. He who is then curious to see the position of the sun at any hour or moment of the day, turns the sphere until the sun or other predetermined indicator of the sphere touches that hour or moment chosen and leaves it there; so all the planets will be placed as they are or have been or will be in the sky at the hour selected.

IX. It will be very simple and have fewer instruments than others.

X. It will be very reliable and precise.

XI. It will not break down easily [...]

XII. It will be almost perpetual, that is, it will last much longer than others.[138]

Later, Servio noted:

There are two kinds of movements in the sphere, one on the outside and the other inside, that is, that which are made in all the planets and planetary circles enclosed in the same sphere, and these are made without winding [*caricatura*]; while no matter how the sphere is turned from the outside, the planets enclosed therein move in proportion to the outer revolution without it ever being necessary to wind anything. This will certainly never happen in any armillary sphere which has more intertwining rings representing the planets. When we want to use these, it does no good to revolve the sphere from outside by hand or with another instrument in order to show the movements of the planets; with this we cannot show the movements; the same will happen in every ordinary clock. Let us take, for example, my watch, which I usually carry with me. Let us take away the winding, that is, the spring and cord that move the wheels. Now that we have removed the winding, I put the hand of the watch and the hours at the first point (I) and begin to turn this clock as you see me. Observe, if you can, the movement of the above-mentioned indicator [...] And if in place of the winding which we have removed, I could put into this clock, a secret of mine, while I turn the clock, which causes the wheels and pointer to move, which was previously done by the winding device [*caricatura*] which we removed, would you then doubt that this was a real clock with a winding and an instrument with the horary movements without winding. What do you say to that? [...] I tell you more: the movements do not come about because of their effective cause, nor do they come from turning the sphere from the outside; they come about rather from their inner motors, that is, from those instruments and devices inside the sphere, which, while the sphere turns, moves the planets inside it. Therefore, turning the sphere from the outside is the condition (to speak with philosophers) in that way essential [*sine quae non*]; in that way, just like moving towards the fire to get warm, turning is merely a condition without which the fire, although certainly the cause of heat, would never warm any subject. [...] I say that the real cause of these movements is that force inside the instrument and that turning it from the outside is purely a necessary condition and absolutely essential [*sine quae non*]. And hence I conclude that although we add a winding on the outer axis of the sphere, as far as the movements of the planets and other inner movements are concerned, that which causes the inner movements of the sphere is without winding.[139]

In contrast to the veiled descriptions in Giuseppe's *Discorso*, Pier Tommaso in his *Lettera*, written eight months later, in an effort to present his version of what had taken place in their inventions, provided divergent statements about the material sphere and how the invention came to be. Therein, although he always mentioned Matteo with respect, he claimed that the invention had originated exclusively with him and that neither of his brothers had been involved in its conception. He insisted, furthermore, that at that time when the material sphere was produced, Giuseppe, the younger brother, "was not yet capable of these things [describing construction of clockwork]," and again at another time he wrote, "my younger brother in that time was a novice; barely beginning

[138] Ibid*,* 52–57.
[139] Ibid*,* 58-64.

three or four years later to work by himself, when I separated myself from him." In fact, Giuseppe was 23 years of age at the time and had completed his apprenticeship.[140]

Pier Tommaso admitted that the material sphere was not actually his own invention in the sense that in reality he had been inspired by the public clock of the town of Terni, and that his invention in fact had been based upon the mechanism of the old public clock. As he related, he had often watched the movement of the great clock's lunar dial in the piazza of Terni, where he had lived some years ago when he was first learning and pursuing his present craft. He observed that the orb was retrograded to the time dial, which made a complete revolution in 24 hours, and the moon opened this sector, but in such a manner that upon each revolution this remained several degrees behind, according to the motion of that planet. Having so often watched these two contrary motions, and being curious to observe the structure of the mechanism, he considered it at his advantage and admired the facility and simplicity with which all of it has been made. In fact, it was nothing more than an internal weight attached and made firm to the related spool [*rocchetto*] corresponding to the orb of the moon and at the bottom, which supported it, and while the axis of the display of the hours inserted into the sphere of the moon made its revolution in 24 hours, the said spool with the weight attached, made it turn backward several degrees, a point which is not difficult to imagine. He went on:

Therefore, having planned much later to make a work of such a manner, and discussing it one day with my older brother [Matteo], I made an exact description of the public clock of Terni. He told me that if this was correct, that it was actually the Archimedean sphere, but only that he had not comprehended at once this fine artifice, judging that it was impossible to construct. After having thought about it for three or four days, and after making many sketches, and having tired himself out in making circles and figures, he maintained that to think more about it was madness, forbidding me to talk about it any more~~;~~. I claimed no less in fact that the sphere of Terni did not contain any other mystery~~,~~, because I recalled exactly how it worked, and a thought came to me to make him understand this artifice in this manner: I took the vice on my work-bench with which I was working and beginning to turn it, I made him observe that the screw was turned counter-clockwise by means of the handle with which one fastened the vice in position, and which served as the weight. He comprised in a moment, by the experience of two motions contrary to each other, the entire artifice of which I was speaking. I therefore made the sphere conjoined to the Clock of Death, that communicated to it the motion of twenty-four hours; it is true that to the motion of the sun I did not adjoin other than that of the moon, because furthermore the work was not capable of more inasmuch as having desired no less to make it entirely whole, and to enclose the motion of the other planets, and instead of the weight necessary to each spool and worm screw, I placed a small figure of an angel made of gilt copper as motive understanding [*Intelligenza motrice*] and then sealed it inside a crystal globe. But to finish the work earlier, and

[140] Campani, *Lettera di Pier Tommaso Campani*, 7 and 15 respectively.

to earn money, all I needed to do was to make the dials for the two planets with the motions of which were best known and most necessary to be understood.[141]

The references to Terni's public clock presents some difficulties, but probably Pier Tommaso was trying to explain the operation of either an internally toothed or annular gear, or some form of differential mechanism. It is not known whether the Terni dial display consisted of a series of separate flat dials, a single coaxial assembly, or a three-dimensional sphere. The town clock of the community of Terni dated to the mid-fifteenth century, when a plan to install a public timepiece had been first considered in 1441 and approved on May 7th of that year. A deputation of two citizens and two standard bearers (*banderari*) was appointed, to award the work to a capable craftsman to be completed for a sum of up to 50 gold *fiorini*. Ten years later, on February 11, 1451, it was noted that the success of the public clock had been of short duration because, although it no longer indicated the time with accuracy, the hand also moved forward rapidly without making a return. The clock was restored, and the movement was reduced in size in order to fit inside the present case, in the style of the one recently made in the city of Spoleto. Inasmuch as the Council had set aside the sum of 25 to 30 gold ducats for disposition in public works, in a contract with a certain Pietro Matteitti, craftsman of Terni, it was stipulated that the price established by the judgment of the governor, after computing and refining it to perfection, was adequate. At the session of February 19th it was reported "*instrumentum fabricationis orologij communis inter Petrum Mathijtti et communem celebratum*."[142]

In 1878, the community hall at the center of Terni was remodeled to a Renaissance style by Benedetto Faustini. It is possible that it was at that time that the ancient clock that Pier Tommaso had observed was discarded and replaced with a modern timepiece without lunary dial.[143]

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[141] Ibid., 17–20 (1660).

[142] Lodovico Silvestri, *Collezione di memorie storiche: tratte dai protocolli delle antiche riformanze della città di Terni dal 1387 al 1816 relative al suo stato, politico, morale, civile, industriale ... parte 1* (Arrone: Thyrus, 2004), 86–87, 113, 416–17. Pietro Matteitti is not recorded among Italian clockmakers.

[143] In World War II, during the bombardment of Terni in 1943–1944, the central tower with its clock was entirely destroyed. Regrettably, Terni's fifteenth century public clock had been totally destroyed either in the remodeling of 1878 or in the World War II bombardment. No illustration of it survives, either in the form of an early print or later photograph.

The source of motive power for the Campani material sphere was never specified, but it appears to have been a concealed spring wound by pulling a cord. This method is reminiscent of novelty clocks produced in the same period that were suspended from a cord and that were powered by their own weight as they descended. In the discourse *Dell'Horologio Muto* that Matteo later wrote in response to criticisms of the Campani inventions, he specified that the motive power of the self-winding sphere was not mercury but another material[144]:

more faithful than mercury, as well as more constant, a material so havy and skillful, that giving to it the principles ones for all, it will never fail: indeed this planetary sphere perfectly enclosed in glass, or in another matherial, it turns fully each 24 hours (as it should), without lagging behind an hour, nay, even a quarter of an hour, or even a minute, and also operates with its usual speed should the sky be clear, without overhanging clouds [and then note that I do not say, or think, that the sky is made or crafted out of clauds) or whether the air be warm or cold, and the motionof the sun and of the other planets will be perpetually moved by our phylosophical mercury, in the same way following the rules that the Craftsman just one time has set, without aberration, so much so that I feel that it will never err, not even once in a thousand years, but depending always upon its own external revolution, whether by hand, or any other external agent. But what is more surprising about our sphere is that by means of its mechanism can be shown in the space of just one hour, visibly, and better than by scanning the skies, the past or future twelve years, the dayly movements of each of the planets, either true or mean, their stations, retrogressions and directions: and this should prove that the sphere of the Campani is by far different from the one made by our adversaries, which is wholly imaginary.

Nor should our adversaries object that the sphere now in the clock of Our Most Holy Lord Pope Alexander VII is imperfect and rough: indeed, in that situation, the Craftsman did not want to create a perfect sphere, but he merely wanted to show the novelty of the movement or movements: he wanted to show the new reaso or new way that we have invented of moving and turning the planets enclosed perfectly in a sphere, with no tension included, nor weight, or wounded spring.[145]

Despite the astonishingly verbose and purposely veiled language of the descriptions provided by the Campani brothers in their writings, it may be possible to glean a few bits of description from them. It is clear that in all the conflicting evidence, Giuseppe Campani at no time claimed to have produced a perpetual motion device, and that the "material sphere" device presented to the Pontiff was by no means a model of the entire planetary system. The misconception by his contemporaries, as well as by his later commentators, of just what the Campani brothers actually had produced derived from their use of the phrase "without tension" [*senza caricatura*]. This was assumed to mean

[144] [Scientific Editor's note: which he mysteriously calls "philosophical mercury"]
[145] BAV, Ms. Ott. Lat. 1886, Campani, *Dell'Horologio Muto,* 25-26.

“without winding” and caused confusion. Giuseppe made it clear that the night clock and the material sphere were two separate entities that could be coupled together, in which instance the sphere was driven by the clock continuously “in real time,” or the sphere could operate even when detached. It was clearly stated that the sphere was static and had no internal source of power. If activated by a push from the hand once daily, the device would demonstrate the relative motions of the elements forward or backward representing the stars, sun, and planets for a thousand years without noticeable error, as would be inherent in any geared planetarium in which the gear ratios were accurate. As Campani explained the invention, it did not require separate adjustment (winding) for each part because the sphere was an integrated system. He did not indicate that the sphere operated continuously by itself forever, as his detractors appear to have concluded.

No explanation was given as to how the planets, etc., were to be reproduced, and it is probable that when Giuseppe wrote the *Discorso* in 1660, he had not yet resolved the problem. It is likely that the model of the material sphere presented to the Pontiff consisted of only the sun and one planet, and that the basic mechanism probably was coaxial, the novel feature being that the various components were exhibited permanently by means of gearing hidden in a small box at the center of the sphere. On the other hand, astronomical clocks exhibited the daily motions of the sun, moon, and stars on flat dials, which were driven by pinions or screws engaging the teeth on the edges of the circular plates bearing the images. In such a case, each component, in principle, could have its own source of power or “tension.” Unless there was an overall regulator, however, these would quickly get out of phase.

A problem to which Giuseppe Campani referred specifically was the apparent motions of the planets against the stars on the celestial sphere as well as their retrograde motions. His reference to the sun’s movement suggests that the sphere was geocentric, implied by his reference to the course of the sun, meaning that the mechanism responsible for rotating the individual planet arms or rings must have incorporated a means of making them oscillate about their mean positions. This was possible with epicycles. It is to be noted, however, that his text was prefaced by the statement “We can build” not “We have built” so he was describing what he hoped or intended to do and not what he had done. All evidence suggests that the sphere had no internal source of power and that it contained gearing permanently connecting the motions of the sun and planets so that their relative motions were always correct. The sphere had to be turned by hand or by some other external agent. It is certain that it did not rely upon atmospheric changes. When there was no external source of power to turn it, it remained static, but whenever or however it was turned, the relative motions of its internal parts, the sun and planets, were always in the correct proportions because they were coupled by the correct gearing.[146]

Despite the publicity that the material sphere received, the secret of its power source was never revealed. There may have been some significance in the fact that in their writings describing the invention of the silent night clock and the material sphere, Matteo and Giuseppe mentioned the marvelous sphere of Cornelius Drebbel, a perpetual motion instrument, about which they said they had learned from an English knight who told them he had seen it in the royal palace in London. It is interesting to speculate whether the material sphere could have functioned on the same principle, operated by changes of atmospheric pressure and temperature.[147]

Drebbel's own description of his invention is contained in a letter to King James I of England that appeared in a work first published in Leiden in 1608. It was entitled "A Treatise on the fifth essence, by Cornelius Drebbel, a great chemist and mechanician. To which is added a letter to the most wise King of Britain, James, on the invention of perpetual motion." Drebbel wrote that being aware that water always flowed downward, he sought and found the reason and was prepared to prove it with a globe that perpetually turned once every 24 hours.[148]

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[146] The author gratefully acknowledges suggestions concerning the probable nature and structure of the material sphere proposed by the late Mr. John R. Millburn of Aylesbury, Bucks, England (October 1996).

[147] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 88–89; BAV, Ms. Ott. Lat. 1886, Campani, *Dell'Horologio Muto*. Cornelis Drebbel (1572–1634) was the Dutch inventor credited with the invention of the telescope and microscope as well as a perpetual motion device. He visited England in circa 1604, where King James I became his patron.

[148] Cornelis Drebbel and Joachim Morsius, *De quinta essentia tractatus, editus curâ Joachimi Morsi. Accedit eiusdem Epistola ... de perpetui mobilis inventione.* (Place of publication not identified, 1621). The first edition was in Dutch published in Leiden in 1608, the second in Haarlem in 1621; Henri Michel, 'Le mouvement perpetuel de Drebbel', *Physis* 13 (1971): 289–94; Jennifer Drake-Brockman, 'The Perpetuum Mobile of Cornelis Drebbel', in *Learning Language and Invention : Essays Presented to Francis Maddison* (Aldershot: Variorum, 1994), 124–47; Henry C. King and John R. Millburn, *Geared to the Stars : The Evolution of Planetariums, Orreries, and Astronomical Clocks* (Toronto: University of Toronto Press, 1978), 99–100.

The purpose of Drebbel's instrument was to demonstrate the days, months, and years as well as the position of the sun in the zodiac, times of sunrise and sunset, the phases of the moon, the moon's angular distance from the sun, and the ebb and flow of tides. Drebbel's invention was first described in print in 1612 by Thomas Tymme, a professor of divinity, as "A Modell or Patterne, representing the motions of the Heavens above the fixed earth, made by Art in the imitation of Nature, by a Gentleman of Holland named Cornelius Drebble, which instrument is perpetually in motion, without the means of Steels, Springs, and Weights."[149]

[Figure]

No great stretch of the imagination was required to conjecture what may have been the probable inspiration for the "material sphere" undertaken by the Campani brothers, a model for a proposed planetarium displaying the motions of the planets. It most likely was by the account of the Drebbel apparatus that the visiting English knight had related to Giuseppe. Later Giuseppe wrote, "Having left to us in writing, that Drebbel's entire sphere was a glass globe "in which," to use the inventor's own words, "after having poured in it a certain most pure liquid, and afer having also added a few drops of a mirable oil, at first occurred a turmoil, and later, thanks to the effect of these secret components, the elements poured in the sphere gradually appeared clearly and divided: shortly after, the part of the liquid that was somehow more pure and shiny coagulated above the elements passing around them, permeated [with the influences] of the sun, of the moon and of the stars; and not by a prepared device from the outside, but by an inner permeating spirit, these [components] extraorinally rotating with a constant motion, miracoulosly reproduced the movement of the skys".[150]

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[149] Thomas Tymme, *A Dialogue Philosophicall : Wherein Natvres Secret Closet Is Opened, and the Cause of All Motion in Nature Shewed Ovt of Matter and Forme, Tending to Mount Mans Minde from Nature to Supernaturall and Celestial Promotion: And How All Things Exist in the Number of Three. Together with the Wittie Invention of an Artificiall Perpetual Motion* (London: Printed by T.S. for C. Knight, 1612), 60–63; King and Millburn, *Geared to the Stars : The Evolution of Planetariums, Orreries, and Astronomical Clocks*, 99–101.

[150] "*In quo*, *purissimo quodam liquore immisso*, *additisque non nullis mirabilis olej guttulis*, *Chaos primum*, *deinde paulatim secretis partibus elementa in globum circunfusa distincte aperteque apparebant: mox purior quadam lucidiorque liquoris pars supra elementa circumvecta concrescebat*, *sole*, *luna*, *Syderibusque vestita; quae non extrinsecus adhibito instrumento*, *sed spiritu intrinsecus permeante*, *mirabili constantique vertigine acta*, *Coelorum motum prodigiose referebant*." Campani, *Discorso … intorno a' suoi muti oriuoli*, 90–91.

Although Drebbel's globe already had become known in England and on the Continent, and had in fact had been included in a contemporary painting by Jan Brueghel the Elder (1568–1625), in which it was clearly delineated,[151] the globe apparently had not become known in Italy in other than Giuseppe Campani's brief account of it. It can easily be imagined how the description by the English knight would have fired the creative minds of all three Campani brothers, causing them temporarily to drop other projects in progress in order to attempt to create something similar. To be noted is the similarity of the enclosure within a glass sphere of the mechanism of the "material sphere." Instead of a device demonstrating perpetual motion, they had conceived of a planetarium demonstrating the movements of the planets around the sun. They did not attempt to reproduce the Ptolemaic concept of the sun and planets revolving around the Earth, but instead they ventured to present the Copernican system of the Earth and planets revolving around the sun. This was a daring enterprise to undertake so soon after the Vatican's censure of Galileo. In developing their project, the brothers succeeded to the extent that they were able to complete an operable working model with at least one planet in time to submit it to the pontiff together with the silent night clock. They were careful to avoid mention of "perpetual motion," however, for even in that period its achievement was considered to be an impossibility. **[Figure]**

Several sources may have provided the motive power for the material sphere; the question is whether they would have been known in Rome and to the Campani brothers in the mid-seventeenth century. Traditionally, the earliest recorded self-winding timepiece is credited with having been invented in the 1600s. It is first mentioned in *Deliciae Physico-Mathematicae*, a work by Daniel Schwenter (1585–1636), professor of mathematics at Wittenberg and Würzburg.[152] Referring to a French work on perpetual motion, an entry of Schwenter's work entitled "A Watch Which Need Not be Wound, because [it is] fitted with a continuous motion mechanism inexpensive to make," stated:

[151] Jan Brueghel the Elder, "Archduke Albert and His Wife in a Collector's Cabinet", Walters Art Gallery, Baltimore, Maryland.

[152] Daniel Schwenter, *Deliciae physico-mathematicae, oder mathematische und philosophische Erquickstunden , darinnen sechshundert drey und sechzig schöne, liebliche und annehmliche Kunststücklein Auffgaben und Fragen auss der Rechenkunst, Landtmessen, Perspectiv, Naturkündigung, und andern Wissenschafften genommen, begriffen seindt ...* (Nürnberg: In Verlegung Jeremiae Dümlers, 1636). The work was published posthumously in 1636 by his heirs, revised and reprinted in 1651 by the lawyer Georg Philipp Harsdörffer (1607–1658), and reprinted under his name in a later edition in 1677.

It is a well-known fact that the human heart, like a going watch, is incessantly in motion and beats day and night. Whether one eats or drinks, stays up at night, or does anything whatsoever, its pulsations do not cease their activities for one moment long as one lives. [...] A man once applied a belt tightly on his skin, and as he breathed, it would rise and fall, thus serving as a perpetual spring for the watch attached thereto, making winding unnecessary, etc.[153]

Elsewhere the invention is attributed to an unidentified Jesuit priest whose first name may have begun with the letter "N." The cleric is first mentioned in notes taken by Louis Moinet from the manuscripts of Abram-Louis Breguet: "The Rev. Father N... devised a watch which he called perpetual in ..." Contained in the manuscript is the note: "Of the perpetual watch wound by the movements of the wearer" and "In 16... the Rev. Father ... devised a watch which he called perpetual because it could be wound solely by means of a moving weight suspended in the case on a horizontal arm." Moinet may have had reference to the invention noted by Schwenter. In a work he published after he left the firm of Breguet, however, Moinet wrote that the perpetual watch was "a German invention copied in France." Later, in 1802, the watchmaker Ferdinand Berthoud wrote, "This watch with *remontoire* [a subsidiary device for keeping the spring sufficiently wound to maintain a constant force] invented in Germany, was brought to France in about 1780."[154]

Also worthy of consideration in relation to the mysterious motive power of the Campani sphere is the contemporary claim for an invention made by the Polish Jesuit Adam Adamandus Kochanski, mathematician to the King of Poland. He described it as "A New Kind of Pendulum for Watches." He claimed that in 1659 he had invented a timepiece controlled by a magnet, and that by means of magnetic attraction was provided the force tending to restore the watch balance to its mid position, in a watch with balance spring to which he equated with the gravity of the pendulum or the spiral spring. He wrote a cryptic disclosure of his invention, the basis of which he claimed was hidden in an anagram in Kaspar Schott's *Tecnica Curiosa*.[155] The anagram's solution is "By the

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[153] Georg Philipp Harsdörffer, *Deliciae Mathematicae Et Physicae, Der Mathematischen und Philosophischen Erquickstunden*, vol. 2, 2 vols (Nürnberg: Endter, 1677), lesson XIV.

[154] Alfred Chapuis and Eugène Jaquet, *The history of the self-winding watch, 1770-1931* (Neuchatel: Éditions du Griffon, 1956), 15–29.

[155] Gaspar Schott, *P. Gasparis Schotti ... Technica curiosa, sive Mirabilia artis: libris XII, comprehensa : quibus varia experimenta, variaque technasmata pnevmatica, hydraulica, hydrotechnica,*

pull of magnets” [*per magnetu[m] tractionem*]. Kochanski’s description was published in 1685 in the scientific journal *Acta Eruditorum*. He wrote:

> I was led to make the discovery, by a chance observation (as I have to admit) of the property of the pendulum in regulating the operation of the ordinary clock, before I had learned that Huygens had made the same application of it. I had obtained a watch with a balance consisting of two spoon-like arms (as it was used in old times), half of which was broken away, and the remainder of which oscillated rapidly, but nevertheless uniformly. I then recalled Galileo’s pendulum, which he had used for measuring time. [...] The analogy of the gravity and the pull of a magnet led me to apply a magnetic pendulum to watches, having observed that magnetic needles oscillated faster or slower, and almost uniformly, depending upon their mass and their distance from the magnet. Although I had conceived this idea in the year previously said [1659], I did not put it into practice before 1667 while in Florence, and then I showed it to my patron, Ferdinand II, Duke of Etruria [Tuscany]. I will describe the arrangement with reference to the sketch. In Figure 50 ABCD represent the sides of a watch opposite the face [reverse of the watch]. AB is a strong magnet; EG is the magnetic pendulum of iron, with its axis at E. CD is a counterweight of non-magnetic material.[156]

The watch, as illustrated in figures 1 and 3 of Kochanski’s work, indicates that the movement turned freely within its case on the central pivots H and F, so that the swing of the pendulum was not affected by any turning movement given to the watch. It may be more than coincidence that this invention was claimed by a member of the Jesuit order to have been made in 1659, four years after the Campani brothers produced their material sphere with its mysterious source of motive power.[157]

FIGURE

The Campani brothers continued to experiment with the development of the self-winding sphere during the next several years, as was reported by Pierre Guisony in a letter to Christiaan Huygens. Guisony proved to become an interesting figure appearing on the scientific landscape of Rome. A physician of Avignon greatly interested in experimental physics, Guisony traveled extensively in Italy and appears to have corresponded with some frequency with Huygens and other men of science of his time.[158]

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mechanica, graphica, cyclometrica, chronometrica, automatica, cabalistica, aliaque artis arcana ac miracula, rara, curiosa, ingeniosa, magnamque partem nova & antehac inaudita, eruditi orbis utilitati, delectationi, disceptationique proponuntur (Norimbergae: sumptibus Johannis Andreae Endteri, & Wolfgangi junioris haeredum, 1664), 692, Book IX, proposition 31.

[156] Adam A. Kochanski, ‘Adami Adamandi e Soc. Jesu Kochanski Sereniss. Polon. Regis Mathematici, Novum genus perpendiculi pro horologiis rotatis portabilibus. Vulgarium elatere vibrante instructorum nova disponitio & ex hac suprema perfectio’, *Acta eruditorum*, 1685, 428–33.

[157] Ibid, Tabula X.

[158] Christiaan Huygens, *Oeuvres Completes*, vol. 3, no. 732, pp. 45–49, *vide* 46 (1890), letter from Guisony to Huygens on March 25, 1660.

During his sujourn in Rome in 1660, after visiting the shop of Giuseppe Campani, Guisony described in some detail the silent night clocks he saw that Giuseppe had in production. “The same person is still working on a kind of marvellous sphere,” he went on, “in which aew the movements of the planets without tension [winding]. As I have not the occasione to see it, I will not say anything about it to you.”[159] It is regrettable that Guisony did not have an opportunity to see and describe the device, for his report might have clarified remaining questions. Other clues to the appearance and construction of the material sphere were to be revealed in the course of events that followed, but none that explain its power source, the naure of which has nevere been resolved.

[159] Ibid., 47.

Chapter IV

ACCUSATION

(1657–1658)

Where is the evidence that doth accuse me?

William Shakespeare, *King Richard III*, Act I, Scene IV

The success of the silent night clock immediately brought countless accolades of praise for their invention from near and far to the Campani brothers, in Rome from prelates of the papal court, the diplomatic corps, the local nobility, foreign heads of state, and from elsewhere. The publicity rapidly developed an elite market, for these timepieces were costly, due partly to the nature of the elaborate clock cases. Nevertheless, there appeared to be no limit to the demand for them from an eager clientele ranging from wealthy local nobility to European crowned heads.

Dazzled by their impressive customers, Pier Tommaso and Giuseppe nevertheless were kept fully occupied in fulfilling the commissions that kept flowing in. Matteo made part of the space in the rectory of San Tommaso available as a veritable temporary working area for his brothers. He also took time from his parochial responsibilities to act as agent for them, promoting their work, negotiating sales, helping to make arrangements with various craftsmen who cast bronzes and constructed the clock cases, and managing other details as need arose.

Although each of the silent night clocks contained an identical clockwork movement, the clock cases that housed them varied with the taste preferences of each of the purchasers. The cases were quite elaborate, similar to those that Pier Tommaso had already produced for the pontiff, often with additional gilt bronze attachments and *pietre dure* inlays. Because of the volume of their work, by this time the brothers had established ongoing relationships with several craftsmen in the city—including a brass founder who cast the brass parts of the movements and the metal decorations of the cases, a gilder, and one or more cabinetmakers or *ebanisti* who constructed the cases. Undoubtedly, among them were some artisans employed at the Vatican who were already known to Pier Tommaso.

The Campani silent night clock differed substantially from other timepieces of the period, featuring a new type, unique not only in its mechanism, which the brothers had developed for recording the time, but unusual also in the style of the clock case that housed it. The clock case was a form that thereafter they used consistently, which varied only by size and decorative elements and was generally duplicated in all of their future timepieces with few exceptions. Its form and style later were copied also by other clockmakers who produced night clocks in competition with the brothers.

Having been intended only for palaces or villas having spacious salons and bed chambers, the cases of night clocks generally were considerably larger than those of other domestic clocks in order to accommodate a dial sufficiently large that provided greater visibility for use at night. The cases were generally 2-1/2 to 3 feet in height, 2 feet in width, and 1 foot or more in depth. The cases were made of veneered woods, generally ebony or ebonized pearwood in keeping with their place and time of use. The dial plate often was framed by single or double columns having gilt bronze capitals and bases, the bases of the clock cases with scroll shape and double scrolling circular and elliptical on the sides, Corinthian pilasters, and the pediment with scroll work and turnings and divided in a manneristic manner.

The primary visible feature of the night clock was the copper panel forming the dial-plate through which the perforated hour numerals were visible, the surface of which was painted with provincial landscapes, allegorical representations of Time, sacred images, or religious scenes. The subject of the dial paintings, any additional ornamentation, and the design of the overall production, in most instances were specified by the patrons for whom the timepieces were being made, or at least approved by them before work proceeded, in view of the costliness of the work. For the most part, the miniature paintings on dial plates of the Italian night clocks were unsigned but were the work of artists particularly skilled in miniature painting. Although the greater number of the paintings on dial plates of the Campani night clocks are unsigned, the identities of several of the artists are known. As we have previously seen in chapter II, the artists selected were not always minor figures in the art world. It is true, however, that some of these less prominent artists produced clock dial paintings early in their careers before achieving renown. Among them were Carlo Maratta, who painted the dial of the night clock presented by Cardinal Barberini to King Louis XIV, among others; Filippo Lauri, whose signature appears on several of the dial paintings; Giovanni Battista Gaulli (called *Il Baciccio*), who, according to the accounts of Cardinal Flavio Chigi, had produced a painting of Endimione for the face of a wall clock for the Cardinal in 1670; Francesco Trevisani, who is conjectured to have been the artist who painted the dial of the large unsigned night clock in the Campidoglio in Rome; and one less well-known, Francesco Ligorino.[160]

It was during this period of lucrative productivity that Pier Tommaso was contemplating matrimony. He had become engaged to Giacoba Giuditta Heroldt, an event that consequently necessitated household rearrangements for the three brothers. As the summer of 1656 was approaching its end, and in anticipation of his marriage, Pier Tommaso arranged with Matteo to provide larger space in the rectory for his temporary use as a shop while he sought elsewhere for a residence having more suitable permanent accommodations. In accordance with Vatican practice for palace employees, he was periodically allotted an allowance for rent. At the end of summer of 1656, for example, Pier Tommaso received the sum of 15 *scudi* "for the rent of the house for six months beginning on 1 April next and to end including the entire month of September next."[161]

Pier Tommaso and Giacoba Giuditta were married in January 1657. The bride, who was about 32 years of age, was Adam Heroldt's daughter. By this time, at the age of 27, Pier Tommaso had achieved recognition in Rome and at the Vatican for his inventions, and it may have been his fellow Vatican clockmaker, Mattia Ertel, also of German origin, who had introduced him to Heroldt, which led to a later acquaintance with his family.[162]

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[160] Antonio Barberini the Younger (1608–1671) was born in Rome, composed poetry in Latin and Italian, and owned a renowned library. He was a nephew of Pope Urban VIII and was created cardinal in 1628 and appointed papal emissary (ambassador) to the court of Louis XIV.

[161] ASV, Sacra Pal. Apost. Varia, "Register of Orders to the Monsignor Treasurer for the Rent of the Houses" (August 26, 1656).

[162] Adam Heroldt was born in Germany circa 1580, and he was working in Rome by 1622, the

The young clockmaker and his bride made their first home in the nearby fashionable parish of San Lorenzo in Damaso during a period when Pier Tommaso was fully occupied (as well as preoccupied) with orders for clocks. It was not until some time later that he had sufficient leisure time to seek a suitable location for his shop.

Time passed quickly and happily at first for the married couple, and on July 8, 1658, Giacoba Giudita gave birth to their first child, a son. Born prematurely, Giovanni Carlo was baptized on July 14, not in their own church but in Pier Tommaso's parish, the Church of San Tommaso in Parione. Attending as a sponsor was the Vatican's "Most Illustrious and Most Reverend Walter de Gualteris." The joys of first parenthood were short-lived, however, for although her infant son survived, Giacoba Giuditta died on July 21, 1658, two weeks after she had given birth, presumably a direct result of childbirth. She was buried in the Church of San Tommaso in Parione with Matteo, her brother-in-law, officiating.[163]

It was a sad time for Pier Tommaso, who was beside himself with grief with the loss of his bride. Meanwhile commissions for his clocks kept his hands occupied if not his mind, for now he had the unexpected burden of an infant son. Undoubtedly, Pier Tommaso's sister Ursula, Matteo's housekeeper, cared for the infant at first, and eventually Pier Tommaso would have hired his own housekeeper and wet nurse. In due course of time, however, Pier Tommaso had to consider the future and set about to seek another bride,.

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year that he produced a quadrant for Pope Gregory XV. A 6-inch brass quadrant, formerly in the Kenney collection and now owned privately, is inscribed "NOVA INVENTIO ET USUS QUADRATIS ET BUSSOLAE AD INVENTAM . . . ADAMO HEROLDO GERMANO CUM PRIVILEGIO S. d. NRI PAPAE GREGORY XV ANNO I." A brass armillary sphere made by Heroldt dated 1648 in the collection of the Science Museum, South Kensington, is based upon the Ptolemaic system. The base bears the design of a fleur de lys transfixed with a sword running diagonally, and another armillary sphere by Heroldt dated 1649 is in the collection of the Osservatorio Astronomico di Roma. These were made during the papacy of Matteo Barberini, Pope Urban VIII, and the possibility exists that Heroldt was an instrument maker employed under papal privilege at the Vatican. Other instruments recorded are a recipiangle sold at Sotheby's on March 17, 1938, a slate sundial dated 1615 noted by MADEX, and a sector in the Germanisches Nationalmuseum in Nuremberg. Derek J. Price, 'A Collection of Armillary Spheres and Other Antique Scientific Instruments.', *Annals of Science* 10 (1954): 172–88, plate 5, no. 5; Surveyors' Institution, *Five Centuries of Maps & Map-Making*, item 590, Kenney Collection. A signed geometrical and military compass by Heroldt is in the Fausto Casi collection in Arezzo; Casi, *Strumenti scientifici dal 1500 al 1800*, 28, 99–199, fig. 13; see also the section *Globi Terrestri ed Celesti* in Fiorini, *Sfere terrestri e celesti di autore italiano oppure fatte e conservate in Italia*.

[163] ASVR, *San Tommaso in Parione, morti*, (1651-1708).

To add to Pier Tommaso's domestic problems was another he was to share with his brothers, an unexpected public attack questioning the originality of their inventions. Despite the widespread praise that had been showered upon the invention of the Campani night clocks, inevitably they also attracted invidious criticism. The issuance of the papal edict that had served as such desirable promotion of the invention also aroused a negative reaction from others. The attack was led by none other than Eustachio Divini, of all people, who until then had been one of Matteo's friends and associates. He had become greatly incensed by the issuance of the papal patent for the Campani inventions, a reaction that the brothers had difficulty understanding. At first, Divini's outrage appeared to have been sparked by jealousy or envy brought about by such considerable success of his former friends in the light of his own failure to produce an operative clock. In fact, however, he may have had other reasons and perhaps just cause, as later events were to reveal.

Although the Campani brothers had been working in relative privacy, Divini had become aware that in recent months they had been working behind closed doors much of the time, setting aside other priorities in order to develop a project the nature of which they would not reveal. Consequently, it was not until the clock had been delivered to the Apostolic Palace that the details of their project became known and attracted public attention. In fact it was not until after the publication of the edict granting them an inventor privilege that Divini publicly demonstrated his resentment and outrage.

Heated confrontations took place directly between Divini and Matteo and also with Pier Tommaso, during which the telescope-maker berated the brothers and accused them not only of plagiarism but also of having misrepresented their work as an invention, which he claimed, in fact, it was not. Despite their protests and efforts to calm him, Divini prepared an angry petition in the form of a *Memoriale* in which he disputed the originality of the Campani inventions and questioned the justification for issuance of a privilege by the Pontiff. He submitted this document officially to Monsignor Farnese in his role as Prefect of the Apostolic Palace and representative of the Pontiff.

Not only was the originality of the silent night clock brought into question, according to Divini, but also that of their second invention, the material sphere. Although no copy of Divini's petition has come to light, the substance of much of its content is revealed in a supporting *Epistola* (or "letter") by the Cistercian scholar Monsignor Juan Caramuel y Lobkowitz, who Divini had enlisted as his ally. The *Epistola* was submitted to Majordomo [or Prefect] Farnese in due course. A response that Matteo subsequently had prepared for publication provides additional details of the argument.[164]

Neither Farnese nor the Pontiff could have anticipated that such a public outcry would ensue from papal acceptance of the two inventions and the issuance of a letter patent. Although papal edicts announcing a variety of mundane and other subject matter appeared with frequency pasted upon billboards and church doors in Rome and other Italian cities, one announcing the issuance of a papal patent for a clock was sufficiently unique in this period and unusual enough to attract special attention.

In his angry protest, Divini ensured that his accusations would be publicized as widely as the patent. His claim that the Campani achievements were not true inventions proved to be embarrassing not only to the Campani brothers but to the Vatican as well, for by implication it raised the question of the Pontiff's fallibility by having granted a patent for inventions that were not original. Furthermore, it also embarrassed members of the papal court and personages of distinction in the embassies at Rome and among the local nobility, who not only had publicly praised the inventions but many of whom also had purchased Campani silent night clocks.

As the accusations and denials arising around the Pope's night clock and the planetary device raged between Divini and chiefly Matteo, who acted as spokesman for his brothers, they directed continuing unpleasant attention to the Vatican, which found itself with no ready means of quelling the dispute. The only organized scientific body in Rome at that time, the Accademia dei Lincei, that might have been enlisted to render judgment on the controversy for some reason did not become involved. The relatively unknown young Campani brothers had not as yet achieved sufficient stature to match that of Divini, a man of mature years and a prominent maker of astronomical instruments with a distinguished clientele; therefore, a peaceful resolution became increasingly difficult if not impossible.

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[164] BAV, Ms. Ott. Lat. 1886,, Matteo Campani, *Dell'Horologio Muto*. The manuscript was censured and not approved for publication. The only known surviving example is a manuscript copy written in pen and ink in a scribe's hand with marginal and in-text annotations by Matteo Campani in his hand preserved in the Manuscript Collection of the Biblioteca Apostolica Vaticana, brought to the author's attention by the late Cardinal Giovanni Mercati.

Furthermore, the future promised to be even more disturbing. Divini unexpectedly managed to obtain support for his claims from Monsignor Juan Caramuel y Lobkowitz, a brilliant man of science who recently had arrived in Rome. An important figure in seventeenth century Church politics as well as in European science, Caramuel had been particularly interested in time measurement and timekeeping and even had published a treatise on the subject. Born in Madrid, Caramuel (1606–1682) was the son of Lorenzo , who had a strong interest in astronomy, was discendant of an ancient Flamish noble family (his grandfather was a minister to Emperor Charles V) and Caterina Frisse Lobkowicz, whose family was related to the royal House of Danmark and to the noble bohemian family of the Lobkowicz.[165] At an early age, he had displayed a talent for mathematics and studied theology at the University of Salamanca, becoming proficient in Oriental languages, philosophy, and literature. After entering the Cistercian order, he was appointed a professor of theology at the University of Alcala and later assigned by his superiors to fulfill various commissions in the Netherlands. In due course, Caramuel received his doctorate in theology from the University of Louvain and was named vicar general of his order in the British Isles. Later, Caramuel was sent to the court of Emperor Ferdinand III, then appointed vicar general to the archbishop of Prague. He distinguished himself during a siege on Prague by organizing the ecclesiastics and defending the city. In 1654, he was sent to Rome to arbitrate a question between the Church and the Bohemian princes. When the bishopric of Campagna and Satrianao became vacant in 1657, that assignment was given to him by Alexander VII. He was recalled to Rome again in 1671, and soon after he was named bishop of Vigevano, where he devoted himself to studies and writing, producing a number of published works.

A man of encyclopedic knowledge, Caramuel dismissed astrology as superstition and attempted to apply a mechanical formulation to astronomy. He contemplated the possibilities of aerial navigation, made meteorological observations, and considered the Earth's physical properties. An erudite and prolific writer, Caramuel spoke 24 languages and published some 262 works of poetry, grammar, mathematics, astronomy, physics, logic, music, politics, metaphysics, and theology. Among them was *Solis et Artis*

[165] [Scientific Editor 2: Bedini wrote in his manuscript that Caramuel was son of a "Lorenzo Caramuel y Lobkowitz, a Bohemian engineer employed in Spain, and a Spanish mother].

Adulteria (Louvain, 1644), a work that included a section on horology, published in Louvain in 1644. After being overtaken by blindness in 1680, his health continued to falter, and he died in 1682 and was buried in the Duomo of Vigevano.

Alexander VII had already been acquainted with Caramuel, whom he had met in Germany, and held a high opinion of his scholarship, if not always of his aims. He first became involved with the Cistercian scholar in 1647 while, as Cardinal Chigi, he was representing the Pope at a peace conference in Munster. This encounter with Caramuel resulted in serious discord between them, because Caramuel published a work that Chigi tried unsuccessfully to impede. Caramuel was known for the laxity of his moral thought, and a number of his writings ended up on the Vatican's *Index Librorum Prohibitorum*. He was cited to Rome in 1655 for some writings he had produced in an effort to resolve a question between the Church and Bohemian princes. Caramuel's work *Theologia moralis fundamentalis*, which had been published in Frankfurt in 1655 and of which the Pope owned a handwritten copy, had been placed on the *Index Librorum Prohibitorum*. Caramuel was strongly opposed to ecclesiastical censorship and claimed that hypotheses and experiments must always be given priority even in theology and that which was not explicitly forbidden should always be allowed. Although Caramuel's ideas caused a scandal among theologians in Rome, the Pontiff valued his intelligence nonetheless and made him a *consultore* of the Holy Office. Caramuel remained in that assignment until 1657, when, at the request of the Pontiff, he was assigned the position of consultant to the Congregation of the Holy Office and Sacred Rites.[166]

During the plague epidemic that had raged through Rome in 1656, Caramuel had distinguished himself by his zealous organization of assistance for the Roman populace. There is no doubt that the Pope was seriously considering him for a cardinal's hat were it not for the considerable opposition to it by the Curia. Caramuel had not made friends among the cardinals and instead had engendered envy and concern to such a degree that they were unanimous in their strong opposition to the Pontiff's wish to elevate him.

Allying himself with Divini in the latter's contra Campani controversy, Caramuel as noted produced a lengthy *Epistola* of no less than 65 manuscript pages, which he

[166] Augusto de Ferrari, 'Caramuel Lobkowicz, Juan', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1976).

submitted to Prefect Farnese. The title was of comparative length to the manuscript: "To the Most Illustrious and Reverend Lord, Girolamo Farnese, Archbishop of Patrass and Prefect of the Apostolic Palace, Caramuel's *Epistola*, A learned and careful discussion about the variety and antiquity of Silent Clocks as well as of *Horophorors* (or hour displaiers) and about the double impossibility of Spheres which without tension display perfectly the orbits and circular paths of Planets (the tension of which [spheres] concerns the size which perfection requires".[167]

[Figure (title page of *Epistola*)]

It is not certain why Caramuel decided to join Divini in his attack upon the Campani brothers, for he was not personally acquainted with either Divini or the Umbrian brothers. He may have felt that Divini, a talented craftsman although not a scholar, was justified in his claim and that he was at a great disadvantage against the erudition of not only Matteo Campani but also of Collegio Romano's faculty, some of who had aligned themselves with the brothers. On the other hand, Caramuel may have welcomed an opportunity to criticize Pope Alexander VII for having issued an unjustifiable patent. His ostensible purpose, however, as Caramuel claimed, was to illustrate with precision that which was the motive presented from the legal as well as from the technical point of view. Because of the love of truth and spirit of those who know him, he wrote, among them Eustachio Divini, he had decided to undertake this *Epistola* and to present it in Latin for several reasons.

The Campani brothers, he began, affirmed that they had made three inventions, the silent clock, a material sphere that without any tension of springs or other power source successfully and perfectly indicated the movements of the planets, and they also claimed to have devised a new method to demonstrate and indicate the hours. Their inventions, he went on, have been blessed with a papal privilege [*privilegio apostolico*]

[167] Juan Caramuel y Lobkowitz, *Ad Illustrissimum et Reverendissimum Dominum Hieronymum Farnesium Archiepiscopum Patracensem et Apostolici Palatij Praefectum Caramuelis Epistola In qua de Mutorum*, *nec Horophororum (seu horas conferentium) Horologiorum varietate*, *et antiquitate atque de Sphaerarum*, *quae fine tensione Planetarum orbes*, *et periodo perfetti exhibeant et duplici impossibilitate (quarum tensionem; altera magnitudinem*, *quam postular perfetio concernit) erudite*, *et accurari disputatur* (1568), BCP, Manuscript 3Qq D90, consisting of 65 full single-columned pages with a drawing [Scientific Editor 2: see: Bullettino della Biblioteca Comunale di Palermo, n. 4: da Giugno a Dicembre 1874, p. 88. Among Bedini's paper there is a copy of this 65-pages manuscript, with the final addittion of a drawing of the drum-shaped mercury-motor of the silent clock. This drawing is almost identical to the one in the Manuscript - Ott.lat.1886 by Matteo Campani of the Biblioteca Apostolica Vaticana].

that began with a summary stating that it was a "Certificate conceded to the children of the Beloved [Pontiff], Pier Tommaso Campani and Giuseppe Campani, clockmakers in the city of Rome."[168]

Caramuel commented on the fine language employed in the edict, worthy of being read by cultivated people, he noted, who often may be occupied by thoughts more elevated than those of the ignorant who were engaged in the mechanical arts. He was cautious, however, to avoid criticism of the Pontiff for having granted the privilege. "Many learned men and members of the nobility praise the Campani as inventors of perpetual motion," he continued. "Why? Because they say they have read the license conceded by the Pope and because they have no cause to doubt that the request of the Campani does not have substantial basis. However, the Campani brothers, to sustain their position, made unlawful use of this reasoning. According to their words," he said, "it is not permitted to presume that the Pontiff is unjust and ignorant for he is in fact a universal judge and head of the Church. It would be unjust, however, if he prohibited the construction of objects of antiquity and would be considered ignorant if he confused antique objects with the new. Furthermore, as long as he thinks that silent clocks are new and recently invented by the Campani brothers, although having already been described in thousands of ancient writings, is a papal patent enough?"[169]

Caramuel pointed out that although the words used by the Campani brothers were ingenious, the wording of the patent was neither accurate nor truthful. Referring to the claims of the Campani brothers, that they had produced a material sphere, he wondered to himself whether anyone had ever seen an *immaterial* sphere. Although the Campani brothers stated that they intended to make their sphere of whatever material (*ex quavis materia*), obviously there were many materials with which such a mechanism could not be made. The Campani brothers, for example, stated that the sphere could be made of glass, but in his opinion it was impossible to construct a mechanism entirely of glass. They asserted, furthermore, that what they have made had been produced in a perfect manner, that their sphere faithfully reproduced the movements of the planets, and that in

[168] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, p. 2.

[169] Ibid., 1-5.

their clock there was no tension, but that was not possible as had been demonstrated by the same Caramuel in the following analysis.[170]

Caramuel defined invention as something introduced to the use of humans and first resistant to mutations and alterations from things already noted. He distinguished between a "real invention" as one not previously existing and a "moral invention" as one that already existed but has been ignored and was reintroduced for use. He explained that one who added to an already existing invention could not be called an inventor. He claimed that silent clocks had already existed in antiquity and therefore that the Campani clock was not a new invention, noting that silent clocks of antiquity included the clepsydra, nevropasta, sciatherica, and automata, all of which were silent.[171] The Campani method of making the hours visible was fine, he agreed, but not original, and therefore not invented by them. Finally, he asserted that it was impossible for a sphere to reproduce the motion of the planets without tension.[172]

Caramuel then went on to describe the clockwork sphere that the Campani brothers had promised to construct. It was to be made of metal but without specifying which one and having a round or spherical form. They indicated that this sphere also could be made of glass, as it was said the sphere of Archimedes had been made, which faithfully reproduced the diurnal and natural circular motions of the planets. They claimed it was without any tension, actually motivated only by an internal power source, which the Campani brothers called "the mysterious element, and which required no intervention from outside." As the Campani brothers said, he noted, "The first movement, the initial impulse, however, has to be given to the movement externally, after which it will function continuously."[173]

The Campani brothers, he continued, claimed that their silent clock maintained its exact function without interruption, but inasmuch as it contained mercury to provide the motive power, it could be argued that the mercury did not remain always in the same

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[170] Ibid.

[171] Ibid., 5-7. *Sciatherica* is the ancient Greek term for "gnomonics"; [Scientific Editor 1: *nevropasta* is a composit term from the Greek *neurós* (= string) and *pastós* (= powder), and possibly means a chronometric device activated by a string released by a powder discharge].

[172] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, pp. 2-5.

[173] Ibid., 3-4 [Scientific Editor 2: Caramuel also anticipates here the chapters of the manuscript where he will discuss these problems in depht].

state and therefore could not serve as a regular measurer. Caramuel mentioned the instability of mercury even when it had been purified many times, suggesting that the Campani brothers probably used unpurified mercury to save cost, and noted furthermore that the use of mercury for timekeeping had been already attempted and abandoned even by Tycho Brahe many years before.[174]

Caramuel then considered the possibility that an agent other than mercury had been used and commented that, in his opinion, *Saturnis* (lead) would have been preferable, but recalled that Tycho Brahe had erred by bringing *Saturnis* to a state of calcification; in fact, it displaced itself with regularity and uniformity of motion when reduced to granules, but the question was whether it could be reduced to granules of a sufficiently small size.[175]

One of the most important and enlightening features of Caramuel's *Epistola* is the evidence he presented concerning a clock that Divini claimed actually to have made a decade or more prior to the Campani invention. This was information that Monsignor Caramuel had obtained from several witnesses who claimed actually to have seen it. Following a discussion of various types of silent time measurers, Caramuel included a statement from a letter written by a certain Raffaello Podronelli dated July 2, 1657, describing a silent water clock that he had seen in Divini's house that Divini had constructed in 1647 or 1648.[176]

Further confirmation of the priority of hydraulic clocks came from the Jesuit Nicola Zucchi, a former rector of the Collegio Romano. He reported to Caramuel that elaborate silent clocks had been constructed earlier at the Jesuit college at Modena and noted that in 1640 he had in fact seen one in the house of a certain Serafini, who became a legionary of the Duke of Modena in 1647 and 1648. Zucchi added that he had seen another hydraulic clock in Divini's home, and he commented that similar clocks made and owned by Francesco Eschinardi and by Niccolò Cabeo were to be seen in Rome. He reported furthermore that Padre Moreto of the Accademia Ferdinandea in Prague also had constructed such a clock in 1650 that had been seen and admired by many.[177]

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[174] Ibid., 4 and 14-18

[175] Ibid.

[176] Ibid., 25.

[177] Ibid. Nicola Zucchi, S.J. (1586–1670), originally from Parma, taught mathematics and physics

Caramuel then quoted a statement sworn by a certain Giovanni Antonio degli Affetti, who wrote, "I the undersigned swear that four years ago, not once but twice I have seen in the house of Signor Eustachio Divini a clock made by him having a simple motion in the form of a container that in the space of one hour demonstrated the hours successively for the duration of twenty-four hours silently and without sound, and that in my presence he showed me how it was constructed and the manner in which the hour was made to move all at one time. He even demonstrated the manner of bringing the hour from its birth [began to appear] until it fell [was fully revealed] with two openings, one of which is encountered diametrically to the other, and how he managed to overcome it." The statement was dated July 18, 1657.[178]

Caramuel then again raised the subject of hydraulic clocks, emphasizing the number of examples that could be found just within the city of Rome, and also concerning yet another type of clock consisting of a container divided into seven or eight compartments within which a fluid was made to run from one compartment to the other but which Caramuel considered to be a most imperfect measurer of time. He attempted to demonstrate that the description of the Campani night clock coincided with those of water clocks of antiquity by describing the compartmented cylindrical clepsydra. If the weight was replaced by a steel spiral to make the wheel move, he suggested, it did not make one an inventor by virtue of having made the wheel move by some means other than a weight. Caramuel criticized also the Latin wording of the patent, stating that in actuality it did not accurately describe the clock. By means of the same premise, he asserted, Divini could be constituted to be the inventor of the telescope simply because with the instruments he produced he had increased its power from earlier examples![179]

Caramuel questioned also the originality of the means used by the Campani brothers to indicate the hours. It consisted of two apertures separated from one part or

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at the Collegio Romano in 1625–1626 and was rector from 1646 to 1649. Later he was involved in the operation of the Collegio's astronomical observatory. He is the author of *Optica philosophica* (1652–1656). See: Ireneo Affò and Angelo Pezzana, *Memorie degli scrittori e letterati parmigiani* (Parma: Stamperia Reale, 1789) vol. V, 170; vol. VI, 773-981; and vol. VII, 668; Giovanni Battista Janelli, 'Janelli, Gian Battista', *Dizionario biografico dei Parmigiani illustri o benemeriti nelle scienze, nelle lettere e nelle arti o per altra guisa notevoli* (Genova: Tip. di G. Schenone, 1877), 486.

[178] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, p. 30.

[179] Ibid., 25-29.

another and completed the revolution of the number of the hours by means of a method he called *orophora* instead of *clock*, inasmuch as it carried forward the hour indicated and in so doing moved it from one part to another. No one doubted that this method of indicating the hours was a fine one, he agreed, but he had already seen this method used elsewhere and had in fact praised it before having seen the clock of the Campani brothers.[180]

On the subject of the material sphere, in which the Campani brothers claimed to have represented the motions of all the planets without tension or winding, he stated that such an object as they described would constitute a miracle. In his view, however, they were only empty words because it is not possible to achieve what they claimed because it presupposed perpetual motion, although everyone was aware that perpetual motion was not possible. The claims made by the brothers that their invention operated with precision was untrue, he insisted, because it had many imperfections. To designate oneself as an inventor it was not sufficient to have achieved perfection of an existing invention or to have improved it.

The first imperfection, Caramuel pointed out, consisted of the number of elements required to produce the motion in the material sphere. “We move in succession all the wheels disposed in a line or with the weight or steel spiral ...” indicating that all the planets were moved by a single motive power, but in addition to this motive power, the brothers indicated the presence of another force that they described in what he considered to be a high-sounding manner to be an “internal force and specifically of the sphere,” which they achieved with more elements that could have been done with less.

The second imperfection, Caramuel explained, lay in the second power source itself, because from the moment that it became superfluous, it impeded the function of the first power source from operating in an exact and perfect manner. The mercury, or whatever other fluid was used, was more compact and dense in winter, while in summer it became more rarified and loose, so that it moved more quickly and with greater speed, passing across an opening of whatever size. Therefore, in the summer, or with artificial heating, the fluids moved with greater velocity and instead moved much more slowly during the winter. In fact, all liquid elements tended to become rarified with movement,

[180] Ibid., 29-30.

becoming in fact even more liquefied, and meanwhile the openings were dilated, as he had already noted. Therefore, the same quantity of liquid would flow one day more readily than it did on another and would not conserve the same quantity and the same proportions in this passage. Caramuel stated that one must therefore give credit to Tycho Brahe who had considered all types of clocks, the movement of which depended on water, sand, or mercury, and found them to be imperfect. Neither dense nor rarified elements changed their weight, they changed their position, and in this case by accident they became heavier.

A third imperfection was claimed by Caramuel to be in the wheel that the Campani brothers stated contained or provided the force or "spirit." He stated that this wheel must in fact be perpendicular because if it tended toward the horizontal plane in the silent clocks made by the Campani brothers, the planets of the material sphere would not function correctly. Caramuel did not explain the nature of the third imperfection but turned simply to repeating that the Campani brothers boasted with unjust pretension when they said they have improved it and brought progress to the art of constructing mechanisms that functioned by themselves (*automatopoeam*).

"But what did the Campani boast of having constructed?" Caramuel asked indignantly. A material sphere made of bronze or of some other metal, or even of glass, as it was said had been the sphere of Archimedes? And because, by serving their cause with the great name of Archimedes, the Campani brothers sought to obtain his reflected fame and glory, and consequently they caused damage, or at least injury, to other inventors.

"I wish to oppose the fiery fervor of the Campani brothers," Caramuel went on, "and since the circumstances require this, I question whether in fact the sphere of Archimedes ever existed, and if that of the Campani, the fabrication of which is treated in the Papal Patent, whether it also ever existed and if it ever will exist!" Caramuel then inserted an extract from Kircher's *Ars Magnetica* in which the Jesuit polymath raised serious doubts as to whether Archimedes had ever actually constructed the sphere that was attributed to him. Caramuel stated that he was in accord with Kircher, that Archimedes had only hypothesized the sphere but that he had never constructed it.[181]

[181] Ibid., 46-47; Athanasius Kircher, *Magnes sive de arte magnetica opus tripartitum* (Romae: Ex

Caramuel wrote that he read in the papal patent that the pontiff had "conceded to Pier Tommaso and Giuseppe, clockmakers in this city, relating to a method that they had discovered for constructing material spheres with movements of the planets without tension, etc." The brothers themselves, he said, in their exposition of their invention, "and from which one has the movement and the impulse of the *primo mobile*: all the other movements, instead, are caused by that maintaining force in eternity enclosed in the sphere itself and that governs the forces of the intelligence that assists it." Were one to read this more carefully, Caramuel indicated, they were saying that all the movements were so caused, not some movements. Therefore, their material sphere was presumed to reproduce the movements of all the planets. But this sphere, he pointed out, was only projected and had not yet been constructed. This sphere that the Campani brothers described, therefore, belonged neither to the past nor to the present, but according to their own words, to the future, and at that moment did not exist. Therefore, if the Campani brothers ventured to include among their inventions a sphere that they had not yet constructed, and if they ventured to claim a patent for it in order to prevent risking having it constructed by others that which they themselves had never made, it seemed extraordinary to the reader that the Campani brothers stated they were imitating Archimedes, since the glory of the invention was of a sphere that they have never constructed but simply believed to be able to construct!

"I will demonstrate in a manner much clearer that the Campani have never constructed that sphere more recently than they have been preoccupied to have it honored with a papal privilege. I intend to demonstrate not as much to emphasize the impossibility of motion without tension, because this by itself cannot be sufficient, but leaving aside this impossibility, I will treat instead of the sphere that reproduces the motion of all the planets. This is in fact that which the Campani have ventured, and have fortified with that patent under false pretenses, in which it is prohibited to others to make this sphere and imposes that this type of sphere, whether produced in other regions by other inventors, is not to be introduced into the province of the papal state. But is it not possible that this sphere is that which the Campani have never constructed? Surely, it is entirely true, and the indisputable testimony of what I have said is reported in the very words of the

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typographia Ludouici Grignani, 1641), Libro 2, Part 4.2, 147.

selfsame Campani. In their statement published in the patent, addressed to other inventors of Rome."[182]

Among other things, the Campani brothers affirm that they "have not had either the time nor the accommodations to bring into public light one of these spheres, complete with all the planets, therefore we make humble supplication to our *Signore* [the Pope] for a privilege of that, so that no one fabricates on the invention." Thus, wrote Caramuel, they affirm that they have received the patent for a sphere that was conceived and projected but did not exist, a sphere that the Campani brothers had never constructed, but that, some day, if they should have the time and favorable circumstances, they said they will construct. But often such beautiful hopes are not realized.[183]

"I repeat that the sphere of the Campani was only projected," Caramuel continued, "never constructed, thus it is no more than such a project as had been the sphere of Archimedes." There are those who maintain that the Archimedean sphere existed, however, and we search through the works of learned writers who so claim to determine its characteristics. This invention owes its fame to the poet Claudian who described it accurately and in detail in his verses,[184] which Bernardino Baldi, abbot of Guastalla, translated in hendecasyllabic form.[185]

"From the words of Claudian one may deduce that the mechanism of Archimedes reproduced only the movement and configuration of the sun and moon. But Cicero augmented and divulged the glory of this invention by affirming in the second book of his *De Natura Deorum* that in that sphere all the planets made their proper phases." And

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[182] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, pp. 30-37.

[183] Ibid*.*, 42-44.

[184] Claudius Claudianus, *Carmina*, 1. Aufl, Bibliotheca Scriptorum Graecorum et Romanorum Teubneriana (Lipsiae: in aedibus B.G. Teubneri, 1893), LI (LXVIII). Claudian was a Latin poet, born in Alexandria, Egypt, who came to Rome circa 395 A.D.

[185] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, pp. 44-45; Bernardino Baldi (1553–1617) was an Italian mathematician and writer. Baldi was born in Urbino and studied mathematics there with Guidobaldo del Monte. In 1580, he entered the service of Ferrante II Gonzaga, prince of Guastalla, and in 1585, he was made a cleric and then bishop of Guastalla with the title and jurisdiction of abbot. Alessandro D'Ancona and Orazio Bacci, *Manuale della letteratura italiana* (G. Barbèra, 1926), 244–66; Raffaele Amaturo, 'Baldi, Benardino', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1963).

repeating the same principles, Caramuel noted, Cicero discussed anew the same sphere in the second book of the *Tusculanae Disputationes*.[186]

"Authors closer to us celebrate this Archimedean sphere using praise as ample as when they intend to honor such a work they cite to be the Archimedean sphere," wrote Caramuel, "and when they wish to praise an inventor, they speak of Archimedes. To note exaggerations in citations I mention only several, the Prince F. F. in order to praise Kircher affirms that he was equal to Archimedes. He also mentioned the verses praising Francesco Montebruno in which he states that Montebruno was a paragon to Archimedes"..Among other authors that he cited were Cornelius Drebbel and Peter Ramo, always in relation to the Archimedean sphere.[187]

In a paragraph commenting on the imperfections of the Archimedean sphere, Caramuel wondered whether the sphere of the Campani brothers, which they claimed reproduced the motions of all the planets but which still did not exist, would have the same imperfections of the wheel of Archimedes when constructed. Then, dealing with the materials with which one must make such a sphere, Caramuel retained that Archimedes had erred as far as material was concerned, by repeating Kircher's opinion that the sphere had been made of glass and was connected with wheels and axes of metal. He also cited the testimony of Tertullian in *De Anima* and quoted an extract from the encyclopedia of Alstedio.[188]

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[186] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, pp. 44-46; Marcus Tullius Cicero, *De Republica*, trans. Clinton Walker Keyes, vol. I, XIV (Cambridge, Mass.: Harvard University Press, 1966), 21–22; Marcus Tullius Cicero, *Cicero's Tusculan Disputations: Also Treatises On the Nature of the Gods, and On the Commonwealth.*, trans. Charles Duke Yonge (New York: Harper & Bros, 1877) Book II; Marcus Tullius Cicero, *De Natura Deorum*, trans. Francis Brooks (London: Methuen & Co., 1896) Book II.

[187] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, pp. 46-47; Peter Ramo—the anglicized form of Pierre de La Ramée—(1515–1572) was a French philosopher and grammarian who held a royal professorship, famous as an adversary of Aristotle and scholasticism, author of a *Dialectique* published in 1555. He became a Protestant and was a victim of the massacre of St. Bartolomew; Henry Paul Harvey and Janet Ewing Heseltine, *The Oxford Companion to French Literature* (Clarendon Press: Oxford, 1959), 395. Francesco Montebruno (1597-1644) was a scholar of mathematics and published the work *Ephemerides nouissimæ motuum coelestium Francisci Montebruni* (Bononiæ: Typis Io. Baptistæ Ferronij, 1645) that was highly praised; Raffaele Soprani, *Li scrittori della Liguria, e particolarmente della maritima ...* (Genova: Pietro Giouanni Calenzani, 1667), 103.

[188] Tertullian, *De Anima* (Amsterdam: J. M. Meulenhoff, 1947), Book 30, section 4; Quintus Florens Septimius Tertullianus (ca. 160–225 A.D.), called the Father of Latin theology, was born at Carthage, the son of a centurion, and raised as a pagan. He was converted to Christianity prior to 197 A.D. Johann Heinrich Alsted (1588-1638), professor of philosophy at the Schola Nassovica in Herborn, was the

Caramuel claimed that the Archimedean sphere could not have been precise, for in fact, the constructor thought to reproduce with a simple movement the circular distances of the errant planets, yet the moon by itself had ten or more diverse movements, each of which was also contrary. In again considering the Campani sphere, the prelate directed attention to what the brothers said or promised concerning their construction. First of all he inquired of what material they planned to make it. They responded that "The material spheres are composed of brass [*oricalco*] or of whatever other metal or material, etc. [...] and also of glass, of which it is said the sphere of Archimedes had been composed." "Of whatever other material," thus spoke the Campani. "Is glass perhaps a material adaptable for this purpose?" asked Caramuel. "Kircher's opinion and mine deny it. Glass, in fact, is an inconstant material (a material that does not obey) and fragile, and cannot be transformed into toothed wheels. Assuming that it is possible to do so, it would be with wheels that are fragile and unadaptable to use. And assuming that the mechanism is made with wheels without teeth—in such a case it would be necessary to include cords of glass, and who could succeed to make them resistant? In any case, the sphere that reproduces the motions of all the planets cannot be made only of glass."[189]

One deduces, Caramuel claimed, that therefore the Campani brothers affirmed things that were false and demonstrated also that they had not constructed the machine that they have promised. "They would show us also a single sphere made exclusively of glass that reproduces the movements of the planets and would give us their reasons. Today in fact our ears are attentively tuned to them and do not wish to believe anything if we do not see it with our own eyes. We are prepared to refute what they had promised to construct—a sphere covered with glass but not made exclusively of glass. Therefore, the Campani contradict themselves if in fact they are unable to make their sphere of glass, then according to their words, they cannot make it either of any other material. And hence it is in a manner lacking criteria that they promised to construct spheres of whatever metal or material."[190]

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author of an *Encyclopaedia septem tomis distincta* (Herbornoe Nassoviorum, 1630).

[189] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, pp. 50-51.

[190] Ibid., 53.

Caramuel then invited the Campani brothers anew to show everyone the functioning of the mechanism that they said they have invented and asked them to provide a practical proof. He then discussed the force enclosed in the sphere [*spiritum inclausum*], which could not be water, as Pier Tommaso had said at one point. Therefore, the Campani brothers were unable to imitate the sphere of Archimedes that, as we have demonstrated above, used water as the primum mobile motive force. The brothers consequently used mercury. But this is not possible because mercury is even more inconstant than water, he said, as already Tycho Brahe discovered in his time, and as we know today. "There is no other way therefore unless we turn to a common method. These silent clocks, in fact, are as imprecise as they are silent. For that reason when they have to be repaired and are no longer silent; can they thus indicate the exact time and be useful throughout Europe?"[191]

"Enough has been said about the material of which the sphere is made", wrote Caramuel, and went on to discuss its form. The Church had condemned in Copernicus and Galileo the heliocentric form of the machine of Archimedes and had judged as heretics those who sustained that the sun was fixed at the center of the universe and that the Earth circulated around it with a diurnal daily and annual motion. Consequently, it is certain that the Campani brothers, being men committed to respect the institutions, do not wish to follow in the steps of Archimedes. Nevertheless, the new astronomical theory hinders that which is held about the Ptolemaic system and its order of the spheres. There remains therefore the system proposed by Tycho Brahe in the mechanical conformation of which scientists have found various difficulties and many impediments that many distinguish to be the thesis of the hypothesis, and although those that conform to the solution accepted by the Church, the varying corrections with that of Copernicus to make move with greater facility and precision the circles of the planets.[192]

After having written exhaustively about the Archimedean sphere and about the mechanism of the Campani invention, which the brothers claimed to be comparable to the Archimedean sphere, Caramuel next considered and examined the mechanisms produced by other celebrated inventors of the past. Caramuel reported that according to the

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[191] Ibid.
[192] Ibid., 54.

measurements that were based on the distances calculated by Kepler, the sphere of Shapur must have been of considerable size.[193] He commented that the size that this sphere must have been so that the positions of the planets which in that one appeared to correspond exactly to those in the heavens. He then considered how large must be the Campani sphere to demonstrate the position of the planets perfectly. He considered that the sphere of Archimedes was more precise than that which Shapur caused to be constructed, about which one read, "The King sat inside this sphere and from there observed the movement of the planets."[194]

Caramuel then proceeded to treat on the astronomical studies conducted by the Persians from antiquity, with particular reference to the *Tabulae Persiae* published in Paris in 1646 by Ismael Boulliau, and which had been cited also by the Byzantine Georgius Chrisouces[195], seen at the court of Emperor Alexis I Komnenos. He then returned once more to the encyclopedia of Alstedio for later information about Shapur.[196]

Returning once more to a discussion of the Campani sphere, Caramuel commented, "After what I have said, I turn my eyes and ears to the words of the Campani, who affirm that enclosed in the interior of the mechanism are the planets, or more accurately that the planetary circles follow the proper movements as much diurnal as natural in imitation of the celestial planets and unwound in a perfect manner their phases or periods." So how do they unwind? Perhaps in a perfect manner? How large would be that sphere that the Campani promise to construct? If in fact in order to represent perfectly the planetary positions the sphere of Sapora could not have had a diameter less than 40 miles, it follows that the Campani brothers either must avoid the use of the term "in a perfect manner" or avoid promising in a thoughtless manner of constructing a sphere of dimensions larger than is humanly possible.[197]

Many years after the time of King Sapora, Caramuel related, another Persian king resumed the studies and the customs of his *avi*, gave himself to astronomy, and sent to King Charlemagne an ingenious sphere, as testified by Bernardino Baldi in his

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[193] Alsted, *Encyclopaedia* tome 2, book 14, part 2, chap. 2.

[194] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, 54-58; Shapur II (309–379 A.D.), king of Persia, surnamed "The Great."

[195] [Scientific Editor 1: May it be Georgius Chrisokokkes]

[196] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, p. 55; Alsted, *Encyclopaedia,* tome 4, book 33, chap. 1, 144.

[197] Ibid., 58.

introduction to the *Automata* of Heron.[198] Among spheres constructed by other inventors, he mentioned a planetarium presented by Guglillermus Zelandinus[199] to Emperor Charles V. He referred also to two spheres made by Peter Ramo similar to that of Archimedes, which Caramuel considered to be an imperfect invention because one that perfectly reproduced the planets in the heavens must have a semi-diameter more than 300 feet. He spoke of the planisphere constructed by Landgrave Wilhelm [IV] of Hesse in which he considered that it was possible that it also included the imperfections of those of the Campani sphere.[200]

Caramuel cited a letter from Christoph Rothmann directed to Tycho Brahe describing the planetarium constructed by Landgrave Wilhelm IV. This invention had been subsequently requested also by Emperor Rudolph II as was confirmed in a letter from the same Landgrave Wilhelm IV to Brahe written in 1592 and cited by Caramuel.[201] In this letter, Wilhelm mentioned also a planetarium projected by Joost Bürgi, and of those presented in 1592 in Prague that Bürgi had projected that still remained to be built that would represent the motions and the orbits of the planets.[202]

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[198] Bernardino Baldi, 'Discorso di chi traduce sopra le machine semoventi', in *Di Herone Alessandrino De gli automati, ouero machine se mouenti, libri due, tradotti dal greco da Bernardino Baldi abbate di Guastalla.*, by Hero of Alexandria (In Venetia: Appresso Girolamo Porro, 1589), 8r.

[199] [Scientific Editor 2: In reality Janello Torriani. The confusion originates from the Cardano's choice to erase the name of this character from the later edition of his best seller De Subtilitate. See: Zanetti, *Janello Torriani and the Spanish Empire*, 205-216]. Guglielmo Zelandino, master clockmaker, claimed to have been summoned from the French court to Pavia in circa 1437 and 1456 to repair the astrarium of Giovanni de' Dondi. He was known also as Willem Gilliszoon of Carpentras and Willelmus Aegidii de Wissekerke. Silvio A. Bedini and Francis R. Maddison, *Mechanical Universe : The Astrarium of Giovanni De' Dondi*, Transactions of the American Philosophical Society 56, pt. 5 (Philadelphia: American Philosophical Society, 1966), 25, 26, 52, 55, 59, 62; Morpurgo, *Dizionario degli orologiai italiani*, 184; Klaus Maurice and Otto Mayr, eds., *The Clockwork Universe: German Clocks and Automata 1550-1650* (Washington D.C.: Smithsonian Institution. Neal Watson Academic Publications, 1980).

[200] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, pp. 58-59.

[201] Ibid., 60.

[202] Karsten Gaulke, ed., *Der Ptolemäus von Kassel: Langraf Wilhelm IV. von Hessen-Kassel und die Astronomie*, vol. 38, Kataloge der Museumslandschaft Hessen Kassel (Kassel: Museumslandschaft Hessen Kassel, 2007); Michael Korey, *The Geometry of Power- the Power of Geometry: Mathematical Instruments and Princely Mechanical Devices from around 1600 in the Mathematisch-Physikalischer Salon* (Dresden: Staatliche Kunstsammlungen Dresden, 2007); Giorgio Strano, ed., *European Collections of Scientific Instruments, 1550-1750* (Boston: Brill, 2009); Christoph Rothmann, *Christoph Rothmann's Discourse on the Comet of 1585* (Leiden; Boston: Brill, 2014); Cristiano Zanetti, 'The Microcosm: Technological Innovation and Transfer of Mechanical Knowledge in Sixteenth-Century Habsburg Empire', *History of Technology* 32, no. III (2014): 35–65. Joost Bürgi—also known as Justus Byrgius—(1552–1632), was a Swiss mathematician and constructor of astronomical instruments. King and Millburn, *Geared to the Stars : The Evolution of Planetariums, Orreries, and Astronomical Clocks*, 72-80.

But, you will say, Caramuel wrote, even the mechanism invented by Bürgi will have to be discarded, if in fact the semi-diameter of the Earth in relation to the latitude of the grain of barley [*grano ordeaceo*] gives a diameter of the firmament equal to 312 feet, the orbits of the planets cannot be represented in a radius [*raggio*] of 3 inches [*pollici*].[203]

In response, these objections were not valid to Bürgi, and in fact he had never promised to construct a sphere in which the planets unwound their proper phases in a perfect manner, and in fact he had constructed that which was within his capability. He had also foreseen this type of objection and had the moon revolving separately from the other planets. Whoever doubts that it was possible to reproduce the circular motion of the moon in a disk the diameter of which is equal to 6 inches, in another planisphere if the moon is removed, as Bürgi had done, sufficient space remained, up to a hand's breadth. A series of measurements for calculating what would be, in the planetarium of Landgrave of Hesse, the distance between the various planets including the Earth and the sun were then furnished by Caramuel.[204]

Caramuel then proceeded to compare the Campani sphere with that of Joost Bürgi, noting that while Bürgi had succeeded in realizing that which was humanly possible, he would have been saying foolish things if he had dared to affirm that in his planetarium the planets, or that is the planetary circles, unwound perfectly, in imitation of the celestial planets, the proper movements, diurnal as well as natural, and the proper phases, here using the phrases used by the Campani brothers. It was impossible, Caramuel continued, that the sphere that the Campani promised to construct would show the planets perfectly in their phases, and this not only for the lack of tension but also for another motive, a motive that would never be resolved even if it were permitted to wind the mechanism every day. In fact from the moment that the sphere cannot be less than 600 feet in size, such a sphere and circles of such size could not be constructed by man of glass, bronze, or iron. The Campani sphere will remain in the world of possible creations, proclaimed Caramuel, and its inventors, as they wish to be called, will have the fame of those who do not maintain their promises made to the Holy Father.[205]

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[203] Juan Caramuel y Lobkowitz, *Ad ... Epistola In qua de Mutorum*, *nec Horophororum ...* (1568), BCP, Manuscript 3Qq D90, p. 60.

[204] The results were presented in a table of Caramuel's manuscript. Ibid., 61.

[205] Ibid.

Admitting that the Campani brothers nonetheless had distinguished themselves by their ingenuity and by their inventiveness, Caramuel said he would accuse of envy anyone who sustained the contrary. The Campani brothers had in fact constructed fine and original mechanisms, he said. Therefore, taking from antiquity to adopt to oneself that which are the exact inventions and the ideas of the ancients, in order to promise impossible things admitting of being considered as having the same standards as others, and all of us will then praise their ingenuity and their modesty.[206]

> Yet, since they retain themselves to be so much superior that they place themselves above others and look down upon them from above, I affirm that the art has not progressed, thanks to the inventions of the Campani, but that instead it has been repressed by this attitude. The spheres of the Campani are in fact defective and in them one recognizes among the other imperfections two defects and principal errors. The first defect is that the sphere they promise as a model was in fact quite rudimentary. It did not include the movements and the trajectories that were present in the machine of the Landgrave, but only, with blind eyes, the phases of the sun and moon. To be able to construct a sphere similar to that of the Landgrave, the Campani must have perfect knowledge of the subject of astronomy, a subject ignored by them at present and also for the most part by constructors of clocks.[207]

But inasmuch as this defect, lack of knowledge of astronomy, was not exclusive with the Campani brothers and was common among other persons, Caramuel passed on to the second defect, which is instead peculiar of the Campani brothers.

The second error of the sphere of the Campani brothers was in the motive power. And this is how this error was demonstrated and was shown to be peculiar to the Campani sphere. The art of constructing mechanisms or mechanical arts in common with all other arts, loves simplicity and is judged to be an error when two wheels or two power sources are provided when only one is sufficient. For this is praised that ingenious invention that takes its name from its 81 points and through the same wheels but diverse from that which the Campani brothers demonstrate in the dial of the hours.[208]

Caramuel provided other examples of inventions of that period that presented a single element capable of generating the motion. The Landgrave's sphere and others produced by various inventors in Europe also were powered by a single source. It is not necessary to add that one motive force receives help from the addition of another, in fact

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[206] Ibid., 62.
[207] Ibid., 62-63.
[208] Ibid.

the opposite happens, and the two forces hinder and each of them is induced to function badly in the presence of the other. Meanwhile, in his opinion, the Campani sphere was the most imperfect that had ever been invented; it was not distinguished in fact from the others by its perfection but by its faulty functioning.[209]

Caramuel's *Epistola*, intended as a denial of the claims of the Campani brothers to inventions that they had produced, resolved itself primarily into an erudite exposition of the horology of antiquity and an exercise in linguistics. By attacking definitions in terminology, he sought to disclaim the right of the brothers to use the word "inventor" when applied to themselves, and "invention" when applied to the achievements they claimed to have made. He attempted to invalidate their claim that their silent night clock and their material sphere were inventions, by attempting to prove that both failed in their functions and that furthermore they had been preceded by other similar inventions in antiquity. Although in this Caramuel failed, he succeeded in demonstrating his considerable familiarity with the literature of both the ancients and moderns. Part of his failure was attributable to his lack of information about the technical aspects of both the silent night clock, such as the nature of its motive power, and that of the material sphere, which the Campani brothers had effectively concealed. It becomes eminently clear that Caramuel had seen only the exteriors of the clock and the sphere and was uninformed of their mechanisms. This is confirmed in the page of drawings he included in his *Epistola* purporting to illustrate his arguments and criticism of the Campani clock and planetary device, with which Matteo took great issue.

[Figure]

Caramuel's remarkable exercise in erudition, although a brilliant revelation of the degree of his scholarship, nonetheless failed to provide a convincing exposition of the failures of the Campani brothers. The violent war in words that flew about the Campani inventions apparently had not come to the attention of the gossipy *Avvisi* and, consequently, it fortunately had a more limited audience, which may be described as the technical world. Divini, formerly a soldier and now a mathematical practitioner and not a scholar, was without knowledge of Latin, and had written his *Memoriale* in the Italian language of the day and dealt primarily with practical aspects of the mechanisms

[209] Ibid.

involved in the controversy. Monsignor Caramuel's *Epistola*, written in Latin, on the other hand, delved deeply into ancient history in his attempt to prove that all the elements inherent in the two Campani inventions had already been known to the ancient and modern philosophers. He quoted from Giovanni Ciampoli, Archimedes Siculus, Tertullian, Claudianus, Alstedio's *Encyclopedia*, Cicero's *Tusculanae*, Girolamo Cardano, and many others.

Pier Tommaso and Giuseppe Campani were understandably distraught by the showers of condemnation from Divini and particularly from Caramuel, but there was nothing they could do to stem the flow. They went about their work, hoping that the conflict would be resolved by someone somehow.

Matteo, on the other hand, was geared for battle and bristling for action. He began preparing an extensive rebuttal in writing in which he responded to each and every one of the claims and criticisms voiced by the clockmaker and the Monsignor. Like Caramuel, he did not stint in the completeness of his title: "Of the Silent Clock, that is, Without the Sound of Its Balance, and of the Material Sphere Having the Motions of the Planets Without Winding. Invented by Pier Tommaso and Giuseppe Campani. Discourse of Matteo Campani Addressed to Signor Eustachio Divini in Response to His Memorial and to a Letter of the Most Illustrious and Most Reverend Monsignor Caramuele That Was Written at the Instance of the Same Divini Against the Works and the Above Named Authors."[210]

Matteo intended that his discourse *Dell'Horologio Muto* would be published, and he wrote page after page in a handwriting that unfortunately left much to be desired and often approached illegibility. After he had completed the entire manuscript, however, and had revised and polished it, he had it copied by a professional scribe writing with a fine hand before submitting it to the Vatican office of censorship for permission to publish.

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[210] BAV, Ms. Ott. Lat. 1886, Matteo Campani, *Dell'Horologio Muto*.

Chapter V

VINDICATION

(1657–1658)

> *Who would not see that the Campani were rashly abusing it (viz., Mercury) in their clocks? Who would not see that they had not discovered the use of Mercury in Clocks? But what Tycho* [*Brahe*] *had discovered many years before and had condemned for unfaithfulness* [*who would not see*] *that they had now recalled it to use after it had been consigned to oblivion and that they had put it back in place to the great loss of the Arts?*
>
> Matteo Campani *Dell'Horologio Muto ...* ,
> unpublished, p. 76 (1658).[211]

It was a situation without precedent, nothing similar was known ever to have happened before in human memory in the Eternal City. It was a conflict fraught with potential embarrassment not only to the Campani brothers but also to the Holy Office. It was finally at this point, when heated words were reaching beyond recall, that the decision was made to refer the conflict for resolution and judgment to an independent authority. The only science-related body in the city, other than the Lincei, was the eminent faculty of the Collegio Romano, a Jesuit institution for the education of sons of the nobility. The decision to seek their assistance may have come from the *camerlengo*, Girolamo Farnese, or perhaps it may have been suggested even by the Pontiff himself. It was realized that a group of these Jesuit scholars would have the technical knowledge to understand the subjects under consideration and to render an honest and responsible judgment, thus avoiding embarrassment to the Pontiff.

Accordingly, a formal request was submitted by Majordomo Farnese to the Reverend Ludovico Bompiani, the incumbent rector of the Collegio Romano. A selection was made from among the professors teaching the sciences and formed into a panel to judge the

[211] [Scientific Editor 2: this is actually a literal quotation of a passage from Cardinal Caramuel's *Epistola*. See the manuscript 3Qq D90 from the Biblioteca Comunale di Palermo, p. 18].

inventions. It was an impressive group, consisting of some of the best informed men of science of the time. Among them were the former professors of mathematics, Giovanni Battista Giattini, Gabriele Beati Jre., Paolo Casati, and Giuseppe Ferroni; professor of philosophy Nicolò Maria Pallavicini; the polymath Athanasius Kircher; and historian Daniello Bartoli, known for his writings in belles lettres and languages.[212]

Giovanni Battista Giattini (1601–1672) was an acknowledged authority in his time on the subject of horology, having constructed a variety of curious timepieces of his own invention. Gabriele Beati Jre. (1607–1673) had been teaching astronomy, mathematics, philosophy, moral theology, natural philosophy, physics, and mechanics at the Collegio for 25 years and also had served as rector of the Greek College. It was because of his knowledge of mechanics and astronomy that he had been added to the panel. Paolo Casati (1617–1707) was distinguished for his astronomical observations and scientific writings, Giuseppe Ferroni (1628–1709) was a professor of mathematics, and Nicolò Maria Pallavicini (1621–1692) was the Collegio's prefect of studies and member of Queen Christina's Academy of Arcadians. Kircher (1601–1680) was the founder and curator of the famed Museo Kircheriano and author of numerous scientific works, Daniello Bartoli (1608–1685) was the official historian of the Society of Jesus, and Silvestro Mauro (1619–1687) and Bartolomeo Conventini (taught at the Collegio Romano between 1657 and 1660) were professors of philosophy.[213]

Several scholars other than from the Collegio Romano also were included in the panel, namely, Giulio Bartolocci (1613–1687), a Cistercian monk of the Italian congregation of the Feuillants and reformed Bernardines; Baldassarre Coluzzi, and the Capuchin monk and astronomer Anton Maria Schyrleus de Rheita (1604–1660) of Rheita, Bohemia. He was the inventor of the Planetologium, which he described in 1645 in his *Oculus Enoch et Eliae*.[214] Although the Jesuit Urbano Davisi (1618–1686).was not a member of the Collegio's faculty, he recently had been appointed procurator general of the convent of Saints Giovanni e Paolo.

[212] Villoslada, *Storia del Collegio romano dal suo inizio (1551) alla soppressione della Compagnia di Gesú (1773)*, 175–76.

[213] Ibid., 335.

[214] Antonio Maria Schyrleus de Rheita was an astronomer and optician. He developed several inverting and erecting eyepieces and was the maker of Kepler's telescope. His binocular telescope is the precursor to modern-day binoculars.

His scientific writings included the Galilean *Trattato della sfera* and treatises on hydraulics and meteorology.[215]

After members of the panel had been selected, arrangements were made for them to visit Pier Tommaso's temporary workshop at the rectory of San Tommaso in Via Parione. There the Pontiff's silent night clock and the "material sphere" were arranged on display. The members of the Collegio's faculty, and others who had been asked to comment, were invited to visit at their leisure and examine both inventions. They had become available for review early in 1657, following the publication of the letter patent in March and some time after the accusations had been voiced by Divini and Caramuel. There they remained on view until early in January 1658, when the last of the reports had been submitted by the judges.

The panel members visited the display on one or more occasions during the summer and autumn of 1657, either alone or often several of them came together. Each member of the panel prepared an individual report in writing. It was not until some months later, however, that all the individual reports finally had been compiled and submitted so that a decision could be prepared for publication. This was in the form of a report featuring the individual statements signed by the panel members. The formal decision, prepared by Giovanni Battista Giattini, former professor of mathematics, stated:

> We[216] have seen and considered in our Collegio Romano the Mute Clock (i.e., the movement of which is noiseless) and which has a new method of displaying the hours in succession, made by Giuseppe Campani [sic] and certainly this clock has been judged by all who have seen and observed it to be a work deserving singular acclaim. There are in it three new inventions, very useful and elegant, which also must be considered of the greatest value. The first is that while the wheels turn no noise is heard for the reason that the time, or as it usually called "breath" [*spiritus*], moves with a hidden device without sound and observes this soundlessness faithfully while keeping the space of the hours equal. The second is the hour with the quarters and semi-quarters appear as if brought down through the sky by a new and unusual movement. The third is that at night the hours, quarters, and semi-quarters are rendered quite visible by means of a lamp concealed within the mechanism. All these features contribute to convenience and beauty.[217]

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[215] Franco Aurelio Meschini, 'Davisi, Urbano Giovan Francesco', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1987).

[216] *Iudicium doctissimorum virorum artiumque peritissimorum. De nouis campaniorum automatis; nempe de horologio muto, seu de horologio consueto ex rotis absque motus strepitu: et de sphaera materiali, seu artificiali cum motibus planetarum absque tensione; idest absque illo artefacto, quod in consuetis automatis Italicè dicitur caricatura ...* (Romae: apud Thomam Coligni, 1658), 5.

[217] Ibid., 3.

The report pointed out that such an invention was original and had never previously been seen or known, and furthermore that it did not compete with Eschinardi's hydraulic clock, described in 1648 in a publication by Mario Bettini, which, it had been noted, "could not be brought to practical realization for any length of time—and a number of people have tried again and again to produce it—but the Campani invention, in which the "breath" of the clock moves equally, has been brought to successful completion without obstacle."[218]

In considering whether the clock merited the patent as a new invention, the report noted "the rotary display [*circumlocutio*] of the hours also is new. To have novelty it is not necessary for it to have no generic likeness to things known, but it is necessary to have something else that known things do not have. Art need not work miracles; but it should so use natural causes [elements] in such a manner that a new effect is produced. Thus, it consists of using a great number of elements [causes] altogether, each of which may be known, to produce nevertheless an effect not previously known. Since, then, the whole combination of parts of such a clock is new, it rightfully enjoys the ten-year privilege." It went on, "And herein let there be no prejudice to the makers, who, as previously have the power to construct clocks and to devise new inventions which do not already exist, which have been discovered by the Campani brothers."[219]

The consensus was that "as for the name of the clock, it is called 'mute,' i.e., noiseless [silent], without sound of the movement. This name seems appropriate and most suitable," and they went on to define the meaning of "mute" in reference to timepieces to be those "which, of its genius or species, ought to make sound but does not. Clocks with teeth and wheels, which generally make a racket, may with propriety be said to talk [make sound]. Therefore, since this clock of ours has both teeth and wheels and through the movement of those wheels shows the hours, it is admirably called mute as if it suffers a deprivation [*privatio*] of speech and not because it is denied [*negatio*] the faculty of speech—to use philosophical terms."[220]

The report then went on to comment also on the material sphere, which similarly appeared to be a new invention. "Certainly, were someone to build a sphere outside of a clock

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[218] Ibid. About Eschinardi's clock see Riccardi, *Biblioteca matematica italiana*, 125. Eschinardi also published it separately twice, as *Horologium hydraulicum*, and "Appendix Ad Exodium de Tympano." See also: Silvio A. Bedini, *Patrons, Artisans and Instruments of Science, 1600-1750* (Aldershot: Ashgate, 1999), 102.

[219] *Iudicium doctissimorum virorum artiumque peritissimorum*, 4.

[220] Ibid.

so that by turning the sphere around by hand once a day, that sphere might nevertheless display the motions of the planets from the turning by means of an internal mechanism, surely this sphere would be a new discovery and should be built by all means. And such is the sphere of the planets described by the Campani brothers. Therefore, it is a new and marvelous discovery and worthy of all commendation."[221]

In addition to the general statement prepared by Giovanni Battista Giattini, the report contained individual attestations by each member of the panel. The statement was subscribed without reservation also by Gabriele Beati and Paolo Casati, formerly professors of mathematics. Casati added "I have seen the above mentioned clock, and two new features in it particularly devised with ingenuity, the noiseless movement of the wheels and the hours clearly visible at night, and for this reason much commendation is owed to the maker. Equally, were a sphere to be built according to the description provided, it will prove to be above all mechanisms of this class, by far the most useful for the study of astronomy."[222] The polymath Athanasius Kircher noted that he was of the same opinion, and the Collegio's historian, Daniello Bartoli, agreed and added a note stating "after carefully examining the structures of both the self-moving mechanism described in the foregoing, in respect to the parts and instruments of the movement, I judge both to be quite original inventions and to demonstrate the greatest talent and usefulness."[223]

In his statement, Gabriele Beati wrote about the material sphere, "I saw the mechanism with the others aforesaid and I found that the sun and the moon completed their movements in the space of twenty-four hours at one rotation [*circumlocutionem*], and completed them without tension, but by means of an internal device which up to this time I had not seen produced by any other craftsman."[224]

The collection of individual statements, to which was added the text of the request to establish a panel that had been submitted to the rector of the Collegio Romano, were to be assembled into the form of a report entitled "Judgment" [*Iudicium*]. Included also were to be statements by several others engaged in scholarly endeavors, some of whom undoubtedly had been solicited by Matteo Campani. One endorsement came from the astronomer, the

221 Ibid., 4-5.
222 Ibid., 5.
223 Ibid.
224 Ibid., 9.

distinguished Capuchin monk Antonio Maria Schyrleus de Rheita, who was in Bologna at that time. Matteo had written to him on two occasions concerning the controversy over the Campani inventions. Schyrleus's reply dealt primarily with the material sphere. "From your two most welcome letters," he had replied, "I have understood sufficiently what efforts Your Lordship's two brothers germane seem to be ably expending on the construction of the Archimedes' sphere. But if that spirit, which is in the glass—that spirit is so knowing and industrious that it is able to put in circular motion, precisely and periodically, the indicators of the semi movement of all the planets in their eccentrics, it will be my great Apollo. If I were present I would devote a midwife's efforts to a childbirth so rare and difficult and useful."[225]

The presence of Schyrleus in Bologna at this time had been brought about as the consequence of an unfortunate incident. Prior to Cardinal Chigi's election to the papacy, the provincial of the Capuchin order had sent him a manuscript to review written by Rheita. After having read it, Chigi returned the document with a handwritten note urging the author to publish it. Schyrleus proceeded to do so in a publication, and ill-advisedly included also Chigi's note. The manuscript contained some propositions that might be liable to censure and would prove embarrassing to Chigi after his election to the papacy; therefore, when Chigi learned that Schyrleus was on his way to Rome from Germany to congratulate him on his election, he sent orders to have him detained at Bologna where he had held free speech conferences.[226]

Urbano Davisi's report provided a more detailed description of the inventions than had most of the others. He certified "I have seen the clock in the home of Pier Tommaso Campani and Giuseppe Campani, clockmakers in Rome. It had been constructed in a manner that without sound of a balance wheel [*tempo*] it displays the hours by a means different from ordinary clocks. This having been brought to me to show to His Eminence Cardinal Giovanni Carlo de' Medici, was judged by him also to be a most beautiful invention, being that its motive power did not derive from the weight of water, as has been seen in other timepieces, which by accident can become dry and therefore said element is not successfully durable, nor

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[225] Ibid.

[226] Reported to Cassini by Alexander VII; Jean-Dominique 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* (A Paris: chez Bleuet, successeur de Jombert, 1810), 272.

can it be adjusted. Therefore, His Eminence [Cardinal de' Medici] told them that they should make a similar one for him."[227]

Davisi went on, "In this manner I have seen from the same [Campani brothers] a constructed clock in a small study [*studiolo*], which indicated the hours differently from all others that I have seen, in the base of which was a round box, on the exterior plate of which exterior plane, by means of a single revolution—caused in twenty-four hours by the clock placed above it–it showed on its plane the diurnal motion, an proper of the sun and of the moon; and that natural motion was not caused by the clock, but by other external causes to that box, which at the beginning was enclosed within it, as they had made the experience, having pulled it out of its place where it was attached, was given to me in my hand, and by me turned over and all at once the sun and moon made the same motion that they had made in the twenty-four hours during which they had been activated by the clock. Whatever manner of motive power it has differs from that which I have seen in other mechanisms made for the purpose."[228] Similar support was provided by Giulio Bartolocci and by Baldassare Coluzzi, both of whom confirmed in much the same words that which Davisi had written concerning the originality of the inventions.[229]

Praise for the silent clock came from other sources as well. On August 17, 1657, Ercole Montini wrote that in April 1656 he had been summoned to the chambers in Rome of Marcantonio Giustiniani, ambassador of the Venetian Republic to the Holy See, to look at a clock that operated without sound. He was told that it had been made by Pier Tommaso Campani for presentation to Pope Alexander VII. He quoted Giustiniani as saying, "In both Germany and elsewhere I have seen various types of clocks that were truly extremely beautiful, but never have I seen a similar refined object [*galanteria*], and an invention of a similar type that was so beautiful." The contents of Montini's statement were verified by Gabrielle Grifoni, the ambassador's secretary, who was there during the presentation.[230]

The Campani brothers, and undoubtedly Prefect Farnese as well as the Pontiff, were greatly relieved with the decision rendered in such an impressive manner with multiple attestations by authoritative members of the Collegio Romano's science faculty and others.

[227] *Iudicium doctissimorum virorum artiumque peritissimorum*, 10.
[228] Ibid.
[229] Ibid., 11.
[230] Ibid., 11–12.

Presumably it was Monsignor Farnese who ordered the compilation and publication of the *Iudicium* and it was to be issued as an official publication of the Collegio Romano, printed with approval of the Collegio's rector and those who contributed to it. The additional supportive statements probably were obtained by Majordomo Farnese and included as further tangible evidence of the originality of the inventions. The report was provided with a comprehensive title, which may have been excessive even by the standards of the time: "Decision of the Most Learned Men, Skilled in the Arts, on the new Automata of the Campani; namely, on the Silent Clock, or the common Clock with wheelwork without noise of motion; and on the material Sphere, or Mechanism with the movements of the Planets without Tension [winding], i.e., without that Artifact which in normal self-moving Objects in Italian is called *caricatura*; on the Sphere, even sealed in glass, or enclosed in some other material, whose individual turnings might do the same to the Sun, the Moon, and the five Moving Stars, as is done every day and night in the Heavens, i.e., that in delay and speed the one movement should rule the most difficult movements of the Planets."

The formal decision reported by Giovanni Battista Giattini, which was to be complied into the published *Iudicium*, was widely distributed. Certainly this should now put an end to Divini's objections, thought the Campani brothers as they began to relax and devote their attention to fulfilling the commissions they continued to receive for their mercury escapement clocks. The impressive report would appear to have had sufficient authority to counteract the criticisms generated by Divini.

But the controversy raged on, fueled anew by the *Epistola* of Monsignor Caramuel, which appeared to have been directed as much against the Pontiff for having exercised poor judgment in granting the papal patent as against the claims of the young inventors. Caramuel's attack left Matteo no choice but to make a strong rebuttal. In a way, he welcomed the opportunity of putting into writing a response to Divini's accusations at the same time he ventured to accost the Goliath of Caramuel.

Then, following hard upon the heels of Caramuel's exhaustive critique and condemnation of the achievements of his brothers, Matteo now valiantly entered the fray in their defense. Caramuel's *Epistola* provided him with an excellent opportunity for equally erudite argument. Matteo lost no time in responding to both Divini and Caramuel. He joined the battle with demonstrated high indignation and considerable self-righteousness in a diatribe responding to both attacks. Soon after April 1657, with great zeal and enthusiasm, he already had begun the preparation of what became a book-length manuscript intended for publication.

While the two younger Campani brothers undoubtedly had been overwhelmed and awed and outraged by the grand display of scholarly erudition spouted by Caramuel, Matteo took it quite in stride for he too was well-read in the classics and considered himself Caramuel's match in scholarship. In producing a rebuttal addressing the accusations made by both Divini and Caramuel, he chose the form of a written discourse, which proved to be even more lengthy than Caramuel's *Epistola*. He spent a considerable amount of time in the preparation of his reply, completing it shortly after the beginning of January 1658, for it contained also references to the reports of the Collegio Romano staff of that date, and he responded in detail to both the comments in Divini's *Memoriale* and Caramuel's *Epistola*.

The final version of Matteo's discourse *Dell'Horologio Muto* consisted of a manuscript of 212 pages.The manuscript went unpublished, and the only known surviving copy has remained buried among the files of the Index Librorum Prohibitorum in the Biblioteca Apostolica Vaticana. Addressing it to Prefect Farnese, because it was he who had initiated the endeavors of the Campani brothers, Matteo obviously intended this work to be published. His salutation and introduction were impressive, and foretold the tone of what was to follow. He responded in the same style as his critics had used, perhaps with a little added pomposity. He was especially careful to avoid any degree of disrespect, however, although his response to Monsignor Caramuel occasionally came dangerously close. Observing every formality, Matteo's text began:

To the most Illustrious and Most Reverend Lordship, Don Girolamo Farnese, Archbishop of Patras and Prefect of the Most Sacred Apostolic Palace of His Most Worshipful Lord and Patron,

Matteo Campani

Presents this petition wherein is shewn that the epistle by the Most Illustrious Lord Caramuel written against his brothers germane does not make its point against them, and that in that epistle it is not their new inventions that are attacked but other imaginary and fictitious inventions which are set up in opposition to them.

Most Illustrious and Reverend Lordship:

A person of note (a bishop, for example) keeps silent when a more noteworthy person speaks (for example, the Sovereign Pontiff), and when a priest of note speaks, the simple priest should be silent. See how learnedly and scholarly my Lord, the Most Illustrious Bishop Caramuel, has written in his most eloquent letter directed to Your Most Illustrious Lordship. In that epistle he has discoursed with the most supreme learning and singular sharpness of wit about clocks in general, and about spheres, against me and my brothers germane, and their sphere and silent clock.

And so one who is a High Priest, high by a double title of priesthood—*scil*, by title of Church and of wisdom, has spoken. I must, therefore, be silent, being a simple priest, or rather lowest and least, what power have I to answer a High Priest? Especially as he is a distinguished Master of the Lyceum, while I cannot be considered even a pupil of the Lyceum. We are summoned before the tribunal of Your Most Illustrious Lordship on a triple charge against us—namely, of rashness, pertinacity, and lying. Out of reverence for so great a man, we make no reply. We wish to be satisfied with testimonies, brought elsewhere, of most learned men, who being truly wise, ought deservedly to be called not only philosophers and peripatetics and most learned theologians, but also most expert in sciences and arts. Nevertheless, there is one thing in that letter that I earnestly request Your Most Illustrious Lordship to notice: namely, that the clock outlined and painted there in the front of the book, according to the mind of our adversaries, is indeed not our clock but a fictional one born of his imagination, because if it were carefully fashioned it would tell the hours falsely, as our adversaries very well claim, nor do my brothers wish to identify that clock as theirs, because it was contained [in the book] to some extent under the appearance of being their silent clock, but they grant that it could be constructed by any craftsman. For our silent clock tells the hours as well and as exactly, without noise and sound, as other clocks of this kind that contain toothed wheels and are excellently fashioned. This Your Most Illustrious Lordship should know from experience, for he is aware of the fact that such a clock was given to the Sovereign Pontiff in the year 1655, and ever since it has provided the proper time to this Supreme Prince, nor would this wisest and most diligent Pontiff permit himself the use of such a timepiece were it useless and inaccurate.

Equally, the sphere fashioned by the opposition party [Caramuel] is imaginary, not a sphere that he describes, which is [a product] of his own imagination and not ours, but taken from a description made by our adversaries without knowledge of its matter and form, or of the principles and cause of its movement, which they further believe is made from common mercury, saying that such material is inept, a thing that we who are of common intellect (our genius always hugs the ground) also concede, for we do not use mercury, but another—the Mercury of the Philosophers—a material more faithful than mercury, as well as more constant, a material so havy and skillful, that giving to it the principles ones for all, it will never fail: indeed this planetary sphere perfectly enclosed in glass, or in another matherial, it turns fully each 24 hours (as it should), without lagging behind an hour, nay, even a quarter of an hour, or even a minute, and also operates with its usual speed should the sky be clear, without overhanging clouds [and then note that I do not say, or think, that the sky is made or crafted out of clauds) or whether the air be warm or cold, and the motionof the sun and of the other planets will be perpetually moved by our phylosophical mercury, in the same way following the rules that the Craftsman just one time has set, without aberration, so much so that I feel that it will never err, not even once in a thousand years, but depending always upon its own external revolution, whether by hand, or any other external agent. But what is more surprising about our sphere is that by means of its mechanism can be shown in the space of just one hour, visibly, and better than by scanning the skies, the past or future twelve years, the dayly movements of each of the planets, either true or mean, their stations, retrogressions and directions: and this should prove that the sphere of the Campani is by far different from the one made by our adversaries, which is wholly imaginary.

Nor should our adversaries object that the sphere now in the clock of Our Most Holy Lord Pope Alexander VII is imperfect and rough: indeed, in that situation, the Craftsman did not want to create a perfect sphere, but he merely wanted to show the novelty of the movement or movements: he wanted to show the new reaso or new way that we have invented of moving and turning the planets enclosed perfectly in a sphere, with no tension included, nor weight, or wounded spring.[231]

This inspired beginning of a response from Matteo on behalf of his brothers was most impressive. At the same time, it was a daring reply to have been made by a simple secular priest, not yet distinguished by any evidence of advanced learning or by means of

[231] BAV, Ms. Ott. Lat. 1886, Matteo Campani, *Dell'Horologio Muto*, 23-26.

publications, to one of the most prominent and learned figures in the Church's hierarchy. When Matteo mentioned the book, he was referring to Caramuel's *Epistola*, a manuscript of substantial size. He noted also that Caramuel had included an illustration in his work purporting to be the Campani silent night clock but that it had no resemblance to it. In a continuation of his response to the original attack on the Campani inventions, Matteo wrote:

About Eustachio Divini, who rashly boasts of having many years ago invented the same means of making the hours and days revolve, I state and will confirm what I say by oath or signature what took place this past month of April 1657; for I visited him at his own house, and I asked him if it was true what I had been told by a certain person, namely, that he also had the new manner of revolving the hours. He [Divini] replied that it seemed so, and I being incredulous, he showed me a model, or original drawing on paper (which he had done at another time for the Illustrious Don Antonio degli Affetti) which I, having examined it, said to him: why, this is not the same as my invention, but totally different. He replied: I have shown how it works to many, and gave them practical experience of how it works, and you want to tell me the contrary? Then I added: It is surprising how you and others have been deceived by false experience, and the reason is that your box of eleven angles can only serve for deception, since the little faces are not marked, nor are there precise sides for indicating the hours, in fact, it is absolutely impossible that this figure made of eleven angles should ever operate successfully, a thing that I proceeded to prove to him in practice and by experiments.

At first I did not wish to publish these writings, nor would I have done so now, except that he had again and again persisted in insinuating that I was a liar, and thus compelled me to do it. A day or so later after the incident in question I repeated my story to two men, still alive, at the pontifical court, and they recall and can verify the fact.

I can also prove my point by conjecturing: because if the Eustachio just mentioned had known or proven the fact before my brothers had published it, either he would have made it known, and would have presented it to the world before mine, or at least have told Mattia Ertel, who has known about it just recently, or even Pier Tommaso Campani, showing them the method of revolution, as well as the new method of telling time, and would have presented the archetype to the Sovereign Pontiff within the Ides [15th] of October 1655—the original of the new clock and the new method of making it revolve and the innovative manner of demonstrating the hours, and that it had been welcomed with the greatest courtesy by the same Holy Sovereign Prince and was carefully inspected with the greatest diligence and study (to the Pontiff's great delight), he [Divini] attempted to imitate that clock of ours and its parts and authoma, employing considerable eagerness and the greatest diligence in stirring up many people.[232]

Apparently, Divini had used every possible means to learn the details of the Campani inventions by inquiring from those who had seen them, asking countless questions but never venturing to approach the Campani brothers directly and request a demonstration or explanation. Matteo went on:

How did the Campani [brothers] make the hours clear by night and visible in the dark? How did he make the clock silent? How was it possible for each and every hour to revolve in succession, with stars rising from only two of the mountains in the pontifical crest and setting at the same mountains? Yet, as

[232] Ibid., 26-27.

is often usual, hope was without issue, for the reason that he had found many asking all those same questions, but none—not even Eustachio—was able to explain these very things.
Our new way of telling time, therefore, is by a simpler process, easier and more practical, which operates excellently, even without a pendulum; thus far we have not put it out in the open, lest someone would attribute it to himself or to Eustachio.
Thus Eustachio in his *libellus* [*Memoriale*] missed the point: either on purpose, for praise, or because he failed to understand the operation of our clock, and hence the tenor of his *libellus* against the Campani brothers is merely a fanciful imagining of operating the clock his own way, and he is more to be censured because he could have asked us the privilege to inspect it with his own eyes, and did not.
Moreover, beside the aforesaid manner of telling time, we have invented a new means of telling time in the dark. Likewise, we have a new way of marking the hours, somewhat like in the first clock which is commonly called "the Clock of Death." I'll conclude—
Was it not wrong to delude not only philosophers, but even astronomers, and easily the Prince Tycho Brahe, and to use his art in an extorted manner by the redaction of a *libellus* which is not true to facts of how time is measured? Also he fired a certain Mercury from his service, branding him as a fugitive servant (as well as ignoring the rest of the philosophers) and damning him as unfaithful? It was so: as is to be seen in the *Epistola* of my illustrious Bishop Caramuel. What if someone ignorant of philosophy, astronomy, or of science posed as learned in these arts and began correcting and chiding them? But what must be said of him who would back such a one, defending him as an artisan and the inventor of a thing he did not invent? Should he not be proclaimed a betrayer of truth, and of having a criminal intent? There is one who judges: for Your Lordship is of upright mind and sound judgment, whom no one has deceived or could deceive, or misled. What more is there to say?[233]

In the course of the ensuing controversy, it was revealed that one reason for Divini's outraged condemnation of the Campani invention was that some years ago he too had been experimenting, albeit unsuccessfully, with the design and construction of a hydraulic clock. This was a project apparently commissioned by Antonio degli Affetti, upon which Divini had been engaged for as long as fully a decade prior to the Campani invention. This provided confirmation that he had in fact worked as a clockmaker before he turned to the production of optical instruments. Furthermore, Matteo had been aware of it. Although many years previously Divini had rashly boasted that he had discovered the same method of having the hours and days revolve, when asked to swear to it in a formal oath, in April 1657 just past, he admitted that he had not yet succeeded in solving the problem of the aforesaid method.

Having heard from another source that the informant also had devised a method of making the hours revolve, Matteo visited Divini at his home, and the latter replied that such seemed to be the case. Divini showed Matteo a model or original drawings, as he had done at another time for the illustrious Don Antonio degli Affetti.[234] Matteo went on to add that if Divini had in fact developed the invention before his brothers had published it,

[233] Ibid., 27-28.
[234] Ibid., 26, lines 12–21.

unquestionably he would have told others about it, and particularly Mattia Ertel, clockmaker of the Apostolic Palace.

Matteo Campani fully intended to publish and distribute his discourse *Dell'Horologio Muto* after obtaining approval by the Church's censorship office. Aware of the poor quality of his own almost illegible handwriting, however, he employed a professional scribe to prepare a clean copy of the manuscript for the printer and perhaps to make one or two more copies for his own file or distribution. After the manuscript had been rendered into final form, however, Matteo was unable to resist the opportunity to delete passages and insert new ones throughout the text and make notations in the margins. Then, in accordance with the law, the scribe's copy of the manuscript, which had been finalized by the addition of Matteo's revisions, finally was submitted for its imprimatur to the Church's office of censorship—the Sacred Congregation of the Index.[235]

As one month went by and then another, Matteo waited anxiously for word concerning approval of his manuscript, becoming increasingly concerned and impatient. He had sent a copy of the manuscript also to Prince Leopold de' Medici for comment. In a letter dated June 19, 1660, concerning a clock that the Prince had commissioned his brother Giuseppe to make, Matteo informed him that two years had passed during while he was still awaiting approval for publication of his book manuscript from the Vatican censors, but that he had been encountering difficulties. "As to that small work, that I had said I wished to send to the printer," he wrote, "it has already been many days, since I gave it to the Master of the Apostolic Palace, who told me that he had not yet finished reading it, and it seems, that there will be some difficulties in passing it, only because I replied to certain oppositions made to me, and that did not demonstrate the truth, and for having given name to those who opposed me. From which for his scruples he demonstrates resistance to the undersigned [?]. I will petition Your Highness for some of your efficacious offices; we hope that the parts will not be discarded in which I discourse on pendulum clocks, and about the most marvelous clocks

[235] By decree of a papal bull issued in 1515 by Pope Leo X, writers within the jurisdiction of the Holy See were required to submit manuscripts intended for publication to scrutiny by a local inquisitor as well as by a bishop or a bishop's appointee. Authors as well as printers who published without permission were liable to fines, destruction of the published material, and even excommunication. After its reorganization in 1542, the Holy Office of the Inquisition became responsible for supervision of all printing in Italy, and in 1559 it promulgated the first Index of Printed Books—*Index Librorum Prohibitorum*—which was applied worldwide.

corrected by means of the pendulum of His Serene Highness, the Grand Duke, and of Galileo."[236]

In a footnote Matteo then added that while he had been in the process of writing the letter, Prince Leopold's chaplain had arrived at his house and had seen the clock made by Giuseppe Campani for Prince Leopold with its painted dial, as at another time he had written, and in case it was not possible to have the other, he would on his return bring this clock with him.[237]

In another communication, Matteo informed an unidentified correspondent that he had turned over "the matter of the book" to his friend Eschinardi. As indicated in Eschinardi's statement, later published in the *Iudicium*, "the book" was a preliminary copy of Matteo's *Dell'Horologio Muto*, which Matteo had sent to Eschinardi prior to the latter's return to Rome from Perugia.[238]

In any event, the Holy Office finally concluded not to grant permission for publication of the work, to Matteo's considerable disappointment and distress. The manuscript copy that Matteo had submitted has remained among the censored and unpublished manuscripts in the collections of the Vatican Library. Although Matteo's manuscript exonerated the Pontiff from having mistakenly issued a patent, the reason for refusal of approval unquestionably was Matteo's response as a secular priest to Bishop Caramuel, a superior member of the elevated ecclesiastical hierarchy, and a distinguished prince of the Church. In directly addressing Caramuel and his objections in his manuscript, Matteo had been careful to employ the most excessive terms of respect; in fact, frequently the extreme obsequiousness might easily have been interpreted only as sarcasm. There can be no doubt that the office of censorship nonetheless considered the tone of the work unseemly in the response of a secular priest to a superior cleric and for that reason it was disapproved.[239]

Following the formal statement of the decision by Giovanni Battista Giattini, all of the individual reports and letters were assembled, resulting in a tract of twelve printed pages, which was published in Rome in January 1658 by the printer Tommaso Coligni under the title

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[236] BNCF, Gal. vol. 276, c. 32. Letter from Matteo Campani to Prince Leopold on June 19, 1660.

[237] Ibid.

[238] *Iudicium doctissimorum virorum artiumque peritissimorum*, 6.

[239] The existence of Matteo's *Discorso* had remained unknown to scholars and unrecorded until 1950, when the late Cardinal Giovanni Mercati searched for and discovered the original copy among the manuscripts of the *Index Librorum Prohibitorum* in the Vatican Library. He informed this author of the work and provided him with a complimentary complete photocopy.

"Judgment" [*Iudicium*]. The *Iudicium* was a most unusual document, combining the attestations of such a wide range of scholars coming together in unanimous agreement in such a unique and extremely sensitive confrontation, and was published in a pamphlet or small tract having the following impressive title-page:

Iudicium doctissimorum virorum artiumque peritissimorum. De novis Campaniorum Automatis: nempe de Horologio Muto, seu de Horologio consueto ex rotis absque motus strepitu: Et de Sphaera materiali, seu Artificiali cum motibus Planetarum absque Tensione; idest absque illo Arte facto, quod in consuetis Automatis Italice dicitur Caricatura. Hoc est de Sphaera, vitro etiam optime clausa, vel alia re undique tecta, cuius singulae conversiones idem efficiant in Sole, & Luna, & quinque Stellis Errantibus, quod efficitur in Coelo singulis diebus, ac noctibus; hoc est, ut tarditate, & celeritate dissimillimos Planetarum motus una regat conversio.
Notet tamen Lector, Lunam ab Authoribus (ad evitandam nimiam molis decem, aut duodecim pedum magnitudinem &c.) non promitti nisi in Sphaera Separata a Sphaera aliorum Planetarum.
Romae, Apud Thomam Coligni, MDCLVIII
Superiorum permissu.

Also included with the *Iudicium* was a separate exchange of letters between Matteo Campani and his friend and former teacher Francesco Eschinardi who formerly had taught physics and mathematics at the Collegio Romano and at the time of writing was teaching at a seminary in Perugia. Having been absent from Rome at the time the panel was being assembled, Eschinardi had not been selected at that time; however, after the panel selection, Eschinardi was recalled to Rome from Perugia by his superiors specifically to participate in the review of the Campani inventions, and he was anxious to learn the truth about the criticism that was commonly being reported about Matteo and his brothers. Shortly after his arrival in Rome, he had been invited by Matteo to come to the rectory of San Tommaso to examine the mechanism of the clock.[240]

On April 27, 1658, after the committee had submitted the *Iudicium* for publication approval, Matteo had written to Eschinardi at Perugia reporting in a rather formal style on the events and explaining his role and that of his brothers. Thus follows the text of the letter written by Matteo Campani to Eschinardi that was later included in the *Iudicium*:

Most certainly, many things have reached your ears regarding what is being said and written about me, and about my brothers Pier Tommaso and Giuseppe, as the result of a certain Privilege that was granted to them. What I find particularly distasteful is what has been spread about me wanting to take credit for the wonderful Hydraulic Clock, which is commonly known to be an invention of yours, especially since there being so many with whom you have generously shared it, particularly in that august city of Perugia, where, I understand, many have already been produced by several of your

[240] *Iudicium doctissimorum virorum artiumque peritissimorum*, 6–7.

students, who are now mastering the craft, and who are not finding in it these problems and defects, which some onthers are convinced to find; but the experience, who is mankind's teacher, against which it is difficult to achieve anything [, shows the opposite]...

It could be inferred from the defects that have been talked about, that what others call a Hydraulic Clock could well be a vase with water and not in essence, a Water Clock, for which no original invention could be claimed unless the aim of its proper and well-tempered functioning was first achieved, requiring no test from the intendents. And they did not care to publish it until father Bettini [published his own water-clock], nor often to put it in practice. Therefore, even the same father Bettini chose to add your necessary addendum to his book, and later once more in the second edition, adding the description of your water clock to it. But the deciding argument rests on submitting them to a comparison test against each other. In fact, if both are done in practice, one in the manner described by father Bettini and the other by you, the results will become apparent. [...]

Therefore, not ever having such pretensions, I can only rejoice in the fact of having been in your school during the year 1648. Especially since thereafter I started to devote myself again to such reawakened speculation as a result of several conversations that took place with you regarding such matters. This was the reason why I allowed my above mentioned brothers to apply themselves to the art of clock making, who seemed naturally disposed to the task by appearing greatly interested.

Providentially, they have found at least a good many Princes, some of them even Kings, who agreed to validate their inventions by commissioning them, which is the greatest compliment that could be hoped for, free from any quarrel or controversy.

Among these [inventions], the most notable is a sphere that although it might be perfectly enclosed in glass (as it is said about the one of Archimedes), being it rotated only externally, as Tullius [Cicero], Lattantius and other testify about the abovementioned Archimedean sphere, it shows us the proper motions of the planets according to their cycles.

Secondly, [invention of] the silent clock that is a common wheel clock, with the only change of the wheel of St. Catherine [crown-wheel], and the spirit [escapement] in place of which there is a small container containing mercury. This silent clock shows the hours with precision and without any sound or noise. You, as well, know that it is impossible to use mercury in the drum of your water clock: therefore, the abovementioned container has to be very different from your drum.

Thirdly, for the added feature of showing the hours at night time, having encountered a few difficulties in adjusting the hour display where the clock's motion is continuous, two openings would be required, through which numbers will appear diametrically opposed the one to the other and for which purpose not only the pentagon is useless, but any other shape is also inadequate, with the exception of the decagon, as you, thanks to your ingenuity and experience, will be able to understand, and I know that the matter is more difficult than it seems at first sight.

I will not attempt to describe in depth the things mentioned here because you would be more comfortable seeing them with your own eyes, when you come to Rome, which to my great pleasure, I understand should happen in a short while. Especially when you will see with your eyes and touch with your hand [these inventions], I know that due to your customary integrity and based upon the authority that you wield in these matters, you will desire and you will be able to judge them in such a manner, that every righteous person will be satisfied, especially if you will record it in your book now being printed, along with other intriguing and ingenious things. It remains only for you to come down soon to clear up the confusion and hope that in the meantime you remember me in your prayers, while I remain humbly and most sincerely yours,

Rome, April 27, 1658

D.V.P.M.R. *Obligatiss. e Devotiss. Servitore*

Matteo Campani[241]

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[241] Francesco Eschinardi, *Microcosmi physicomathematici, seu compendij, in quo clare, & breuiter tractantur præcipuæ mundi partes, coelum, aer, aqua, terra : eorumque præcipua accidentia*, vol. Appendix (Perusiæ: Bartoli & Angelum Laurentium, 1658), unpaginated. Eschinardi's hydraulic clock is described and

In one of Eschinardi's scientific writings, also published in 1658, *Microcosm Physicomathematical or Compendium, in which the Main Parts of the World (the Sky, the Air, the Water and the Earth) are Clearly and Briefly Discussed Together with Their Main Attributes*, he reprinted Matteo's letter, together with a description of his own invention of a hydraulic clock illustrated with line drawings.[242]

Pope Alexander VII had bided his time, meanwhile, until a vacancy occurred in the bishopric of Campagna and Satriano in the Kingdom of Naples; the Pontiff immediately took the opportunity to remove Caramuel from Rome by appointing him to that position, assuring him that in Naples he would find ample time for his studies. It is generally believed that the appointment was deliberately made so that the removal of Caramuel from Rome effectively pacified the cardinals and at the same time eliminated a constant source of criticism.[243]

As already noted, no copy of the accusations made by Divini has been found and what is known of them is derived principally from the accusations defined in Caramuel's *Epistola* and in the rebuttal in Matteo Campani's *Dell'Horologio Muto* and other responses. In the latter, Matteo responded one by one to each of the libels in Divini's *Memoriale* and in Caramuel's *Epistola*. His words made it obvious that he and Divini had been well-acquainted and that they had enjoyed a friendship for a decade, formed when Matteo first had visited Rome in 1646 or 1648. To Divini he responded:

> in the ten years that I have been in this city, I have had your acquaintance from the beginning, as you know, during which we had the most intimate conversation, on the occasion that you wished to learn the construction of the water clock from Father Eschinardi of the Society of Jesus, which I, working together with him, was in the process of making in the German College in your neighborhood. There you have learned to craft that water clock, which you now pretend to be a [holy] relic, even though it was the most imperfect of all that were made, not only because of the excessively small size of the drum which is caused by the most notable alteration, but for the construction of two drums in one, against which I spoke to you and which furthermore the same year 1648 I had demonstrated to you with [the water clock made togheter with Eschinardi] that I had offered in homage to Cardinal Barberini. You, having noted imperfections in these water clocks too noteworthy, dismantled your clock in order to sell the parts, that is, the case and the dial, and to that effect offered them to Sig. Giovanni Battista Peperelli, at the moment pastor of the Society of Jesus, but for the small dimension,

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illustrated with line drawings at the end of *Tractatus tertius*, 1–10.

[242] Ibid.

[243] De Ferrari, "Caramuel Lobkowicz, Juan", 621–24; Charles Coulston Gillispie, ed., *Dictionary of Scientific Biography*, vol. 3 (New York: Scribner, 1981), 61; Angela Marino, 'Il colonnato di Piazza S. Pietro : dall'architettura obliqua di Caramuel al "classicismo" berniniano', *Palladio*, 1973, 81–120.

he did not like it. You praised the invention, but you minimized its use as much as possible, which now today you praise extremely.[244]

Meanwhile, as the discussion concerning the originality of the Campani inventions continued to be fought on the battlefield of Rome, orders for the ingenious new timepiece kept flowing in, and Pier Tommaso and Giuseppe Campani were able to ignore the conflict while being kept fully occupied in fulfilling the orders. In addition to members of the Chigi family, for whom they produced clocks, other distinguished clients included Cardinal Carlo de' Medici and both his nephews Grand Duke Ferdinand II and Prince Leopold, King Philip IV of Spain and his consort Mariana of Austria, and King John Casimir II of Poland.

Matteo's function in this operation of mass production consisted of providing assistance in the promotion and marketing of the clocks. At the same time he probably was involved as well with making arrangements with the craftsmen who produced the individual clock cases and their parts. He was particularly qualified to undertake all this negotiation because of his familiarity with the community and its craftsmen. Clients expressed personal requirements, although in principle the cases always retained the same basic elements of the architectonic structure with a painted copper dial. Often the cases were further adorned with columns having gilt bronze bases and finials, and if the client requested additional decoration, gilt decorative attachments and miniature gilt bronze statues were provided. It is possible also, however, that some of these embellishments made by other craftsmen were commissioned directly by the cabinetmaker instead of by the clockmaker.

Thus, while Pier Tommaso and Giuseppe constructed the clock movements and dials, they also had to deal with brass founders, gilders, miniaturists, and cabinetmakers who produced the component parts of the cases, all of which were produced elsewhere and then assembled in Pier Tommaso's clock shop. The prices established by the brothers for their silent night clocks were substantial, for included had to be not only the cost of their own work but also the costs of the many elements that went into the construction of the elaborate cases, to which a rewarding profit margin had to be added for themselves. The clients for whom the clocks were made were of a level of society that experienced no problem in paying the prices requested.

[244] BAV, Ms. Ott. Lat. 1886, Matteo Campani, *Dell'Horologio Muto*, 46–47.

As the rumblings of the violent conflict diminished, Giuseppe, who had completed his apprenticeship, continued to work with Pier Tommaso, making every effort to improve his knowledge at the same time. Pier Tommaso had established his own home by this time and was living with his young family in the parish of San Lorenzo in Damaso near the Cancelleria, where he had developed a shop in part of his home.

During the next several years, Pier Tommaso and Giuseppe profited considerably from their enterprise. Although the division of income is not recorded, after costs of materials and costs for other skills had been paid, undoubtedly the larger share of the net profits went to Pier Tommaso who was responsible for producing the major part of the work. After subtracting fees for his room and board at the rectory, a smaller but still substantial share was forthcoming to Giuseppe, and some financial arrangement with Matteo must have been made, possibly to support his own scientific experiments or as donations to his Church. The profit realized from their invention of the silent night clock and its production for a long list of distinguished purchasers launched both of the younger Campani brothers into comfortable circumstances that made them permanently able to work independently thereafter.

By this time Pier Tommaso had terminated his employment at the Vatican in order to maintain his own shop on a full-time basis. It is probable that Giuseppe put aside a large part of his income into savings to be used later to pay for the purchase of tools and materials with a view to establishing his own shop. The relatively cooperative arrangement of the three brothers seems to have lasted as long as the great demand for silent night clocks continued, presumably attaining its apogee in 1658 or 1659. By this time, Giuseppe had enough technical training and experience to enable him to undertake projects of his own, while still living in the rectory. Throughout this period, Matteo attempted to continue in combat with the accusations of Divini and Caramuel, hoping that publication of his discourse *Dell'Horologio Muto* ultimately would serve as a culminating rebuttal.

Matteo, now having to cope with the accusations from Divini and Caramuel, also became increasingly concerned by dissension that had arisen between his two younger brothers regarding their relative roles in the night clock's invention. Each of the brothers proceeded to publish his own account. Matteo's claims had already been presented in his unpublished discourse *Dell'Horologio Muto* and repeated at other times in later publications. Giuseppe was the first to publish an account of the invention in a small volume entitled:

Discourse of Giuseppe Campani Concerning His Silent Clocks and on the New Archimedean Sphere, *and on Another Most Rare and Useful Invention by a Conspicuous Personage*. In a dedication to Cardinal Farnese dated April 14, 1660, he noted "I must publicly confess that my obligations to you are infinite for the benefits you have brought to me and to the members of my house. I have become so accustomed to receiving your munificence without ever being able to repay it except by the reverent acts of an obsequious soul ..."[245] He reminded the Cardinal that the latter was best informed of the veracity of the statements made in the book and of the events described because for the most part they had occurred in his presence.[246] He went on to say that in developing the mercury escapement clock he and his brother Pier Tommaso had been greatly assisted by discussions with and advice received from the older brother, Matteo. He clearly indicated, however, that the silent clock was not Matteo's invention but a combination of contributions from all three brothers.[247]

Considerably annoyed by the publication of young Giuseppe's *Discorso* on silent clocks without his involvement or approval, Pier Tommaso also immediately went into print presenting his version of the events. This was in a very small publication having the excessively long title: *Letter of Pier Tommaso Campani*, *to One of His Friends*, *in Which He Demonstrates the Origin*, *and the Artifice of the Clock That He Had Fabricated in the Year 1656*. *With the Sphere of the Planets*, *and Now a New Invention of Clocks He Devised That Are Silent if One Wishes, or Not Silent*, *Without Any Fluid Component*.[248]

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[245] Campani, *Discorso ... intorno a' suoi muti oriuoli*, I-VII.
[246] Ibid.
[247] Ibid., 2-19, 31-32.
[248] Campani, *Lettera di Pier Tommaso Campani*.

Chapter VI

OSCILLATING BARS (The Crank Lever Escapement)

(1657–1659)

> *The knowledge that it could have been possible for me to make those, and other similar oppositions against me, made me apply my mind to search for other new methods, and more perfect ones, for making Silent Clocks, free of any suspicion of imperfections resulting from the nature of mercury, and of whichever other similar fluid materials etc.*
>
> Giuseppe Campani, *Discorso ... Intorno a' suoi muti Oriuoli ...* (Per Francesco Moneta, Rome), pp. 12–13 (1660).

Despite the publicity attending the horological inventions of the Campani brothers and the issuance of a papal patent, which had brought about the much publicized attacks first from Divini and then from Monsignor Caramuel, the brothers were greatly relieved by the appearance of the publication of the *Iudicium*. It was a favorable judgment from a wide range of the scientific community that effectively stilled the critics. Nevertheless, the brothers continued to have some concern. "This novelty so applauded by the great and esteemed by the knowledgeable [...]," as Giuseppe wrote, "nonetheless suffered censure."[249] At the same time, it brought about a substantial favorable change in the circumstances of all three Campani brothers. Their silent night clocks advertised themselves, and during the succeeding months, Pier Tommaso and Giuseppe found themselves fully occupied fulfilling commissions for their unusual timepieces that came from various directions.

Shortly after the Campani brothers had delivered their first silent night clock with mercury escapement in addition to the "material sphere" to the Pontiff in October 1655, a curious unexplained event occurred in the life of Giuseppe. Early in May 1656, he received the gift of relics from Monsignor Marco Antonio Oddi (1602–1668) of Perugia,

[249] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 11.

consisting of two saints: bones of Saint Lucius the Great and teeth of Saint Maximinus.[250] Scion of a local noble family, Oddi had been appointed Vicario of Perugia in 1661, and in 1665, he was named cardinal by Pope Alexander VII.[251]

The notarial act accompanying the relics stated that previously the objects had been maintained in the Church of Santa Cecilia in Trastevere, one of the oldest places of Christian worship in Rome. Oddi obtained permission from several ecclesiastical authorities to make the donation, and it was further specified that Giuseppe had the right to dispose of the relics as he wished: to keep them for himself, to donate them to another, or to send them outside of Rome. This incident remains without explanation. One possibility is that Giuseppe had been sent to receive his schooling at the Jesuit school in Perugia, as had his brother Matteo, and that it was while there that he became acquainted with Monsignor Oddi. The relics may have been a reward for scholarly achievement.

While producing silent night clocks, meanwhile, neither Pier Tommaso nor Giuseppe appear to have made a practice of placing their signatures on clocks they produced with the mercury escapement, or if so, none is known to have survived. As work progressed, they experienced increasing concern with the awareness that mercury night clocks had a terminal life span which inevitably would present a problem that would have to be faced sooner or later. This they were determined to try to resolve. They knew that the mercury escapement was not the ultimate solution to a successful silent night clock because in time the mercury would cause corrosion, rendering the timepiece inaccurate or non-functional. At the same time, they realized that the concept of a silent night clock had become eminently marketable among the Italian privileged and wealthy, as demonstrated by their sales. Consequently, the brothers became more and more anxious to devise a more practical replacement for the mercury escapement. While Pier Tommaso unsuccessfully sought a resolution in experiments with automata and various types of clockwork movements, Giuseppe was directing his own studies of the problem in another direction.

The pendulum had not as yet been applied as a regulator for clockwork, and Christiaan Huygens had not yet reported his invention. Timepieces of the period

[250] ASR, Pinus Landus, vol. 206, p.te 2, fol. 45r-v.

[251] Gaetano Moroni, *Dizionario di erudizione storico-ecclesiastico da S. Pietro ai nostri giorni*, vol. XCIX (Venezia: Tipografia Emiliana, 1840), 175.

traditionally utilized the crown wheel and verge escapement regulated by means of either a bar balance or a circular balance. Clocks thus regulated could not be made silent, however, and in fact were extremely noisesome. Pier Tommaso, in common with other clockmakers of his time, relied on the crown wheel and verge escapement regulated by a circular or bar balance for his clocks other than his night clocks with mercury escapement. This crown wheel and verge escapement was the one he had used in the two timepieces he already had produced for Pope Alexander VII prior to venturing into the production of the silent night clock.

In his earlier clocks, however, Pier Tommaso made a practice of inverting the crown wheel and verge escapement, varying from the common form that was the standard practice. The inversion of the crown wheel escapement was not widely applied; it appears to have made its appearance in the mid-seventeenth century, first in Rome. As well as is known, its use was limited primarily for clockmakers in that city. In addition to the Campani brothers, it was applied some years later also by Johannes Wendelius Hessler of Rome and by Johann Philip Treffler, the German mechanician and clockmaker in the service of the Grand Duke of Tuscany, in his night clocks.[252]

The earliest, and in fact the only, documentation presently known relating to the inverted crown wheel escapement occurs in a seventeenth century Italian manuscript. An album of designs of anonymous authorship, it also contains several letters exchanged between two unidentified correspondents to which were appended two sketches of a clock having an inverted crown wheel but with a pendulum regulator.[253]

The inverted form of the crown wheel and verge escapement may have been an early independent attempt to apply the pendulum regulator without having had prior knowledge of Galileo's concept nor of Huygens's subsequent application of such a device. It is to be recalled that although Huygens's application of the pendulum regulator, patented in 1657, became known almost immediately, whereas, for the most part, however, knowledge of Galileo's clockwork concept remained unknown outside of the Florentine Medici court until the mid-nineteenth century. It was only then that the

[252] Giovanni Wendelino Hessler, German clockmaker in Rome 1680–1690; Morpurgo, "Orologi del Campani in Vaticano," 89. Johann Filipp Treffler of Augsburg served as mechanician and clockmaker at the Medici court circa 1645–1670; Silvio A. Bedini, 'Johann Philipp Treffler: Clockmaker of Augsburg', *Bulletin of the National Association of Watch and Clock Collectors* 7, no. 69 (1957): 541.

[253] Morpurgo, "Orologi del Campani in Vaticano."

drawing that had been made in 1659 by or for Viviani, which Prince Leopold sent to Ismael Boilleau in Paris to be forwarded to Huygens, first came to light and became public knowledge.[254]

It is a curious coincidence that the only known surviving examples of clocks utilizing the inverted crown wheel and verge escapement appear to have been made in Rome. Several of the early clocks made prior to 1658 by Pier Tommaso and Giuseppe that were not night clocks undoubtedly utilized a bar or circular balance. Tangible illustrative evidence of the use of the inverted crown wheel and verge with pendulum regulator, which is effectively dated after 1659, occurs in another seventeenth century horological manuscript of anonymous authorship containing a compilation of pen and ink drawings and descriptions of a variety of clocks of the period. An Italian night clock is the subject of two of the illustrations, one identified as a "Front view of a clock in the Roman style that indicates only the hours, quarters, and minutes." The dial is shown to have a semi-circular opening, the circumference of which is marked in units of 5 from 5 to 60, with the quarters indicated in Roman numerals above it. The well-drawn landscape scene features a bridge over a stream with a lone tree nearby and a building and a mountain in the distance. The second drawing is captioned "Dial that is situated behind the above front view of the clock that shows by means of an opening the hours that are indicated in two circles."[255]

[Figures]

An interesting surviving example of a clock having the inverted crown wheel and verge with pendulum regulator, formerly part of the Medici collections, was almost certainly the work of the court clockmaker and mechanician, Johann Philipp Treffler,

[254] Silvio A. Bedini, *The Pulse of Time : Galileo Galilei, the Determination of Longitude and the Pendulum Clock* (Firenze: Leo S. Olschki, 1991), fig. 8.

[255] *Trattato sulla Maniera per Costruire Orologi. Trattato di Diversi Orologij. Il primo adunque Trattato sara degli Orologi Elementari; il Secondo dei Orologi materiali; ed il terzo misto di molti altri ingeniosi e studiosi.* Italian manuscript, second half of the 17th century, Bedini collection; provenance: Abate Luigi Canonici (1727–1805); purchased by the Reverend Walter Sneyd in 1835; later owners were Bernard Quaritch in 1903, G. H. Baillie in date unknown, and H. Alan Lloyd in 1951; acquired by this author in 1953. A fourth page provides a "Table of the parts that serve the above-mentioned clock." "Letter S" depicts the large revolving dial with its two openings, the first marked for the uneven hours 1, 3, 5, 7, 9, and 11, and the second opening for the even hours 2, 4, 6, 8, 10, and 12, with projections between each that are moved by a projecting lever as the main revolves clockwise. This arrangement is the second version of disposition of hour numerals on the revolving disk. Another drawing, marked "G" and captioned "Diagram of the above-mentioned Clock in the Roman Style," is a diagram of the movement, with spring barrel and fusee geared to two wheels and featuring the inverted crown wheel and verge regulated by a pendulum.

although unsigned. It is inscribed “Made in the Gallery of His Most Serene Highness in Florence” [*Fatto in Gallerie De S[ua] A[ltezza] S[erenissima] Fiorenza*].[256] Apparently, it had been commissioned for the Accademia del Cimento, probably for use in its experiments. The fact that it is a night clock indicates that it was made subsequent to the 1656 night clock invention of the Campani brothers, and because it is regulated by means of a pendulum, which may have been a later addition, it is dated after 1659 and perhaps even later.[257]

[Figure]

The inverted crown wheel and verge escapement appears to have been adopted by Treffler as a standard form in his work. The several other known surviving examples of his night clocks utilize this arrangement, while the general form of the movement and case were copied from those of the Campani night clocks. Treffler produced several night clocks during his employment at the Medici court and after his return to Augsburg in 1670. His night clocks were not silent, however, each utilizing an inverted crown wheel and verge escapement with pendulum.[258] **[Figures]**

In the same year that the Campani brothers presented their first silent night clock to the Pontiff, Christiaan Huygens in Holland was reaching a solution in his experiments with the application of the pendulum as a regulator for clockwork. Achieving success in the following year, he was granted a patent in 1657 and published an account of his invention in his famous book *Horologium Oscillatorium sive de Motu Pendulorum* (1673).[259]

An unusual night clock, although unsigned and not silent, that possibly had been produced by Pier Tommasso or Giuseppe Campani during this period was formerly in the collection of an English peer. The movement incorporates an inverted crown wheel and verge escapement, regulated by a bar balance. A study by several professional clockmakers confirmed that the bar balance arrangement is original, although part of the present bar balance itself is a modern replacement. The space arrangement of the clock’s

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[256] [Scientific Editor 2: Antonio Lenner, the owner of the clock, is not convinced of Bedini’s attribution of the timepiece to Treffler].

[257] Collection of Dott. Ing. Antonio Lenner, Milan.

[258] Antonio Lenner, ‘Johann Philipp Treffler : orologiaio in Augsburg e Firenze’, *La Voce di Hora* 41, no. Dicembre 2016 (2016): 5–20.

[259] Huygens, *Christiani Hvgenii ... Horologivm oscillatorivm.*

interior is such that there is not nor was there ever sufficient space to accommodate a pendulum rod of the required length. Housed in an elaborate case, its entire outer surface is veneered throughout with tortoise shell over gold leaf, with ebony trim. An opening at the front near the base screened by a gilded carved wooden grid, lined on the inside with thin red silk, enables the passage of air to fuel the oil lamp used to illuminate the clock at night; it did not serve as a window for observing whether the pendulum was operating, as in pendulum-regulated night clocks.[260]

[Figures]

For the time being, Giuseppe continued to work together with Pier Tommaso, now in a partnership, in the latter's new workshop, primarily to help fulfill commissions for silent night clocks with mercury escapements. He treasured whatever leisure hours he could save for himself, during evenings and holidays, in order to devote time to his own projects. He worked alone for long hours in his room at the rectory, convinced that it would be possible to make operable clocks silent and determined to find a solution before Pier Tommaso solved the problem.

For some time Giuseppe had become impatient to establish his own shop and was eager to experiment with some projects of his own. Despite Pier Tommaso's occasional derogatory comments, Giuseppe had progressed rapidly in his mastery of the horological arts. He had demonstrated considerable ingenuity, with a capability to work entirely independently. Giuseppe finally made arrangements with Matteo for temporary shop space of his own in the rectory until he could have a shop of his own. Although Matteo had no particular professional manual skills in mechanical arts himself, he provided moral and physical support to his youngest brother, contributing guidance as needed from his knowledge of the laws of physics.

Finally, by late 1657, Giuseppe had become financially able to make the move to a workshop of his own. He purchased space in a building in the Vicolo del Sora, across the street from his brother's church, at the corner facing the office of the notary of the Cardinal Vicario. One or two small shops in the building front on the street level were occupied by local merchants, as they are to this day. Giuseppe probably arranged his

[260] Night clock with inverted crown wheel and verge escapement and bar balance regulator, Bedini collection.

living quarters on the ground floor, reserving a room in which he could meet publicly with clients and other visitors. His workshop was situated on the upper floor where he could maintain total privacy. Upon Matteo's urging, he developed the habit of keeping his work room locked at all times, even during his own presence, in order to limit knowledge of his projects and work in progress from prying eyes of strangers and undoubtedly those of his brother Pier Tommaso as well. Matteo arranged for Giuseppe to display his clocks as they were completed to be viewed by the public on the street side of the rectory when it was not in use for storage of parishioners' cadavers awaiting funerals and burial. The arrangement worked reasonably well for the time being.

Due to the high cost of materials, clockmakers in this period generally produced completed clocks only in fulfillment of commissions they had received and rarely on speculation. The occasional display of a completed clock Giuseppe had made for one of his clients therefore served as advertisement of his work. Matteo now lived alone in the rectory except for his curate, his housekeeper, and occupants of rooms that he rented out.

Giuseppe had few clockmaking tools of his own at first, but little by little he managed to make some of them, and with income from his clock sales, he purchased others he needed. His first requirements were a large, sturdy work bench, a table lathe, and cupboards for storage of work materials. It was not long before Giuseppe began to attract some of the same clients he had shared with his brother, and there were also new faces.

To help pay his overhead costs, Giuseppe sublet one or two rooms in the remaining space in the building. In November, for example, he sublet a room on the second floor to Domenico Cianti, son of the late Gabriele, at a monthly rent of 12 *giuli*, automatically renewable month by month with the provision of 10 days' notice. Cianti's access to the room was limited to passing through the street door facing the Palace.[261]

Giuseppe's independent research eventually resulted in the invention of the crank lever escapement, an achievement that led to final total estrangement with Pier Tommaso. Giuseppe Campani, while experimenting with a mechanical clock in his efforts to develop a timepiece that operated in total silence, was completely unaware that at the

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[261] ASR, Pinus Landus, Ufficio del Cardinal Vicario, Off. 31, vol. 216, pp. 489r-v, 514r (November 24, 1659).

same time Huygens in the Netherlands was experimenting with the pendulum regulator for clockwork. Having discarded the mercury clepsydra as an escapement, Giuseppe had constructed a brass clockwork model with a wheelwork movement in which he now experimented with the application of two balance wheels instead of one. One that he inserted in the time train was in the form of a small bar balance. Then he began experimenting with a second bar balance, a makeshift larger balance attached to the back plate. Later, in a publication in which he described the circumstances of the invention of the mercury escapement night clock, Giuseppe also provided a vivid account of his accidental invention of a remarkable new escapement for silent night clocks. He related that:

The knowledge that it could have been possible for me to make those, and other similar oppositions against me, made me apply my mind to search for other new methods, and more perfect ones, for making Silent Clocks, free of any suspicion of imperfections resulting from the nature of mercury, and of whichever other similar fluid materials, or flowing ones, etc.

I began by undertaking a careful examination [of the matter], and after long and pondered analysis, I concluded that nothing would lead me to the means I sought except to situate the wheel popularly called the *tempo* [balance wheel] of the clock, so that it was not activated by the verge [serpentina] but by another device; because its axis or rod must be continually accompanied by it without ever withdrawing from it. In this way it seemed to me (as in fact it did happen) that every noise could be eliminated and a real timepiece could result that was truly silent and free of every combination or mixture of material foreign to ordinary clocks having toothed wheels.

[...] I then made a brass model which turned out very well, just as I had wished. Now this model was made so that it would run as well with two *tempi* [balance bar] as with one; with this difference, however, that only one balance bar made the clock free from every sound or ticking and strokes of the balance bar and any other implement and device, retaining only a silent and very light sound of a tiny distaff with the teeth of a wheel; and this sufficed to let one know, were he to put his ear to the clock, that it was silent but not dead; or that with two *tempi* [balance bars] it did indeed make the clock sound totally silent. At any rate, I thought it would be much better to simplify the clockwork by using only one *tempo* [balance bar] instead of two. Hence I lengthened the arms of the new *tempo* [balance bar] as much as I thought was necessary, and using wax, attached two little lead wings [weights] to the ends of these arms. To determine how its movement would turn out, I wound the instrument and while I was contemplating the silent movement of the balance bar, the little wing on the upper arm dropped off and only that one of the lower arm remained. And here, to my amazement, because of the novelty of the situation, I saw that the *tempo* [balance bar], although not balanced, continued its motion; and that moreover, its motion was even. [...] This came to be the perpendicular or pendulum discovered by the very learned Sig. Galileo Galilei, to measure time with exactness, as well as the duration of his celestial observations.

[...] I applied the pendulum to my ordinary neck watch and then hung the watch on the wall. Observing it for many days, I noted that it always maintained its equal motion and that the vibrations of its balance were always made in equal time, even though the force of the spring and of the wheels were unequal [...].[262]

[262] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 12-17.

Giuseppe was greatly excited by his discovery, and when he informed Matteo of it, the latter too was equally impressed, as he realized its implications. Their invention of the silent night clock no longer need rely upon a source of such impermanence as corrosive mercury but could function even better and permanently with mechanical wheelwork. By early 1658, Giuseppe had finalized his first silent night clock with wheelwork, which incorporated his new crank lever escapement. He then contracted to have an appropriate case made for it by the same craftsman that the brothers had employed for making clock cases for their mercury escapement clocks. Losing no time, he then completed a timepiece featuring the invention to be presented to the Pontiff.

Pier Tommaso, meanwhile, although equally impressed upon learning of Giuseppe's invention, was less than laudatory about this development. Jealous beyond measure, he became increasingly angry and abusive. It was difficult for him to accept the fact that his younger brother, whom he continued to claim "was still only a novice," had surpassed him in his own art. Even more difficult to accept for Pier Tommaso, was the fact that Giuseppe now not only was about to market his invention independently but also was applying for a papal patent in his name alone. He suspected that Matteo had a hand in his moving so quickly, and this led to more harsh words between them. Although Matteo attempted to heal the breach, he was unsuccessful, and the bitter argument over Giuseppe's invention drove the two brothers further apart. Matteo, while undoubtedly torn by the fraternal dissension that had ensued, nonetheless supported Giuseppe, as having the rights in the matter, and continued to provide him with advice as he proceeded with planned to market his new invention.

With Matteo's assistance, Giuseppe also prepared an application for a papal privilege for the new invention, as he and his brothers had done with the mercury escapement timepiece. Finally, early in January 1658, Giuseppe was ready and delivered his first silent night clock with the innovative crank lever escapement to Pope Alexander VII. Several weeks later, on February 7, 1658, the Pontiff instructed the Vatican treasurer to order payment for it to be made to Giuseppe in the amount of "20 *scudi* for the above-mentioned clock according to agreement and which was delivered."[263]

During the next several months, Giuseppe waited anxiously for a response to his application for a patent. Although the Pontiff has expressed considerable interest and sincere pleasure with the new silent clock, Giuseppe decided it unwise to proceed to market clocks with his new escapement until a protective papal patent had been issued. He had been told that it was not unusual for as much as a year to elapse between the date of submission of an application and a response was received, which might be either the granting of the patent or a refusal. In Giuseppe's case, a full year and seven months elapsed before he received a response granting the patent, dated August 30, 1659. Giuseppe's patented new invention was first formally publicly announced by one of the papal *Editti*, posted on the portals of churches throughout the Christian world. It stated as follows:

Antonio Barberino bishop of Frascati,
Cardinal Camerlengo of the Holy Roman Church

Having His Holiness Our Lord Pope Alexander VII. with his Apostolic letters in form of a brief [*Breve*] sent last August on the 30th [1659], granted the herein reported privilege to Giuseppe Campani, because, by his own efforts, he has invented, [to be placed] in common and ordinary timepieces constructed of toothed wheels, some device or artifice of escapement [tempo] that without the use of mercury, and of whichever other similar fluid materials, or other flowing substance such as sand or other kind of dust, it makes the clock silent, so that one cannot hear the sound usually heard in ordinarily [mechanical] timepieces. Moreover, those clocks that will be endowed with the abovementioned device or arrangement of the escapement (as one can see in a similar clock made by the abovementioned Giuseppe) are different and more perfect than the other silent clocks, equally mechanical [made of toothed wheels], and with a certain phyx with mercury inside, and previously in several occasions publically exhibited in Rome by the abovementioned Giuseppe and by his brother Piertomasso [sic], regarding the making or construction of which mercury-clocks, they obtained from His Holiness that there be granted to them a similar privilege.[264]

In the following text of the edict then was repeated in Latin the same standard phrases as had been contained in the privilege for invention issued to the brothers in 1657. The papal privilege was valid for:

[263] ASV, Sacro Palazzo Apostolico, section "Varia", Registro di ordini a Monsig[o]r Thesoriero, vol. 772, p. 147.

[264] ASV, *Miscellanea, Armadio IV*: *"Bandi"*, vol. 27, fol. 455

a period of ten years by certain letters of ours, in the like form of a Brief, sent the 7th of March 1657, for this device, or artifice of time [escapement] requiring no fluid or flowing material whatsoever. Since, however, as the same petition [*expositio*] added, this invention was not discovered without great and assiduous labor by the above-mentioned petitioner, and Giuseppe fears lest others who seek profit from another's work and industry should usurp it to the grave damage of Giuseppe, and accordingly desires that we provide for him opportunely in these present [matters] and grant what is petitioned below: We, wishing to favor the same Giuseppe with special favors and graces, absolving, and considering that he will be absolved from any censures of excommunication, suspension and [or] interdict, and any other ecclesiastical sentences and penalties inflicted by the law or a judge on any occasion or cause, if he happens to be in any way involved in them, for the effect of these present letters moved by the petitions humbly put forth in his name regarding this [matter], we concede and grant by our Apostolic authority and the contents of these letters to the above-mentioned Giuseppe, that for the next ten-year period no one can make timepieces with the above-described artifice of time lacking noise, recently invented by the same Giuseppe, either in the City [Rome] or in the rest of the ecclesiastical state, mediately or immediately subject to us, even though under the pretext of adding, subtracting or changing anything, or to put them up for sale and sell them if made elsewhere, without the express permission of the same Giuseppe.[265]

The edict stated furthermore that copies of it had been posted in the Campo dei Fiori and in several other usual places. A note appended at the bottom of the sheet assured the public, "The above-described clocks are most exact. And they are made in [Via] Parione opposite the Office of the Vicar [*Incontro l'Ufficio del Vicario*]."[266]

Consequently, when it was learned that young Giuseppe had invented and patented a new form of the silent night clock featuring an entirely mechanical movement instead of mercury, one that operated with complete accuracy and was entirely silent, there was an immediate favorable response. Public announcement of Giuseppe's new invention was made shortly after Giuseppe had acquired his own shop. After its proclamation in one of the *Editti* with the text of the patent, the invention was reported also in the *Avvisi*.[267] The privately subscribed and hand-delivered gossip sheet appeared at irregular intervals. In addition to reporting the social scene in Rome, and particularly featuring current scandals, often it also contained such notices of innovations. As a consequence, the same clientele and others who had been informed now visited Giuseppe's shop in the Parione to see the new timepiece and to purchase it.

[265] Ibid.
[266] Ibid.
[267] ASV, Segreteria di Stato, *Avvisi*, , anno 1659, Roma.

Among those acquiring one of Giuseppe's clocks with crank lever escapement was Grand Duke Ferdinand II of Tuscany, as reported in the account of the famous Milanese collection of Manfredo Settala, in which also was mentioned the Grand Duke's interest in pendulum clocks. It reported that in the ducal collection was "a very fine clock similar to the one which the craftsman Campano [sic] made most ingeniously, with a pendulum, to the order of His Holiness Pope Alexander VII. A most praiseworthy and striking invention, not so much on account of the ingenuity of the work, as of its infallible indication of time. In the great silence of the night it also is quiet, and does not interrupt the repose of mortals; and if anyone, waking, desires to know the number of hours passed, here is his desire fulfilled, for, shining through the darkness, it shows the number of the hours."[268]

Giuseppe's earlier participation with Pier Tommaso in the production of the mercury escapement night clocks had been financially lucrative for both of them. Shortly thereafter, Giuseppe's invention of the crank lever escapement, by the time that he was only 23 years of age, placed him prominently among the most specialized artisans in Rome. He had made such remarkable progress in a technical field, to the degree to which others would have been content to settle into such a distinguished career for the remainder of their lives. Considering his origins, as a farm boy with limited education growing up in a remote provincial hill town, he was well along the road to success.

Giuseppe undertook short trips from time to time back to Castel San Felice to visit his father and perhaps remaining boyhood friends as well. Undoubtedly, his mind occasionally compared his present existence with memories of the simple life of his earlier years. The contrast with the active new world he now inhabited must have been overwhelming. It was now filled with constant activity that contrasted sharply with the even tenor of his pastoral origins. He found himself with a prominent role in a new world peopled with many eminent virtuosi engaged in the sciences or the arts, and with frequent association with the Vatican.

Giuseppe's natural reticence and sense of privacy, supported by Matteo's concerns for maintaining the confidentiality of his endeavors, served him well and

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[268] Paolo Maria Terzago, *Museo, ò Galeria, adunata dal sapere e dallo studio del sig. canonico Manfredo Settala nobile milanese*, trans. Pietro Francesco Scarabelli (In Tortona: Per li figliuoli del qd. Eliseo Viola, 1666), Chapter VI, 25-34. Baillie, *Clocks and Watches*, 74.

became a permanent characteristic of his personality, often observed by others. As noted, in seventeenth century Italian society, skilled craftsmen—such as goldsmiths, jewelers, and makers of clocks and scientific instruments—were for the most part associated with patrons of substance. They, as well as others who worked independently like the Campani brothers, achieved a social status substantially elevated from members of the working classes. Although some prospective purchasers wishing to place an order might send a page or other servant to summon the clock or instrument maker to his residence to receive instructions, others occasionally came in person, often interested in observing the work in progress because a number of factors regarding specifications and detail required decisions before the work was completed. As a rule, the work was not completed in advance on speculation because of the time and effort involved in construction as well as the cost of the clock case and decorative elements.

Over the course of the next several years, upon the urging of Matteo and his Jesuit friends, Giuseppe began to direct some of his attention to serious scientific studies, dividing his time with commissions he fulfilled for timepieces with hours devoted to study at either the Collegio Romano or the papal university La Sapienza. During this period, he produced several silent night clocks equipped with his crank lever escapement for the Pontiff and members of his family as well as others for members of the papal court. One feature of Giuseppe's clocks equipped with the crank lever escapement is that they were recognized to be remarkably accurate timekeepers. The clocks that Giuseppe made that had been commissioned by Pope Alexander VII, his brother, and his nephews were distinguished in every instance by a gilt brass pendulum bob in the form of an eight-pointed star, featured in the Chigi family coat of arms.

Despite the envy and annoyance aroused in Pier Tommaso by his "untrained" younger brother's brilliant invention of the crank lever escapement, he too lost no time in taking advantage of the opportunity to exploit it by developing his own version of the crank lever escapement. Although derived from the same principle, he was careful to ensure that it assumed a form that varied sufficiently and would not violate Giuseppe's patent. Thus, it enabled him to abandon the silent night clock with mercury and produce silent night clocks with his own form of the escapement, which he featured thereafter in his silent night clocks. Although lacking the simplicity of Giuseppe's version, it nonetheless was successful, and he continued to use it in night clocks he made thereafter.

Pier Tommaso's modification of the crank lever was unquestionably a violation of Giuseppe's patent, since the basic principle was the same, and it is significant that he made no attempt to patent his version. Although Giuseppe had reason to sue his brother for patent violation, he did not do so. Soon both Pier Tommaso and Giuseppe added the features of a striking mechanism and an alarm to some of their silent night clocks, so that they could strike the hours, or be silenced, and also be provided with an alarm when required, yet remaining classified as silent night clocks.[269]

The unhappy private conflict with Pier Tommaso occasionally depressed Giuseppe as time went on, as did lingering reverberations of Divini's enmity. He found refuge by retiring to his clockmaking work as well as in his new program of studies of the optical sciences. As a consequence of the income he had derived from the overwhelming success of the mercury escapement and later of his crank lever night clocks, he now found himself in extremely favorable financial circumstances.

Anxious to promote his crank lever invention beyond the confines of Rome, Giuseppe contemplated the possibility of bringing it to Florence to the attention of Grand Duke Ferdinand II, known for his interest in the sciences. By means of the Grand Duke's influence, he might be brought to the attention of the Accademia del Cimento, the scientific society that the Grand Duke and his brother Prince Leopold sponsored. Giuseppe also had in mind that both the Grand Duke and his uncle, Cardinal Carlo de' Medici, had purchased mercury escapement night clocks from the Campani brothers and, consequently, should be interested to learn of the new invention that superseded them. Such a course of action may have been suggested to Giuseppe by Matteo, or by one of their Jesuit associates, possibly Daniello Bartoli, who had demonstrated an interest in Giuseppe's career.[270]

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[269] [Scientific Editor 2: An examples of night clock by Giuseppe Campani with alarm, is held in Antonio Lenner's collection].

[270] Giuseppe Campani, *Ragguaglio di due nuove osservazioni una celeste in ordine alla stella di Saturno ; e terrestre l'altra in ordine a gl'istrumenti medesimi, co' quali s'è fatta l'vna e l'altra osservazione. Dato al sereniss. principe Mattia di Toscana da Giuseppe Campani da San Felice dell'Vmbria di Spoleto* (In Roma: Per Fabio de Falco, 1664), 8–9.

Hopeful of obtaining a letter patent also from the duchy of Tuscany, Giuseppe made elaborate plans for his travel to Florence. He took with him his pendulum regulated neck watch and a clock equipped with his new crank lever escapement, which he was prepared to demonstrate to the Grand Duke. It would be the first time that he was traveling any great distance, and he may have been accompanied by Matteo. Preliminary travel arrangements were made through either the office of Cardinal Carlo de' Medici or of the Medici representative at the papal court.

The sights Giuseppe encountered on his journey dazzled the young clockmaker, as did the sculptures and other art wonders in the city, about which he had heard and that now he viewed firsthand. Despite the excitement of the journey to Florence and his visit to the Medici court, where he had been received by the Grand Duke himself, Giuseppe met with disappointment, as he explained after his return:

> Since this appeared to be an invention that was very useful and beautiful, I brought it to the Grand Duke of Tuscany but his Serene Highness, rising my incredulous amazement, showed to me a clock of similar artifice constructed from one of his own inventions, indicating to me that the Grand Duke with his own studies and applications had ingeniously invented the same that I had discovered by chance. Then he showed me a print of a similar clock although different in some aspects, being an invention made in Holland by Christiaan Huygens, and finally, to honor me even more, his Serene Highness showed me a large old chamber clock constructed by Sig. Galilei which had similarly the pendulum for regulator, which, although being moved in a manner not so perfect, as was his own, and also quite different from the clock of the Dutchman [Huygens], it could not be denied nevertheless that this also was a pendulum clock. And it is necessary in consequence to confess that Galileo had been the first inventor of pendulums and of their application to ordinary clocks and that the Grand Duke had made the first which gave it the necessary disposition and simplicity which was lacking in the clock of Galileo [...].[271]

According to Giuseppe's account, he became aware that he had been the first clockmaker in Rome to invent and display a timepiece similar to that already invented by the Grand Duke of Tuscany—that is to say, the modification of the Galilean model made in fact by Johann Philipp Treffler that utilized a pendulum regulator. Giuseppe had independently applied the pendulum as regulator without having had any prior knowledge of the aforesaid three inventions, namely, those made by Galileo, by Huygens and. by the Grand Duke (actually by Treffler). The claim expressed to Giuseppe by the Grand Duke, of having made a similar clock of his own invention to which had been adapted the principle of the Galilean model and completed to indicate hours and minutes,

[271] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 17-19.

may be construed to mean that it was one that Treffler, his court mechanician, had been commissioned to produce based upon the principle embodied in the Galilean model and to which he may have added elements derived from other sources. It may be further explained by a passage found among Viviani's papers:

> His Serene Highness the Grand Duke, always the perspicacious promoter of whatever was useful and new, showed himself to be curious for some means of having the number of the vibrations of the pendulum—the free and natural pendulum—without tediousness and with assurance—that would have motivation without (as did Galileo's clock) connection with or dependence upon extraneous sources [...]; Filippo Treffler of Augsburg, most ingenious and perfect artisan, in truth so deigned by many princes, from this active beginning fabricated that gracious little machine [...] that in order to conserve the motion of this pendulum by a same verticality, proposed and put into operation various inventions [...] the aforesaid Filippo adapted the invention to a chamber clock for His Highness that showed the hours and the minutes [...].[272]

The Grand Duke, however, may have been referring to a clock made by the Dutch clockmaker Salomon Coster (c. 1620–1659), which Giuseppe may have misunderstood the Grand Duke to claim as his own invention. A year earlier, the Grand Duke had received as a gift from the King or Queen of Poland, conveyed through Tito Livio Burattini, such a clock made by Salomon Coster in 1657. The print shown to Campani was a copy of the published engraving that had been sent to Prince Leopold in 1658 of the pendulum-regulated clock invented by Huygens illustrating his work, later inserted in his *Horologium Oscillatorium sive de Motu Pendulorum ad Horologia Aptata Demonstrationes Geometricae* (1673).[273]

Despite Giuseppe's disappointment upon learning that his invention of the pendulum regulator had in fact been pre-empted by others, he nonetheless submitted a petition to the Grand Duke requesting a letter patent for his new invention from the Duchy of Tuscany. Although the pendulum regulator had proven to be a prior invention that preceded his own, the crank wheel escapement was nonetheless a new invention that was entirely his own and justified the issuance of a patent. The Grand Duke approved, and the Tuscan privilege for invention was granted on April 14, 1660. It was in the form

[272] Letter from Viviani to Prince Leopold, August 20, 1659: Antonio Favaro, *Amici e corrispondenti di Galileo Galilei*, vol. 19. Vincenzo Viviani (Venezia: Officine Grafiche Carlo Ferrari, 1912), 658–59.

[273] Christiaan Huygens, *Oeuvres Complètes de Christiaan Huygens* (La Haye: M. Nijhoff, 1888), Tome XVII, 37-38; Tome III, 94.

of a statement addressed to the Grand Duke from Giovanni Battista Gondi of the Medici court who had written and signed it on April 16th. The purpose of the document was:

To inform [Your Serene Highness] that Giuseppe Campani by means of the enclosed memorandum [*Memoriale*] proposes to have discovered an invention of silent clocks, and requests that if your Highness concedes a Privilege that for ten years no one in the felicitous States of Your Highness can work or construct or sell such silent clocks of any type, concerning which a number of Professors of the art of clockmaking in the Galleria were consulted and who have responded that they have nothing to say against this privilege. Inasmuch as Your Highness generally concedes privileges for new inventions, it is represented that a privilege can be conceded to Campani for ten years with the usual conditions that the invention is truly a new one, and that no privileges have already been granted to others for it.[274]

As noted therein, Campani's petition to the Grand Duke had been reviewed by the Palace clockmakers, probably including Viviani and perhaps Treffler, prior to granting formal approval for a patent. It was specifically noted in an entry at the bottom of the document that the privilege was conceded for 5 years, instead of the period of 10 years that Gondi had recommended.

Among Giuseppe's clients for silent clocks equipped with his new invention of the crank lever escapement was the second wife and widow of King Felipe IV of Spain, Doña Mariana of Austria, who served as regent during the minority of her son Carlos II. It was one of two clocks she subsequently presented as gifts to Don Fernando de Valenzuela, her prime minister and court favorite. In an inventory listing his possessions, which included a great number of timepieces, the silent night clock was subsequently described as: "A light[ed] clock, with pendulum, made by Giuseppe Campani in Rome, with a case of ebonized pearwood. Appraised by José Mateo, clockmaker of the Queen Doña Mariana, at 2,500 reales of *plata de vellon*."[275]

Fernando de Valenzuela (1630–1692) had been born in Naples and had established himself at the Spanish court by his marriage to Maria de Uceda, a lady-in-waiting to Doña Mariana. In 1671, the Queen appointed Valenzuela "introducer of ambassadors," after which anyone having a petition to the throne was required to apply through him. He became the duende of the royal palace, and it also was believed in court

[274] ASF, *Arch. dell'Auditore della Riformagioni*, filza 45, cc. 498–499r-v.

[275] Luis Montañés, 'Los relojes de don Fernando de Valenzuela : una notable colección, reunida en el s. XVII', *Cuadernos de relojería* 4, no. Julio, agosto, septiembre (1955): 12. [Scientific Editor 2: 2 *reales de vellon* = 1 *real de plata* or silver *real*]. Two clocks by Giuseppe Campani, were included in the inventory of the properties of Don Fernando de Valenzuela: they were evaluated 2,500 (the one here taken in account) and 3,300 *reales de vellón*. Archivo de Palacio, Madrid, Leg. 16, fol. 413v;

circles that he was the queen's lover. After he had been dismissed from the court in 1675 for intrigue, the queen made him Marquis of Villa Sierra and appointed him ambassador to Venice. Subsequently he became governor of Granada. Then Valenzuela organized a court intrigue that enabled him to return to the Spanish court. The Queen regent next appointed him prime minister and made him a grandee, over the strong objections of the older grandees. During the palace rebellion of 1678, he fled to the Escorial, was captured, degraded, exiled to the Philippines, and all his property was confiscated. He died in Mexico in 1692.[276]

Valenzuela's silent night clock may in fact be the one that is presently in Rome in the Salón Azul of the Embassy of Spain to the Holy See. The movement's back plate is inscribed in the usual manner, "*Joseph Campanus inventor Romae 1659*." The addition of the date indicates that this clock was among the earliest that Giuseppe made with his new invention. The dial painting features a religious scene from the Old Testament that appears to represent the story of the prodigal son. The dial opening consists of a semi-circle having two openings for the numeral disks, which are attached in the earliest form used by the Campani brothers. The original crank lever escapement is missing and has been replaced with a crown wheel and verge with pendulum attached directly to the verge staff. The clock case of tinted pearwood is of the simplest form, consisting of the door with the dial painting on the reverse side of which the movement is attached. It is likely that the original case was more elaborate and that at some time in the course of the years it had been damaged and segments were saved to create the present case while the remainder was discarded. It is to be noted that the rear wall of the case is lined with a sheet of metal as a fire preventative and that the chimney of the original lamp remains.[277]

An illuminating report on the night clock with mercury escapement of the Campani brothers, as well as a passing reference to Giuseppe's night clock with crank lever escapement, was provided by Pierre Guisony, who, as noted earlier, had in his correspondence with Huygens reported having seen the "material sphere" in Campani's shop. In his report of the same visit he had made to Rome in the spring of 1660, he wrote:

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[276] Ibid. Real Academia de la Historia (Spain), 'Colección de documentos inéditos para la historia de España' LXVII (1877): 297 and followings.

[277] Rome, Embassy of Spain to the Holy See, Salón Azul. [Scientific Editor 2: Among Bedini's corrispondence there are some letters from the 1980s from the Spanish Embassy to the Holy See and from the Spanish Government about this enquiry.]

Someone told me in Florence that for some time pendulum clocks have been found there and they even drew a rough pencil sketch of one for me that Galileo had made relating to that invention. Here [in Rome] I have found an artisan who not only makes them with pendulums, but even which do not make even a single sound at night, with the advantage which yours have, of being wound without losing time, and a thousand other refinements. He showed me the three that the Grand Duke of Tuscany had commissioned from him, and one that he repaired for the King of Spain [Felipe IV]; he has a brother [Matteo] who is a mathematician, with whom we talked about you: he asked me to greet you when I write to you, and since he is about to publish a treatise on clocks, without doubt you will not be forgotten. He [Giuseppe] has two inventions to make clocks silent, the one by putting a measured quantity of quicksilver into the drum which is pierced with openings and divided into little compartments, pierced within by some little holes so that this substance does not flow so quickly from one compartment to the other, and that consequently, the cord which is rolled around it, and to which are attached the counterweights, unwinds only slowly. (I call them counterweights, comparing them with the weight of the mercury which they are to overcome). By means of these it does not make use of the crown-wheel, nor of that verge which has two little pallets that cause all the noise in this type of apparatus. Truly, clocks of this type are not wound without loss of time, but I find that one can perfect them on this point, if one were to use a double cord, as you do, and a small counterweight in place of the mercury, that it was necessary to take away from the drum. As for the second invention, that he could eliminate the noise without mercury and using a pendulum, I leave to you to clarify in your study.
Yet I find that of beauty in his clocks, in which he causes the hours to pass by means of a circle, without using a clock hand, and thus it never seemed any more than was necessary. You will be very pleased to read two words of this, that I have seen others of them, that are certainly the same invention. One makes use of the round tablet [sic] raised in front to show the clock, in the center of which inside is stuck the lower part, for example, of a pentagon, if one only needs to indicate up to six hours: at each of the sides of the pentagon corresponds and rests a little piece of wood which bears some one of the hours, and all these pieces are strung together with an iron wire around the pentagon; from the way that this adorns this type of instrument, one calls them chaplet in hydrostatic. Now if one moves this big tablet necessarily in one turn a piece of the string of beads [chaplet] will advance itself in place of its neighbor, because there are only five places, and because there are six little pieces to be placed. Thus if one makes a hole in the big disk which corresponds to one of these little pieces that are inside, all the hours will appear successively in their order, even during the night in a dark room, if one keeps a lamp lit inside the case which contains all the mechanism.[278]

Guisony's sojourn in Rome in 1660, during which he visited the shop of Eustachio Divini and later that of Giuseppe Campani, proved to have occurred at a particularly fortuitous time for the latter. The issuance of the *Iudicium* in 1658 that officially had resolved the bitter conflict between the two artisans had been succeeded in the next year by Giuseppe's invention of the crank lever escapement for his silent night clocks, upon examples of which he was at work at the time of Guisony's visit and which Guisony failed to explain to Huygens.

[278] Letter from P. Guisony to C. Huygens on March 25, 1660, in Huygens, *Oeuvres Complètes de Christiaan Huygens*, 1888, Tome III, nos. 732, 46–47.

Guisony's report revealed that although he had been provided with a detailed view of the mercury escapement night clock, its motive power, and its dial arrangement, he was not shown the mechanism of the night clock with the crank lever escapement nor were its details described to him. Guisony appears to have become confused between the two brothers Matteo and Giuseppe and their individual accomplishments.

During the next several years subsequent to his invention of the crank lever escapement, Giuseppe devoted his efforts primarily to the production of silent night clocks and day-and-night clocks incorporating his new invention for important clients. He now protected the privacy of his workshop even while working alone as a clockmaker, as he was later to do as an optical instrument maker, excluding everyone except Matteo from his place of work and jealously guarding the secrets of his techniques. Because of the location of his shop situated directly opposite the rectory in Parione, he had the constant cooperation and support of his brother Matteo, who not only appeared to have taken charge of Giuseppe's public relations but who also from the very beginning had assumed the role of promoter of his work. From the time that Giuseppe began working as an independent clockmaker producing clocks on his own and during the next several decades, until about 1677, Matteo's rectory continued to serve as a show room for display of examples of Giuseppe's new inventions, where Matteo pridefully demonstrated them to potential clients and men of science.

Matteo's role as Giuseppe's mentor and manager is reflected frequently in his correspondence, such as in a letter from Matteo to Prince Leopold in June 1660. He wrote regretting that he had been unable to forward the clock that the Prince had commissioned from Giuseppe because the painting of the dial plate had proven to be unsatisfactory and had to be made anew. If delivery of the timepiece was to be further delayed, he wrote, it could be due only to "my desire to satisfy the orders given by His Serene Highness to Monanni on account of the dial painting; [...] and despite the continued solicitations from him as well as from me, it has as yet not been possible to obtain the courtesy due Your Excellency".[279]

[279] BNCF, Ms. Gal. 276, c. 32r. Letter from Matteo Campani to Prince Leopold on June 19, 1660. See also: Enrico Morpurgo, 'Una lettera di Matteo Campani', *La Clessidra*, no. August (1956): 12–13.

Giuseppe's early success at the age of his early twenties assured his future as a prominent clockmaker in the Eternal City. In addition to Pope Alexander VII and his two nephews, numbered among his clientele now were other wealthy princely and clergical patrons attracted by his work for the Pontiff. Among Giuseppe's early papal commissions was one for two clocks that he completed and delivered in the autumn of 1659. On October 22, Pope Alexander VII ordered the Vatican's Monsignor Treasurer General "to pay the sum of 140 *scudi* to Giuseppe Campana [sic] to be delivered in person as the price of our two clocks made by him in the service of His Holiness according to agreement and which have been delivered."[280]

An interesting anonymous and undated document surviving among the papers of Pope Alexander VII preserved in the Chigi family archives in the Vatican Library describes the two clocks Giuseppe made for the Pontiff:

Concerning the new Silent Clocks, and relating to others not silent [noisy] which have, like the former, the pendulum for regulator.

First it is necessary to advise that no automatic clock, that is, made with materials, or self-propelled [automatic] instruments, whether the motive power proceeds from a weight, or is due to a spring, or of whichever other artifice, for the past, succeeds perfectly accurate: Therefore, in all as much the same things, which give measure to time (and which is, that which came to be called the Tempo [escapement] of the clock) is by itself variable and alterable, as can clearly be seen in everything used until now to regulate all the automata.

Therefore, the astronomers seeing themselves deprived of the perfect clock necessary for them for measuring exactly the duration of an eclipse, for example, or of an ascension, or when the setting of a star occurs [*occaso*], go seeking of such measure the sound of the beats, which during the time in all observations, is given by the pendulum bob suspended by a fine thread that is vulgarly called the Pendulum.

Secondly, one should be aware that each clock (even if poorly made), even if it is capable to conserve the motion once conceived, which is regulated by a Pendulum, that it has for a regulator the Pendulum, will be infallibly exact, which by invincible reason can be demonstrated, and with the same experience can be seen in two clocks of this type displayed to His Holiness our Holy Father.

Thirdly, the above mentioned clocks are adjusted to their proper measure by raising or lowering by its screw threads the hanging ball [bob]; because inasmuch as when its hands are furthest from the clock [lowest] more time is required for its vibrations. And finally for the two above-mentioned clocks, one should be advised that they were made with that rule and disposition, that every full beat of that Pendulum, that is, one going and one returning of the bob, is one second; that 60 full beats constitute a complete minute, 900 beats constitute one quarter of an hour, and 3,600 constitute a full hour.

[280] ASV, Sacro Palazzo Apostolico, section "Varia", Registro di ordini a Monsig[o]r Thesoriero, vol. 773, p. 1111; Ozzola, *L'arte alla corte di Alessandro VII*, 79-80. The disparity in price of the clocks (only 20 *scudi* for the one paid on February 7, 1658) was probably due to the degree of elaboration of the individual cases, some of simple structure and others decorated with *pietre dure* and gilt bronze additions.

Therefore, with the said clocks it is possible to measure exactly the fastest motion [*corsi velocissimi*] of whatever one wishes to be mobile, and we can use them for other various curiosities.[281]

Little is to be learned from the document, however, except that it discusses the application of the pendulum as a new invention capable of regulating the motion of a clock much more accurately than did the commonly used balance wheel, which was kept in motion only by the winding of the clock without having in itself an independent regulatory ability. There can be no doubt that the author of the document was Giuseppe Campani, and that it related to the two clocks he had delivered to the Pontiff, for the description of the vibrations and beats of the pendulum are extremely similar to passages in Giuseppe's *Discorso*. It is to be noted, furthermore, that the pendulums in Giuseppe's crank lever clocks also beat seconds, requiring one full second for a swing and return.[282]

Giuseppe's crank lever escapement was first publicly noted in 1664 in a publication by the Jesuit scholar Kaspar Schott (1608–1666), published just 6 years after Giuseppe had invented it and for which he had obtained a papal privilege for invention. Schott was a professor of mathematics at Würzburg who wrote about all of the physical sciences then known in an effort to cover all human knowledge. Giuseppe's escapement was one included among the *Mirabilia Chronometrica*, but it is difficult to identify the escapement from either the illustrations or the text from among those illustrated and described in Schott's remarkable compendium entitled: *Technical Curiosities or Artificial Wonders, comprised in XII books; in which are set out divers Experiments, and diverse Pneumatic, Hydraulic, Mechanical, Graphical, Geometrical, Chronometrical, Automatic and Cabalistic Constructions and other secrets and marvels of Artifice, rare, strange, ingenious and, for the greater part new and hitherto unknown, for the use, delectation and discussion of the learned*.[283]

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[281] BAV, Archivio Chigi, Vol. E VI 205, fol. 275.

[282] Morpurgo, "Orologi del Campani in Vaticano." Morpurgo was unaware of the pope's purchase of the two clocks in 1659 and assumed that the document related to another clock that has remained in the Vatican's collection to the present, now stored in the Ufficio della Floreria.

[283] Schott, *Technica curiosa,* vol. 2, book IX, M*irabilia Chronometrica*, 617–727, pl. III, fig. 10 (1664); Paul M. Chamberlain, *It's about Time* (New York: R.R. Smith, 1941), 199–201. Schott's pl. III, fig. 10 illustrates a crank lever escapement, undoubtedly based upon Giuseppe's invention. The letters A, B, and C represent a bell crank pivoted to the frame at A and driven by the crank D revolving about the center E. The pinion H and crank K appear to be superfluous and remain without explanation.

Schott had collected descriptions of a large number of horological movements for this work, the sources of none of which he identified. The chapter on the pendulum, for example, failed to mention Huygens, who had published on the subject only six years previously. It is obvious that the artist who provided the drawings for Schott had not in some instances even seen the devices that he illustrated and that he lacked understanding of their functions, for apparently occasionally he had parts left over, without attributed purpose.

In 1670, some six years later, the crank lever escapement was again noted, this time by Francesco Lana Terzi (1631–1687), Jesuit professor of physics and mathematics, in his published collection of descriptions of new horological inventions. This was a work impressively entitled: *A Selection of Some New Inventions. A Work by Father Francesco Lana, Jesuit of Brescia, to show the hidden principles of Natural Philosophy in accord with exact theory in the most remarkable inventions and experiments hitherto discovered by writers on this subject, and some new ones by the author himself*.[284]

Lana's work was made famous for his remarkable design that was included of an airship. It was the first scientific attempt to represent lighter-than-air aircraft and the first logical formulation of the balloon problem, as well as his equally interesting prophecy for its military possibilities. Lana described the crank lever escapement in "A clock with pendulum connected by a crank to the last wheel"[285]. Although his account of it was published within only a decade after its invention and the issuance of a patent, Lana did not identify the inventor nor the occasion.[286]

The crank lever escapement was reinvented several times in the eighteenth and nineteenth centuries and was featured in several published works on horology. Almost a century after Campani's invention, in 1741, it was illustrated and described in a series of watch and clock escapements in Volume I of the *Traité d'Horlogerie, Mechanique et*

[284] Francesco Lana Terzi, *Prodromo, overo, saggio di alcune inventioni nuove premesso all'Arte Maestra. Opera che prepara il P. Francesco Lana, Bresciano della Compagnia del Giesu. Per mostrare il piu reconditi principii della Naturale Philosofia, reconosciuti con accurata Teorica nelle piu signalate inventioni, ed esperienze fin'ora ritrovate da gli scrittori de questa materia altre nuove dell'autore medesimo* (Brescia: Per il Rizzardi, 1670).

[285] Ibid., 71–72.

[286] Francesco Lana Terzi was a member of a noble family settled in Brescia [Venetian Republic]. He entered the Jesuit order and was one of the most distinguished men of science of his day. He was professor of mathematics at Ferrara [Papal States] for a time. Cesare Preti, 'Lana Terzi, Francesco', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 2004).

Pratique by Antoine Thiout the Elder, advertised as Clockmaker to the dowager Queen of Spain and to the Duke of Orleans. He noted that this escapement was used in night clocks because it is said they made little noise.[287]

A decade later, in 1751, a version of the escapement was again described, this time by l'Abbé Bernard-Laurent Soumille (1703–1774) as the "*Échappement de Pendule*". It appeared in the *Histoire de l'Académie Royale des Sciences pour l'Annee 1746* (published 1751) publications of the Académie Royale des Sciences in 1746, and from which it was reproduced in Gallon's *Machines et Inventions* in 1777.[288]

The crank lever escapement once again came to attention late in the eighteenth century in an article entitled "A crank to answer the purpose of an Escapement in Clocks", by Simon Goodrich. Goodrich's version interposed springs between the crank and the crutch. In 1814, Edward Massey invented "Massey's Escapement," which was described as a crank lever escapement but was not related to Campani's invention.[289]

Essentially, the crank lever escapement is quite simple. It can be likened to a clock's striking train, at the end of which is a "fly" or speed governor. In the Italian night clock, the fly often takes the form of a bar balance or dumbbell, and one of the pivots of its arbor is extended through the clock plate to receive a disc that is secured to its extremity. A pin driven eccentrically into the face of the disc carries a pivoting crank arm, the other end of which engages a similar pin located a short distance below the clock pendulum's fulcrum on the face of the pendulum rod. The eccentric pin converts the

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[287] He described the crank lever escapement in the following words: *Le Rouage du mouvement est composé comme celui d'une Sonnerie. Le Pivot du dernier Pignon porte quarrément le Chaperon A sur lequel est placée une Cheville qui entre dans le bout du Levier B qui faqit charniere en C, & qui se meut dans le petit Cocq D, de sort que le Chaperon A tournant toujours du même cé fait le meme efft qu'une Manivelle, qui oblige le Pendillon G à aller du coté E & F, il porte une Cheville qui entre dans une ouverture longue fait au plat du Pendule pour le maintenire en* vibration; Antoine Thiout l'aîné, *Traité de l'horlogerie, méchanique et pratique, approuvé par l'Academie Royale des Sciences, par Thiout l'ainé, maitre horloger à Paris ... Avec figures. Tome premier [-second]*, 2 vols (A Paris: Chez Charles Moette, 1741), v. 1, 89–112, pls. 39–44, fig. 6.

[288] Jean-Gaffin Gallon, *Machines et inventions approuvées par l'Academie royale des sciences, depuis son établissement jusqu'à present avec leur description. Dessinées & publiées du consentement de l'Académie, par M. Gallon. Tome premier[-septième]* (A Paris: Chez Gabriel Martin, 1735), vol. 7 (1777), 325-34, where it is reproduced Bernard-Laurent Soumille's 'Echappement de pendule', *Machines et inventions approuvees par l'Academie Royale des Sciences.*, 1751.

[289] Simon Goodrich, 'A Crank to Answer the Purpose of an Escapement in Clocks', *Transactions of the Society of Arts* 17 (1799): 327–32; Thomas Young, *A Course of Lectures on Natural Philosophy and the Mechanical Arts* (London: Printed for Joseph Johnson, by William Savage, 1807), vols 2, 194.

disc's rotation to a linear reciprocating motion of the crank arm, a motion that is transferred to the pendulum rod to give the required oscillation.

While the speed of a clock's striking train is regulated by its fly, the true regulator of the crank lever escapement is not its fly, but the pendulum. The fly here serves to prevent the fluctuations of power delivered to the crank by acting as a damper, absorbing surges and supplementing any short-term dearth. While this generally ensures a constancy of the pendulum's oscillation, there is still a minor tendency for the train of wheels to "drive" the pendulum, thus overcoming the pendulum's natural regularity. Such a situation is abhorrent to precision timekeeping.

In fact, over a period of time, the crank lever escapement had scant distribution although it provided some interest in the succeeding century. One form or another of the crank lever escapement has been reinvented even as late as the twentieth century, but in each instance it has had a limited application. In recent times, Major Paul M. Chamberlain in his volume *It's About Time* illustrated and attempted to explain some of Schott's escapements, including the crank lever.[290]

An interesting fact about seventeenth century Italian clocks originally equipped with a crank lever escapement is that in none of them does the escapement appear to be repaired or have been replaced with another crank lever. The problem appears to have been that the mechanism provided too much of a problem for the local clockmaker to repair it, who being unfamiliar with it and to save time proceeded to replace the damaged escapement with a common dead beat escapement, which was much easier to use. Extremely few of the silent night clocks by Giuseppe or Pier Tommaso Campani have retained their original crank lever escapement intact.

In clocks that Pier Tommaso produced after 1659, and equipped with his new silent escapement and pendulum regulator, he also replaced the common circular balance with a modified form of bar balance, confirming a prior familiarity with the bar balance, which he may have utilized for his pre-pendulum-regulated clocks.

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[290] Chamberlain, *It's about Time*, 199–201.

Chapter VII

A HOUSE DIVIDED

(1658-1660)

Three are the notable differences between these silent Clocks of mine, and others that are ordinary and common: the first concerns the precision and equality of the movements; the second pertains to the display of the hours; the third refers to the human use and convenience.

Giuseppe Campani, *Discorso ... intorno a' suoi muti oriuoli ...*
(Per Francesco Moneta, Rome, 1660)

Pier Tommaso had become well-established in Rome in the next several years after his arrival in Rome from the Umbrian hills. As a fashionable clockmaker, his specialty of costly, complicated clocks and automata were bringing him recognition, initiated particularly by the several elaborate timepieces he had produced for the newly elected Pontiff and also due in part to his recent position as a clockmaker employed in the Apostolic Palace. The invention of the silent night clock brought greater public awareness to his work, particularly from members of the papal court and foreign embassies in Rome.

One of the latest timepieces that Pier Tommaso is known to have made for Alexander VII was identified in the Vatican treasury records as "a clock given by him for the use of Alexander VII," for which Pier Tommaso received payment of 100 *scudi* on February 26, 1657, from the Vatican treasury. This clock was another of Pier Tommaso's elaborate timepieces probably equipped with automata.[291]

The income of the two clockmaker brothers from their endeavors had been not only substantial but also sufficient to enable Pier Tommaso to terminate his employment at the Vatican and establish his own quarters, into which he had moved from his brother's rectory. Pier Tommaso's plan for marriage had effectively separated the brothers, and

[291] González-Palacios, *Fasto romano*, 151; Ozzola, *L'arte alla corte di Alessandro VII*, vol. 31, 80.

consequently, each had developed his own clientele. Now about 22 years of age, Giuseppe already had demonstrated his competence as a mechanician and clockmaker.

Prior to the time that Giuseppe became an independent clockmaker and had begun to fulfill commissions on his own for the Pope and members of Chigi family, Pier Tommaso had produced clocks for Pope Alexander VII. In 1656, Pier Tommaso produced a clock featured as part of an ebony *studiolo* decorated with agates and other stones, having six columns with gilt copper bases and capitals supporting as many statues, all similar. Made "for the service of His Holiness," he received payment for it on January 19, 1656, and in the following year he made another timepiece for the Pontiff.[292]

Thereafter, however, Pier Tommaso received few if any more commissions for clocks from the Pope, nor from the Medici princes in Florence. Pope Alexander VII and his Chigi nephews as well as the Medici princes thereafter seemed to have purchased clocks exclusively from Giuseppe. No reason is apparent for this loss of clientele by Pier Tommaso, and he continued to maintain an elite clientele among wealthy patrons in the city and elsewhere.

Following the birth of Pier Tommaso's child and the subsequent death of his wife in 1658, despite Pier Tommaso's apparent professional success—or perhaps because of it—it was during this period that he began to experience other serious family difficulties. His success in business was reflected in his new home and fine workshop, and at this time he may have employed one or perhaps two shop assistants. He was extremely successful and amassing substantial income from his work. For some reason, however, for which no explanation has been found, he was constantly in need of money. Over a long period of time he had been borrowing large sums from his father. The cause for the need for these loans is not known. He may have been gambling and losing large amounts in the process, success may have made him overconfident and extravagant, or there may have been some other reason.

Whatever may have been the source of his problem, a serious breech developed between Pier Tommaso and his father in Castel San Felice. Whatever justification he may have had, as a consequence of the quarrel, Pier Tommaso proceeded to take the unusual and shocking action of suing his parent. Although the cause that led to this action was not

[292] Ibid.

specified, details of the conflict and its resolution are revealed in a notarial act of "Agreement between Angelo and Pier Tommaso Campani, executed in Rome on March 22, 1659." The action was taken by Angelo in response to the lawsuit that his son had brought against him but did not describe its exact nature. Angelo's act stated that Pier Tommaso had received many loans of money from his father, finally amounting to a considerable sum that now the son was unable to repay. Thereupon Angelo decided to deduct this debt from the portion of the inheritance that would be due to Pier Tommaso upon Angelo's death. Because the act concerns a most unusual if not unique situation, it is quoted in its entirety:

Pier Tommaso Campani, son of Angelo of Castel San Felice in the Diocese of Spoleto, of his own will and with the permission of his father, Angelo, has lived for several years in Rome with his brother Reverend Matteo—parish priest of San Tommaso in Parione—and his other brothers until 1656. During that time Pier Tommaso has always practiced the art of clockmaking; in the practice of this art, Pier Tommaso has until now earned a considerable amount of money and, with God's will, he hopes also to continue to do so in the future. In the past two years [since 1657], however, the above-mentioned Pier Tommaso has been living on his own (as he still does with the intention of continuing to do so, as he affirms), living apart from both his father and his brothers mentioned above. Pier Tommaso has always kept for himself all the money that he has earned, and he still has this money in his house and in his workshop located in Via Pellegrini, where he lives; thence he transferred all his goods and the belongings that he had in the previous workshop located in Parione. Moreover, together with the possessions that he has moved to Via Pellegrini, he also keeps in his new house and in his new workshop each and every [part of the] property that had belonged to the dowry of his wife Giacoba Giuditta, as it will be indicated below.

It is sure and certain that the above-mentioned Angelo, father of the above-mentioned Pier Tommaso, anticipating the day of his death, wants and intends to provide for both his own son Pier Tommaso and Giovanni Carlo, son of Pier Tommaso and of the late Giacoba Giuditta, whom I have mentioned previously. Angelo also decided to act in the sake of peace, and therefore he aims to remove the discords existing between himself and his son Pier Tommaso; such dissensions being caused by the lack of respect and obedience that are due to Angelo as a father. Finally, also in order to satisfy all the requests of his son Pier Tommaso, Angelo decided to reach such a decision and have it recorded in a public manner so that the truth will be visible forever.

These are the reasons why, therefore, that the above-mentioned Angelo Campani—personally known to me [the notary Bernardo de Sanctis] and son of the late Proserpio of Castel San Felice—being the father and grandfather of the two above-mentioned men, respectively, having before everyone and everything the complete and full parental authority on every one and each of his sons, grandsons, and descendants (an authority from which neither Pier Tommaso nor Giovanni Carlo can in any way set themselves free), decided and expressly declared that neither his son Pier Tommaso nor his grandson Giovanni Carlo can ever bring a suit against him, nor he himself can bring a suit against them, no matter what the reason or the pretext for doing so might be said to be, or the manner of carrying it out. Moreover, he [Angelo] grants them [Pier Tommaso and Giovanni Carlo] now and forever the permission to live apart and separate from him, and to continue on their own their trades, activities, and whatever else. Furthermore, keeping in mind his last day and anticipating it, and in order to prevent any discord or dissension that might occur between the aforesaid Pier Tommaso and his other sons after his death, Angelo has decided and wishes to assign to Pier Tommaso a complete portion of the inheritance of both Pier Tommaso's parents, in the manner that will be indicated below. Therefore, Angelo, who is Pier Tommaso's father, will grant Pier Tommaso the same amount of money that should be given to all of Pier Tommaso's living brothers, taking the money—divided into equal parts of 300 *scudi* each through a legitimate and Trebellianic partition—from the above-mentioned inheritance of their father and their mother. He [Angelo] also permits Pier Tommaso to keep all and each of the goods that he [Pier Tommaso] has obtained in the manner specified above; he [Angelo] also grants him [Pier Tommaso] all the rights that he has over those goods together with all the money that he [Pier Tommaso] will receive and obtain in the future from his already-mentioned activity and work as an artisan and from the goods that, as just mentioned, have been granted him. Therefore, he [Angelo] renounces spontaneously every and each right over these [i.e., Pier Tommaso's] goods and gives up all the rights to the same Pier Tommaso who is present here and accepts them for his own good and that of his heirs and descendants. To them [i.e., Pier Tommaso and his descendants] Angelo gives all the rights that he has over the goods and the profit that Pier Tommaso has already made or will make through his work, giving up, moreover, all his actions regarding these goods and this profit.

Finally, the same Pier Tommaso—in order to calculate the part of the above-mentioned paternal and maternal inheritances due to him now and in the future and [the part] of the profit that might come out of such legitimate and Trebellianic portion of the inheritance and from any other portion as well that could be due to him in a regular and lawful manner—has admitted and declared that he has repeatedly received from his father, the above-mentioned Angelo, a relevant sum of money that he [Pier Tommaso] cannot pay back easily at the moment. Moreover, he [Pier Tommaso] has admitted and declared that—in place of the remainder of the portion due to him of the above-mentioned paternal and maternal inheritances and giving up every other sum that he might request from his father for any reason or on any occasion (and therefore as a complete and final payment to be registered now officially)—he has received from the above-mentioned Angelo, who is present here, the sum of 60 *scudi*, a sum that he has received in *giuli*, in silver *testoni*, and in golden *doppie*. After having collected this money, Pier Tommaso has given up the lawsuit, and in giving it up he acknowledges that he and his father have come to a settlement and that he cannot claim anything else from his father and he sets his father totally and completely free from any duty regarding the share due to him from the above-mentioned paternal and maternal inheritance, coming therefore to a final and total agreement. The facts being thus, Pier Tommaso is requested by his own father Angelo to keep intact and to preserve all the dotal property and dowry itself that belonged to the late above-mentioned Giacoba Giuditta, admitting that he will do so in front of me and all the present witnesses; with it Angelo refers to all and each dotal personal property and to anything brought to him and handed over to him by Giacoba Giuditta with her dowry, goods that all have been noted and described in the betrothal certificate between Pier Tommaso and the late Giacoba Giuditta Heroldi drawn up by me here on 4 January 1657. I have personally recorded those goods one by one and I have listed them carefully in that inventory, and it is known that those belongings are kept in boxes under Pier Tommaso's custody, and they still happen to be just as they were described in the inventory. He also shows 300 *scudi* counted right here during the preparation of this act which Pier Tommaso states belongs to the money of the dowry and he also affirms that for his own benefit he had deposited them in the *Monte di Pietà* in Rome with the aim to use them for his own trade, as proven by a coupon of 300 *scudi* and 85 registered at the above mentioned *Monte di Pietà* in Rome.[293]

[293] Contract between Angelo and Pier Tommaso Campani on March 22, 1659: ASR, Notary Bernardo de Sanctis, c. 838-39, 848-49.

The notarial statement then noted that still remaining in Pier Tommaso's custody were also the clothing and all the objects pertaining to his late wife's dowry that he had listed in a notarial act drawn up on January 25, 1657. Angelo added that, during these two years, Pier Tommaso had not only kept the dowry received by Giacoba Giuditta, but that he had also considerably increased it by adding to it profits from his own work. He noted:

> and the dowry that he has received from the above-mentioned Giacoba Giuditta has not only been kept by him but also considerably enlarged, given that, in addition to the dowry, Pier Tommaso also had the capital of his above-mentioned workshop in Via del Pellegrino and the profits that he has made out of it, as I have already said. In consideration of all this, the above-mentioned Angelo, giving his consent to Pier Tommaso's requests with which the latter asks to keep the complete administration of all the dowry as necessary to the maintenance and to a better education of his son Giovanni Carlo, leaves in the hands and under the full control of Pier Tommaso all the above-mentioned dotal possessions for all the reasons already pointed out here by Pier Tommaso, adding that he has decided to do so not just to allow Pier Tommaso to support his son in a better and more comfortable manner, but especially to provide the boy with a better education so that he might apply himself to some good art and find himself in the best possible condition.[294]

The common practice was for the dowry to be returned to the late spouse's parent, but in view that she had predeceased him, the practice was modified as indicated. Then followed the standard phrases and formulae to ensure that all that had been stated represented the true and final wills of the contracting parties and repeating that none of them would bring forth any claim against the decisions that have just been made. The act was drawn up in Pier Tommaso's workshop in Via del Pellegrino in the Parione quarter, in the presence of Pier Tommaso, Angelo (who had made the journey from Castel San Felice for the signing), and the Reverend Guglielmo Roncani (who had traveled from Castro Meggiano, in the diocese of Spoleto) representing Angelo Campani. Pier Tommaso was represented by Bernardo Maltraverso of Rome.

Angelo was determined to settle once and for all time the disputes between himself and Pier Tommaso that had arisen from the latter's lawsuit, as well as any other disputes between his sons arising from the patent rights or other problems relating to their activities, presumably their inventions. Angelo claimed, furthermore, to have some rights in these activities, possibly because of the loans he had made to Pier Tommaso, for he

[294] Ibid.

was willing now to hand over to Pier Tommaso all his own rights to them. The division was to be made in equal parts of 300 *scudi* for each of the three brothers.

Although infrequently encountered in modern times, the practice of parental authority, a father's *patria potestas*, in which a son was set legally free of paternal authority only by means of a contract signed by father and son, appears to have been a tradition current in Italy during the past several centuries.[295] The fact that Pier Tommaso was already married with a family and was well-established in business in the community of his choice before achieving his freedom from parental control suggests that the delay was attributable to the extreme financial obligations he had already incurred. In Roman law a "*Trebellianica proportio*" is that part of an inheritance that has been calculated according to the dispositions introduced by the law of Marcus Trebellius Maximus. In 56 B.C., Trebellius introduced a law having as its aim the regulation and partitioning of the inheritances and the role of the individuals involved in them.

As a single parent burdened with an infant child, Pier Tommaso soon had no alternative but to consider marriage once more, even though such a short time for mourning had elapsed since his bereavement. It may have been in the course of one of his periodic visits to the region of Castel San Felice that in nearby Scheggino he had met his new bride, Rita Vittorini, daughter of Alessandro Vittorini. A short courtship was followed by their wedding in mid-summer of 1659.

During the next six years, the marriage of Pier Tommaso and Rita Vittorini was to produce several progeny. Their first child, a daughter they named Maria Giuditta, was born and baptized in their parish church of San Lorenzo in Damaso on March 10, 1660, with His Excellency Don Tommaso Ferentillo of Interamna as sponsor. Their second child, another daughter, Eufemia, named after Pier Tommaso's mother, was born on April 7, 1661, and baptized on April 14, with the sponsors Ursula Campani (Pier Tommaso's sister) and Don Pietro Paolo Vallemano of Fabriano present. In 1663, Rita

[295] A notable example occurred in the case of Pietro Crinito [Pietro del Riccio Baldi], a well-known sixteenth century Italian scholar of Latin and Greek literature, who was set free by contract from his father on August 31, 1502: Roberto Ricciardi, 'Del Riccio Baldi, Pietro', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1990), 266.

gave birth to a third child, a daughter to be named Girolama Antonia Hieronyma, who was baptized n the Church of San Lorenzo in Damaso.[296]

Pier Tommaso's second marriage lasted approximately six years, then Rita died on November 20, 1665, also as a consequence of childbirth. She too was buried in the Church of San Tommaso in Parione. It was a saddened Pier Tommaso who made the journey to Scheggino with his three young daughters to place them in the care of his father-in-law's family. He waited three more years before attempting marriage again. This time he married Clara Cosimi, and in the next few years, three more children were added to his brood.[297]

Giuseppe, meanwhile, had been happily working alone for some time in his new quarters, kept occupied with commissions for timepieces from a distinguished clientele. Included were several more requested by Pope Alexander VII for clocks that probably were intended to be presented as papal gifts to important personages or members of his family. On February 7, 1658, and on October 22, as previously seen, the Pontiff ordered payment of 20 *scudi* to be made to Giuseppe Campani "for the above-mentioned clock according to agreement, which was delivered to His Holiness",[298] and of 140 *scudi* "for the price of our two clocks made by him for the service of His Holiness and which had been delivered in accordance with agreement".[299]

Giuseppe adopted the same form of signature for all of his later timepieces as had his brother Pier Tommaso. Without variation, his name identifying him as an inventor in Rome was inscribed upon the back plates of each of his clock movements, the inscription in Latin script, "*Joseph Campanus inventor Romae*." Although Giuseppe never did so, Pier Tommaso frequently added to his inscriptions not only the location of his shop but also the date when the clock was made. Giuseppe had included dates on the inscriptions of the five known surviving examples of his earliest clocks, four of which he had

[296] ASVR, San Lorenzo in Damaso, *Libri Batt. (1658–1668)*, fols. 92, 235.

[297] ASVR, *S. Nicola in Arcione*, *morti,* S. Tommaso in Parione, Novembre 1665. [Scientific Editor 2: for what concerns Pier Tommaso's subsequent trip to Scheggino, and for his wedding with Clara Cosimi, I was not able to find the archival references once found but not recorded by Silvio Bedini. Further research in the Archives of Spoleto and Rome will eventually bring to light these documents].

[298] ASV, Sacro Palazzo Apostolico, "Varia", Registro di ordini a Monsig[o]r Thesoriero, vol. 772, p. 147.

[299] Ibid., vol. 773, p. 1111 (October 22, 1659); Ozzola, *L'arte alla corte di Alessandro VII*, vol. 31, 80.

produced in 1659 and another dated 1660. He did not include the date nor his shop location in any of his later work. Although his clocks originally incorporated crank lever escapements, later clock repairers, being unfamiliar with Giuseppe's invention, experienced difficulty in repairing them and removed them and replaced the damaged original escapement with the then modern anchor escapement.

The most elaborate of these surviving early clocks produced by Giuseppe in 1659 is presently in the famed repository the Grünes Gewölbe in Dresden. It is stated in the museum inventory records that the timepiece had been a gift from Pope Clement IX to Elector Frederick Augustus the Strong (1670–1733). The possibility suggests itself that instead it had been a gift to Elector George I, the predecessor of Frederick Augustus, presented to him by Pope Alexander VII within the last several years of his reign. Nonetheless, the catalogue attribution may be correct. The clock unquestionably had been commissioned in 1659 by the reigning Pontiff, Alexander VII, who presumably had retained it and it may have remained in the Apostolic Palace after his demise in 1667. It is possible that his successor, Pope Clement IX, while seeking to make an appropriate gift to the German monarch at a later date, may have been informed of the presence of the clock and, appreciating its beauty, appropriated it and presented it to Frederick Augustus.

The clock case of tinted pearwood with ebony trim is somewhat smaller in size than most of the Campani night clocks. The outer surfaces of its front and side panels are inlaid with floral motifs heavily executed in *pietre dure*, with the dove of peace featured at the center of the front panel, which is bordered on both sides by pillars that are inlaid with lapis lazuli, a favored selection, and other rare marbles. Three gilt bronze statuettes, suggesting they may have been designed by Gian Lorenzo Bernini, are situated one on each side of the case and another over the pediment.

As with Giuseppe's other surviving clocks of the early period, the dial opening is of the earliest version, in the form of a semi-circle having two, not three, disks for the hour numerals, each portraying six numerals. The movement with crank lever escapement appears to be intact, although the pendulum is missing.[300]

[300] Jean Louis Sponsel, *Das grüne Gewölbe zu Dresden: ein führer durch seine gesichte und seine sammlungen*, vol. 2 (Dresden: Bard, 1928), 47.

Another of the clocks Giuseppe produced in the same year, presently in the collection of the Galleria degli Uffizi in Florence, has not been as fortunate, for only the gilt brass clock movement survives. Presently, it is fitted into a carved wooden bracket clock case of later vintage having an also later enamel dial with two hands. Identifying the maker is the inscription with Giuseppe Campani's standard signature on the back plate, "*Joseph Campanus inventor Romae 1659*." Contained in the clock case is a note handwritten in ink on paper stating that the clock formerly belonged to the family of the Doge Manin [of Venice]. The note is signed by Antonio Tonioli, son of the late Giovanni Battista Tonioli, who had been in the Doge's service.[301]

Among Giuseppe's earlier clocks is one formerly owned by the late Count Pier Lamberto Mosca Lamberti having the movement attached to the rear of the clock case door as in other examples. The back plate is inscribed in the usual manner, "*Joseph Campanus inventor Romae 1660*." The original movement has been replaced with a fusee movement having an escapement *a roue de recontre*. There is some question about the clock case, which is of simple design and made of ebonized pearwood. It appears to be only part of the original clock case, now consisting of the door of the case to the rear of which the movement is attached, and the top and sides appear to be made from parts of the original pediment and sides. Inasmuch as this is an early example of Giuseppe's work, did he present it in such a simple case, or was the original case damaged and only these parts survived?[302]

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[301] Enrico Colle and Simonella Condemi, *Tempo reale e tempo della realtà: gli orologi di Palazzo Pitti dal XVII al XIX secolo*, Firenze Musei (Livorno: Sillabe, 2016), 20–21. Originally equipped with a now-missing crank lever escapement, the mechanism has been badly butchered to convert it to a crown wheel and verge movement with pendulum, which is attached directly to the verge staff. [Scientific Editor 2: Bedini added that: Another of Giuseppe's early crank lever escapement clocks dated 1659 is in a private collection in Rome. The unsigned dial painting features Christ arising from the tomb where Mary Magdalene had been holding a vigil nearby. The dial opening is a full semi-circular, indicating that the revolving plate incorporated only two disks with the perforated hours, the earlier form used after the separate hour numerals of the type introduced by Eschinardi. Regrettably, although the fusee, mainspring drum, and several wheels of the time train remain, much of the movement is missing. The case is made of the simplest form, of ebonized pearwood, having plain slender columns at each side of the main panel and three wooden finials decorating the pediment and upper surfaces. A fourth clock bearing the date "1659" was owned by Prince Ruspoli and maintained in his palace on Largo Goldoni in Rome. The maker may have been either Pier Tommaso or Giuseppe but more likely the latter. It was repaired in recent times by the late Rome clockmaker Orlando Zijno (in the collection of Dr. Arch. Egisto Ercadi, Rome). According to Antonio Lenner, this clock was a forgery].

[302] Correspondence with the late Conte Lamberto Mosca Lamberti (1956). Presently in the collection of Antonio Lenner.

As well as can be determined from contemporary descriptions and surviving examples, Pier Tommaso and Giuseppe both continued to specialize almost exclusively in the production of night clocks, although a few occasional examples are known of more standard types of timepieces by these makers. During the period when Giuseppe first ventured into clockmaking on his own, for example, he produced one or more timepieces of standard types, spring-wound bracket clocks designed for the homes of the wealthy. Among these was a bracket clock contained in a parallelepiped case of walnut having sober and elegant lines with simple cornices and wooden onion-style feet. The pediment features a gilt brass round medallion depicting a portrait bust of Saint Peter crowned with the papal tiara made of three crowns, with heads of angels and small cherubs of bronze. Based upon surviving original fragments, the iron dial plate, the spandrels of which are missing, was recently recovered with crimson-colored velvet. The clock strikes twelve. The brass chapter ring features the six Roman hours occurring twice, separated by stylized cross-shaped separators, the spaces between them divided into four parts to indicate the quarter hours. The single hand is a replacement. The round gilt brass movement has a catgut fusee for the time train and a barrel for the strike train. The time train consists of three wheels and the Catherine wheel with a crown wheel and verge escapement regulated by a pendulum attached directly to the verge staff. There is no indication that the movement has been converted from a balance wheel. The *ponticelli* of the escapement wheel and verges have been reconstructed. The back plate of the movement is inscribed "*Joseph Campanus inventor Romae*".[303]

Following quickly upon the success of his new crank lever escapement, in late 1659 or early in the following year, Giuseppe undertook to record an account of his invention for publication. While so engaged, and undoubtedly at Matteo's urging, he expanded the written account of his invention of the crank lever escapement to include as well a history of the invention of the earlier mercury escapement silent night clock and of the planetary sphere model and described how they came to be. Occasional segments in Latin presumably were translations contributed to the work by Matteo, whose *Dell'Horologio Muto* had not as yet been approved for publication by Church authorities.

[303] In the collection of Giancarlo Beltrame, Vicenza, inventory no. 153. Mara Miniati and Paolo Brenni, *Orologi e strumenti della collezione Beltrame* (Prato: Giunti, 1996), 70, no. 15.

They agreed that meanwhile Giuseppe's published account would serve as the first means of informing the public about their cooperative achievement. Inasmuch as Giuseppe was not a member of the clergy, he was not liable to as severe a scrutiny by Church censors as Matteo might be. Although he mentioned the approval of the invention by members of the faculty of the Collegio Romano and others, Giuseppe chose to not include in his account the accusations from Divini and Caramuel nor the subsequent vindication.

On April 24, 1660, Giuseppe completed the writing of his account, which in translation he entitled: *Discourse of Giuseppe Campani Concerning His Silent Clocks and On the New Archimedean Sphere*, *and on Another Most Rare and Useful Invention by a Conspicuous Personage*. It was published in a very limited edition as a small volume of 111 pages measuring 3 by 4.5 inches. Giuseppe dedicated the work to Cardinal Girolamo Farnese in acknowledgment of the latter's support and involvement in the events described therein. The work received the imprimatur of official clerical approval without a problem.

Giuseppe stated in the introduction "To the Readers" of his little volume that in his work he would present an account of newly invented "automata." This is a word occurring frequently in discussion of the Campani inventions and is clearly related to complicated clocks as well as to "the material sphere" patented by the Papal Brief of March 7, 1657. Giuseppe noted further that he had discovered another type of automaton of considerable precision that was much more perfect than the pendulum regulator and which he anticipated would serve navigators for determining longitude at sea.[304] This statement made in passing presaged the first inkling of a project that would occupy him some years later. Despite these promises to the reader, however, Giuseppe failed to fulfill several of them in his work, nor did he further describe at that time the new type of automata he had mentioned for serving to determine longitude at sea, for example.

The text of Giuseppe's book was divided into three parts, the first dealing with inventions, the second concerned with silent clocks, and the third with spheres or planetariums. He wrote about the ease of converting useful items into inventions, lost inventions, the principles of invention, and inventions that were needed, in addition to two sections relating to the first and sixth discourse of Ciampoli. "The rare and useful

[304] Campani, *Discorso ... intorno a' suoi muti oriuoli,* "A' Lettori", unnumbered pp.

invention of a conspicuous personage" was mentioned in the final section, only briefly. This was the perpetual motion apparatus invented by Cornelius Drebbel, the Dutch physicist and chemist.

The publication of Giuseppe's *Discorso* does not appear to have attracted particular attention in the popular press of the time, but it did bring forth a violent reaction from Pier Tommaso. Despite their father's efforts to resolve the problems that had arisen between his sons, Pier Tommaso used the opportunity to make an open break with his younger brother. He promptly went to work to produce and publish an even smaller volume presenting his own claims to the invention of the silent night clock. Completed eight months after the publication of Giuseppe's *Discorso*, on December 18, 1660, and issued later in the same month, Pier Tommaso's account was very brief, consisting of but a few pages. It was presented in translation as: *A Letter ... to One of His Friends*, *in which is demonstrated the origin and the artifice of the clock which he constructed in the year 1656*, *with the Sphere of the Planets*, *and now at present*, *a new invention of clockwork discovered by him which is silent if desired*, *or not silent*, *without having any fluid content*. [305]

Although Pier Tommaso's *Lettera* did not include a formal dedication; it was addressed to "My [dear] Sir" to whom he expressed his great obligation, and it may be assumed that it was Cardinal Farnese, and that his little book was intended to correct misconceptions arising from Giuseppe's publication. The *Lettera* began, "Since the very great obligation that I profess to Your Lordship will not permit me to deny to you any thing that is in my power." Pier Tommaso then went on:

> I cannot neglect to satisfy your curiosity by describing the manner with which I make silent clocks, and spheres or exhibits of planets that move without having to be wound. I assure you that it is much easier for me to make them than to describe them, and to whatever skills I may pretend in my clockmaking, I confess otherwise ignorance as a composer of letters; I am more skilled with handling the filing tool than the style, and I have greater pleasure in completing a fine work [of craftsmanship] than pulling out my hair because I have to weave together a fine discourse. Therefore, at the beginning of this declaration I hope you will excuse my pen if it appears to be crude and if my method of writing is too simplified; I will make it at least more candid and more natural, and therefore less artificial, the truth less suspect to any of my friends.[306]

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[305] Pier Tommaso Campani, *Lettera ... ad un Suo Amico*, *nella Quale Dimostra l'Origine e l'Artificio dell'Oriolo da lui Fabbricato l'Anno 1656*, *con la Sfera de Pianeti*, *et Adesso di Presente*, *una Nuova Inventione d'Orologgio Ritrovato da lui Muto se si Vuole*, *o non Muto*, *Senza Nessuna cosa Fluida* (Per Giacomo Dragondelli, Rome), p. 3 (1660) [n. G.S.].

[306] *Ibid.*, pp. 3-4 (1660).

Pier Tommaso then related that his lifelong inclinations had always been toward invention, or the imitating or perfecting of existing finely crafted works, particularly in the field of clocks and automata. He had begun the first work that he produced with methods that were not simple but capricious and out of the ordinary. His spirit was never satisfied, he wrote, until he was able to remove from clocks that importunate sound caused by the balance [wheel] that was fastidious to the ear, particularly at night. He thereupon applied his ingenuity for several days to this consideration, and after various designs had come to his mind, he paused at that of mercury. He recalled having once seen a clock, the invention of which was not new, that operated by means of water running within a compartmented cylinder. He imagined that mercury would be more successful in a container having four compartments to enable it to run from one to another of them by means of a small opening, if it replaced the ordinary balance wheel, to receive by means of wheels the motion from the power source, whether that of a falling weight or a spring.[307]

Discussing this with his older brother, Matteo, suggesting that by this means he hoped to make a silent clock, since, as he said, "My brother (here I speak of my older brother, the younger not yet capable of these things) did not immediately agree with me."[308]

After relating the events that led to the successful production of the silent night clock with mercury escapement, Pier Tommaso then went on to discuss the production of the material planetary sphere. He described how he had applied the material sphere to his Clock of Death, a timepiece he had previously produced for Pope Alexander VII that communicated its motion of 24 hours "and although it is true that the sun had not joined any other but that of the moon because the work was not capable of more, although I would have desired not a little to make it complete, and enclose as well the motions of the other planets, and instead the weight for each pinion and worm screw."[309] He added the figure of a small angel of gilt copper as the "motive intelligence" or indicator, and then

[307] Ibid., 5-9.
[308] Ibid., 7.
[309] Ibid., 19-20.

enclosed it all in an attractive glass globe. In order to complete the work sooner, and to earn money, he added, it was sufficient to limit the sphere to only the two planets of which the motions were the more common and necessary to be known.[310]

Pier Tommaso then briefly mentioned how he had "reduced clocks to make them both silent and not silent, depending on the wishes of whomever was to use them, without the use of mercury or other fluid matter".[311] This, he stated, he had managed to accomplish with the greatest simplicity utilizing only two simple wheels for the time train, and two others for the strike train, if one wished to include them, but in such a manner that "the entire work requires little space, and it succeedes in being marvelously accurate despite the employ of a spring, the latter lasting for twenty-six hours, or more if desired, that [the work] does not fear either dust nor humidity, so that ,whenever increased the force to twice, nevertheless it operates always at the same rate and to the same measure, and thus I abandoned making clocks with mercury escapements."[312]

Although by this time Pier Tommaso had developed a variation of Giuseppe's crank lever escapement, to which he had added what he described as "a silent and not silent" arrangement, he made no mention in his little volume that the invention of the crank lever escapement in fact had been made by Giuseppe and not by himself. He described only his own clocks that, like those made by Giuseppe, he now made having a striking and a strike-silent attachment. Although Pier Tommaso's clocks functioned upon the same basic principle of the crank lever, there was substantial variance from the version invented by his brother. Notwithstanding that, due to the similarity in principle and function, Pier Tommaso's adaptation actually violated Giuseppe's patent, out of a sense of loyalty and perhaps with his father's advice, Giuseppe was determined to ignore it.[313]

The earliest known surviving dated example of Pier Tommaso's night clocks with his version of the crank lever bears the date 1663. It was a particularly important commission he received from either Pope Alexander VII or possibly Cardinal Landgrave Frederic of Hesse. The clock bears the signature "*Petrus Thomas Campanus Inventor*

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[310] Ibid., 20.
[311] Ibid., 20-21.
[312] Ibid., 21-22.
[313] By the time that Pier Tommaso was writing, Giuseppe already had obtained a papal privilege for his own horological inventions.

Romae in 1663 " and forms part of a *prunkschrank*, or state cabinet, presented as a gift to Emperor Leopold I. A number of the cases for the clocks being made by Pier Tommaso and Giuseppe Campani had been produced by the same craftsman, Jakob Hermann, a German cabinetmaker working in Rome.[314]

The cabinetmaker Jacob Hermann was born in 1615 in Germany, probably learning his craft in Augsburg. Because of the dearth of work resulting from the Thirty Years War, he sought employment by emigrating to Italy, where he established himself in Rome with a shop at San Ignazio. He became known locally as "Giacomo Ermanno" or "Ermano," the form of the name he used thereafter in signing his work. Dedicated to perfection in his work, he had a reputation for being a meticulous but hard-headed craftsman. By 1651, his name was already to be found in official documents relating to artistic activities at the Vatican. Hermann produced a great many works for Pope Alexander VII and for Clement IX, but papal commissions appear to have diminished thereafter. Hermann was a master of veneering, particularly in ebony, and his work frequently was decorated with lapis lazuli and *pietre dure* inlay and other intarsia.[315]

The *prunkschrank*, completed in 1668 and which is presently in the Kunsthistorisches Museum in Vienna, is considered to be probably the most outstanding of Hermann's art. The cabinet itself is a masterpiece of the style of the period executed and signed in two places "*Giacomo Erman fecit Romae 1668*." It is to be noted that the clock it contained, by Pier Tommaso Campani, is dated and had been made five years earlier.

The design of this *prunkschrank* was conceived as the facade of a large church, with three arches, each slightly concave, the columns made entirely of lapis lazuli with gilt bronze columns, finials, and capitals and miniature paintings on the exterior of the *prunkschrank* depicting events in the life of Emperor Constantine executed in the style of Raphael. The inserted paintings on copper and panels of rare marbles are intended to reflect the relationship between Constantine and the Church. Scenes of Rome are featured in miniature paintings on the inside of the doors to the numerous compartments inside the cabinet. The columns are covered with lapis lazuli, panels of amethyst matrix

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[314] Vienna, Kunsthistorisches Museum, *Inventar-Buches*, Inv. no. 3395, "Prachtschrank."

[315] Bertolotti, *Artisti belgi ed olandesi a Roma nei secoli XVI e XVII*, 246–247, 266 *et seq*.; Ozzola, *L'arte alla corte di Alessandro VII*, 78-79.

[*amethystmutter*], and rare marbles and with *pietre dure* inlay. Only one of the miniature paintings is signed, by Francesco Ligorino, who may have created all of them.

As noted, the cabinet was a gift to Emperor Leopold I from a donor whose identity is uncertain. Although some sources state that the donor was Pope Alexander VII, it seems less likely inasmuch as he had died the year before the date of Hermann's signature. It is possible, however, that it could have been ordered by the Pope but that it had not completed or delivered before his death. More probable is the claim proposed by other sources that the donor was Cardinal Frederic of Hesse-Darmstadt, a person of considerable influence in European politics of his time. He had been named a cardinal following his conversion to Roman Catholicism, and in 1655 Pope Alexander VII had offered him the honor of receiving Queen Christina upon her state arrival in Rome.[316]

Ludwig von Pastor, in his account of the reign of Alexander VII, mentioned this *prunkschank*, which he erroneously identified as a magnificent "*scrigno*", that is, a casket or money box, constructed in Rome in 1663, that had been a gift from the reigning Pontiff to Emperor Leopold I. It was, von Pastor went on to state, an object that demonstrated "many relations with the Emperor Constantine represented by the allusion to Leopold's war against the Turks."[317] In view of the date on the clock, it seems plausible that in fact it was this item that had been the gift of Alexander VII to the Emperor mentioned by von Pastor. It has been suggested that the date "1668" appearing with Hermann's signature may have been 1663 and had been misread, although this seems unlikely. In 1677, the cabinet was recorded in the inventory of the imperial collections.[318]

From Hermann's business accounts, it is apparent that the cabinetmaker produced not only the wooden structure of clock cases but also negotiated for the decorative elements as gilt bronze capitals and bases of columns and provided other gilt bronze or copper decorations in addition to inlays of *pietre dure* with which parts of the case might be covered, such as the one in Dresden's Grünes Gewölbe. He was responsible also for

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[316] Hans Vollmer, Ulrich Thieme, and Felix Becker, *Allgemeines Lexikon der bildenden Künstler von der Antike bis zur Gegenwart : Hansen - Heubach*, vol. 16 (Leipzig: Seemann, 1923), 497–98; Giuseppe Brusa, *L'arte dell'orologeria in Europa: sette secoli di orologi meccanici* (Busto Arsizio: Bramante Editrice, 1982), pl. XLII-XLIV.

[317] Pastor, *Storia dei Papi dalla fine del Medio Evo*, vol. 31, 109.

[318] Bertolotti, *Artisti belgi ed olandesi a Roma nei secoli XVI e XVII*, 246-248.

ordering the gilt bronze statuettes that occasionally were additions on some of the clock cases. It is possible also that some of the *pietre dure* panels were not assembled by the cabinetmaker in Rome but were ordered from independent craftsmen working in Rome, where there was a steady market for that work, or from the Medici *pietre dure* factory in Florence.[319]

Hermann played an important role in the success of the Campani night clocks, for he appears to have been the primary maker of cases for clocks produced by both Campani brothers; consequently, it is interesting to find surviving records relating to some of his commissions. Some concept of the range of Hermann's work is derived from a review of his surviving business accounts. The earliest of these dates from the beginning of the papacy of Alexander VII, by whom he was to be chiefly employed during the latter's tenure.[320]

Hermann produced work also for the papal summer palace, the Quirinal, which in that period's records was designated as the "Apostolic Palace of Monte Cavallo," named for the great sculptural group of the horse tamers Castor and Pollux and their steeds. Roman copies of Greek originals, they have never been buried and are one of the city's landmarks. Papal commissions for Hermann's work appear to have been processed through the *forieri* [paymasters] in the service of the Quirinal. For example, Hermann recorded, "On June 7, 1668, by the same *foriere* was sent to me a base [*piede*] of a cross of ebony that was broken enough that I reassembled and polished it anew to serve to have placed on it a copper crucifix at a cost of 80."[321]

On August 9, 1656, Herman was commissioned to construct two cabinets [*studioli*] veneered in black ebony having various compartments. On November 20, 1669, Herman "by order of the Monsignor Majordomo of the Apostolic Palace" paid six porters for having brought four large cabinets to the Monsignor's apartment at Monte Cavallo and taken to the apartment of Cardinal Giulio Rospigliosi on the following day and then brought again to Herman's shop. On the 24th, he was ordered by the Majordomo to bring "a large cabinet of stone" to the palace at the Arco di Portogallo, and the following day

[319] Alvar González-Palacios, 'Itinerario da Roma a Firenze', in *Splendori di pietre dure: l'arte di corte nella Firenze dei Granduchi*, ed. Annamaria Giusti (Firenze: Giunti, 1988).
[320] Bertolotti, *Artisti belgi ed olandesi a Roma nei secoli XVI e XVII*, 246-248.
[321] Ibid.

the same cabinet, after having been ornamented, was to be taken to the summer papal palace at Monte Cavallo, to display to the Pontiff. After many days, the cabinetmaker was instructed to bring it to his own home with all his men in the shop. He lost much time and he paid the porters for making this trip by order of the Majordomo in the amount of 5.86 *scudi*. The account totaled 40.70 *scudi*, paid August 12, 1671. This was reported in a record signed by Herman at his shop at San Ignacio:

> Account of the work performed by me Giacomo Herman furniture maker at S. Ignatio for the palace of Monte Cavallo by order of and in the service of the Pope Clement on May 2, 1670. First I gave an occasional table of green ebony 6 palms long and 3 palms wide to place in front of the bed of His Holiness, consigned to Sig. *foriere* . . . 14 *scudi*.
>
> On July 7th I was called to the Palace of Monte Cavallo to re-glue several cornices of the *studiolo* [cabinet] of "the Clock of Death" and another *studiolo* [cabinet] worked with mosaic in two vaults with one of my youths [apprentices?], *scudi* 1.40. Total *scudi* 21.70.[322]

It is to be noted that the Clock of Death, which Pier Tommaso had produced for Pope Alexander VII in 1655 or earlier, had remained in the Quirinal Palace following the Pontiff's death in 1667. The reference made to repairs of the clock's *studiolo* confirms that the timepiece was housed in a cabinet, not merely a clock case on a table top.

From 1662 to 1666, Hermann was listed as a trustee [*depositario*] of the Confraternita del Camposanto Teutonico dell'Urbe [Brotherhood of the German Cemetery in the Eternal City], and in 1670, he was elected chamberlain [*camerlengo*] of the organization. He died in Rome on October 23, 1685, at the age of 70. The registers of burials in the cemetery of Santa Maria in Campo Santo, under the date of October 23, 1685, noted "Giacomo Herman furniture-maker was deposited into his family vault opposite the Christ [statue] in the cemetery; he was seventy years of age." His nationality was not given, but in the registration of the burial of his son, G. B. Herman, which had occurred previously, in July 1661, it was noted he was of German origin.[323]

Other cabinetmakers who may have produced some of the clock cases for the Campani brothers as well as for other clockmakers in the same period, and the quality of whose work was by no means inferior to that of Hermann, included the Swiss craftsman Giovanni Sigrist, the German Johan Falker (Giovanni Falgher), and Niccolò Cavallino, a

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[322] Ibid.

[323] Ibid.

cabinetmaker and intarsianist working in Rome. Falker produced a number of works for Pope Alexander VII and Cardinal Flavio Chigi.[324]

Pier Tommaso's skills with automata, which he had mentioned in his *Lettera*, had resulted in the production of not only the Clock of Death for the Pontiff's bed chamber but also the elaborate clock he had produced for Pope Alexander VII in 1655 for presentation to Queen Christina of Sweden. In 1668, he invented a clock having operative automata, the first example of which he presented to Pope Clement IX, who granted him a letter patent for it that protected his invention for a period of ten years, during which "no clockmaker, vendor of clocks nor any other person of whatever state, grade, or condition can make them, nor have made for him in Rome, nor in any other place immediate or immediately subject to the Ecclesiastical State, nor said instruments even if modified, with the addition or lack of any part."[325]

No surviving example is known of this new invention by Pier Tommaso, but the patent stated that it featured a clockwork-operated statue and instrumentation that activated a fan, or separate instruments that agitated the air with their movement. The letter patent, issued by the *camerlengo* Cardinal Antonio Barberini, was dated September 6, 1668. Noted below the edict's printed text was the notice that "Pier Tommaso Campani lives in the Trastevere near Ponto Sisto, and maintains his shop in Via del Pellegrino opposite the end of the Cancelleria."[326]

Meanwhile, following his invention of the crank lever escapement, Giuseppe's time was occupied in fulfilling commissions for silent night clocks with his new

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[324] Ibid. On January 24, 1657, Falker was consigned two new cabinets and two tables of *granatiglia* for the service of His Holiness, and on July 31 of the same year, he produced an ebony cabinet with gilt copper decorations and with paintings protected by glass panels. In May 6, 1656, a "cabinetmaker in Banchi" named Cavallino consigned a casket of ebony in the form of an urn with gilt bronze feet which served as an ink stand [*calamaro*] for the service of His Holiness." Other *ebanisti* and goldsmiths working in Rome in this period were Giovanni Cheller, Remigio Chilazzi (or Kilkolz), Ranier Bruch, Antonio Chiccheri (Kicker), and Giovanni Effiguer. Remigio Chilazzi received 75 *scudi* on October 28, 1640, for four frames executed in ebony and tortoise shell made by him "in accordance with the design and esteem of Cav. Bernini." On August 1, 1631, Gaspare Mola, a master of the type of mosaic work called *commesso di lapide*, had been paid 60 *scudi* for a frame made of a mosaic containing lapis lazuli, carnelian, and other stones and painted on copper in the interior with a scene of the Annunciation. pp. 277, 284. Ozzola, *L'arte alla corte di Alessandro VII*, 8; Alvar González-Palacios, 'Bernini as a Furniture Designer', *Burlington Magazine* 112, no. 812 (1970): 718–23; Vollmer, Thieme, and Becker, *Allgemeines Lexikon der bildenden Künstler von der Antike bis zur Gegenwart*, 16:497–98; Goffredo Lizzani, *Il mobile romano* (Milan: Görlich, 1997).

[325] Archivio Segreto Vaticano, Miscellanea, Armadio IV: Bandi, vol. 27, fol. 456

[326] Ibid.

escapement as well as several other types for princely patrons, the demand for which continued into the next decade. In addition to these he produced special timepieces even in his final years, generally on commission, such as the "Falling Ball Clock" [*Kugelaufuhr*], which he made as late as 1698 or 1699.

Of his silent night clock Giuseppe wrote, "But this novelty so praised by important personages, and esteemed by knowledgeable people, such as those whose judgment was published in 1658 [the Jesuit faculty of the Collegio Romano], could have subdued the two censures by reason of the same material of which the new artifice was composed in part. For one thing, no one has seen the method in which we utilized the mercury inside its container, which operated so miraculously well, and if they had, could not have called it useless and inept".[327]

Throughout this period, Matteo had continued to act as Giuseppe's informal agent and promoter of his work. After Giuseppe established his own shop, he worked alone, apparently without assistants or apprentices. Matteo's role as Giuseppe's representative is exemplified in the correspondence relating to a number of commissions that Giuseppe received from the Medici princes in Florence. Writing in the summer of 1660, for example, Matteo expressed to his Medici correspondent, probably Prince Leopold, that although the clock His Excellency had commissioned from Giuseppe had been completed, the painting of the dial plate had proven to be unacceptable and had to be done anew. Consequently, delivery of the clock had been delayed only to be able "to satisfy the orders of Your Highness given to Sig. Monanni concerning the painting; we have until now been awaiting the discretion of the artist selected by the same Sig. Monanni, and although he has been continually solicited as much by him as by me, he has not as yet had the courtesy of His Excellency. This appears to me to be an example of overbearing license; if it were up to me I would send the clock with the existing painting delivered without waiting, because then Your Highness could have it altered to suit your wishes. Meanwhile I will await your most gracious orders."[328] Monanni, whose name appears from time to time in the Campani–Medici correspondence, was the master of the

[327] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 11-12.
[328] Letter from Matteo Campani to Prince Leopold on June 19, 1660: Biblioteca Nazionale Centrale, Ms. Gal. 276, c. 32r.

post in Rome and served as the agent for transmission of mail and packages from Rome to Florence and the Medici court.

In the same letter, Matteo then took the opportunity to comment that he was still anxiously awaiting permission from the Vatican's office of censorship to proceed with the publication of his book manuscript, but that apparently it was encountering difficulties. This was the book-length manuscript *Dell'Horologio Muto* that Matteo had prepared in rebuttal to Divini and Caramuel.

The matter of the delayed delivery of the clock was resolved five months later, when Matteo informed Cardinal Giovanni Carlo de' Medici that he was consigning to Monanni a clock completed by his brother Giuseppe, and that Monanni was to arrange to have the dial painted and a clear glass panel [*cristallo*] installed to protect it.[329]

It is not surprising that two of the incumbent Pope's nephews were among Giuseppe's frequent patrons. On June 21, 1661, Giuseppe was paid 80 *scudi* for a silent day-and-night clock for Cardinal Flavio Chigi, a timepiece having a hand or index and pendulum regulator installed in an ebony case with "the *cristallo* painted like death" being delivered on June 6. The morose theme depicting Chronos wielding his scythe to sever the thread of life of one of his victims is found more than once among the miniature paintings on dial plates of night clocks.[330]

The Pontiff had arranged for his older nephew Flavio to study with the Jesuits before preparing for ordination. After he had taken the priesthood in June, on April 9, 1657, the Pontiff raised him to the cardinalate. The titular church to which he was assigned was Santa Maria del Popolo. In subsequent years, Cardinal Flavio's uncle conferred even more titles and honors upon him, including naming him prefect of the Vatican library. As cardinal-nephew, he became known as Cardinal Chigi the Elder, and in his youth he was described as a gentle young man of 25, distinguished by a round face and dark curly hair. Balanced and cultivated, he was courteous and without superfluous mannerisms. The young cardinal distinguished himself both as an efficient administrator and as a diplomat. His chief interests remained philosophy and science in addition to

[329] Letter from Matteo Campani to Giovanni Carlo de' Medici in November 1660: Archivio di Stato di Firenze, *Arch Med.*, filza 5336, c. 283.

[330] Biblioteca Apostolica Vaticana Arch Priov., *Chigi Giornale A*, N. 456, c. 193r. The painting is believed to have contained the image of a skeleton or a representation of Father Time.

hunting, drama, conversation, and the pleasures of the table. His morals were irreproachable, and although no scandal ever attached to his name, other contemporaries spoke of his sensuality, noting that in his palace at Ariccia he had assembled a collection of portraits of 36 of the most beautiful ladies of Rome.

Cardinal Flavio Chigi had acquired a villa facing the great thoroughfare leading from Santa Maria Maggiore to the Pincio, situated at the point where today Via Nazionale crosses Via Depretis. There he developed an extensive garden, in the casino of which he housed a notable museum collection. It included mounted exotic animals, costly oriental costumes, the horn of a unicorn, mummies, etc. His collection of other antiquities was displayed mainly in his palace adjacent to the church of the Santi Apostoli. He purchased a number of sculptural works that had been recovered in Rome and surroundings. They were much restored in accordance with current tastes, and the collection was famed as one of the foremost of its kind in Rome. It was purchased in 1728 and removed to Dresden.[331]

Giuseppe never ceased experimenting with concepts of clockwork and designs of timepieces, and he produced several of unique forms. One of the most unusual was a timepiece he made for Pope Alexander VII at a date not known. Of the various silent night clocks made by Giuseppe Campani for the Chigi Pope and his successors, this is the single Campani night clock that has survived on the Vatican premises to the present time. The timepiece is a day-and-night clock—having an ordinary dial readable in daylight as well as an illuminated dial for the night time—contained within a large clock case, which subsequently had been greatly modified. The only part preserved is the door of the case, having the clock dial and movement attached behind it, as well as segments of the original case modified to form the sides of a box-like structure that presently encloses the clock. The movement originally incorporated Giuseppe's crank lever escapement, which later was replaced by the present anchor escapement, and the original pendulum bob, which would have been in the shape of an eight-pointed star, also was been replaced later by one with a heavy lenticular bob.

The dial plate consists of a large copper panel decorated with a painting representing a turbulent storm at sea, which may have been painted later over the original

[331] Stumpo, "Agostino Chigi."

painting, which may have been damaged. At the upper center of the dial is an opening behind which passes a circular painted copper dial plate divided equally into 24 hours, each numbered and captioned and decorated with a delicately painted scene from the New Testament, the superb quality of which is in considerable contrast to the coarseness of the outer dial painting.

A second large dial, of plate glass, is attached below in the lower half of the movement and is geared to the upper dial. In reverse upon it are the same 24 hourly segments, consisting of miniature paintings each of which illustrates a scene from the life of Christ but without captions. The lower dial is illuminated by means of an oil lamp or small *lucerna* situated opposite the dial on the inside of the lower part of the rear panel of the clock case. The movement is of an unusual form that differs from all other known surviving examples of Giuseppe's work. The back plate of the clock movement bears the customary Campani signature in Latin "*Joseph Campanus inventor Romae*."

Commissioned at an unknown date from Giuseppe Campani by either Alexander VII or his successor Clement IX, this most unusual timepiece was displayed for many years in the Apostolic Palace in the *Sala della Falda*, the private robing room used by the reigning Pontiff while preparing himself before making ceremonial appearances. At some later period, the clock was relegated to permanent storage in the rooms of the *Floreria Apostolica Vaticana*, where it now remains, unseen and forgotten.[332]

Figure

The present-day absence in the Vatican of clocks that had been commissioned by the various pontiffs from the Campani brothers, or from the Ertel clockmakers and other contemporary clockmakers, is understandable to a degree. The tradition was that upon the death of a pontiff, a division was promptly made of his possessions, dividing those items that are state property from those of a personal nature. The latter are returned to his family, while the state property remains in the Vatican. Generally, a pontiff's personal clothing was distributed among his personal servants. In addition to this disposition, however, there have been many opportunities throughout the centuries for stealthy and illegal removal of items from Vatican collections before and after the formal division of papal property had been made.

[332] Morpurgo, "Orologi del Campani in Vaticano": 19-21.

The continued popularity enjoyed by Campani night clocks among the rich and famous inevitably led to the rise of a number of imitators. Few if any seemed to have attempted to violate the Campani patents during the periods specified prior to about 1669. Almost immediately after the protection of the patents had terminated, however, imitators were already making night clocks in Rome, Genoa, Bologna, Florence, and Milan as well as other cities. None of their timepieces were silent, however, because none incorporated crank lever escapements.

Among the earliest to copy Giuseppe Campani's style was Johann Philipp Treffler, mechanician and clockmaker of the Medici court. During his employment in Florence for more than a decade between 1656 and 1667, he had become familiar with the several Campani silent night clocks purchased by the Medici princes. It may in fact have been during his employment in Florence that Treffler produced his first night clocks, possibly after 1667, the expiration date of the 1657 Campani patent. Treffler reproduced the approximate size and style of the Campani clock cases, although they were constructed by other cabinetmakers. He also utilized the earliest arrangement of hour numerals on individual disks linked on a chain with which the Campani brothers had experimented, and he used clockwork movements having an inverted crown wheel and verge situated at the bottom of the movement. Although by so doing he violated conditions of the Campani patent, he may have felt safe in doing so after his return to Augsburg, when he no longer was under the constraints of the Holy See.[333]

By the later decades of the seventeenth century, at least a dozen other Italian clockmakers were producing night clocks in at least five cities in addition to Rome. Although none of them incorporated a silent escapement, generally they were housed in cases reproducing the *aedicola* style similar to those of the Campani brothers. A number of these later night clocks were not signed by their makers, possibly because of the uncertainty concerning the papal patents. Among the later makers who did sign their night clocks were Ludovico Manelli of Bologna, Marco Santucci of Naples, Niccolò Rosso and Francesco Papillon of Florence, Giovanni Battista Callin and Enrico Capello of Genoa, Alfonso Vaccari of Ferrara, Johannes Wendelius Hessler, Carlo Caerugi and Marco Miroglio of Rome, and Giovanni Antonini and F. Danielli, whose place of work

[333] Lenner, "Johann Philipp Treffler."

was not indicated. The most prolific among them was Manelli, several of whose surviving night clocks are among the most beautiful and of the finest quality.[334]

Imitators made the night clocks in a variety of sizes, ranging from models of full size for palaces and large mansions to others substantially smaller, several of the latter operated by means of small watch-movements. Often the movements of the imitations utilized crown wheel and verge escapements and were pendulum-regulated, although a few were regulated by means a balance wheel. Mostly they were spring-driven, although a few weight-driven examples are known. The favored subject matter of the dial paintings ranged from religious to allegorical. After having been featured for decades in princely surroundings, by the end of the seventeenth century the changing mores and the development of domestic clocks brought about the demise of the large timepieces, and they were replaced by the more popular smaller bracket or table clocks with anchor escapement.[335]

The night clock maintained its vogue in Europe for a full half century during a period of great scientific activity brought about by developing technology, which required and provided greater precision. A factor that had figured in the night clock's development, which is not to be overlooked, is the invention of the magic lantern, first popularized by Athanasius Kircher's *Ars Magna lucis et umbrae* (1646). The popularity of the night clock in Italy resulted in its travel to England as well, where they were produced by at least five of England's most notable clockmakers: Thomas Tompion, Edward East, Joseph Knibb, the several members of the Fromenteel family, and Henry Jones.

The English clockmakers may have been inspired by one of the several Italian night clocks brought to England and owned by Sir John Cope, Archbishop Abraham Sharp, or Prince Rupert, or by an Italian night clock said to have been sent as a wedding gift in 1664 by Grand Duke Ferdinand II to the English queen, Catherine of Braganza, at the time of her marriage to King Charles II. There has been speculation concerning the Queen's clock and the probable identity of its maker. Was it Italian, or had it been made

[334] Gian Carlo Del Vecchio and Enrico Morpurgo, *Addenda al Dizionario degli orologiai italiani edizione 1974 di Enrico Morpurgo* (Milano: Tipografia Nava, 1989); Giuseppe Brusa, 'Italian Night Clocks', *Antiquarian Horology and the Proceedings of the Antiquarian Horological Society* 9, no. 2 (1975).

[335] Bedini, 'L'orologio notturno: un'invenzione italiana del XVII secolo'.

for her by the prominent English clockmaker Edward East? Or did she have both clocks? In his famous *Diary*, Samuel Pepys mentioned the Queen's night clock in reporting a visit to Whitehall in the company of a Mr. Pierce. The latter, he wrote, "showed me the Queene's bed-chamber, and her closett, where she had nothing but some very pretty 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," confirming that it was without question a night clock, undoubtedly one of smaller size being so close to the bedside.[336]

In the course of time, Italian night clocks began to lose favor among the wealthy in Italy as well as in England, partly because of stylistic changes in furniture and partly as a consequence of the advent of clocks of greater accuracy and of a more sophisticated appearance and portable nature. Although the excessive size of Italian night clocks was suitably accommodated in the large salons and bed chambers of palaces and great mansions, they rarely fit as readily in later modest dwellings. In time they were ignored also by clock collectors and antiquarians because of their great size, the often unpopular religious subject matter of the dial plates, and difficulty in repairing the movements, all factors contributing to the consequence that many of these clocks perished of neglect. Discarded in attics and basements, the undesirable atmosphere that, whether too dry or too humid and with lack of air circulation, caused separation of parts of the woodwork attributable to drying of the glue and damage to other elements of decoration. Some were transformed by later dealers and owners by discarding the original clock cases and accommodating the movements and dials in more convenient small clock cases, sometimes with replacement of the original dial plates with smaller dial plates and chapter rings.

Giuseppe's horological inventions were protected by his patents during the earlier decades of the second part of the seventeenth century, but thereafter, as other clockmakers were producing similar clocks, his increasing fame as a maker of

[336] Samuel Pepys, *The Diary of Samuel Pepys, Transcribed by the Rev. Mynors Bright from the Shorthand Manuscript in the Pepysian Library at Magdalene College Cambridge, Edited with Additions by Henry B, Wheatley, F.S.A.*, ed. Mynors Bright (New York: The Heritage Press, 1942), vol. I, 165, entry for June 24, 1664. Samuel Pepys (1613–1688) held various roles with the English Navy Board and was involved with the building of the Tangent Mole and its later destruction. His diary for the period 1660 to 1669 and his records and comments reflect much of what is known of English everyday life of the period; his diary has become one of the world's classic writings.

astronomical instruments forced him to devote less and less time to clockmaking, so that the competition did not concern him as much as it did his brother Pier Tommaso.

Chapter VIII

NEW WORLDS

(1660–1664)

> *My soul [...] was elevated to these thoughts by the infallible certainty of that real possibility which a man has to improve his good works. This knowledge, confirmed afterwards in me by my particular inclination and anxiety to discover the truth about that uncertain system of the star of Saturn [...] was the chief reason for making me apply my mind and hand to dioptrical studies, to which the celebrated Father Daniello Bartoli, S.[ocietatis] J.[esu], had exhorted me for a long time.*
>
> Giuseppe Campani, *Ragguaglio ...*
> (Per Fabio de Falco, Rome), pp. 8–9 (1664).

Despite Giuseppe's success as an independent clockmaker and his enthusiastic dedication to his craft, he could not but have become uncomfortably aware of the limitations of his chosen career. The success that he had shared with his brother Pier Tommaso since 1655 in the invention of the mercury escapement timepiece had been not only mentally rewarding but also had been financially remunerative. Following this early cooperative success within the next three years, with his own even more successful invention of the crank lever escapement, Giuseppe, now still in his twenties, already was established firmly among prominent Italian clockmakers.

The revival of classical influence in Italy was bringing about increased interest in the sciences as well. The development of collections, favoring at first classical antiquities, were expanded to include fine art and numismatics, and in time natural curiosities were added as well, ranging from ostrich eggs and stuffed crocodiles to minerals. Meanwhile, aggressive exploration and discovery had pushed back the limiting horizons of the known world, generating considerable interest also in objects from foreign lands brought back by returning explorers and missionaries.

It was a time when emerging studies in natural philosophy signaled advances also in horology and scientific instrumentation. With the new sciences, the requirement for improved means of measurement and observation led to the birth of logarithms, calculus, and the slide rule. In horology, the invention of the pendulum-regulated clock, such as Giuseppe already had experienced, brought about new means for measuring time, and eventually made time-telling possible for everyone instead for only the privileged few. Man's increased knowledge of weather was achieved with the thermometer and the barometer. The visibility provided for the first time by the invention of optical instruments made possible the study of natural wonders hitherto unknown, opening up new areas for research. After mid-century, following Galileo's observations of previously unknown worlds in the skies, the discoveries in his own world about him made possible by means of the microscope not only enlarged man's vision of his familiar world but also introduced him to other unknown worlds in outer space and those hitherto unseen around him.

Giuseppe gave serious consideration to the promise being offered by this new venture, but as he looked ahead to his future, Giuseppe considered the alternatives. Realizing how much he abhorred routine, he knew he would not remain satisfied as just a maker of domestic clocks, a career limited to the whims of wealthy clients. Nonetheless, his mind kept wandering forward to other aspects of horological development yet to be explored, and he anticipated that new fields remained for him to venture. At the same time, he kept being persistently drawn toward the new sciences that were emerging in Europe. Perhaps he could do both. Some of these considerations he shared with associates of his brother Matteo among the Collegio Romano's faculty, with whom Giuseppe had become acquainted. Just as the recent invention of the pendulum-regulator was to revolutionize clockmaking, in the same manner optical instruments promised to introduce him to wonders beyond the beyond.

Realizing he would be undertaking an entirely new career if he were to make the move now without further procrastination, Giuseppe at first was undecided. The popularity of astronomical observation that had been increasing from Galileo's time promised a growing market for telescopes, as well as an urgent need for their improvement. Clearly, astronomy was now in the process of developing into an important science, with opportunities for new craftsmanship for the production of improved lenses and telescopes. Its growing popularity invited a lucrative future even more than that of the clockmaker.

Astronomy, to be sure, was a greatly specialized field of endeavor with a market for its products that still was extremely limited, but it had the advantage that as yet there were relatively few makers of astronomical instruments in Italy or elsewhere, so that the number of Giuseppe's competitors was few. Prominent among Italian telescope makers, for example, there had been Francesco Fontana in Naples, Evangelista Torricelli and Ippolito Franchini in Florence, and Eustachio Divini, formerly one of Matteo's close friends and associates, in Rome.

Earlier, Divini also appeared to have worked as a clockmaker, but without much success, before achieving recognition as a successful maker of lenses and telescopes. It may have been the early acquaintance and friendship that Giuseppe's brother Matteo once had with Divini, now acknowledged as the most prominent maker of astronomical lenses and telescopes in Italy, that may have directed Giuseppe's growing interests toward the same endeavors. It is also possible that while urging Giuseppe to select dioptrics as a new career, it may have crossed Matteo's mind that in doing so, his brother would be competing with his former friend, who until then had virtually no competition. As Matteo and Giuseppe debated the issue, they concluded that a career in optics and dioptrics held the highest potential for professional and lucrative monetary benefits, although it also had its problems. One was that few resources existed for study in that field of endeavor, and as Giuseppe considered opportunities available for apprenticeship and training, for example, it was obvious that the most desirable master and teacher would have been Divini, but irreparably damaged relations no longer made that possible. Eventually, it was Daniello Bartoli, the Collegio Romano's renowned Jesuit historian, who convinced young Giuseppe to take the plunge and venture forth into this new career. Bartoli, who taught the classical history of the Jesuit order and of foreign missions, was also fairly well-informed on the subject of the sciences. During the years that he had been engaged in theological studies at Bologna, he had at the same time studied under Giovanni Battista Riccioli, the Jesuit astronomer who had made a series of ingenious experiments with pendulums and falling bodies. In his publications, Bartoli expounded on the works of contemporary physicists and popularized them, particularly in relation to the physical analysis of sound, barometric experiments, and the concept of experimentation with atmospheric pressure. It was later, from 1670 to 1674, that he served as rector of the Collegio Romano.

Bartoli had befriended the young clockmaker, and having become aware of Giuseppe's youthful restlessness and recognizing his bright mind and eagerness for achievement, Bartoli urged him to invest his time in studies of scientific optics. He urged particularly the need for familiarity with the works of Euclid, in order to develop the skills required for astronomical optical instrument-making.[337]

One aspect to which both Giuseppe and the practical Matteo gave particular serious consideration was the potential market. Would he be able to realize an income comparable to that which he was earning in clockmaking, Giuseppe probably wondered. That would depend upon his potential clientele. There was a distinct advantage to being situated in such a large city as Rome with its established elite as well as a changing population. There was the Roman nobility, which included the wealth of the families of the Chigi, Barberini, Rospigliosi, Pamphili, Colonna, Borromeo, and Altieri, among others. Of considerable importance also was the presence of the papal court and its embassies representing the major countries of the Christian world. Each of them had a changing sophisticated staff with sufficient means to indulge in costly avocations. It was indeed cause for pause. Furthermore, Giuseppe realized, he had a made-to-order clientele in the embassies, the clerical hierarchy, and the occasional wealthy merchants with whom he already had become familiar because they had been purchasing his clocks.

Although upon first view astronomy appeared to be an interest dominated by the few professional men of science, further consideration revealed that in addition to these were members of the religious teaching orders in colleges and universities. The Jesuits, in particular, engaged in astronomical observation. There also were the amateurs, among whom were the princes and prelates and the idle privileged, partaking in scholarly pursuits as an avocation or a social pastime. In fact, it was primarily these wealthy amateurs having scientific interest who were the ones who could afford to indulge

[337] Alberto Asor-Rosa, 'Bartoli, Daniello', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1964); Charles Coulston Gillispie, ed., *Dictionary of Scientific Biography* (New York: Scribner, 1970), 484; Carlos Sommervogel, *Bibliothèque de la Compagnie de Jésus*, vol. 1 (Bruxelles: Schepens, 1890), Bibliographie, 966–985.

themselves with the astronomical instrument maker's products. The difficulty in obtaining suitable materials, as well as the time required to produce successful instruments, had to be reflected in the prices for which they were sold, prices that consequently were substantial when compared to the cost of commodities.

Among Giuseppe's resources in his new endeavors was the convenient presence of his brother Matteo, who frequently provided advice (probably too often and frequently unasked) and who could translate Latin scientific texts for him, which he required for study. Particularly valuable also was Matteo's wide acquaintance and friendship among men of science interested in astronomy, such as Vincenzo Viviani and the Capuchin monk Antonio Maria Schyrleus de Rheita. After much thought and long discussions with Matteo and Bartoli, Giuseppe made the occupational plunge, with the assurance of being capable of continuing to support himself handsomely meanwhile by the production of clocks incorporating his invention.

Giuseppe already may have demonstrated an interest in optical instruments even before the break in relations that had occurred between Divini and the Campani brothers. Undoubtedly, he had become familiar with Divini's work from early visits to his shop. Once Giuseppe's decision was made to venture into optics, he became enrolled in studies at either the Collegio Romano or the papal college university La Sapienza. As he wrote several years later, his desire to improve himself, and his interest in the emerging science of astronomy that had been fueled by recent discoveries being made in searching the skies, were his primary reasons "for making me apply my mind and hands to dioptric studies, to which the celebrated Reverend Daniello Bartoli, S.J., had exhorted me for a long time."[338]

Giuseppe turned to his new studies with eagerness and dedication. He soon discovered that relatively few published sources were available for study. The first important contribution to the theory of optics was *Dioptrics* by Johannes Kepler published in Augsburg in 1611, which provided the law of refraction and the principle of the astronomical telescope, with the image inverted when biconvex objective and ocular lenses were combined. The optical system of the Dutch telescope (also called Galilean)

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[338] Campani, *Ragguaglio di due nuoue osseruazioni*, 8–9.

consisted of a convex objective and concave ocular lens, a system that continued in use for some three decades.

Kepler at first had ignored the advantages of the astronomical telescope, which had been first realized by Christoph Scheiner in 1615. By 1600, it already had become well-known that light could be reflected and refracted and that, in specific instances, it became possible to determine the angle of refraction. Although realizing some of the advantages of the astronomical telescope, Kepler did not make one. The study of focal distance of lenses, which Kepler had initiated for the concave lenses, had been completed and generalized in 1632 by Bonaventura Cavalieri.[339]

Willebrord Snell had discovered the sine law of refraction that René Descartes published in 1637 in his *Dioptrique* under the form of the law of sines.[340] The theory of optics was to make further progress in the second half of the seventeenth century, particularly as the result of the work of Christiaan Huygens.

As previously noted, by the early 1660s, Divini had achieved recognition as the foremost maker of optical lenses and telescopes in Rome and throughout Italy. He had emerged from obscurity by about 1646 to become a leader in the field and had remained uncontested as his instruments were being sought far and wide. For example, as early as March 1650, Johannes Hevelius had written to Athanasius Kircher to inquire concerning the range of optical instruments being offered "by the Roman craftsman Eustachio Divini."[341]

Again, two years later, Hevelius complained in a letter to Kircher that he had not received the lenses that Divini had promised to send him, and through Kircher he ordered from Divini a telescope of 45 palms to cost not more than 70 imperial thalers.[342] In his reply, made several months later, Kircher confessed uncertainty as to whether a telescope

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[339] Kepler, *Dioptrice seu Demonstratio*, 70–72; Augusto de Ferrari, 'Bonaventura Cavalieri', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1979).

[340] René Descartes, *Discours de la méthode pour bien conduire sa raison : et chercher la vérité dans les sciences* (Leiden: Jan Maire, 1637), 19–21; Snell's description of the law of optical refraction using cosecants, which he had developed in 1621, was posthumously published by Isaac Voss, *De lucis natura et proprietate* (Amstelodami: apud L. & D. Elzeviros, 1662), 36.

[341] Letter from Johannes Hevelius to Athanasius Kircher on March 12, 1650: Pontificia Università Gregoriana, Rome, *Carteggio Kircheriana*, v. 357, fol. 342; John E. Fletcher, 'Astronomy in the Life and Correspondence of Athanasius Kircher', *ISIS* 61, no. 1/206 (1970): 52–66.

[342] Letter from Johannes Hevelius to Athanasius Kircher on October 7, 1652: Pontificia Università Gregoriana, Rome, *Carteggio Kircheriana*, v. 568, fol. 120; Fletcher, "Astronomy in the Life and Correspondence of Athanasius Kircher": 66.

having a focal length of 45 palms was indeed superior to one having a focal length of 36 palms.[343]

When Giuseppe entered the field of scientific optics, the art was still in a state of infancy. The only makers of lenses at first had been the spectacle makers, but their techniques and resulting products proved to be inadequate for the new instrumentation that was required. The first appearance of instruments for observation—the telescope and subsequently the microscope—had taken place in the Netherlands in the early seventeenth century and brought about an immediate flowering of new interest in the skies and eventually in botany and medicine as well. As a consequence, the persistent and steadily increasing demand for the instruments led to the development of scientific optics. Traditionally, Sacharias Janssen is credited with the invention of the telescope, and, in some accounts, his father Hans Martens Janssen also is associated with the invention. This claim derives chiefly from a work by the French Pierre Borel, which is based primarily upon evidence presented by Sacharias Janssen's son before the burgomaster of Middelburg on March 3, 1655, attributing the invention to Sacharias and his father in 1590. A deponent, Willem Boreel, who in 1655 was Dutch ambassador to France, stated that as a boy in Middelburg he had played with Sacharias Janssen, adding: "as I often heard, Hans Martens and his son Sacharias Jensen, were the first to invent the microscopes".[344]

No date was mentioned, but it was asserted that Janssen presented one of his instruments to Prince Maurits of Nassau and later gave another to Archduke Albertus of Austria, who, it was said, presented it to the Dutch inventor Cornelius Drebbel. Pierre Borel and others may have mistaken the words of Sacharias Janssen's son's testimony of 1655 when he spoke of "long tubes" and "short tubes" and had interpreted the latter to be microscopes. Hans Sachariassen Janssen may have intended to say "astronomical

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[343] Letter from Athanasius Kircher to Johannes Hevelius on February 22, 1653: Staatsbibliothek, Marburg an der Lahn, *Darmstaedter Dokumentensammlung*, F.2.c. 1646 (1).

[344] "*Iohannes* (H.[ans] M.[artens]), *cum Filio suo Zacharia* (S.[acharias] J.[ensen]), *ut saepe audivi, Microscopia primi invenere*": Pierre Borel, *De vero telescopii inventore, cum brevi omnium conspiciliorum historia. Ubi de eorum confectione, ac usu, seu de effectibus agitur, novaque quaedam circa ea proponuntur. Accessit etiam centuria observationum microcospicarum* (Hagae-Comitum: Ex typographia Adriani Vlacq, 1656), 35.

(Keplerian) and terrestrial (Galilean) telescopes.” In actuality, his evidence related only to telescopes inasmuch as he had not been questioned about microscopes.[345]

The greatest challenge faced by the seventeenth century makers of optical instruments was the availability of optical glass suitable for producing acceptable lenses. Despite improvements in equipment and techniques, some of the difficulties in producing optical glass of sufficient clarity were not to be resolved until a century later. Three major problems had to be overcome in order to obtain suitable glass: a better understanding of the optical properties of lenses was needed, improvement of the imperfect quality of glass then available was required, and development of equipment and techniques for figuring the lenses was necessary. By the second half of the seventeenth century, each of these problems had been considered in turn, and partial solutions had been achieved, but it was not until the beginning of the nineteenth century that the problem of purity of glass finally was entirely resolved, and homogeneous glass free of striations and bubbles was achieved.

Meanwhile, optical glass generally continued to be produced by traditional methods, and experimentation was casual and empirical at best, with erratic results. Most of the early lenses were produced from a soda–lime–silica combination. To 1000 parts of sand were added 350–380 parts of soda and 180–230 parts of limestone. The fusion of glass was attained with considerable difficulty, and accordingly early glass workers tried to achieve it by keeping the fusion temperature of the glass as low as possible, with the consequence being that the product was frequently unstable. Even when the greatest care was exercised, lens blanks frequently were marred by one or more defects arising from the process of production. They might have entrapped air bubbles and/or *striae*, or small specks of charred vegetable matter that had been one of its components would be present. Following a common practice, Italian glass workers traditionally extracted the required amount of alkalis for glass-making from local plants. Soda was derived from ashes of a species of ferns grown near the sea shore, with the consequence that Venetian glass generally had a strong basis of sodium. Tartar, which contained potash, had to be added to soften the dark tint of the glass and to lighten its clarity. On the other hand, it was

[345] Albert Van Helden, ‘The Invention of the Telescope’, *Transactions of the American Philosophical Society* 67, no. 4 (1977): 5–9.

discovered that species of ferns that grew inland contained a substantial amount of potash, so that glass produced in Florence, for example, was sodium-potassic, quite similar to the Bohemian glass used for optical purposes in modern times.

It is not surprising to find that the earliest important advances in lens and telescope production were made in Italy, which had given birth to the first spectacles. One reason was because the finest glass of all Europe was being produced at Murano in the Venetian Republic. Furthermore, the best equipment then available for grinding and polishing lenses was that which had been developed by Venetian mirror makers and polishers of *pietre dure*. It was not until the second decade of the seventeenth century that a glass factory had been established in Florence under Medici patronage. It soon began to produce optical glass of a quality that competed with that of Murano, although never excelling it.

In early periods of Venetian glass making, excessive sodium oxide was introduced to the mixture to lower the fusion temperature, but as a consequence it often caused the glass to devitrify. In the course of time, even improved techniques of casting, cutting, grinding, and polishing failed to achieve optical glass having absolute clarity, a basic problem that remained unresolved.

The place of origin of a piece of glass often could be determined by its chemical composition. Silica was obtained by grinding and pulverizing certain small pebbles found in local river beds. In Venice, these were procured from the Ticino River [Duchy of Milan], while Florentine glassmakers collected pebbles from the Arno River, especially from the area of Falterona. The preference for silica found in pebbles from these sources was because they contained only minimal traces of iron, so that they turned white when exposed to fire. In an effort to achieve greater clarity of the glass product, instead of the pebbles, Florentine glassworkers frequently substituted quartz from other locations, such as that found in the Versilia River or fragments of rock crystal that occurred in nature.[346]

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[346] Antonio Neri, *L'Arte vetraria distinta in libri sette del r. p. Antonio Neri fiorentino : ne quali si scoprono, effetti marauigliosi, & insegnano segreti bellissimi, del vetro nel fuoco & altre cose curiose* (In Firenze: nella Stamperia de'Giunti, 1612), 1–14; Antonio Neri, *L'Arte Vetraria: The Art of Glass*, trans. Paul Engle, vol. 1 (Hubbardston, MA: Heiden & Engle, 2006), 11–30; Piero Ginori Conti, 'Il vetro per l'ottica in Italia', *Atti della Società Colombaria di Firenze* Anno 1930–1931, Communicazione nella adunanza del 9 febbraio 1931 (9 February 1931).

Until the beginning of the sixteenth century, lenses had been ground and polished entirely by hand. The earliest evidence of mechanical equipment that may have been used for the purpose seems to have been machines described and illustrated by Leonardo da Vinci in his *Codex Atlanticus* and in his other notebooks. He designed, or recorded, what appears to have been the earliest precision grinding instrument—identified as a machine for internal grinding of the workpiece being held in a screw-type vise.[347]

Leonardo also described a smaller, hand-powered apparatus for grinding the edges of sheets of glass. This machine could be positioned either vertically or horizontally; in either case, the workpiece was supported mechanically and guided in relation to the wheel. Of related interest is yet another of Leonardo's sketches of a *strumento da sfere*, a mechanism complete with grinding attachment, for producing "spheres." Another drawing of this machine is captioned "which may be turned by means of water or manpower, and which is good for [making] mirrors".[348] Leonardo's machines cannot be correlated directly with the grinding and polishing of optical lenses, but they may have provided a basis for the later development of such an apparatus.

By 1600, the only equipment known to be available for optical lens production was that employed by Venetian mirror makers, by Florentine spectacle makers, and by the polishers of Florentine mosaic *pietre dure*. Although at first the production of optical glass had been the purview of the spectacle makers, new means of producing lenses had to be sought if the potentials of the telescope and microscope was to be realized. Galileo struggled with the problem of obtaining suitable clear glass for lenses throughout his career, from the first telescope that he made until his last.

At first, Galileo's source for glass had been the mirror makers on the island of Murano; selections of the Murano glass often were made for him by several of his

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[347] Leonardo da Vinci, *Manuscript B*, Institut de France (Roissard, Grenoble), fols. 13r, 21v (1960); Robert S. Woodbury, *Studies in the History of Machine Tools* (Cambridge; Londres: M.I.T. Press, 1973); *History of the Grinding Machine; a Historical Study in Tools and Precision Production.* (Cambridge, Mass.: M.I.T. Press, 1964), 18–23.

[348] Matthew Landrus, *Instruments and Mechanisms: Leonardo and the Art of Engineering: Drawings by Leonardo from the Codex Atlanticus*, Codex Atlanticus 17 (Novara: DeAgostini, 2013), 20, 28; Domenico Laurenza, *Leonardo's Machines: Da Vinci's Inventions Revealed*, ed. Mario Taddei and Edoardo Zanon (Newton abbot: David & Charles, 2011), 173–76; see also: Paola Manni, Marco Biffi, and Davide Russo, eds., *Glossario leonardiano: nomenclatura delle macchine nei codici di Madrid e Atlantico* (Firenze: L.S. Olschki, 2011).

friends, among them Girolamo Magagnati (ca. 1565–1613) of Lendinaram who worked at Murano producing mirrors and specialized colored glass.[349]

Another who was particularly helpful to Galileo at this time was Giovanni Francesco Sagredo (1571–1620), one of his most intimate friends in his Padua period. Scion of one of the Venetian Republic's wealthiest and most influential families, he pioneered the development of optical glass as a project of personal interest. In about 1609, he had become interested in the theory of vision and had familiarized himself with much of the published literature on the subject, including Kepler's *Dioptrics* and Giovanni Battista della Porta's works, either *De refractione* or *Magia naturalis*. Although most of Galileo's correspondence with Magagnati, as well as his letters to Sagredo, have been lost, a substantial number of communications from Sagredo to Galileo have survived, providing a record of the state of optical glassmaking in this period as well as identification of the most important makers of Galileo's lenses.

Because of the difficulty experienced by Galileo in obtaining lenses, Sagredo constituted himself agent in Venice to procure them for the sage. As Sagredo reported, the most important of the Venetian mirror-makers was known only as Master Antonio, with a shop at the Sign of San Lorenzo in Venice's Frezzaria. He was a poor good man who had been first a mirror maker and then was reduced to producing lenses for telescopes of every length and it might be said that at one time he alone produced lenses.. Sagredo informed Galileo that Master Antonio was anxious to obtain his commissions, and subsequently commented that he had substantially repaired his fortunes by means of the work he received from Galileo. His fortunes having improved to such an extent, in fact, that he had abandoned his customary trade as mirror-maker and grinder of stones and devoted himself entirely to making lenses for telescopes. Sagredo added that Master Antonio had become capable of producing lenses "of large diameter" and was able to work on more than one lens at a time.[350]

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[349] Antonio Favaro, *Amici e corrispondenti di Galileo Galilei*, vol. 3. Girolamo Magagnati (Venezia: Officine Grafiche Carlo Ferrari, 1896), 441; Stillman Drake, 'Galileo Gleanings: XIV: Galileo and Girolamo Magagnati', *Physis* 6, no. 3 (1964): 269–86.

[350] Letter from Giovanfrancesco Sagreto to Galileo Galilei, August 24, 1613: Galileo Galilei, *Le opere di Galileo Galilei: Edizione nazionale sotto gli auspici di Sua Maestà il Re d'Italia*, ed. Antonio Favaro, vol. 11 (Firenze: Barbera, 1901), 553. See also: Letter from Giovanfrancesco Sagreto to Galileo Galilei, June 2, 1612; ibid., 314.

Several other Venetian workers produced lenses for Galileo, including Giacomo Bacci, who maintained a shop in the Calle delle Acque in Venice, and Armanno, the only spectacle-maker known to have produced lenses for scientific instruments at this time, although he was the least successful of Galileo's providers.[351]

Two methods for preparing glass blanks for lenses were commonly used. One method was for the foundry to cast glass in the form of plates, from the most suitable section of which the lens makers would cut disks, selecting the area containing the least number of impurities. Another method was for the glass worker to pulverize the glass and cast it into forms, or molds, of spherical shape having the precise radius of curvature required for the final product. Sagredo experimented extensively with molds, which he provided to those glass workers he employed.[352]

The molds in which the glass was cast were made and shaped from a mixture of finely ground Venetian rottenstone mixed with egg white, calfskin, and dried white lead. Pulverized glass was placed into such a mold, which then was inserted into a small stone kiln. Large lenses were cast by the glass workers for Galileo who then polished them to the desired specifications. Few of these early glass blanks have survived in their original state.

The production of perfectly clear glass still remained a problem that was seemingly insuperable. A contributory factor was the nature of the molds, which were less than satisfactory and the length of which "gives rise to obscurities," as Sagredo had reported. Galileo repeatedly complained about the foreign inclusions they contained that made the lenses unusable, and although Sagredo reported them to the Murano glass workers, no satisfactory solution could be found.[353]

The achievement of an acceptable lens was not only a question of size and shape alone, however, for although the mirror makers were able to produce lenses having the desired curvatures, even the finest pieces they produced might enclose impurities and contain air bubbles. Consequently, Galileo often was forced to purchase lenses in substantial numbers, from which he selected out the few having the least number of

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[351] Bedini, *Patrons, Artisans and Instruments of Science, 1600-1750*, 105.

[352] Galileo Galilei, *Le opere di Galileo Galilei: Prima edizione completa condotta sugli autentici manoscritti Palatini e didicata a ... Leopoldo II granduca di Toscana*, ed. Eugenio Albèri (Firenze, 1842), Tomo VIII, 263 and 364.

[353] Olaf Pedersen, 'Sagredo's Optical Researches', *Centaurus* 13, no. 2 (1969): 139–50.

impurities for use in his instruments. As late as 1616, he reported in a letter to Sagredo that of a batch of 300 lenses made by Bacci, only 22 were acceptable.[354] Sagredo informed Galileo in the following year that Master Antonio had been working for months without being able to produce lenses of suitable quality, only mediocre ones.[355]

Galileo was at a loss concerning disposition of the number of imperfect lenses he was acquiring and dismissed Sagredo's suggestion that he give them as gifts to those who kept asking him for lenses in the belief "that by means of your benediction you are able to convert window glass into telescopes".[356]

Bacci, meanwhile, was faring no better than before. Two years later, Sagredo finally discontinued his services because, as he informed Galileo, "Bacci is my friend, and every time I go to see him he gives me as many lenses as I wish, and always 'exquisite' ones, according to him; he is always proved to be lying, however, and his price is invariably 3 Lire for each, so that I no longer make use of him".[357]

Later in that year, Sagredo again resumed his research, working with Murano glass workers in his efforts to achieve an improved quality of glass. As he informed Galileo:

> Experience has indicated that the more or less clear color is no matter for consideration. Bubbles, which these Murano workers call *puleghe*,[358] are not very harmful, but only the twistings are, some twisted threads often found in the glasses caused by mixing glasses of different batches. One therefore must attempt to make the glass homogeneous and uniform in all its parts, since these differences in the glass give reason to believe that there are different degrees of hardness causing rays to be refracted when instead they should proceed along straight lines through the glass, and having been refracted, to take other and mutually different courses than they should follow, wherefore the images are seen as double and foggy.[359]

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[354] Giovanni Polvani, ed., *Pubblicazioni Del Comitato Nazionale per Le Manifestazioni Celebrative Del IV Centenario Della Nascita Di Galileo Galilei: Presidente, Giovanni Polvani ... [et Al.* (Firenze: G. Barbèra, 1964), vol. 2, ed. 5, 105; Silvio A. Bedini, *Science and Instruments in Seventeenth-Century Italy* (Aldershot: Variorum, 1994), 318.

[355] Galilei, *Opere di Galileo Galilei*, 11:vols. X through XIII.

[356] Carlo Vittorio Varetti, 'L'artefice di Galileo: Ippolito Francini detto Tordo: contributo agli studi galileiani e alla storia dell'ottica', *Rendiconti della Reale Accademia nazionale dei Lincei* 15, no. 3–4 (1939): 221.

[357] Letter from Giovanfrancesco Sagredo to Galileo Galilei, March 18, 1618: Galilei, *Opere di Galileo Galilei*, vol. 11, vols 12, 376.

[358] [Scientific Editor 2: Venitian for "fleas"].

[359] Letter from Giovanfrancesco Sagredo to Galileo Galilei, August 4, 1618: ibid., vol. 12, 405.

Sagredo went on to describe an experiment made in Murano under his supervision, in which 200 pounds of finely powdered ashes were passed through progressively finer and finer sieves until only 16 pounds of the finest powder remained. The same process was followed with 200 pounds of powdered gravel from Ticino [*giara macinata del Ticino*], which was reduced to 15 pounds. The two powders then were thoroughly mixed, and a little manganese was added; then they were baked and reduced to powder once more in a color mill and then placed in a mold in the glass oven. Despite their great expectations, the experiment proved to be a failure because the fire in the glass oven became extinguished before the process was finished. Then it occurred for a period of almost the next three months that all the ovens on Murano were cooled down to enable them to be cleaned.[360]

Despite this setback, Sagredo continued his experiments, utilizing 200 pounds of chippings of pure rock crystal as his raw material. This experiment also failed because of the rupture of the mold; only a few lens blanks were recovered, most of which later broke during the process of grinding because they had cooled too quickly.[361]

Although Sagredo was greatly preoccupied with political events and other public affairs during a time span of almost a decade, he nonetheless managed to pursue his experiments with lenses unabatedly. Several more trials made by Sagredo also failed. When another mold broke, the Murano workers used the broken pieces of glass to make mirrors without Sagredo's knowledge or consent, which cost him heavily. Finally, Sagredo succeeded in having a large plano-convex lens with a diameter of one span made from his rock crystal glass. It took twice as long to grind as ordinary glass, and the result proved to be no better than a lens of ordinary glass. This appears to have been Sagredo's last experiment, and he died the following year.[362]

Galileo continued to use glass from Murano and Venice for almost a decade, during which time he endeavored to entice some of the mirror makers to work for him privately but was not successful. Failing this, he looked about for other sources. At just this time, Florence was enjoying a revival of the arts and crafts under the sponsorship of

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[360] Ibid.

[361] Letter from Giovanfrancesco Sagredo to Galileo Galilei, December 15, 1618: ibid., 427.

[362] Letters from Giovanfrancesco Sagredo to Galileo Galilei, December 22, 1618: ibid, 429; March 8, 1619, ibid., 445; March 30, 1619, ibid., 446-447; May 11, 1619: ibid., 453. See also: Pedersen, 'Sagredo's Optical Researches', 142–49.

the Medici grand dukes. As part of it, in 1617 Grand Duke Cosimo II ordered the installation in the Boboli gardens of a well-equipped furnace modeled upon those used in Venice for the production of fine glass and enamels for making artificial cameos. To provide instruction in these arts, the Grand Duke called for artisans from Murano.[363]

It was at about this time that Galileo realized that yet another potential source for the grinding and polishing of lenses were Florentine workers in *pietre dure*, who might be able to adapt their equipment and technique to the new needs. He discovered that a talented young lapidarist, named Ippolito Francini (called "Il Tordo") was working as a polisher of *pietre dure* in the Medici workshops. This artisan was often confused with another craftsman working in the same place in the same period because the name "Mariani" was also attributed to him because it was the cognomen of his mother. Galileo immediately commissioned Francini to produce lenses for him; by 1619, Francini had established his own shop, and by 1623, he was producing lenses exclusively for Galileo's telescopes. Francini continued to supply most of Galileo's lenses for the next two decades, presumably making them under Galileo's direct supervision. Francini continued in the Grand Duke's employ until his death in 1653.[364]

The fact that the lenses Francini produced for Galileo were far superior to any that Galileo had obtained from Venice was due in part to the fact that the optical glass being produced in Florence at this time was of marked better quality than that available in Murano. An even more important factor was that Francini used a special lathe that he had designed and constructed for lens grinding and polishing. It enabled greater precision than other lathes then in existence. The improvements in Francini's lathe over the *tornio in aria*–literally: "lathe [operated] aerially"-are readily apparent even in the quaintly drawn woodcut reproduced in a work by Carlo Antonio Manzini. The crank wheel and pattern are mounted horizontally instead of vertically and are so placed that the artisan could keep constant watch over the work. He was able to manipulate it accurately while it was in progress, exerting the pressure required without excessive fatigue. The mechanism was illustrated in Manzini's work, wherein it was noted that it had been designed and

[363] Reino Liefkes, *Glass* (London: V&A Publications, 1997), 54.

[364] Antonio Favaro, *Galileo Galilei e suor Maria Celeste* (Firenze: G. Barbèra, Editore, 1891), 405, n. 1; Varetti, 'L'artefice di Galileo', 8–71.

built by “a skilled lens maker in the famous Galleria of the Most Serene Grand Duke of Tuscany whose name is Ippolito Francini, and who is called Tordo”.[365]

Occasional references of considerable interest relating to the technology of lenses made for astronomical purposes are to be found in Galileo’s papers and are worthy of further study. In December 1633, for example, Bernardo Conti wrote to Galileo to confirm the purchase of powdered lapis lazuli to be used by Francini for producing blue tinted lenses for observing the sun in accordance with Galileo’s instructions. This semi-precious stone, long favored for jewelry, was customarily used as a tint in oil painting when powdered; consequently, it was extremely expensive.[366]

In a letter written in 1637 to Fra Fulgenzio Micanzio in Venice, Galileo noted that Grand Duke Ferdinand II “for some months has been so preoccupied in making lenses that he is perpetually bringing the one who works continually to his villas and all other places: and His Most Serene Highness always supervises the work and does not want the Master [Francini] to work for anyone else, and is so miserly that no one receives any esteem”.[367]

Meanwhile, others in Italy also had begun experimenting with the development of lenses and telescopes, among them Antonio Santini, Fabio Colonna, Giovanni Lodovico Ramponi, Danielo Antonini, Giovanni Antonio Magini, and Paolo Lembo, with all of whom Galileo corresponded at one time or another.[368]

One of the most important printed sources on lens making in the seventeenth century is a work already noted that was published in 1660 at Bologna by Count Carlo Antonio Manzini (1600–1677). Entitled *L’Occhiale all’Occhio, Dioptrica Practica*, a full rendering of its title in English is “The Eyeglass to the Eye. Practical Optics by Count

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[365] Carlo Antonio Manzini, *L’occhiale all’occhio, dioptrica practica, dell Co. Carlo Antonio Manzini Dottore Collegiato etc. Dove si tratta della Luce; della Refrattione de Raggi; dell Occhio; della Vista; e de gli aiuti, che dare si possono à gli Occhi per vedere quasi l’impossibile. Dove in oltre si spiegano la Regole Pratiche di Fabbricare Occhiali a tutte le Viste, e Cannocchiali da osservare i Pianeti...* (Bologna: per l’herede del Benacci, 1660), 162; an extensive review of Manzini’s work appeared in the ‘Description of a Microscope of a New Fashion’, 837–40.

[366] Letter from Bernardo Conti to Galileo on December 7, 1633: Galilei, *Opere di Galileo Galilei*, vol. 11, vols 15, 348.

[367] Letter from Galileo to Fulgenzio Micanzio on November 20, 1637: ibid., v. 17, 220; Varetti, ‘L’artefice di Galileo’, 4–5.

[368] Carlo Vittorio Varetti, ‘Contributo alla storia dell’ottica nella prima metà del secolo XVII dal canocchiale di Galileo alle lenti del Torricelli’, in *Unione Matematica Italiana, Atti del Secundo Congresso, Bologna, April 1940* (Unione Matematica Italiana, Bologna: Odersi, 1941), 573; Varetti, ‘L’artefice di Galileo’, 204–97.

Carlo Antonio Manzini Doctor and Academician, ecc. In which he analyzes the Light, the Refraction of Rays, the Eye, the Sight, and the aids that can be given to the Eyes in order to see those things almost impossible [to be seen]. In which, moreover, he explains the Practical Rules to make Eyeglasses for every kind of Sight, and Telescopes, to observe the Planets, and the Fixed Stars, from the Earth, from the Sea, and other (instruments) to magnify Thousands of times the smallest among the close Objects."[369]

In his time, Manzini was an acknowledged authority on optical matters, had personally engaged in grinding and polishing object lenses, and was in contact with contemporaries involved in lens and telescope making, including Francesco Fontana and Divini. He made astronomical observations from his private observatory, which he maintained at his villa at Bettedizzo near Bologna. Manzini had a wide range of scholarly credentials for a man in that period. Not only was he a member of the Bologna nobility, a doctor of philosophy, and a member of the faculty of the University of Bologna, but he was also an author of published works on various phenomena, including comets, geodesy, and declination of the compass, including a work on the circumference of the Earth and the means to determine meridians.[370]

L'Occhiale all'Occhio, Dioptrica Practica is an extremely valuable resource on the theory of optics and on the state of contemporary lens making, recording much of what was then known about the tools and techniques of the contemporary lens makers. After a chapter relating to the invention of spectacles and the telescope, the three chapters following are concerned with optics, the anatomy of the eye, and the mechanics of vision. The remainder of the work deals exclusively with the manufacture of lenses, means of ascertaining their quality, and the various purposes to which each type of lens was best suited. The glassworks at Murano was described as well as the optical worker's table for the precise measurement of lenses, and the illustrations include a lens grinder, glass cutting shears, grinding and polishing lathes, and several optical instruments.

In his work, Manzini particularly extolled the achievements of Eustachio Divini, whom he considered to be the foremost and possibly the only maker of optical lenses and instruments for commercial distribution working in Italy at that time. He wrote: "O Art

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[369] Manzini, *Occhiale all'occhio*, title page.

[370] Carlo Antonio Manzini, *Stella Gonzaga, sive Geographica ad terrarum orbis ambitum et meridianorum differentias ...* (Bononiae: Typis H.H. Ducii, 1654); dedicated to Charles II, Duke of Mantua.

more than Human, unparalleled, and as I said, almost Divine: also because nowadays lives in Rome a Eustachio Divini, whose fame has surpassed that of anyone else in this Art, so that because of his excellence, I think that in the future the Art, as if brought by him to a more excellent level, could be called Divine".[371]

Manzini made reference to Divini repeatedly in the text and featured a full-page portrait of Divini, bearing the caption, "Eustachio Divini from S. Severino [...] at 49 years of age, judged by men of science the first in this art until now to have practiced perfectly the fabrication of the large telescopes".[372]

[Figure]

Divini was unquestionably the foremost maker of optical instruments in Europe at the time that Manzini's work was published. Within the next decade, Divini published several works in the form of public letters addressed to Manzini. In view of what apparently was a close association between the Manzini and Divini, it is possible that a part of the contents of Manzini's work may have been derived from information provided by Divini, who already had been engaged in optical instrument making for the past 15 or more years. It was not long after the publication of Manzini's book, however, that Divini's position in instrument making was to be challenged and soon usurped by none other than Giuseppe Campani.

Giuseppe Campani undoubtedly was familiar with Manzini's work at the time of its publication, which coincided with his own venture into the field, and certainly he would have made good use of it. Particularly helpful to him would have been the extensive text relating to lens production—descriptions of lens grinding and polishing lathes, selection of abrasives, and other details. It was scarcely two years following the publication of Manzini's work that Giuseppe began to produce optical lenses and telescopes that eventually would surpass those of Divini.

For the most part, the equipment and techniques of the early makers of lenses to be used for scientific observation are known today only from manuscripts, sometimes in

[371] "*O Arte più che Humana*, *impareggiabile*, *e quasi dissi Divina: tanto più*, *che hoggidi vive in Roma uno Eustachio Divini*, *la di cui Fama quella di ogni altro di quest'Arte a dietro si lascia; onde*, *per la di lui eccellenza*, *credo potersi per l'avvenire*, *come che da cotestui promossa al maggior segno*, *chiamarsi l'Arte Divina*"; Manzini, *Occhiale all'occhio*, To the Reader. [n. G.S.].

[372] Ibid*.,* Divini is mentioned at pages 118, 170, 174, 188–189, 191, 245. Divini's portrait in unpaginated plate.

references in correspondence, a few contemporary drawings, and a handful of surviving instruments. Consequently, Manzini's compilation provided a particularly valuable resource. The earliest equipment known to have been developed for the purpose of lens making that he mentioned appears to have been a lathe he described literally as a "lathe [operated] aerially" or "in the air" [*tornio in aria*]. A glass blank in the operator's left hand was held firmly against the turning mold above eye level, operated by a foot pedal, while the operator turned a crank wheel with his right hand.[373] This arrangement was particularly tiring for the craftsman, who could exercise only minimum control over the manipulation of the glass blank. This equipment may have evolved from that employed earlier for the grinding and polishing of small disks for spectacle lenses. Because of the limited control over the workpiece, the accuracy of the final product relied chiefly on the skill of the artisan and his ability to work under stress.[374]

Generally, seventeenth century lathes for grinding and polishing lenses turned the tool instead of the glass blank. After the glass had been melted and cast into a mold of the desired diameter to produce a blank, it was attached to a "muller," a handle made of wood or of hollowed-out stone; the glue used consisted of any one of various types of pitch or resin. The traditional abrasive used to grind lenses was Venetian rottenstone, while well-purged and minutely ground emery, white sand, or *tripoli* were required for polishing them. The material was dampened and applied to soft buckskin fitted tightly over the form or mold. The tool, or pattern, needed to be ground as precisely as the lens was to be. The mold was made of one of several metals, including iron, steel, copper, brass, pewter or lead, depending upon what was required for the particular stage of grinding or polishing. The patterns, whether made flat, concave, or convex, also were made by being cast in wooden forms, turned to final precision, and polished on a hand lathe.

The glass blank was fastened to a muller with an adhesive and held against the turning pattern. The adhesive consisted of an infusion of liquefied yellow pitch, resin, and finely ground clay to which a dram of pulverized glass had been added. Another glue

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[373] Ibid., 156-159.

[374] Silvio A. Bedini, 'An Early Optical Lens-Grinding Lathe', *Technology and Culture* 8, no. 1, Winter (1967): 74–77.

used for the same purpose consisted of a mixture of black Spanish pitch, sealing wax, and plaster.

That these traditional abrasives used for lens grinding and polishing had long been well-known is confirmed in a manuscript treatise by Giovanni Cristoforo Bolantio. He concurred that in his opinion the best abrasive was Venetian rottenstone because it could be pulverized so that gritty particles could be reduced to a minimum. For the final polishing, the pattern was replaced by a wooden form or mold having the same shape. Bolantio has not been identified, but it is believed he had been an instrument maker working in Rome or possibly Florence in the later seventeenth century.[375]

A subsequent development in the design and production of lathes for lens grinding and polishing was reported by Manzini to have been achieved by himself as an improvement upon a lathe that had been described and illustrated by Abbot Emmanuel Maignan (1601–1676), in his volume entitled *Perspectiva Horaria*, *sive de Horographia Gnomonica tum Theoretica*, *tum Practica* (*Horological Perspective, or, Gnomic Horography, both Theoretical and Practical*).

The Manzini lathe was an improvement also over Francini's lathe in that the operation was performed more directly. The crank wheel was connected horizontally to the pattern and the glass blank at the end of a rod supported upon an elementary work rest so that the constant support permitted the workpiece to remain true to the center of the pattern at all times. The workpiece was moved forward by means of a tail stock held between the ways of the bench. This type of lathe served as the basis for the metal-working lathes developed later in France and England.[376]

In his work, Maignan also mentioned that he had \become acquainted with Divini, referring to him as an outstanding master of his craft, despite the fact that he was a newcomer to the art, noting that he had begun to work as a lens maker only several years earlier.[377] This account is consistent with other sources reporting that Divini first began to produce his lenses and telescopes in about 1646.

[375] Silvio A. Bedini, '"A Treatise on Optics" by Giovanni Christoforo Bolantio', *Annals of Science* 52 (1995): 103–26.

[376] Manzini, *Occhiale all'occhio*, 221–23.

[377] Maignan, *Perspectiua horaria,* 687.

The title of Maignan's book continued at some length: *"In which the ancient gnomons are further developed and in which the plan and best geometrical design are given, not only of the common sun dials, which indicate the hours by a straight ray and shadow, but also of other sun dials of a new invention, which show the hours by reflection and refraction of ray and shadow. Among these is especially admired the catoptric and dioptric of Thaumanatias wherein the solar ray is reflected and refracted by a cylindrical mirror, all rays which center in the sphere circulating geometrically in the same manner as an iron. The light in accordance with its proper nature has its parts given in accordance with the ratio of reflections and refractions as given by physical principles. There follows, then, the most reliable method of making a telescope, or sundial, not only spherical but also hyperbolic and elliptical. Written by R.P.F. Emanuel Maignan of Toulouse, of the Order of Minims, Professor of Sacred Theology..."*.[378]

Three different lathes for turning spherical mirrors of curious construction are illustrated in engravings in Maignan's work, requiring structures constructed with massive timbers, and the work also contained illustrations of the convex tools for grinding the surfaces of metallic mirrors used for optical purposes.[379] In his classic work on turning, the contemporary writer Charles Plumier mentioned Maignan the person but not his book. He wrote, "I have sought out and observed the most skillful, among them our R. P. Emmanuel Magnan [sic], Religieux Minime, as myself, of the Province of Toulouse, known by all Europe for his rare skill and happy genius. It was he who first added to training given me by my father, who enjoyed the exercise and taught me all he knew."[380]

While Galileo serves as a historical milestone in the evolution of scientific apparatus, having been an early example of those who combined theoretical and mathematical knowledge with practical craft skills in the production and use of telescopes, he appeared at the end of the medieval tradition of instrument-making and the emerging development of applied precision measurement and development of experimental and applied science. Galileo was among the first who combined the

[378] Ibid., title page.
[379] Ibid., Prop. LXX-LXXVIII, 689-705.
[380] Charles Plumier, *L'art de tourner, ou de faire en perfection toutes sortes d'ouvrages au tour ...* (A Paris: chez Charles-Antoine Jombert, libraire du roy pour l'artillerie & le génie, 1749), preface, page ix.

theorist's appreciation of the need for improved tools with a practical ability to design and/or construct the ones he needed, drawing upon work of many others who also did so. As a consequence of the use of astronomical instruments established by Galileo by the mid-seventeenth century, and the development of optical techniques by instrument makers such as Divini and Campani during the next several decades, Italy emerged as the foremost center for the production of scientific optical instrumentation, and it was not until the beginning of the next century that England moved into first place.

By the time of Galileo's death in 1642, the craft of lens making had been achieving substantial progress. Important developments followed one after another in rapid succession in Italy as well as elsewhere. In Danzig, for example, in 1647 Johannes Hevelius (1611–1687) proposed a method for grinding several small lenses simultaneously by means of a vertical lathe using a wooden pattern fitted to the mandrel. Several lens blanks could be secured with pitch to this wooden disk-like pattern, and the metal-grinding tool was pressed down upon them as the pattern revolved until the blanks were ground to the curvature of the tool. Polishing was accomplished in the same manner.[381]

Divini described his own techniques to some degree in an open *Lettera* to Manzini published in 1663.[382] Based upon his close friendship with Manzini, it is likely that at first he used a lathe somewhat resembling the one illustrated in the latter's book as having been developed by Francini in Florence. Later Divini almost certainly adapted a lathe of the type improved by Manzini from the one illustrated by Maignan in 1648.

A significant comment concerning the glass that Divini used for his astronomical lenses occurs in the writings of a contemporary, the Englishman John Beale, writing in the 1650s. Commenting on the construction of astronomical instruments, Beale wrote "no cristal, nor the best Venetian glass of this present age, is so good for the most powerful tubes as the old Venice glass, and glass which is somewhat greenish. 'Tis also more naturall, and more helpfull to the eie and less glaring with refractions." He then added,

[381] Johannes Hevelius, *Johannis Hevelii selenographia: Sive, Lunae descriptio ... Addita est, lentes expoliendi nova ratio; ut et telescopia diversa construendi, et experiendi, horumq[ue] adminiculo, varias observationes coelestes, inprimis quidem eclipsum, cùm Solarium, tum Lunarium ...* (Gedani [Gdansk] edita: Autoris sumtibus, Typis Hünefeldianis, 1647), 11.

[382] Divini, *Lettera*, 27-41.

"Eustachio Divini (the most famous workman in Rome) for his telescopes useth the best of old looking glasses."[383]

Beale mentioned the matter again in a letter to Samuel Hartlib written a decade later, in which he noted, "Eustachio Divino, helpes himself by broken pieces of old looking glasses".[384] This appears to be confirmation that the glass produced by the mirror makers of Venice remained superior to glass produced by other makers available at that time.

Soon after Divini had begun to marketing his lenses and telescopes, he also used them for making his own astronomical observations. In 1647, 1648, and finally in March 1649, Divini observed the moon in its different phases, using several of his own large telescopes, including one of 24 palms and another of 16 palms. Divini utilized a micrometer of his own design, consisting of very fine threads arranged in the form of a grid disposed upon the lens upon which he placed the most exact possible image of the lunar spots. Divini's lunar map was preceded by one that had been published in 1645 by Langrenus (the Dutch Michael Van Langren). The first documented use of a micrometer was in 1640 in England by William Gascoigne, whose technique was used later by Christopher Wren for lunar mapping.

The final version of Divini's map prepared for publication was probably drawn for him by his brother, the artist Cipriano Divini. It was the first exact astronomical observation of the moon, with what appears to have been among the earliest uses of a micrometer. Divini's map was issued in the form of a large engraved broadside, entitled "The Lunar Map," and dedicated to Grand Duke Ferdinand II, to whom Divini sent a copy. He forwarded another copy of the map to the Magistratura of Sanseverino, the governing body of the town in which he was born. He reported proudly in his writings that on two occasions he had been received in audiences by Pope Alexander VII at the Apostolic Palace, during which the Pontiff had discussed astronomy and mathematics with him, sciences in which His Holiness said he took a particular interest.[385]

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[383] "Mr. Beale. Concerning Perspectives Tubes and Telescopes": British Library, *Sloane 548*, fol. 18, (courtesy of Anita McConnell).

[384] Letter from John Beale to Samuel Hartlib on February 17, 1660: Sheffield University Library, *Hartlib Papers*, Hartlib 67/22/7A-9A, (courtesy of Anita McConnell); Silvio A. Bedini, 'Seventeenth Century Italian Compound Microscopes', *Physis* 5, no. 4 (1963): 401 and 404.

[385] Otello Marcaccini, 'Eustachio Divini astronomo ed ottico e la sua "carta lunare"', *Appennino*

Galileo is to be credited to a large degree for the fact that, in the seventeenth century, it had become possible to establish a closer relationship between men of science and artisans who provided his tools. Their ability to work closely with the instrument makers resulted in a generation of instrument makers who differed substantially from their predecessors. The researches made by seventeenth century astronomers into the theory of optics and optical systems did not lead to any demonstrable improvements in the instrument, however, although some of the makers went on to make important astronomical observations with their own instruments and published them, as did both Divini and Campani.

By 1660, the average length of a good quality telescope was approximately 25 feet, and by the end of the next decade, the length had increased to as much as from 40 to 50 feet. The most useful astronomical observations made between 1650 and 1670 utilized instruments of moderate length, probably not exceeding 35 feet. Between 1670 and 1680, the so-called "aerial telescope" had come into being. The increase in length of the instrument had become so great that it became practical to completely eliminate the tube between the eyepiece and the object lens. Thereafter the length of telescopes continued to increase until telescopes measuring more than 200 feet had been achieved before the end of the century. There were exceptions, such as Divini's telescope of 35 feet produced in 1649 and a telescope of 140 feet that Hevelius had produced early in the 1670s. It is to be noted that Campani's telescopes were consistently considerably shorter—and consistently better—than those made by his contemporaries.

Giuseppe Campani had made rapid progress in his studies, experimenting as he proceeded. Concluding that many improvements remained to be made in the optical structure of telescopes as well as in techniques for grinding lenses, he became determined to achieve them. This was a period during which astronomical optics was undergoing a major change. A larger field of view had been made possible by the astronomical telescope that gradually had been replacing the Galilean telescope, providing a higher magnification that still proved useful. Galilean telescopes could provide higher

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Camerte, Voce Settempedana 34, no. August (1969); Otello Marcaccini, 'Sanseverinati alla Corte di Alessandro VII: Fulvio Servanzi, G. B. Cancellotti, Elustachio Divini', *Appennino Camerte, Voce Settempedana* 42, no. October (1955): 1; Maria Mucillo, 'Divini, Eustachio', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1991).

magnification as well, but they were useless because the field of view became even smaller. With the astronomical telescope, magnifications up to 100 times were the maximum usable until the field lens came into use. Between 1635, the date of Giuseppe's birth, and the time that he produced his first telescope, at some time between 1660 and 1662, magnification of the most powerful instruments had risen from 30 to 150, and the length of these instruments had been increased.

As Giuseppe later stated in his *Ragguaglio*, he had been inspired to dedicate himself to the study of optics and by means of his interest in astronomy to attempt "to discover the truth of that uncertain system of the star Saturn."[386] The shape of Saturn had appeared painted in the fantasy of his observations in a very disparate manner. The restricted range of telescopes then available limited the observer's ability to determine details to such a degree that in fact Galileo himself had imagined that Saturn consisted of three bodies, having a central larger globe with two much smaller planets, one at each side; the telescope Galileo used was not capable of rendering a better view. Campani understood that all of the dispute concerning the form of the system of Saturn had been derived from the failure of instruments, and he proposed to start an action all over again to "apply the mind, and the hand to the study of Dioptrics" toward the end of bringing more light to the mysterious planet.[387]

At first Giuseppe's venture into telescope-making was kept extremely secret from everyone except possibly selected members of his immediate family. To all outward appearances, ostensibly he continued working as a clockmaker in his shop, while in fact he was studying and experimenting with the development of astronomical instrumentation. With Matteo's assistance, and without attracting undue attention to his activities, Giuseppe had managed to purchase or have made for him all the tools and equipment he required for embarking upon his new craft. Both he and Matteo were familiar with the tools and materials required from having observed the contents of Divini's workshop from time to time, and gradually he managed to duplicate them.

Presumably Divini was using a lathe similar to the one developed by Francini in Florence that had been illustrated in Manzini's work. Using it as a prototype, and

[386] Campani, *Ragguaglio di due nuoue osseruazioni*, 8.
[387] Ibid., 9.

carefully studying its potential and analyzing its deficiencies, it is probable that Giuseppe managed to design and construct a lathe that, although generally similar, was greatly improved, as was evident from the fine quality of the very first lenses he produced.

The secret behind the superiority of Giuseppe's lenses, from the first ones he made and throughout the rest of his career, when compared with those made by Divini and other European makers, was to remain the subject of much conjecture among men of science not only in Italy but elsewhere in Europe too. Presumably, Giuseppe's advantage may have resided to a degree in the design of his lathe but more likely it was largely attributable to his techniques for grinding and polishing the lenses.

Although Giuseppe's secret has never been completely resolved, a clue may be derived from a little work by Matteo published in 1677 that he had dedicated to King Louis XIV. Matteo reported how, early in 1659, he had visited Florence, where he met Grand Duke Ferdinand II. He described how during his visit to the Medici court, "I was in the habit of spending some time each day in the Grand Duke's museum. I saw there the famous mechanism for smoothing and polishing diamonds".[388] This probably was the lathe that had been used for lapidary work by the Grand Duke's grandfather, Francesco I, and was then being preserved with others of the Medici family's scientific artifacts in the Palazzo Pitti.

Giuseppe also had traveled to Florence in the same year to demonstrate his newly invented crank lever escapement and pendulum-regulated timepiece to the Grand Duke and to seek a letter patent. He too had been shown the contents of the Grand Duke's *studiolo*. Probably because his visit was concerned with his clockwork inventions, Giuseppe may have been limited in his attention, for later in a published account he noted only the horological items he had seen therein. He mentioned having seen the relic of Vincenzio Galilei's incomplete old clock, and the public clock completed by Treffler with a pendulum regulator, the pendulum-regulated clock of the Huygens invention made by Salomon Coster that had been sent as a gift to the Grand Duke from the Polish court,

[388] "Hac re diu multumque apud me pensitata; omnesque in partes cura, et cogitatione versata; tandem cum initio anni 1659, Florentiam me contulissem, ibique in musaeo Serenissimi Magni Ducis, quotidie agerem, casu accidit illic videre artificium illud, quo adamantes teruntur, et poliuntur": Campani, *Horologium solo naturae motu*, 9-10.

and the engraving of Huygens's invention.[389] It is possible also that Giuseppe had not seen nor remembered the lathe but that Matteo later reminded him of it and described it to him. If so, some feature of the ducal lapidary lathe may have inspired innovations that Giuseppe incorporated into his own equipment.

During the several years that Giuseppe had been working independently after having separated from his brother Pier Tommaso, he became engaged at the same time in the study of optics and had begun to make lenses and telescopes. Nonetheless, he remained fully active as a clockmaker, marketing a number of timepieces featuring his crank lever escapement, one after another without interruption. As a consequence, except possibly for their most intimate friends, few of his own or of his brother's acquaintances became aware of his new interests and related activities. He had agreed with Matteo's plan that in order to derive the greatest advantage from his emergence in his new field of endeavor, it was essential to conceal information about his projects.

By late April of 1662, Giuseppe had produced his first successful telescopes. The first telescope he had made he presented as a gift to Bartoli in acknowledgment of the Jesuit historian's support and encouragement. The instrument was equipped with four lenses and measured 10 Roman palms in length. As revealed in later correspondence, among the first to have an opportunity to test this particular instrument were Vincenzo Viviani of the Medici court and Candido Del Buono, a man of science from Florence who happened to be in Rome during the spring.[390]

Based upon a statement made by Count Lorenzo Magalotti, the historian Targioni Tozzetti ascribed to Antonio Maria Del Buono the design of an ingenious mounting for one of the very long telescopes he erroneously described as having lenses made by Campani. Prince Leopold was so impressed with it that on June 15, 1661, he had a drawing of it sent to Huygens with the comment that "a way of making a telescope occurred to Antonio Maria, brother of the late Paolo del Buono," noting that his instrument was extremely elegant and easy to handle. There may be some confusion in

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[389] Campani, *Discorso ... intorno a' suoi muti oriuoli*, 17-19.

[390] Campani, *Ragguaglio di due nuoue osseruazioni*, 25. Candido Del Buono (1618–1676), abbot at Campoli, was a native Florentine who had learned mechanics while studying with Galileo. He had constructed an areometer and an apparatus for measuring the density of vapor. Both he and his brother, Paolo Del Buono (1625–1659), were members of the Accademia del Cimento. There were two other brothers as well, one of whom, Antonio Maria Del Buono, was an instrument maker.

this account, for Giuseppe had not begun to produce long telescopes until some years later, so that the details of the reference remains in question; perhaps Magalotti had been misinformed.[391]

Also among the few who were the first to test Giuseppe's telescope was the mathematician Michelangelo Ricci (1619–1682). He had obtained a telescope of 17 palms made by Campani with which he observed the planet Saturn at one o'clock in the morning on August 10, 1663. Three days later, the instrument was tested also by three others: Monsignor Bussi, Count Giulio di Montevecchio, and Antonio Caracci. Two months later, one of Giuseppe's friends and patrons, not identified, also observed Saturn with his telescope and made a sketch of what he had seen, which coincided with the details of Giuseppe's observation.[392]

With the success of his astronomical instruments now assured, Giuseppe lost no time in concentrating on producing others, and by November 1662, one or two of his terrestrial telescopes equipped with four lenses had begun to appear in Paris. These telescopes were highly praised by all who had seen them, including Christiaan Huygens, who described the construction of one of Giuseppe's instruments in his "Dioptrica."[393]

Matteo was aware that in order for Giuseppe's instruments to gain superiority over those of Divini, first of all it was necessary to avoid bold confrontation. Nevertheless, he realized that physical examination of the rival telescopes was required. In particular, he was anxious to prevent the release of any information about Giuseppe's newly invented compound eyepiece, while Giuseppe was in the process of establishing his position and reputation in the field.

Matteo therefore proceeded to arrange for public comparisons, called *paragoni*, to be made of the Divini and Campani instruments to establish the superiority of one over

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[391] Huygens, *Oeuvres Complètes de Christiaan* Huygens, 129–231, with drawing by del Buono; Giovanni Targioni Tozzetti, *Atti e memorie inedite dell' Accademia del cimento e notizie aneddote dei progressi delle scienze in Toscana, contenenti secondo l'ordine delle materie, e dei tempi memorie, esperienze, osservazioni, scoperte, e la rinnovazione della fisica celeste e terrestre, cominciando da Galileo Galilei, fino a Francesco Redi, ed a Vincenzo Viviani inclusive* (Firenze: da G. Tofani stampatore, 1780), vol. I, 436, described and illustrated in II, 799–800, plate IX; W. E. Knowles Middleton, *The experimenters: a study of the Accademia del Cimento* (Baltimore, MA; London: Hopkins University Press, 1971), 30.

[392] Campani, *Ragguaglio di due nuoue osseruazioni*, 21.

[393] Christiaan Huygens, 'Dioptrica', in *Oeuvres Complètes de Christiaan Huygens*, vol. IV (La Haye: M. Nijhoff, 1888), 266–71; *Oeuvres Complètes de Christiaan Huygens*, vol. XIII (La Haye: M. Nijhoff, 1932), 469–473 and 607; letter from Pierre Petit to Huygens, construction of a Campani telescope.

the other, and he deliberately managed each time to manipulate the event so that it resulted in disadvantage to Divini. As a consequence, Divini emerged as a serious, successful artisan of good repute being constantly heckled and harassed and having to protest Matteo's near-Machiavellian actions, as the latter clearly took every possible unfair advantage of the former. On these occasions, Giuseppe appears to have remained neutral and undoubtedly was repeatedly made uncomfortable by his brother's scheming.

There is no doubt that Matteo's reason for maintaining secrecy concerning Giuseppe's work was for the purpose of embarrassing Divini before others at every opportunity that offered. In fact, already he had been contemplating how he could do so by publicly comparing Divini's instruments with those of Giuseppe. For several months during 1662, others who had been observing the two brothers commented that they apparently had an inordinate amount of leisure time that enabled them to wander casually about Rome while deliberately displaying a telescope of excellent quality to friends and acquaintances whom they met. Divini eventually became aware that the "telescope from Holland" was not in fact a foreign import and that in all likelihood it had been produced locally by none other than one of the Campani brothers. They would not admit it, however, and he could not be certain at first whether the maker was Matteo or Giuseppe.[394]

In the summer of 1663, Divini commented on it in a published open *Lettera* to Count Manzini. Concerning tests that could be made with his telescope, he went on, "Here in Rome, already for many months there has been wandering about with some pomposity with a telescope said to be of 10 palms, with 4 lenses, and given the name, from what I have been told, that it has come from Holland. It is believed, however, that it was made in Rome: these individuals have gone round and round where they could learn that there are telescopes of mine; and some comparative tests have been made. And it has been told to me by more than one that they desire chiefly to be able to compare it [their telescope] with one of mine of the same length, because until now they have encountered only some longer or shorter instruments."[395]

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[394] Divini, *Lettera*, 41–42.
[395] Ibid.

Divini could not forego the opportunity for sarcastic comment. If this telescope "supposedly from Holland" should prove to be superior to his own in a fair trial, he added, he would willingly perform some work of piety, "such as marrying some spinsters or even buying a bell for some poor church!"[396]

Divini subsequently succeeded in obtaining confirmation that the telescope in question had indeed been made by Giuseppe Campani. In fact, several years later, in 1666, in another letter to Manzini, Divini reported, "After these signs there followed another competition, and it was in that time that Sig. Campani claimed his telescopes to be a work that had been made in Holland. . .".[397]

The fact of the matter was that Giuseppe, under Matteo's entrepreneurship, had deliberately been displaying the instrument about the city at every opportunity without revealing that he was its maker and leading others to assume that it had been imported. It proved in fact to be an instrument of outstanding quality, the secret of its great success obviously due to the arrangement of the lenses in the eyepiece. It was for this reason that the instrument was being exhibited by the brothers only on a one-to-one basis, without permitting it to be dismantled. By not admitting Giuseppe's role in its production, the brothers avoided another early confrontation with Divini; their claim that the instrument was of Dutch origin was relatively safe inasmuch as communications between Rome and the Netherlands were somewhat infrequent.

There was no question but that the competing claims for the telescopes could be resolved by no other means than by staging a public trial. The only method of testing telescopes was obvious—to have them used to observe the same object under the same conditions. Testing telescopes by observing a printed page was a known procedure. A placard was prepared that contained a selection of words or lines of writing in varying sizes arranged in meaningless groups. Adrien Auzout in Paris appears to have been one of the pioneers in developing these test sheets, and later Tito Livio Burattini in Poland adopted the same procedure for testing his own telescopes. Divini also was accustomed to the procedure, and when in 1663 it was reported that Campani's telescope revealed more detail of the moon than his had shown, Divini exploded. "For the love of God," he

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[396] Ibid., 61 [Scientific Editor 2: note that the Italian for "bell" is *Campana*].
[397] Divini, *Lettera*, 30.

proclaimed, "let us not take the uncertain objects in the sky and in the air to test telescopes, for that [purpose] two lines of writing placed at a distance will suffice!".[398]

An example of the devious manner with which Matteo arranged a competition, or *paragone*, that took place in 1663 was reported by Fabrizio Guastaferri, one of Divini's associates and the author of several articles on hydraulics.[399] Matteo had invited him to come to the monastery of San Giovan Paolo and bring his Divini telescope in order that that it could be compared with one made by Giuseppe. Guastaferri sent an account of what had occurred in a letter to Divini, which the latter subsequently quoted in his published *Lettera* of 1666.[400]

Guastaferri wrote that he had been invited to visit the Jesuit professor Reverend Urbano Davisi (1618–1686) at his quarters in the monastery. Upon arrival, he found that Matteo and Giuseppe were already on the scene, ready to begin the test. Assuming that the *paragone* was to be a scholarly and fair comparison, Guastaferri naively brought forth his 8-palm Divini telescope. To his surprise and consternation, he found that Matteo and Giuseppe were about to compare it with a 10-palm instrument they claimed "had come from Holland," and apparently they already had made many tests with it.

Matteo promptly suggested that a comparative test be made on the spot, and only then was it discovered that Guastaferri's instrument by Divini was equipped with a concave ocular lens while Campani's telescope had a compound eyepiece. Claiming that there would be considerable difficulty in replacing the compound eyepiece in Giuseppe's instrument with a concave ocular for the purpose of the test, Matteo convinced Guastaferri to borrow the lenses from another shorter Divini telescope he owned and put together a compound eyepiece for his 8-palm Divini instrument. This was not a simple matter, for it also required lengthening the tube, which Guastaferri managed to achieve but with considerable difficulty, by attaching an extension. Although the two instruments were now generally compatible, the Divini telescope nonetheless was makeshift at best, lacking rigidity as well as proper alignment, while the Campani telescope was

398 Divini, *Lettera*, 60-61.

399 Fabrizio Guastaferri, 'Osservationi del Signor Fabritio Gvustaferri intorno al peso di diverse acque', *Giornale de' Letterati* per tutto l'anno 1672 (1672): 63–67; and the subject of an accompanying article, 'Nuova bilancia de' liquidi del signor Fabritio Guastaferri', *Giornale de' Letterati* per tutto l'anno 1669 (1669): 71–73; *Lettera di Fabritio Guastaferri al sig. Gio. Francesco Saliti con la quale gli dà parte de suoi trattenimenti* (In Roma: Per Giacomo Dragondelli, 1663), 12–13.

400 Divini, *Lettera*, 27-30.

scientifically designed and properly assembled. Continuing his report to Divini, Guastaferri wrote:

> After many viewings, I commented also that I too would be satisfied [by a comparison] with the concave [ocular lens], to which Matteo replied that they did not have a concave lens. I suggested that we do it alternately with the same concave of yours. After he had refused my many requests with the same excuses, Signor Giuseppe explained that they did not wish to alter in any manner the combination of the lenses made by the [Dutch maker] master of these. To which I replied that I had not hesitated to alter the combination of your glasses with the said disadvantages, and since it seemed to me to be rather unfriendly behavior in an argument between virtuosi, I withdrew the telescope from the observations.[401]

Divini had not as yet been given an opportunity to examine the Campani telescope nor even to see it nearby with his own eyes. In anticipation of another comparative competition, Divini had constructed a 10-palm telescope equipped with a compound eyepiece, but he had not as yet managed to arrange to have a trial with it or to be present at one. In the 17 or more years that Divini had been making and selling telescopes, a substantial number of them, albeit of varying quality, were privately owned in Rome. There were not more than one or two Campani instruments as yet in existence, however, and these were never permitted to leave the hands of the maker. In this manner, the Campani brothers managed to exercise complete control over the circumstances under which their instruments would be tested. The trials were unfair to the extreme, for somehow Matteo always managed to find means to arrange matters so that Divini was never able to be present.

It was tremendously frustrating for Divini, a well-established middle-aged artisan of high repute in his field, to find himself pitted publicly without his consent or control against a young, 28-year-old hitherto unknown newcomer. He was being taunted in a most unpleasant and unprofessional manner by Matteo. When Divini learned that the Campani brothers claimed that their 10-palm "Dutch import" telescope was as powerful as one of his of 20 palms, the frustrated Divini finally took matters into his own hands and issued a challenge of his own. In his published *Lettera* he wrote:

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[401] Ibid.

I begged [the man who informed me] to be so kind as to make a wager on my behalf. And because the claim is exorbitant, I wish the wager to be likewise. That is to say, if I lose, I am willing to forfeit 100 doubloons [200 *scudi*], and if they lose, I shall be content with only a hundred scudi, with the proviso, however, that the test is to be made in this manner: that letters are put at such a distance that with their telescope they can be read, and that they then move backward with their telescope until they cannot read the proposed letters any longer. And at this point, where theirs cannot be read any more, I put mine of twenty palms. And if the letters can be read, mine will still have won, and if not, they will have won a nice sum of money and the honor which would truly be very great, since their telescope is only half as long as mine. But what is the use of such boasts and so many words? Come, whoever you are, with whatever telescopes you want, old or modern [Galilean or astronomical with compound eyepieces], assign me the length and I shall make one like it. Just let the wager be made, so that in this way the issue can be settled.[402]

It was no sooner than Giuseppe's telescopes had made their initial public appearances and were acknowledged to be his work and not Dutch imports that a series of dramatic events evolved, following quickly one after another in rapid succession. Almost immediately, the scene assumed all the characteristics of a staged scenario of dramatic proportions, deliberately and meticulously orchestrated by none other than Matteo Campani. From the very inception of Giuseppe's venture into the production of optical instrumentation, Matteo, presumably in his unspoken role as head of the Campani family in Rome, constituted himself not only agent of "his little brother," but also assumed the role of his director and stage manager as well. Giuseppe, 15 years younger than Matteo, undoubtedly obediently accepted the guidance of his elder brother albeit with hesitation and unspoken concern, being young enough to be embarrassed and retain reservations. He must have been appalled and mortified time and again by some of his brother's unceasing endeavors to embarrass Divini, and he repeatedly must have protested Matteo's outrageous behavior, for it greatly embarrassed him as well. Matteo's occasional less than entirely honest dealings in this regard were hardly befitting a man of the cloth, but he probably excused them as means of assisting his little brother's career. At the same time, Giuseppe admittedly was becoming even more ambitious and determined to succeed in the new career he had undertaken, to the same degree of success that he and Pier Tommaso had attained in clockmaking, and thus he allowed himself to be led as Matteo willed. Much as he sought to establish his reputation in the field, however,

[402] Divini, *Lettera*, 53–55.

he was reluctant to become a party to damaging Divini's reputation, as Matteo seemed determined to do, certainly at first.

No longer hiding behind the subterfuge that the Campani brothers were using an instrument made in Holland, Giuseppe faced the prospect of another scheduled contest and set to work to construct a telescope of equal length with the one made by Divini that not only would surpass it but also would provide a challenge for him. Furthermore, he hoped to use the new instrument to verify the astronomical observations he had been making. Giuseppe next produced several long-focus objectives approximately equal to the one Divini had made for Cardinal Flavio Chigi. With these, he combined one of his compound eyepieces consisting of three lenses, rendering them into telescopes of 50 to 55 palms. Instruments of such a length were difficult to manage, however, and Giuseppe next devised an elaborate mount to support the instrument so that it became easier to manipulate. With this new instrument, Giuseppe verified his earlier observations of Saturn.

Events succeeded one another in rapid succession. On April 27 1664, Giuseppe used his newest telescope to demonstrate publicly the discoveries he had made of the planet Saturn.[403] Three days later, another comparative trial (*paragone*) was scheduled to compare Campani's new telescope with the one that Divini had made for Cardinal Flavio Chigi. The test was arranged without, however, first informing Divini that it was to take place. Once more the encounter was subtly orchestrated by the Campani brothers, chiefly by Matteo. By appearing on the scene in advance of the others, Matteo and Giuseppe managed to gain as much advantage for themselves as possible. This was to the discomfiture of Divini, who had been kept totally unaware and uninformed of the forthcoming trial until the last moment. To add insult to injury, the Divini instrument to be used in the comparison had been in the Cardinal's possession, from whom the Campani brothers had managed to borrow it without informing Divini.[404]

When every preparation for the test had been completed and all was in readiness, Divini was summoned from his shop at 9 o'clock at night and directed to go to a certain garden in Rome, without being advised of the reason. Completely mystified, and

[403] Campani, *Ragguaglio di due nuoue osseruazioni*, 23.
[404] Divini, *Lettera*, 38–45.

expecting to meet a new client perhaps, he arrived to discover Giuseppe's telescope of 50 palms with four lenses already adjusted upon a tripod or trestle made for the purpose, while Divini's telescope of 52 palms, the first that he had made with his new invention of reversed duplicate lenses, had been placed somewhat haphazardly upon the arm rest of a chair. Both instruments were trained upon a placard bearing writing that had been placed some distance in front of them. Divini was invited to observe through the telescopes. He was not permitted to make any changes nor to check the lenses of his telescope, although he had not seen his instrument for some time. After he had looked first through one instrument and then the other, he inquired whether the lenses of his telescope had been cleaned. He was told that this had been done, but upon turning to look through it once more, he observed that his instrument showed the letters much more obscurely and he was forced to admit that the Campani instrument showed them more clearly.[405]

As was to be anticipated, Divini took strong exception to Giuseppe's account in his *Ragguaglio* published later in the same year (summer 1664), because the Campani brothers had refused his offer to exchange lenses or to make a trial with only two lenses, which would have enlarged the print. He complained that the "path" or line of sight in which the printed object had been exposed was surrounded on all sides by trees that did not permit sufficient penetration of light into the area. Consequently, his telescope with four reversed double lenses provided 14 refractions whereas that of Giuseppe provided only 8, so that Divini's had 6 more refractions. Furthermore, Divini claimed, his instrument enlarged the object more than did Giuseppe's, "and therefore for these two reasons the gloomy lighting must therefore have made it more obscure and for this reason I state that the telescopes must have need to be tested with equal tests".[406] In his *Ragguaglio*, Giuseppe reported his version of this trial:

> Many and diverse tests were made during an entire year using [for the object to be observed] not only ordinary characters written in ink upon a white background, such as had been done in the past with one of my telescopes of 50 palms in length, having 4 lenses [a compound eyepiece and objective], and another similar instrument by Mr Esutachio Divini of 52 palms in length believed to be of unrivaled value. Both instruments were of the same length directed to a piece of writing posted at a proportional distance: whereas with mine every little minute character could be seen clearly and distinctly, and the entire writing could be read without any difficulty, while with the other [Divini's] being so wretched that at the termination of the first line, which consisted of capital letters, it could hardly be read as every one that could be seen with the

[405] Ibid.
[406] Ibid.

naked eye without being able to distinguish any of the other characters; I was ready for my part to return to make the experiment and the test, as much at that distance or at any other, and under any sky, not only with the same telescope but also with others made by the same author and having the same length, which were actually much better . . . demonstrating with clear evidence the disparity of their value, given however the equality of the acuity of their [lenses] and of the length of the telescopes, and of the material.[407]

To add to Divini's further embarrassment and frustration, Cardinal Chigi, for whom he had made the telescope to be tested, also had been invited to attend and was present as a spectator at the competition. Divini realized the prospect that if the Campani instrument proved to be the better one, his client also would be embarrassed, and he begged the prelate to allow him to replace what appeared to be an instrument that was probably inferior with another he had made, but without success.[408]

Inasmuch as the two instruments were supposed to be of the same focal length, Divini suspected subterfuge. Inquiring from Giuseppe whether his telescope was made with double or single lenses, the latter replied that it had simple lenses. Giuseppe then suggested that if Divini wished to clarify the situation, they could exchange the lenses in the instruments, which would then indicate which of the objectives was superior. Matteo intervened promptly, however, objecting to the exchange.[409]

This event enabled Matteo to inform acquaintances in Florence of the outcome of the comparison and to gloat over Divini's predicament. The results of the comparison were reported also by Giuseppe Campani in his *Ragguaglio*, noting with somewhat of a degree of smugness, "inasmuch as with mine [telescope] every character, even the smallest, was clearly and distinctly seen, the entire piece of writing was read without any problem, while with the other [Divini's telescope], so uncertain was its outline that one could scarcely read the first line, which was made up of capital letters, without being able to recognize any other character".[410]

Matteo belatedly wrote to Viviani, enclosing some publications he had promised to send him:

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[407] Campani, *Ragguaglio di due nuoue osseruazioni*, 14–16 (1664).

[408] BNCF, Gal. vol. 254, cc. 264a–264b, 265a; *Viviani Papers*, fol. 264v, letter from Matteo Campani to Viviani on May 24, 1664.

[409] Divini, *Lettera*, 40.

[410] Campani, *Ragguaglio di due nuoue osseruazioni*, 15.

I am writing also to inform you that the identity of the foreign author of those two telescopes, that had been seen here in Rome by you and by Sig. Candido il Buono, has finally been discovered. Those two were the first works that issued from the hands of Giuseppe my brother and your devoted servant. For he was greatly hard pressed by a certain Superintendent of Dioptrics to [apply himself to] the total application to the same profession in which, by the grace of God, he has profited greatly; in a test made at the end of last April with one of his telescopes, which were 51 and 55 palms in length having 4 lenses, compared with that of 52 palms in length by Sig. Eustachio Divini; this remained so far behind of that [of Giuseppe], that some lines of writing upon paper posted at a proportionate distance (which could be clearly read) and with an object lens of 61 palms and with the other of 66 palms, and was able to read other letters that were the tiniest capitals of the first line.

While the same Sig. Eustachio Divini, who was present at the contest, ingenuously confessed the great disparity, he was induced to beg Cardinal Patrone [Cardinal Chigi], who also was present, to allow him to make a new lens, because as he said, it was not proper that His Eminence should have a telescope of such a poor quality, etc. The tube was made with extraordinary polish and exquisiteness, and my said brother has disposed it in such a manner, that any one who moves it and turns it where he wishes, like any other small instrument with the same lever [or staff, *bastoncellli*] that strains it towards our eye. If we have good weather tomorrow, I shall show it to Sig. Michelangelo Ricci and to many other gentlemen who had wished to observe with it, wherefore in order that they will have more exact information from elsewhere than from me.[411]

The pressure for scheduling another open contest had mounted rapidly by October 1664, fueled by the spreading knowledge that this so-called “Dutch import” had in fact been made by “the young newcomer,” Giuseppe Campani. At last Divini appeared to have assumed control of the situation, for now it became generally known that he had made a telescope of 10 palms and had urged that a public trial be held with it and with the comparable Campani instrument. Matteo finally had no alternative but to agree to a trial, which was to be held on October 3l in the vineyard of the Medici Palace at the Trinità dei Monti high up on Monte Pincio, where Prince Mattias de’ Medici resided.

Ostensibly, the purpose of the meeting was to make observations of the planet Saturn for the purpose of testing Divini’s long telescope. Divini was invited by the Cavaliere Procurator Pietro Basadonna, ambassador of the Venetian Republic to the Holy See, to demonstrate once more the telescope he had made for Cardinal Flavio Chigi, since the first trial made of it had occurred on a day having very poor visibility. The instrument had a focal length of 52 palms with reversed duplicate lenses.

[411] BNCF, Gal., 254, cc. 264a–264b, 265a; *Viviani Papers*, fol. 264v, letter from Matteo Campani to Viviani on May 24, 1664.

Divini was asked if he minded whether Campani also was present, inasmuch as he had promised to bring his “Dutch” telescope of 10 palms that Divini had expressed a desire to see. It was suggested that Divini could bring one of his own having the same specifications in order to make a comparative trial of both. The ambassador drove by Divini’s shop in his carriage to call for him, and when they arrived together at the selected testing ground, they found that also present once again was the “gentleman” Giovanni Lutij, a mutual friend of both Divini and the Campani brothers.

Matteo and Giuseppe Campani arrived together, accompanied by a large number of gentlemen and virtuosi. Among those attending were distinguished officials of church and state as well as important men of science. In addition to Lutij and Pietro Basadonna, notables included mathematician Urbano Davisi, professor of geography Pietro Andrea Bufalini, and professor of public law Concitto Pica, both on the faculty of the university La Sapienza. Surprisingly, also present was Gian Domenico Cassini, then professor of astronomy at the University of Bologna, who happened to be in Rome on Vatican business. Giuseppe brought not one telescope of 10 palms, but two of them, while Divini had only the one he brought attached to its support. Because Giuseppe complained that he did not have supports for both of his instruments, Divini suggested that he should select the better of the two to be directed like Divini’s telescope to the same object.

The results of the trial revealed that Campani’s instrument showed objects more clearly, although Divini’s instrument demonstrated greater magnification, so that this first public trial was essentially a standoff. Divini used the opportunity, meanwhile, to obtain affidavits in writing about his instrument from Davisi, Basadonna, Bufalini, and Pica as well as Cassini.[412]

Throughout this period, Divini had remained in the forefront of all others in the production of instruments having objectives of long focus. His major achievement was the previously noted telescope of 52 palms equipped with a terrestrial eyepiece that he had made in 1663 for Cardinal Chigi. It was a costly instrument, for which the Cardinal had paid the handsome sum of 500 *scudi*. The eyepiece consisted of a somewhat complicated arrangement, with two equal plano-convex lenses with their convex sides facing each other. Divini claimed that the arrangement reduced chromatic astigmatism

[412] Divini, *Lettera*, 31-38.

and provided a larger and flatter field of view. It was an instrument, he claimed, such as had never yet been produced by any other and that he called "new" because the four lenses were made and disposed in a novel manner. This telescope, he stated, was superior for it provided a wider field around the object being viewed; there was none of the "color" of chromatic astigmatism around the eyepiece, which was composed of large convex lenses having small sphericity, and finally, he noted that the image was inverted without curvature.[413]

As exemplified in two telescopes of 3 palms that Divini had produced the previous year for Count Manzini, he had learned how to exchange the object lens without having to change the "signs" or markings inside the tube. He had been able to replace a broken lens in a telescope that had been brought to him during a weekend without having to move the signs in the least manner.[414] Although he described this telescope as having four lenses, in actuality it contained six lenses in addition to the objective, each of which was *plano* on one side and concave on the other, with the curved sides facing each other and the outer sides flat.[415] Divini's *Lettera* of 1663 contained a valuable account of the lens-maker's techniques and materials and the success or failure of each, and he also discussed having had experiences with some examples of glass from Venice. and Rome.[416]

Divini proposed that if Grand Duke Ferdinand II were asked to schedule a trial to compare the instruments, he felt assured that it would be managed with the greatest degree of fairness, implying that trails supervised by others had not. He then suggested that in order to simplify the matter, he would send for a mutual friend to whom he would give a piece of glass of exquisite quality, taken from the same matrix from which in the previous year he had fashioned an objective of 12 palms for Grand Duke Ferdinand II. He would allow 8 days for the other individual to make his lens, who could then send it to the Grand Duke for comparison. Divini felt, however, that there would be no need for much ostentation in making the comparison because of the multitude of examples of his work that he had produced were adequate evidence of his ability.

413 Ibid., 6-10.
414 Ibid., 11.
415 Ibid., 14.
416 Ibid., 33-41.

He pointed out that, during the previous summer, when the Grand Duke had ordered a hand telescope from both Divini and Campani, Divini had sent his instrument promptly by the next paid mail messenger [*procaccio*], whereas delivery of Campani's hand telescope had been delayed for a month and many more days before it was forwarded. Furthermore, Divini claimed, he knew that Campani's instrument was inferior to his own. Divini then proceeded to list examples of Campani's work that did not support the claims that Campani had made for them, and stated that Campani had in fact used forms for shaping his lenses.[417]

At this time, Giuseppe began to concentrate upon designing and constructing instruments that would serve him for making his own observations of the planet Saturn. With a telescope of his own design and construction, he made his first observations of the system of Saturn in 1663, and he published the results of his observations in the following year in a tract he entitled the *Ragguaglio*, meaning "the comparison." Campani had first observed Saturn with two of his new telescopes, one of 17 palms and another of 25 palms equipped with an eyepiece having a focal length of 2 *oncie*. He had detected a shadow on the body of the planet's ring, a phenomenon that had already been observed in Florence 3 years earlier but had not been published. He reported that the outside of the ring appeared to be less bright than the inner side. He also observed a dark streak on the body of the planet near the inside edge of the ring indicating that the ring unquestionably surrounded the planet. This provided evidence that Huygens had been correct and that Honoré Fabri's counter claim was in error. Giuseppe then constructed a model of the planet to confirm his observations. On April 27 1664, he again observed Saturn, observing from 5:30 in the afternoon until 9:30 at night. He used his new telescope of 55 palms having two objectives, one of 52 palms and the other of 50 palms, without varying the distance of the eyepiece, which had a focal distance of 3 *oncie* 1 minute from the eye.[418]

Later Giuseppe also reported in his *Ragguaglio* that on August 10, 1663, Michelangelo Ricci had observed Saturn with Giuseppe's telescope of 17 palms, presumably in Giuseppe's presence. As previously noted, other observations of Saturn

[417] Ibid., 66–75.
[418] Campani, *Ragguaglio di due nuoue osseruazioni*, 17-24.

were made in his presence by other notable characters: Monsignor Bussi, Count Giulio de Montevecchio, and Antonio Caracci. Meanwhile, while Giuseppe kept himself occupied with making celestial observations with his instruments,[419] Matteo allowed more time to elapse before allowing Giuseppe to contemplate entry in another competition; undoubtedly, it was a delay deliberately determined by Matteo to enable Giuseppe to complete the construction of two more instruments. These were telescopes of 17 palms and 25 palms, respectively, specifically designed for astronomical observation and having very strong single biconvex eyepieces.

[419] Giuseppe Campani, *Lettera di Giuseppe Campani intorno all'ombre delle stelle Medicee nel volto di Giove, ed altri nuovi fenomeni celesti scoperti co' suoi occhiali* (Roma: Fabio de Falco, 1665).

Chapter IX

THE "*RAGGUAGLIO*"

(1664–1665)

> *I turned to the study of Dioptrics, applying myself with all my spirit, and all my attention, to the invention of a lathe [that would be] most precise for the shaping of glasses without other means such as forms. And succeeding finally, not without the greatest effort and after innumerable experiments, achieved not by the weakness of my ingenuity, but as a gift from God ...*
>
> Giuseppe Campani[420]

Early in 1664, undoubtedly in response to persistent urging from Daniello Bartoli as well as from his brother Matteo, Giuseppe began to compile an account of the celestial discoveries that he personally had made with telescopes of his own construction. There was good reason for him to use every opportunity to move ahead at this time to establish himself in the marketplace, now that his telescopes had become known and praised. He set to work, and after assembling notes he had made during his observations, he began to render them into narrative form. He was not unfamiliar with writing, having already had the experience several years earlier of publishing a tract on the invention of the silent night clock.

Giuseppe completed a manuscript in April, and after making revisions and polishing it further with Matteo's assistance, he took his copy to Fabio de Falco, a local printer. He entitled the tract in the cumbersome style of the period with the title often resembling the table of contents: "Report of Two New Observations, One Celestial

[420] Campani, *Ragguaglio di due nuoue osseruazioni*, 13-14.

Relating to the Star of Saturn, and the Other Terrestrial Relating to the Same Instruments with which were made One and the Other Observations."[421]

It was a volume of small size, containing 42 pages, yet it proved to be effective enough to launch him successfully upon his new career. He remembered Matteo's experience with his failed *Dell'Horologio Muto* and that it was required that all works intended for publication first had to be scrutinized by Church censors before being approved for publication. Consequently, probably with Matteo's guidance, Giuseppe followed a procedure frequently adopted by men of science of his time to ensure that their scientific writings, even if not actually approved, in all likelihood would avoid such censorship. The practice was to request approval of a member of the Church hierarchy or someone of elevated political status, to dedicate the work to him, and who generally agreed to accept the honor. Accordingly, Giuseppe dedicated the *Ragguaglio* to "the Most Serene Prince Mattia of Tuscany," a younger brother of Grand Duke Ferdinand II. The prince already was acquainted with Giuseppe, having acquired a silent night clock from him.

In his text, Giuseppe generously credited Bartoli with having inspired and encouraged him to study optics and dioptrics and to undertake a new career in lens making, with which he proceeded to use this knowledge to explore the skies and its celestial system on his own. As Giuseppe explained, "my particular inclination and impatience to discover the workings of the planet Saturn, which has been the subject of great interest to your [Medici] court and of a long controversy among many men of science; this was the chief reason leading me to apply my mind and hand to the study of dioptrics, to which the renowned Rev. Daniello Bartoli, S. J., had urged me for a long time."[422]

The impact that Campani's little volume made upon the world of astronomy at the time of its appearance was sufficient to establish a permanent place for the emerging young artisan/astronomer into in the firmament of the developing new science. Among stargazers, he soon was considered as an astronomer to be at least on a level with that of Eustachio Divini, although not elevated to those of Christiaan Huygens and Gian

[421] Ibid.
[422] Ibid., 8–9.

Domenico Cassini. The timing of the publication of the *Ragguaglio* could not have been more auspicious, unquestionably as a consequence of Matteo's careful planning. It was a grand piece of theater that raised questions and eyebrows among his peers and aroused concerns among his competitors.

The word *ragguaglio*, meaning "comparison" or "report," was particularly appropriate, for in fact Giuseppe's account provided not only a report of his observations of the planet Saturn but also of the trials [*paragoni*] being held for the purpose of comparing the relative merits of the telescopes he made with those of his rival Divini. In the first part of this work, Giuseppe discussed his astronomical observations and what he had discovered relating to the planet Saturn. The single illustration included had been engraved from "a sketch of the phenomenon of Saturn drawn at 1:00 in the morning" in October 1663 by "a gentleman patron skilled in draughting and design," an artist not identified.[423]

Campani had observed the planet with his own telescopes of 13 and 18 feet in focal length and saw it as consisting of a central globe surrounded by a ring or band, as he had illustrated in his engraving. In the accompanying text, Campani reported that Saturn was surrounded by a circle that "in appearance has the shape of an ellipse, that is situated about the globe in such a manner that a portion of the upper or superior part of the aforesaid globe is hidden by it, while on the other hand the lower part of the circle is partly covered and hidden by the same globe so that the inferior part remains behind and the superior part in front of the star, as is best understood from the place and position of the circle and from those outlines of the same circle that are lightly shadowed, as well as of the globe or disk of Saturn. . . ."[424]

The current argument taking place among observers of Saturn, Giuseppe theorized, was caused by the fact that until then the planet had been observed consistently by means of instruments of inferior quality, and consequently, it had not been properly viewed. This was a deliberate criticism of Divini's instruments, inasmuch as Divini was the major provider of telescopes in that period, and it also reasserted Giuseppe's claim

[423] Ibid., 21-22.
[424] Ibid., 17-18.

that, in the comparative trials that had been made, his own telescopes had proven to be superior.

Another claim made by Giuseppe in the *Ragguaglio* that aroused the greatest reaction from many sides was his revelation that he had invented and used “a lathe of great precision for working the lenses without other means or forms.” His lenses of 50 and 52 Roman palms, he claimed, were the first that he had produced with his new invention.[425] Despite the most rigid tests to which the lenses subsequently had been subjected, they proved to be entirely successful and of as fine a quality as their maker stated. Giuseppe then devoted the second part of his work to reporting the terrestrial observations he had made, which he now presented as arguments countering Divini’s claim that a telescope suffered from turbidity of air in proportion to the power of the instrument.[426]

Ostensibly intended as a contribution to the state of the art of astronomy, in actuality the *Ragguaglio* served at the same time as an aggressive attack upon his rival Divini. Despite the fact that mention of Divini’s name had been carefully avoided in the printed text, the work only thinly disguised the continuing controversy between the two telescope makers. Whether by accident or intent, however, the passage describing the trial or paragone held on April 30, 1664, ended at the bottom of a page with the words “and of another similar [telescope] 52 palms in length.” In the space below these words in the margin of the page, was inserted by hand an addition in pen and ink, in many if not all copies of the little book. The insertion contained the phrase “of the Signor Eustachio Divini” [*dell’ S. Eustachio Divini*], which fitted neatly into the narrative and within the space.[427] The omission of the three words from the printed text may have been because of a printer’s oversight. Or Giuseppe originally may not have intended the three words to be part of the text but later he or Matteo realized that it provided another opportunity to fuel the fire of their rivalry and added them. It is possible, of course, that the three words had been deliberately omitted in order to insert the handwritten addition, a means by which greater attention would be attracted to the presence of Divini’s name.

[425] Ibid., 13-14.
[426] Ibid., 28-37.
[427] Ibid., 14.

Divini was convinced that the latter was the case and complained of it in his published *Lettera* of 1666, in which he claimed, "and then, in order to denigrate my telescope further, he published the results of the *paragone* in print, in which since the name of him who had made it was omitted, he wrote in his own hand, in many copies, '*dell' S. Eustachio Divini*.'"[428]

In an obvious criticism of Divini's instruments, Giuseppe went on to claim how his own telescopes were superior, explaining that he had succeeded in eliminating chromatic astigmatism (the presence of color fringes) in his three-part ocular lens. This was made possible, he stated, by the fact that in order to render his lenses into the required sizes and shapes, they were fashioned upon a lathe without first being cast in molds.[429]

The printer Fabio del Falco in Rome already had begun setting the manuscript in type early in July, when Giuseppe was informed by Cassini at Bologna that in the course of using one of Giuseppe's telescopes, he had observed for the first time the shadows of Jupiter's satellites. He watched as they passed across the disk of the planet; he also had distinguished mountains that appeared to be projecting from the moon's limb, which he also communicated to Giuseppe.

Losing no time, Giuseppe immediately hurried to the print shop where he interrupted the printing of his work. He then quickly rewrote the final section of the manuscript and gave the revised pages to the printer. The little volume containing the revised text finally was issued from the press in July 1664. Copies were immediately distributed by Matteo and Giuseppe to significant figures in the scientific world in Rome and Florence, to scholarly periodicals for review, and to men of science overseas.[430]

The impression that the publication of the *Ragguaglio* had made upon the scientific world in France and England is reflected in correspondence of the period. The Royal Society of London received communications concerning Campani from several correspondents in France. The broadside had come to the attention of French mathematician, physicist, and astronomer Adrien Auzout just after he already had written

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[428] Divini, *Lettera*, 41.
[429] Campani, *Ragguaglio di due nuoue osseruazioni*, 13, 30, 36-37.
[430] Ibid., 38-42.

his first letter to the Abbé Charles, so the French astronomer thereupon composed and forwarded a second letter to the Abbé.[431]

Auzout reports that in a letter to the Abbé Charles, Giuseppe commented upon a communication that the Abbé had received from Auzout that had referred to the illustration of Saturn published in the *Ragguaglio*. Giuseppe noted that in the course of several observations he had made subsequent to the *Ragguaglio*'s publication, he had observed various new particulars that he had then planned to report.[432] In late July or early August 1664, Giuseppe commissioned a large broadside to be engraved, which was to serve as a supplement to his recent work, on which were featured Cassini's observation of this newly discovered phenomenon as well as Giuseppe's own observation of Saturn. Giuseppe diplomatically dedicated the engraved broadside to Cardinal Flavio Chigi, the Pontiff's nephew, and distributed copies of it shortly after the publication of his *Ragguaglio*.[433]

Auzout at first made a practice of circulating copies of his letters in manuscript form to others in addition to the named addressees. His letters to the *Abbé* Charles later were published in the *Memoires of the Académie Royale des Sciences*, entitled, in translation, "Letter to the *Abbé* Charles, about the *Ragguaglio* of Two New Observations [Made] by Giuseppe Campani, with Remarks where he has presented New Discoveries in Saturn and in Jupiter, and of various other curious items concerning the large telescopes, &c. With some letters to M. Hooke & Oldenburg, their Responses, and the Description of the Micrometer, by M. Auzout, of the Royal Academy of Sciences." The letters were reprinted in the fourth issue of the *Philosophical Transactions*.[434]

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[431] Adrien Auzout, *Lettre à M. l'abbé Charles sur le 'Ragguaglio di due nuove osservationi, etc.', da Giuseppe Campani, avec des remarques où il est parlé des nouvelles découvertes dans Saturne et dans Jupiter et de plusieurs choses curieuses touchant les grandes lunetes, etc., par Adrien Auzout* (Paris: J. Cusson, 1665).

[432] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, 364-68.

[433] Giuseppe Campani, *Eminentissimo Principi Flavio Chisio S.R.E. Cardinali. Quod in Saturno et Iove Vitreis Lentibus Torno a se nuper invento formatis Deprehendit et Romae primus oculis spectandum exhibuit JOSEPH CAMPANUS. Obsequij et observantiae argumentum DD* (1664), in: Huygens, *Oeuvres Complètes de Christiaan Huygens,* vol. 5, 118-19.

[434] Auzout, *Lettre à M. l'abbé Charles sur le 'Ragguaglio di due nuove osservationi, etc.', da Giuseppe Campani*; Charles Hutton, Georges Shaw, and Richard Pearson, eds., *The Philosophical Transactions of the Royal Society of London, from Their Commencement, in 1665, to the Year 1800*, Abridged, with Notes and Biographic Illustrations, by Charles Hutton, Georges Shaw, Richard Pearson, vol. I, from 1665 to 1672 (London: printed by and for C. and R. Baldwin, 1809), 2–3 no. 4.

Although Auzout's letters to the *Abbé* Charles were by no means not uncritical of Giuseppe, they inadvertently succeeded in spreading Campani's name and fame. Giuseppe was first informed of Auzout's letters from copies of them that Cardinal Barberini had arranged to have made and forwarded to him from Paris late in October 1664[435]. Giuseppe derived pleasure from the French astronomer's comments, which Matteo translated into Italian for him.

Auzout reported that when he had criticized Giuseppe's claims about this observations, the Italian stated that:

> 1 The circle of the exterior, that is, towards the exterior circumference, is less lucid and less clear, as far as the middle of its plane and of the middle in verso the disk of Saturn, is clearer and more lucid of the same disk.
>
> 2. The extremities of the disk there and here towards the upper part, appears somewhat obfuscated and less clear than the remainder of the disk . . . that which I have not said or believed ever occurred of the shadow of the circle, leaving this to the judgment of the *signori* Astronomers, meanwhile to me is left only to note punctually the appearance in the manner itself that I see it, without involving myself with other.
>
> 3. The circle being somewhat shadowed by a band close to the part apparently inferior part of the Globe.[436]

Campani's observations and publications became known in Paris and London almost immediately. In August 1664, Sir Robert Moray presented a letter to the Royal Society that had been written by Huygens at the Paris observatory relating to "a new observation concerning Saturn, made the last spring at Rome, by one CAMPANI, viz., that the circle of Saturn had covered part of its sphere above, and had been covered thereby below, even with a little shadow upon the circle below, and upon the sphere above: which observation Mons. Huygens looked upon as confirming his system. It was also remarked in the same letter, that the said observer at Rome pretended to have a new way of making optic-glasses by means of a *turne*, without making use of a mold".[437]

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435 Maria Luisa Righini Bonelli and Albert Van Helden, "Divini and Campani: A Forgotten Chapter in the History of the Accademia Del Cimento," *Annali dell'Istituto e museo di storia della scienza di Firenze* 6, no. 1 (1981): 90–93.

436 Auzout, *Lettre à M. l'abbé Charles sur le "Ragguaglio di due nuove osservationi, etc.", da Giuseppe Campani*, 34.

437 Thomas Birch, *The History of the Royal Society of London for Improving of Natural Knowledge, from Its First Rise: In Which the Most Considerable of Those Papers Communicated to the Society, Which Have Hitherto Not Been Published, Are Inserted in Their Proper Order, as a Supplement to the Philosophical Transactions* (London: Millar, 1756), vol. 1, 464, August 31, 1664. Sir Robert Moray (1609–1673) was a Royalist courtier and an energetic correspondent with European men of science. He was a founder of the Royal Society of London to which he served as liaison with the royal court.

Another communication from Paris arrived in the following month, as Secretary Henry Oldenburg informed the Society, in which it was reported "at Rome observations of Jupiter had lately been made with the new glasses of CAMPANI, by means of which, six belts had been discovered in that planet, four of which had appeared more obscure, and two more clear than the rest of his body".[438]

In October 1664, René François, Baron de Sluse, a mathematician from Liege, sent another copy of Campani's broadside to Huygens. He noted that since Carlo Dati had recently sent him two copies of these observations made by Campani, he was forwarding one to Huygens. He believed the broadside would prove to be of interest because nothing similar about Jupiter could be observed by even the best telescopes of the Medici princes.[439]

The text and the drawing of Campani's engraved broadside confirmed that, in 1664, Campani had discovered and sketched Saturn's inner or "crepe" ring. This ring was to be rediscovered almost two centuries later, in 1850, by Professor George Phillips Bond at Harvard College. Observations of new divisions, and of the transparency of the crepe ring, made at Cambridge brought about a revision of the theory that the rings were of a solid structure. After further review, in 1851, Bond advanced the hypothesis that the rings were of a fluid state. Bond also is credited with having discovered Hyperion, Saturn's eighth satellite. Although it was not to be found in Cassini's drawing of the streak [*raie*], the division of the ring into two zones of unequal brilliance was very clearly indicated, and this information Giuseppe planned to include in a work that he had been preparing for publication and that Matteo hoped would bring his brother's name and fame to all of Europe.[440]

Giuseppe's broadside apparently had received a wide distribution in the scientific community. Sluse wrote again to Huygens early in January 1665 informing him that he

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[438] Ibid., 471, September 28, 1664.

[439] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, 117–18, letter from Sluse to Huygens on October 2, 1664. Sluse noted in his letter that, during the past few years, he had worked with the mathematician Famiano Michelini on a book written in Italian about "The Direction of Rivers" and a first volume about the experiments of the Accademia del Cimento.

[440] Edward Singleton Holden and Mrs Richard F. Bond, *Memorials of William Cranch Bond: Director of the Harvard College Observatory, 1840-1859, and of His Son George Phillips Bond, Director ... 1859-1865* (New York: C.A. Murdock & Company, 1897); Henry C. King, *The History of the Telescope* (London: Charles Griffin & Co., 1955), 249.

had received from Michelangelo Ricci yet another copy of Campani's broadside, which Huygens had already received a copy of with Sluse's letter from early October.[441]

In January 1665, following immediately upon his return from foreign travels, Francis Willoughley appeared at the Royal Society to present "his philosophical observations" that he had made abroad. He produced "a printed cut representing SATURN and JUPITER. and what CAMPANI had lately observed in them by means of his new glasses, wrought by a turn-tool without a mold, viz., that July 30 h. 2-/2 *noctis*, he had seen in one of the black belts of JUPITER two blacker spots, moving therein, which Signor CASSINI had first given him notice of, conceiving them to be shadows of the Satellites, which he had seen come out of the western disk of the planet".[442]

It was at about this time that Oldenburg produced before the Royal Society two printed pages of the *Journal des Sçavans* that had been sent to him from France. As he reported, "Notice was particularly taken of the account contained in this Journal concerning Signor GIUSEPPE CAMPANI's book of his new optic glasses made by a *turne* [lathe] without a mold, and the new discoveries made thereby in JUPITER and its Satellites".[443]

A month later, the Royal Society was informed by Oldenburg of an account he had received from Italy concerning "the effect of the new optic glasses of CAMPANI tried upon several characters." Oldenburg was desirous to have it translated into English for the next meeting and, at the same, time Moray and Hooke were asked to find a suitable place from which to make similar observations "with glasses made in England of about the same length with those of CAMPANI".[444]

This appears to have been the first information that the English had about the use of text on placards for comparing telescopes. It was not long before the same means would be used also by the Royal Society. Soon after Oldenburg had obtained a translation of the account, it was ordered that Moray, Hooke, and other members of the Royal Society were to meet on the following Thursday evening to make observations with

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441 Huygens, *Oeuvres Complètes de Christiaan Huygens,* vol. 5, no. 1303, 117–18 (1890), letter from Sluse to Huygens on January 2, 1665, with enclosure, and pp. 118–119, on July 6, 1664, 9 days before the Ides of July, which occur on July 15.

442 Birch, *History of the Royal Society of London*, vol. 2, 3, January 4, 1665.

443 Ibid., 6, January 11, 1665.

444 Ibid., 17, February 22, 1665.

comparable "lenses made by Reeves, of the same length, upon the same characters, observing the circumstances described in the paper concerning distance, light, &c".[445]

The ongoing competition of the telescopes of Divini and Campani in Rome, meanwhile, continued to maintain interest overseas. In the following May, Oldenburg read a letter he received from Auzout in Paris "giving a further account of the contest between EUSTACHIO and CAMPANI about optic glasses [. . .] ".[446]

Almost 2 months later, Oldenburg was informed by Nicolas Steno from Rome—who also had written in May, mentioning "the emulation between Divini and Campani about optic glasses"—of his opinion that Campani had been mistaken in some of his observations, having taken the spots adhering to the body of Jupiter as shadows of its satellites.[447]

Surprisingly, Giustiniani, the Venetian ambassador to the Holy See, had sent to someone in Paris a paper printed in Latin, which was transmitted to Oldenburg for presentation to the Society. It contained accounts of the observations made in Italy by Cassini, Campani, Divini, and others "about the spots discovered by them in Mars, and the rotation of this planet about his own axis, confirming what had been discovered in February and March preceding in England by Mr. Hooke."[448]

Later that same year, the Royal Society received a letter containing an account that "Campini [sic] had caused to be made at Rome a tube of 100 palms, very light, being in four pieces shutting into one another. . . .".[449]

At a meeting of the Society in November 1666, Sir Paul Neile took the occasion to mention that he had seen a short glass [telescope] of Campani's workmanship brought out of Italy by Mr. Nevill, and he considered the glass to be very good. He was asked to procure "a sight of that telescope for the Society", which he promised to do.[450]

Meanwhile, the publication of the *Ragguaglio* provided Matteo with an opportunity to initiate a personal correspondence with Christiaan Huygens. He did so by enclosing a complimentary copy of Giuseppe's tract with a letter in which he spared no

[445] Ibid., 20, March 1, 1665.
[446] Ibid., 88, May 5, 1666.
[447] Ibid., 102.
[448] Ibid., 98, June 20, 1666.
[449] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 4, 498, October 27, 1666.
[450] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 2, 319, November 5, 1666.

adjectives in his unrestrained salutation. Addressing Huygens as "Most Erudite Sir," he wrote, " the reason that I have been prompted to write to you is the great renown of your name. In fact, that first and never sufficiently praised invention of yours concerning the marvelous system of Saturn—which has been accepted by many learned and noble men since the moment they saw it, although some rejected it simply out of prejudice—leads me to inform you by means of this letter concerning the exactitude of this system that you have discovered. This [precision of the Huygensian theory] has been clearly shown by lenses created by means of a new method, as you will readily see by reading the enclosed short treatise written by my brother, a text that I am sending you as a token of my respect and friendly disposition towards you." Matteo also made use of the occasion to convey greetings from Daniello Bartoli, "reverend father of the Jesuit order, a most learned man in every science and art, whose name is mentioned in the treatise".[451]

Huygens's response to Matteo's self-serving letter was routed to Matteo through Michelangelo Ricci. This letter from Huygens has been lost but was acknowledged in Matteo's response written in early December, commenting on the well-known ring discovered by Father Honoré Fabri. He also responded to Huygens's repeated query concerning Giuseppe's lathe and provided renewed assurances that it was indeed just as it had been described by Giuseppe in his *Ragguaglio*. Matteo enclosed a new drawing of more recent observations made by Giuseppe of Jupiter and Saturn, noting that some errors had crept into the earlier drawing that Huygens had received from Sluse. He explained that Giuseppe's observations had been made with his telescope of 25 palms, equal to 16 French feet, and that he had seen the ring of Saturn clearly and distinctly. He also commented that the Medicean clouds he had observed moving across the face of Jupiter had not once been noted by Cassini.

Matteo explained that he had been absent from Rome for the past several months, for reasons that were never revealed, and urged that to ensure safe delivery of future correspondence, it should be addressed to him in the care of Daniello Bartoli at the Collegio Romano. This was not the only occasion on which Matteo asked correspondents to direct mail to him other than to his own address and through another source; several

[451] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, no. 1304,,193-94 (1893), letter from Matteo Campani to Christiaan Huygens, enclosing a copy of the *Ragguaglio* on August 1, 1664 (Kalends).

times in his letters to others, he requested that mail was to be directed to him through either Bartoli or Michelangelo Ricci. The reason for Matteo's insistence that mail to him should be directed through channels other than his own address at his rectory has never been explained. Could it have been because his clerical superiors may have been objecting to his extensive extra-ecclesiastical activities in the realm of the sciences?[452]

Huygens already had received a copy of the *Ragguaglio* and had read it, and several weeks later he informed Sir Robert Moray, one of his English correspondents. "It had arrived with a letter from Rome," he said, "containing a small publication written by the brother of the one who sent it to me. They are named Montani [sic] and the book contained a new observation of Saturn that he had made this past spring of the fashion marked on the figure to demonstrate that the circle of Saturn is situated at a height of a part of the sphere and is covered below by a little shadow on the circle below and on the sphere at the top. They boast of inventing a new method of making glasses [lenses] by means of a lathe, and without otherwise using forms [molds]. I do not know what this method could be, but always they cite or claim having testimony from witnesses who have seen the extremely excellent lenses superior to those of Divini, for the rest, the observation confirms in every way my system [. . .]".[453]

In a later communication to Moray, Huygens again mentioned "the small book of Montani" [sic], adding that he had received also a copy of Giuseppe's large engraved broadside, "the printed illustration that in addition to the noted observation of Saturn reproduces a fine one of Jupiter, on the disk of which can be seen the passing of the shadows of the two satellites, and shortly thereafter they separate from the disk. I had never thought that this observation could be made, in view of the smallness of its companions, and it is not necessary that their lenses are of extraordinary perfection. If that of Reeves of 60 *pieds* is as good, it will be possible to discover the said shadows when the eclipses arrive".[454]

Matteo communicated to Viviani concerning the publication by Huygens on the rings of Saturn, noting that in Rome with Giuseppe's telescopes the rings were clearly in

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452 Ibid., no. 1258, 119–21, letter from Huygens to Robert Moray on October 10, 1664.

453 Ibid., no. 1253, 107–10, letter from Huygens to Robert Moray on August 29, 1664, including drawings.

454 Ibid., no. 1258, 119–21, letter from Huygens to Robert Moray on October 10, 1664.

evidence, although Honoré Fabri did not believe it, even though he had been invited to come and observe; however, he failed to appear. In this letter, Matteo enclosed a copy of a work about "the Huygensian system of Saturn", probably the *Ragguaglio*.[455]

Matteo missed no opportunity to promote his brother's achievements in Florence as well as in Rome. Although he had already informed Viviani of them, in late August he sent a somewhat ingratiating letter to Prince Leopold. He began by commenting that it was well-known that among the Prince's virtuous entertainments one from which he received great pleasure was the time he spent in contemplation of the marvelous wonders of the skies, in which from time to time new discoveries were being made by means of optical instruments that constantly were being improved and perfected. Having been aware of this princely preoccupation, Matteo accordingly enclosed Giuseppe's engraved broadside of the rings of Saturn, humbly explaining that it was "produced by one of my brothers" and that it depicted a celestial event that he had discovered. The Medici princes already were well-acquainted with Giuseppe's work as a clockmaker, for each of them had purchased several of his night clocks, but as yet they had not become fully aware of his achievements in astronomy. Matteo, once again acting as his brother's advance agent, took the opportunity to inform them also of Giuseppe's success in producing telescopes and in making astronomical observations.[456]

Up until now, Giuseppe had produced only a few telescopes. In 1662 or 1663, he had presented the first telescope he had made to Bartoli, and in 1663 or 1664, he had given Cassini an instrument of 23 palms [513.82 cm.].[457] During this period, in fulfillment of a request from Cardinal Antonio Barberini in Paris, he had sent him a terrestrial instrument of 4-1/2 palms [100,53 cm.]. There it had been examined at the Paris Observatory by Huygens, Auzout, and others, all of whom had judged it to be far superior to any telescope of comparable length then available in Paris. Furthermore, they were curious to learn whether a Campani telescope of 50 palms [11.17 m.] would be superior to their own long telescopes. With his letter to Giuseppe acknowledging receipt

455 BNCF, Gal. 254, fol. 269, letter from Matteo Campani to Viviani on August 2, 1664.

456 BNCF, Gal. vol. 277, c. 33 (*Cart. Gal.* vol. 18, fol. 33), letter from Matteo Campani to Prince Leopold on August 30, 1664.

457 [Scientific Editor 2: a *palmo romano* is equivalent to 22.34 cm, or about nine inches].

of the telescope, His Eminence included several writings by others, including a letter to Giuseppe from the Abbé Charles. The Cardinal wrote:

As these *virtuosi* cannot commend me sufficiently about the telescope you sent me recently, they wished to write to you directly, and it is with pleasure that I have undertaken to send you their letters and the discourses which have been held on the same subject, in order not to deprive you of the praise that is owed to you, and also to provide you with greater stimulus to hasten the work on the other telescope of 50 palms. This is awaited here with impatience by all these men who are curious to see if the effects of the difference which they have not yet been able to recognize in other telescopes will be in proportion to the size. They also hope that you will communicate to them all the observations that you will make in the future concerning these matters and I pray in wishing you all good things from God.[458]

It was at this time that Giuseppe produced a telescope equipped with an object lens and an eyepiece combining three lenses that enlarged 14 times.[459] Auzout compared it to a telescope made by Huygens that was equipped with a mirror and noted that the Campani instrument had proven to be superior to Huygens's telescope that enlarged only 12 times. The inadequate polishing of its mirror had rendered the image of Huygens' telescope less clear. Adrien Auzout also was preoccupied with the building of telescopes and constructed objectives of great focal length that in comparison were always inferior to those of Campani.[460]

By this time Giuseppe Campani's reputation had become well-established, his skills were recognized, and his instruments were highly prized, particularly at the Medici court. Nonetheless, when in 1665 Grand Duke Ferdinand II wished to have a hygrometer made, he directed the court mathematician, Vincenzo Viviani, to supervise the project, which he specified was to be made by his court mechanician and clockmaker, Johann Philipp Treffler. The Grand Duke intended to send the instrument as a gift to Pope Alexander VII in the name of his brother Prince Leopold. It was to be delivered through the intermediary of his minister, Monsignor Cesare Magalotti, and so he notified him through the latter's brother, Count Lorenzo Magalotti (1637–1712). In informing his brother, the Count mentioned that, since the Duke wished to present the gift to the Pope,

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458 Righini Bonelli and Van Helden, "Divini and Campani," 90–91, letter to Giuseppe Campani from Cardinal Antonio Barberini with enclosure on October 24, 1664.

459 [Scientific Editor 2: this is probably the same telescope made for Cardinal Barberini: Auzout says that it measured *"3 pieds and 2 pouces"* that makes a good meter, like the one sent to France to the Cardinal the same year].

460 Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, No. 1273, 145. Letter to Christiaan Huygens from Auzout (November 1664).

the instrument must be achieved with the greatest perfection. He counseled his brother that in this regard it should be made by "Campani and other artisans who make things of such perfection." Meanwhile, however, the Duke had already instructed Viviani to send a description of the hygrometer that had been designed by Francesco Folli together with instructions about how to construct it to Johann Philipp Treffler, who happened to be in Augsburg at the time.[461] Viviani, complying with his instructions despite his personal inclinations, had no choice but to send sketches as well as a description of the proposed hygrometer to Treffler in Augsburg instead of to Campani.[462]

One evening after having returned from a visit to the Collegio Romano, Paolo and Ottavio Falconieri whiled away the hours making observations with the Campani long telescope. In the course of the evening, Ottavio mentioned to his brother that he had spent the earlier part of the day with Pope Alexander VII, demonstrating for him the use of the hygrometer, "the instrument that serves to determine the differences in the moisture of the air," invented by Grand Duke Ferdinand II in 1655. This was the hygrometer that had been made by Treffler.[463]

Later that evening, Ottavio Falconieri took the time to write to Lorenzo Magalotti reporting on the success of the Grand Duke's gift to the Pontiff. He described how:

> during the audience I had yesterday with His Holiness, I had an opportunity to demonstrate to him the use of the instrument for moisture. The substance of that [audience] is that it appears to me that His Holiness expressed great curiosity to see [the instrument] and afterwards testified to an equal enjoyment of having seen it and having no small pleasure with the gift. I concluded this from seeing that, notwithstanding the fact that yesterday morning he had held an audience with the French ambassador, the Pope was more than usually surrounded by ordinary matters like this one which could now be on his bedside table. Although in the antechamber there were persons awaiting audiences who ordinarily do not go there except when summoned on serious matters, it pleased His Holiness to have me called in without making me wait while Cardinal [Flavio] Chigi remained present. His Holiness also wanted me to show him this instrument in detail, and he praised the very ingenious and most beautiful invention, adding praise for the genius of the inventor.[464]

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[461] Targioni Tozzetti, *Atti e memorie inedite dell' Accademia del cimento*, vol. 2, parte I, 337 *et seq*.

[462] Maria Luisa Bonelli, 'Note su alcuni strumenti igrometrici del sec. XVII posseduti dal Museo di storia della scienza di Firenze', in *Actes du VIIIe congrès international d'histoire des sciences : Florence-Milan, 3-9 septembre 1956* (Congrès international d'histoire des sciences, Florence-Milan: Gruppo italiano di storia delle scienze, 1956), 410–21; Silvio A. Bedini and Johann Philipp Treffler, *Agent for the Archduke: Another Chapter in the Story of Johann Philipp Treffler, Clockmaker of Augsburg* (Firenze: Leo S. Olschki, 1961).

[463] Archivio di Stato di Firenze, *Carteggio di Artisti*, vol. X, fol. 128, letter from Ottavio Falconieri (1646–1676) to Prince Leopold on October 20, 1664.

[464] Maria Luisa Righini Bonelli and Albert Van Helden, "Divini and Campani: A Forgotten

Ottavio Falconieri arranged to forward to Giuseppe Campani the copy of Auzout's writings to the Abbé Charles that Cardinal Barberini had sent from Paris with his instructions that it was to be delivered to Giuseppe. Auzout's writings concerned Saturn and other observations he had made with some of his telescopes. Auzout had returned the borrowed copy of the *Ragguaglio* to the Abbé Charles accompanied by his letter of October 20, 1664, in which he expressed his thoughts concerning the book and to which he added his own observations of Saturn and Jupiter. He praised Campani for having devoted himself to making lenses, "because he promises to make them free of all defects compared to [those made by] others." Assuming that Campani was in no hurry to divulge his new invention, Auzout begged the Abbé to encourage him to make lenses of 100, 200, and 300 palms (about 22, 45, and 67 meters). He asked the Abbé, furthermore, to assure Campani that there would be no need to struggle with the difficulties that would be encountered in managing such great tubes because Auzout claimed that 2 years previously he had found an invention that made it possible to observe without tubes, and he is convinced that one of his friends had written about this to someone in Rome or Florence.[465]

Ottavio Falconieri also planned to send Magalotti a copy of the published letter from Auzout to the Abbé Charles concerning Saturn and his other observations, which he was having translated from the French. He also was including a copy of Giuseppe Campani's broadside showing Saturn and Jupiter. All of this, he advised, would arrive with the Lyons courier.[466] Falconieri forwarded to Magalotti two letters from Auzout addressed to the Abbé Charles dealing with various subjects, which then were to been sent by him to Campani. Explaining that he did not have time to translate them from the French, Falconieri commented that Auzout promised great things, although he arrogated to himself some things that were not totally his own, such as the invention of the aerial telescope. Auzout claimed it was he who had made the invention of aerial telescopes,

Chapter in the History of the Accademia del cimento," *Annali dell'Istituto e museo di storia della scienza di Firenze* 6, no. 1 (1981): 87–89, letter from Ottavio Falconieri to Magalotti on December 6, 1664 *on varia*.

[465] Robert M. McKeon, 'Établissement de l'astronomie de précision et oeuvre d'Adrien Auzout' (Sorbonne, 1965), 121–25.

[466] Righini Bonelli and Van Helden, "Divini and Campani," 88–89, letter from Ottavio Falconieri to Lorenzo Magalotti on December 6, 1664.

using a telescope without a tube, a genuine claim although he was not the only one to have made such an instrument, but he already had the idea to do so by the summer of 1663. Candido del Buono claimed the same invention under the name *arcicanna*, but it is not known whether it post-dated Auzout's idea.[467]

In his communication to the Abbé Charles, Auzout had reported that 15 or 18 months previously he had made two telescopes, one of 130 palms (29 meters) and another of 220 palms (49 meters). With these he had hoped to discover something new in the skies, had he the good fortune of making them in perfect proportion to their lengths, and if he had available a suitable place in which to use them. He said he had reason to believe that he would be able to observe great things with another instrument of 40 palms that he intended to make after he had succeeded in obtaining suitable materials of excellent quality that he required for it.[468]

Auzout then inquired about the length of that long tree-lined avenue that Campani mentioned in his book, claiming that from that distance he had been able to read those small letters with his telescopes of 35 palms (781,9 cm.). In order that he too could make the comparison with his telescopes observing from the same distance, M. de Méru–a telescope maker from Nevers who also had invented a lathe to grind lenses–had requested a sample selection of the same letters.[469] Auzout, sent Campani a sample of those placards having letters that he had been able to read with his own instrument so that Campani could satisfy himself with the comparison. He believed that there was a certain advantage to having Campani make this test in Rome because of that city's thicker air. On this subject, he commented that he had been informed by Thomas Rasmussen Walgensten, a Dane whom he considered to be most knowledgeable about telescopes, that the air in Denmark and Holland was very different from that in Italy, particularly during the daylight hours. He said that telescopes made by Divini and those made by others that appeared to be excellent in Italy could not be used elsewhere unless the ocular

[467] Ibid., 94-97, letter from Ottavio Falconieri to Magalotti on December 9, 1664.

[468] Auzout, *Lettre à M. l'abbé Charles sur le "Ragguaglio di due nuove osservationi, etc.", da Giuseppe Campani*, 2.

[469] Ibid.

was replaced by a weaker one. With the ocular used in Rome, he added, objects observed appeared dark and hazy.[470]

Auzout reported having tested telescopes having focal lengths of 35 and 50 feet (12.3 meters and 16.2 meters) by using them to make observations of some letters on a placard placed at a distance of about 1,620 Roman palms (362 meters) in the open air. It was his claim that large telescopes suffered more visibly and with less alteration from the various states of the air that prevailed in different weather conditions under which these observations were made. It was not clear whether Auzout made these observations with the lenses contained in tubes or without the tubes in accordance with his new invention. In all probability, the observations were made with lenses without tubes since he had stated earlier that from this distance he could easily and with convenience observe with telescopes of 50 and 70 palms (11.2 meters and 15.6 meters) without tubes, which appear to have been the same telescopes of 35 and 50 feet as those with which he claimed to have observed.

When the weather was fine, Auzout stated, he had managed to read the letters marked A and some words of those marked B. He was never able to read any of those marked C, however, because the letters were too slender, even though they were capital letters. He recorded that another telescope of 46 palms made by or owned by a certain d'Espagnet enabled the same letters to be read. The telescopes of Auzout and d'Espagnet, fitted with a single convex eyepiece, produced an inverted image. Auzout thereupon simply posted his test sheet upside down to compensate for the inversion. Without the use of a telescope, the letters could be read at a distance of 15 feet (4.9 meters), and the telescope revealed them as they would appear only 8 feet away with the naked eye without a telescope. All that this would require, he affirmed, was that it should be properly tested by Campani from the same distance and under the same conditions with one of his own telescopes and that he should report the result.[471]

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[470] Bonelli and Van Helden, 'Divini and Campani', 107. Thomas Rasmussen Walgensten (1627–1681) was an architect, almanac maker, and skilled lens grinder [Povl Engelstoft and Svend Dahl, eds., *Dansk biografisk leksikon*, 2. udgave, vol. 25 (København: Schultz, 1933), 51–58; Maurice Daumas, *Les instruments scientifiques: aux XVIIe et XVIIIe siècles* (Paris: Presses Universitaires de France, 1953).]

[471] Righini Bonelli and Van Helden, "Divini and Campani," 109; d'Espagnet was a Conseiller du Parliament de Bordeaux.

In considering Giuseppe's observations of Saturn and Jupiter, Auzout stated that he suspected that Campani's imagination played a greater part in those observations than did his eyes. Auzout asserted that Giuseppe had claimed manifestly to prove that he had seen things that were impossible to see because they were not there, and that he had not seen things that were there and that others reported to have seen. Auzout pointed out that Campani could hardly have seen a dark band on the planet's disk immediately adjacent to the inside of the ring. Such a shadow effect was ruled out, he stated, by the relative positions of Sun, Saturn, and Earth in 1664.[472]

Campani's response was that he never said that it was a shadow. But whatever it was, he claimed he had seen it, and he would allow astronomers to argue amongst themselves about its nature. Campani was vindicated in 1848, when the so-called crepe ring was discovered. Auzout dwelt on this theme throughout the rest of his letter. It is to be noted that, in his discussion, he claimed to have been the first to discover the interruption in the bright ring surrounding Saturn, an interruption caused by the shadow that was cast upon the same ring by its disk. Two years previously, Auzout went on, he had noticed that which had, however, been first observed by Prince Leopold in July or August of 1660 and [of which a report] had been sent in October 1660 to Ricci in Rome and to Huygens in Holland.[473]

Auzout then announced that he planned to publish a certain treatise in which he would describe how to use telescopes without tubes. In addition, he would describe four or five new uses for large telescopes that had not yet been suggested by others. The tract, which was entitled "Treatise on the Utility of the Large Telescopes and of the Manner of Using Them without Tubes" [*Traité de l'Utilité des Grandes Lunettes et de la Maniere de s'en Servir sans Tuyau*] was never published, however, and its manuscript is now lost.

Auzout took the time to search for errors made by Campani in the *Ragguaglio*, or what he considered at least to be rash statements, and then asked the Abbé to make very gracious excuses to Campani on his behalf. It was Magalotti's opinion, however, that

[472] Ibid., 111.

[473] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 3, 151–67; the shadow of Saturn's body on its ring was indeed first observed in Florence in August 1660 as reported to Huygens. BNCF, Gal., fols. 289, ff. 20 *et seq*.

Auzout had succeeded in trashing Campani thoroughly and with great elegance. In an extract from the first letter that Auzout had sent to the Abbé Charles, Magalotti wrote:

> And if in claiming the invention of these telescopes without tubes, this man [Auzout] had not been discovered to have appropriated for himself the invention of the *arcicanna* of Candido del Buono, as I suspect from what the Abbot Falconieri had written to me, or that [invention] of the telescopes of His Highness, which are used without tubes, circulating it about as being something new and his own creation, I would judge him to be a worthy scholar and sincere. Also that he is a friend of truth. But by saying, where he speaks of this invention of his, that he firmly believes that some idea of it has come to Rome or Florence is a certain indication that he intends to take steps so that he can say to anyone who might claim himself as the inventor that he has stolen it from him. Yet I could err in all this, and I want to believe that this is the case as long as the invention is not published, which it will be shortly, since he is not being held back by anything other than convalescence from a long illness, if I heard correctly.[474]

It was not until later, in December 1664, that another trial session of the telescopes was scheduled to be held in Rome. The site selected for the event was upon one of the most elevated points of the city, at the Church of San Pietro in Montorio. Situated high up above the Vatican on the Janiculum, the church had been built in 1481 for Ferdinand and Isabella of Spain. Flights of steps punctuated a steep path that opened out in front of the church upon a terrace; from this point was available one of the most celebrated views of the Eternal City. Behind the church in the cloister was the famous Tempietto of Bramante, marking the place where it was believed that St. Peter had once been crucified.

It was an ideal site for the trial of the telescopes, which was held "in the presence of many *virtuosi*, Princes, and gentlemen." Giuseppe Campani demonstrated the same instrument of 50 palms that he had already displayed before, and Divini presented the second telescope he had made following the comparison that had taken place in the gardens of the Medici palace on Monte Pincio but on which he now had replaced the optics with simple lenses.

In preparation for the tests, both competing instruments were lined up side by side and directed toward the same object, a printed placard. After all of the other participants had taken turns and looked through each of the telescopes and made test observations with them, Divini also did so and stated that he was quite satisfied with the test. He added

[474] Righini Bonelli and Van Helden, "Divini and Campani," 105–15, Magalotti's extract of Auzout's letter to the *Abbé* Charles of October 20, 1664, which was dated October 13, 1664, in the printed version [see Auzout, *Lettre à M. l'abbé Charles sur le "Ragguaglio di due nuove osservationi, etc.", da Giuseppe Campani,* 1–14].

that if the others would not render a decision, he would do so. After everyone had remained silent, Divini then ventured the remark that in his opinion his own instrument performed ["terminated" was the word he used] better than had the Campani telescope. Hearing this, the others all maintained silence as before except Matteo Campani, who disagreed with Divini's statement.[475]

Thereupon one of those present commented that it would have been preferable to have tested each telescope equipped with only two lenses, that is, with equal optics, therefore having the same acuity. Matteo's immediate response was that neither he nor Giuseppe had brought with them lenses of equal quality. Then Divini, in a generous gesture and wishing to be accommodating, suggested that inasmuch as it happened quite by chance, he had brought along some of the same glass, that is, lenses, of the same shape or configuration. He offered that Matteo could make a selection from them and replace those in the Campani instrument for purposes of the test if he wished. Matteo then quickly used the excuse that he did not wish to mix Divini's work with that of his brother, "just as if he truly had scruples about mixing the work of another with his," scoffed Divini.[476]

Divini persisted with his complaint, commenting that when Giuseppe had presented Cassini with a telescope of 25 palms, in actuality he had given him only the object lens, implying that Cassini then had to obtain an eyepiece from some shopkeeper. It must be said, Divini went on, that if the Campani brothers had such scruples about not mixing their work with that of another, it could be only for fear that their instrument would be recognized to be inferior.[477]

Divini went on in his *Lettera* to report on another test of the telescopes that had been undertaken at his house during which a comparison was made of Giuseppe's telescope of 7-1/2 palms [167.55 cm] equipped with two lenses and a Divini instrument that also had two lenses but which was of greater length. Present during the test, Divini reported, were Angelo Loredano (the owner of the Campani telescope), the Reverend Honoré Fabri, Raffaello Prodanelli, and Fabritio Guastaferri. Both instruments were directed toward the same object, which consisted of a placard containing writing that was

[475] Divini, *Lettera*, 43–47.
[476] Ibid.
[477] Ibid., 47-49.

placed at a proportional distance in front of a window of Divini's workshop. Guastaferri was the first to test the telescopes and concluded that the Campani instrument was superior. Then, as each of the others also made comparative observations, none contradicted Guastaferri, much to Loredano's great pleasure.

Next, Divini conducted the gathering of observers to a room on the upper floor of his house and arranged the same telescopes in a window opening that was some 16 palms above the ground. He then directed the men to observe the same writing through the instruments. Guastaferri was the first to do so and commented that the same telescope that in the room below had proven to be of little value now turned out to be of superb quality. Divini thereupon claimed that long telescopes suffer more from dense air and that, at the lower window, there had been vapor rising from surrounding roofs that did not reach the upper window.[478]

Divini went on to relate how on another occasion, when he was passing by the Church and cloisters of San Onofrio, he happened to have two of his telescopes with him, one of 52 palms and another of 64 palms, that he had just completed making. The brothers Salvatore and Francesco Serra, who apparently had been passing by, stopped to speak with him. Salvatore Serra was one of the first observers after Cassini to have recognized the rotation of the planet Mars around its correct axis. The brothers told Divini that, several days previously, while making observations directed at Castel Gandolfo with a Divini telescope, they had been able to recognize the cross on top of the cupola. They commented that on the previous day, however, they had been unable to distinguish it with two Campani telescopes. One of these, of 50 palms, had been sent back from Florence, and the other was one made later by Giuseppe. The Serra brothers pointed out to Divini that the church of San Onofrio, which was situated halfway down the Passeggiata from the Janiculum, was a greater distance from Castel Gandolfo than was the Church of San Pietro in Montorio.[479]

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[478] Ibid., 49-51.

[479] Ibid., 55–57; Serra's observation of Mars was reported in his publication *Martis revolubilis observationes Romanae ab affictis erroribus vindicatæ* (Roma: Giacomo Dragondelli, 1666). See François Terby, *Areographie, ou etude comparative des observations faites sur l'aspect physique de la planete Mars depuis Fontana (1636) jusqu'a nos jours (1873)*, Académie Royale de Belgique. Mémoires couronnés, etc., 39. no. 1 (Bruxelles: F. Hayez, 1879), 38–39, 59–61; *Etudes sur la planète Mars, explication des dessins exécutés en 1666 par J.D. Cassini, J. Campani, Salvator Serra et Hook - 10me notice* (Bruxelles: F. Hayez, 1877), 548–55.

Divini was particularly skeptical about Giuseppe's claim that he had invented a lathe with which he said he ground and polished lenses from raw glass without first casting the glass in molds or making use of forms for finishing them. Divini quoted from what Giuseppe had written in his *Ragguaglio*:

But since this new discovery of mine, and other phenomena observed in Saturn as well as in Jupiter, with my first telescopes, does not give occasion to anyone to believe that they were produced accidentally, but by means of art, and industry; inasmuch as you have seen many of my lenses, and all of them of the same fine quality, you can give testimony of them to the world; inasmuch as you know by experience, that the instrument or lathe that I invented, with which I fashion my lenses, is not subject to those defects, that can result from the use of forms, and of the uncertainty of the hand, the motion of which is unequal; and is liable to error, rendering also fallacious and uncertain the degree of curvature of the figure.

From the same slab of glass [*cristallo*] I would select two pieces suitable for making two objectives, each of 50 palms for example, and labeled, that remain the same in the work, and I will take from each a small chip and for those who are curious to disprove it, I will give the choice of the piece, retaining for myself a chip of yours and consigning to him a chip of mine, on the condition that by the end of three days each one of us must have finished the work [of making a lens]: and without being able to make any prior test in particular, to expose it to public testing, that is, to the trial to be made with every exactness by diverse *virtuosi*. So that it indubitably will become known by means of the superior quality of one of the two objectives which of us has the finest art, and who is the more certain to give to lenses the perfect spherical figure.[480]

Campani's claim that he did not use forms [molds] for shaping his lenses continued to create a stir for some time after the publication of the *Ragguaglio*. Most of those men of science throughout Europe who were involved with production and/or testing of astronomical instruments, such as Huygens, were skeptical, and Auzout for one, could not imagine how it was possible to produce lenses in such a manner. In England, news of Giuseppe's claims for his new lathe inspired Robert Hooke, the mechanician of the Royal Society, to consider such an invention in addition to his many others. He promptly announced in 1664 that he had in fact had the same idea and also that he had invented a means of grinding and polishing lenses. He produced the apparatus in the following year and illustrated it with a speculative design in his *Micrographia,* which appeared in January 1665. Hooke's invention was in the form of a lathe consisting of two inclined axes connected together. When an illustration of his lathe was published, both Auzout and Huygens expressed strong doubts concerning its capability. The design subsequently led to a debate in the press between Auzout and Hooke in which Giuseppe

[480] Giuseppe Campani's *Ragguaglio* quoted in Eustachio Divini, *Lettera,* 65–66.

Campani's name occurred often, and consequently it was made better known thereafter among European men of science.[481]

The proposal to grind and polish lenses on a lathe without first casting the glass in molds was not entirely new when Giuseppe first proposed it. Almost a decade earlier, in about 1650, a certain king's counsel at Nevers [*avocat du roi*] named de Méru had constructed such a lathe by means of which a tool, guided horizontally, ground a piece of glass attached to the axis of the lathe. Auzout mentioned to Abbé Charles this lathe made. It was Auzout's opinion, however, that such a lathe was limited and would work well only for very small instruments of not more than 3 or 4 feet in length, which were in fact the largest sizes made by de Méru. No details were provided concerning the means by which de Méru's tool was guided. Auzout, who appeared to be familiar with it, stated "it made numerous sizes [*grandeurs*] of lenses, by means of a *régle droite* that advanced and returned horizontally, while the glass turned at the same time, and gave it more or less its curvature." The lathe apparently did not arouse particular interest among de Méru's contemporaries, and the equipment remained in the cabinet of curiosities of the Parisian instrument maker Pierre Petit and appears not to have been used. Auzout mentioned that he had offered to send a drawing of the lathe's design to Campani.[482]

By the end of the century, there was no doubt that Giuseppe was able to produce telescope lenses that were far superior to any produced by his contemporaries. Whether he had in fact achieved this by means of the invention of a new type of lathe without the use of molds remained in question throughout his lifetime. As already noted,[483] a clue to Giuseppe's lathe may exist, however, in "the famous mechanism for smoothing and polishing diamonds" that his brother Matteo saw in the "museum" of Grand Duke Ferdinand II while in Florence in 1659. The "museum" was the *studiolo* of Grand Duke

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[481] Robert Hooke, *Micrographia: or, Some physiological descriptions of minute bodies made by magnifying glasses. With observations and inquiries thereupon.* (London: Printed by J. Martyn and J. Allestry, 1665), Preface. Robert Hooke (1635–1703), inventor and experimentalist, was Curator of Experiments to the Royal Society of London. He was highly competitive, constantly quarrelsome regarding priorities with other men of science, and noted for the speed of his ingenuity. After the great fire of 1666, Hooke furnished specialized surveying services for the rebuilding of London and assisted Christopher Wren in designing the new St. Paul's Cathedral. His name is associated with the fundamental laws of the theory of the elasticity of bodies.

[482] McKeon, 'Établissement de l'astronomie de précision', vol. II, 314-16; Daumas, *Les instruments scientifiques*, 54.

[483] See chapter VIII.

Francesco I, the only member of the Medici family who personally had engaged in lapidary work, and the mechanism Matteo mentioned was unquestionably his lapidary lathe.[484]

The Medici lapidary lathe has not survived, and no illustrations or descriptions of it are known. It is probable that it was similar to the cutting bench or lathe of Ottavio Miseroni, the Milanese lapidary employed in the imperial court at Prague. The Miseroni lathe, which constitutes the earliest known representation of a lapidary lathe, is represented in a Flemish painting dated 1635 in the Národni Galeria in Prague. Because Matteo mentioned having observed the Grand Duke's lapidary lathe, it is likely that Giuseppe also saw it during his visit to the Medici court in the same year. It has not been possible to determine from their accounts of their visits to Florence whether the brothers made the trip together or separately, although they were there during the same period.[485]

A survey of the literature on the history of diamond cutting and polishing suggests that the Medici lapidary lathe may have been a version of one of several lathes described and illustrated in the work published in 1676 by the French architect and writer André Felibien (1619–1695). One machine for grinding and polishing diamonds featured a horizontal polishing or grinding disk, or *scaife*, having a vertical axis driven by a rope pulley from a large wheel operated by a horizontal crank drive; the swinging lever had two handles. This was quite a departure from the vertical forms of the three types of lathes used by lens makers in Campani's time, such as the one developed by Ippolito Francini in Florence and the one used by Divini in Rome, both of which were illustrated in Manzini's manual of 1660. The earliest illustration depicting the grinding and polishing of diamonds is a drawing by the Dutch artist and poet Jan Luiken, in whose works was delineated equipment similar to that described by Felibien.[486]

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484 Daumas, *Les instruments scientifiques*, 54.

485 Campani, *Horologium solo naturae motu*, 10. He had written "*Florentiam me contulissem*, *ibique in musaeo Serenissimi Magni Ducis*, *quotidie agerem*, *casu accidit illic videre artificium illud*, *quo adamantes teruntur*, *et poliuntur*."

486 Miseroni lathe; André Félibien, *Des principes de l'architecture, de la sculpture, de la peinture, et des autres arts qui en dependent: avec un dictionnaire des termes propres à chacun de ces arts* (À Paris: chez Jean-Baptiste Coignard, 1676); Paul Grodzinski, 'The History of Diamond Polishing', *Transactions of the Newcomen Society Transactions of the Newcomen Society* 28, no. 1 (1951): 2–3; Jan Luiken, *Menschelyke Beezigheden Bestaande in regeering, Konsten en Ambachten, na orde van het A.B.C., in honderd figuuren, Zinrijk uitgebeeld. in koper geëst[!] en gesneeden* (t'Amsterdam: Verkooft bij A. d. Winter en J. Bormeester, 1695), plate 18.

The possibility exists that the lapidary lathe in the Medici *studiolo* incorporated some unusual principle that Giuseppe mentally noted and later adapted in developing a lathe of his own, which enabled him to grind and polish lenses without casting blanks. He was not the only artisan to design and construct a lens-grinding lathe in this period. Christiaan Huygens and his father Constantijn developed a comparable apparatus and techniques of their own. In a drawing produced in about 1660, one of Huygens's devices for polishing lenses was described as a *baton.* The lens blank was mounted at the end of an arm [*baton*], pivoted at its upper extremity, and counter-weighted to keep the lens blank pressed firmly against the rotating tool. As the weight was moved to the right, the pressure on the glass blank increased. In a visit to England in 1661, Huygens described his methods and apparatus at a gathering of his fellow members of the Royal Society. The pattern was cast from copper or brass and was figured while pressed tightly against the form by the weighted bent pole. When the metal pattern was ready, the lens blank was fitted to it and polished with moistened emery on the same equipment with which the pattern had been produced. The final touches were accomplished with a cloth polisher tied around a round block of slate ground to the curvature of the pattern, the soft cloth being coated with wax and pitch. Tripoli or powdered putty was used for the final polishing of the lens. His technique was subsequently studied and described by Samuel Molyneux.[487] As did other contemporaries engaged in the same endeavors, Huygens continued to wrestle with the problem of developing an adequate apparatus for perfecting lenses. In a drawing dated 1665, he illustrated a machine having the polishing tool rotated by a gear drive while the belt simultaneously turned the lens blank mounted upon a lower spindle.[488]

Although universal skepticism greeted the claim made by Giuseppe Campani in the *Ragguaglio* that he produced his lenses by working directly from the glass on his lathe without casting blanks, the fact remained that his lenses, however produced,

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487 King, *The History of the Telescope*, 57–59; Robert Smith, *A Compleat System of Opticks: In Four Books, Viz. a Popular, a Mathematical, a Mechanical, and a Philosophical Treatise : To Which Are Added Remarks upon the Whole* (Cambridge; And at London: Printed for the author, abd sold there by Cornelius Crownfield ; By Stephen Austen at the Angel and Bible in St. Paul's Church-yard, and Robert Dodsley at Tully's Head in Pall-Mall, 1738), vol. III, 281-301, re. Samuel Molyneux's account.

488 Christiaan Huygens, *Taille des lentilles pour microscopes et lunettes à longue vue*, in Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. XVII: L'horloge à pendule 1656-1666, no. III, pp. 239, 301-04 (1932).

excelled those of all his contemporaries. The question continued to puzzle men of science for at least another century, and it was generally protested that what Giuseppe described was impossible to achieve. No one in Giuseppe's lifetime, however, had been given an opportunity to visit his workshop or to view the interior of his work room or to examine his equipment, which he jealously guarded. Campani refused to provide a description or a further explanation of his lathe, and in time, as his secret was not revealed; the subject was shelved as meanwhile other lens makers continued to cast their glass in molds before grinding and using forms for shaping them.

A major problem shared by makers of astronomical lenses in this period, as previously noted, derived from the unsatisfactory quality of glass that was generally available. It was recognized throughout Europe that the very finest glass was the quality called *cristallo*—produced in Murano in the Venetian Republic—which was ground and polished for mirrors of the finest quality. The glass was colorless, achieved by using manganese for discoloring. Being virtually devoid of impurities, it had comparatively greater clarity, and it was named *cristallo* because it resembled rock crystal or quartz.

Glass of *cristallo* quality was a precious commodity for all levels of society in that period and particularly for the scientific community; whenever possible, lens makers and other glass workers purchased pieces of this selected glass directly from glass makers or dealers in Murano. Broken fragments of *cristallo* that had been discarded by the mirror makers were sold by vendors who traveled from Venice to the larger Italian cities where they wandered about advertising these wares. It was from such vendors or mirror makers in Murano or Venice that Galileo had acquired lenses before he was able to obtain glass from the Medici glassworks in Florence. The broken pieces of mirror quality that were offered were generally irregular in shape but for the most part were free of imperfections such as air bubbles, striations, or inclusions of grit or vegetable matter. The surfaces had been ground parallel in the shops of the mirror makers, and generally the quality of the polishing of both upper and lower surfaces was sufficiently intact and needed only more final polishing. Then, instead of first having to melt and shape the glass in forms or molds, since the glass discards of mirrors consisted of flat panels, the lens maker cut suitable segments having circular circumferences from unblemished sections of such panels. These segments the lens makers then ground and polished on their lathes to the correct sizes and thicknesses.

Vendors of broken pieces of Murano glass wandering the streets of the larger cities were fairly common, for they were included in a series of contemporary woodcuts illustrating common trades. Such a vendor was featured bearing a basket on each arm filled with glass items and pieces of broken glass with the verse:

I bring from Murano cups and wine glasses
Unpolished bowls, and various other things
And I also bring a basket full of broken glasses.[489]

[Figure]

It is known from surviving records that Divini in Rome, Johann Wiesel in Augsburg, and John Beale in England frequently used pieces of old broken mirrors of Venetian glass for fashioning their lenses, and it is almost certain that Giuseppe also utilized this resource and used broken mirror pieces. Even when the glass was free of most of the inclusions, however, a persistent problem remaining was the presence of air bubbles. In order to eliminate them, Divini wrote that as did other lens makers, he experimented by remelting the glass into forms, made as shallow concave or convex containers. During the cooling process, however, the glass frequently broke, and Divini eventually abandoned the practice.[490]

In France, Huygens demonstrated considerable interest in Giuseppe's instruments, and although the two maintained a correspondence, unfortunately only a small part of it has been found. In his published *Lettera* of 1665 to Cassini, Campani mentioned having received a letter from Huygens in which the latter thanked him for having confirmed the observations of Saturn that Huygens had made in 1659.[491]

Huygens also commented on the *Ragguaglio* in a reply to Prince Leopold's communication in May, where he congratulated the prince on Italy's scientific achievements and the presence there of so many men of science who day by day

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[489] Luigi Zecchin, *Vetro e vetrai di Murano: studi sulla storia del vetro*, vol. 2 (Venezia: Arsenale, 1989), 105: "*Mi porto da Muran*, *e tasse e gote / Bosse unpolete*, *e varie d'ogni sorta*, */ E togo anca un barato i vetri roti*."

[490] Divini, *Lettera,* 29–39.

[491] Campani, *Lettera di Giuseppe Campani*, 11.

maintained a vigil of the skies. He mentioned that through Flavio Chigi, then canon at Liege, he had been informed by means of a letter "from the most famous Cassini" concerning the shadows of the Jovian satellites on the face of the planet and of the planet's revolution upon its own axis. This phenomenon had been brought to light, he wrote, in a published narrative by Giuseppe Campani concerning the new observations he had made of Saturn, which helped to confirm Huygens's hypothesis concerning Saturn's ring. As to Cassini's most recent observations of the shadows of the Jovian satellites, Huygens mentioned his own observations of the phenomenon that he made during the previous year in which the shadow of the third satellite predicted by Cassini had appeared. He noted, furthermore, that Campani also mentioned for the first time a new invention he claimed to have made, a lathe for grinding and polishing lenses. Huygens wrote:

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 proposed here for the first time a most beautiful invention of a lathe for fashioning lenses. However, at first view, it appears to me to be barely possible, thus it appears that others also doubt inasmuch as that which is most important, that the lenses that were shaped with this lathe are superior to those that are produced by the customary method, without any machine at all, nor yet for what I know is that controversy finished.[492]

As to Cassini's most recent observations of the shadows of the Jovian satellites, or Jupiter's satellites, Huygens mentioned his own observations that he had made during the previous year of the phenomenon in which the shadow of the third satellite predicted by Cassini had appeared.[493]

Of related interest are surviving fragments of a correspondence that took place between Auzout, the French instrument maker Pierre Petit, and Christiaan Huygens's brother Constantijn, who owned a Campani telescope. This instrument had been seen in 1664 in Cardinal Antonio Barberini's palace in Paris by Huygens's father, who became very enthusiastic about it and attempted in every way possible to acquire it. Pierre Petit (1594–1677), a French maker of telescopes working in Paris, informed Huygens that the latter's father had begged him to intercede with the *Abbé* Charles because he was convinced that Cardinal Barberini "[might be willing] to trade the telescope for an

[492] Huygens, *Taille des lentilles pour microscopes et lunettes à longue vue*, in Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 17, no. III, 287-304.

[493] Ibid., vol. 6, no. 1548, 54-55, letter from Huygens to Prince Leopold on June 22, 1666.

English microscope he was offering in exchange. It appeared, however, that the Cardinal was resolved to keep the telescope and that there was nothing that could be done to change his mind".[494]

Pierre Petit then described the Campani telescope in question, but wishing to promote his own work, he endeavored to minimize the Italian instrument's quality, stating that he too would be able to make lenses like Campani, if only he could obtain in Paris the optical glass that Campani used.[495] Evidently, Petit did not convince Huygens, who in 1664, after having constructed one of his mirror telescopes, had sent it to Auzout in Paris in order to have it compared with Campani's instrument. As previously noted, the judgment of the French astronomer, whose competence could not be questioned, left no doubt that Campani's instruments were of superior in quality even than those made by Huygens. Auzout, who also was himself a maker of lenses, could do no less than admit he had never seen lenses as clear and as well-polished as those made by Campani.[496] The matter aroused Huygens's curiosity, who then in 1666 went to Paris, it was said, to examine the telescope in person. His judgment, expressed in a letter to his brother Constantijn, is sufficiently important to quote: "The beauty of the Campani telescope [I have seen] at the home of the *Abbé* Charles lies in the fact that it is without colors of iris [achromatic astigmatism, color fringes] and that one does not perceive any spot in the ocular glasses; that the opening is sufficiently large without yet the problem of making objects appear at all curved and that it represents very distinctly an example of the fine quality of his lenses".[497]

After having examined the instrument with considerable attention, Huygens in another letter to his brother (July 22, 1666) went on to report on its technical aspects. The eyepiece was composed of three perfectly equal lenses of 1 inch and 10 lines of focus (4.79 cm), he noted, and the objective had a focus of 2 feet and 5 *pollice* (75 cm), and the total length of the instrument was 3 feet and 3 *pollice* (102 cm). The aperture, however, was 19 mm, the diameter was 17 mm, the distance from the eye to the first ocular was 39

[494] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 4, no. 1078, 266. 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].

[495] Ibid., 267.

[496] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, no. 1273, 145. Letter to Christiaan Huygens from Auzout (November 1664).

[497] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 6, no. 1546, 48.

mm, from the first to the second was 93 mm, and the distance from the second to the third was 100 mm. Taking note of all of its measurements, Huygens set to work to produce a similar instrument. He had difficulty in obtaining glass of sufficiently fine quality, however, and in developing an adequate form or mold for constructing the objective lens, as Huygens himself recounted.[498]

It was formed with the first lens a distance from the second that was double their communal focal distance, the second from the third of a distance slightly inferior to double the common focal distance. The system of the first two lenses was telescopic and had the function of re-erecting the image formed in the objective without altering its dimensions. The finer quality of telescopes, therefore, were those having the telescopic system in the ocular, the absence of chromatic aberration, with the aperture made discreetly ample, and the absence of spherical aberration. These qualities noted by Huygens had already been commented upon by Campani in 1664 in his *Ragguaglio* in which he had noted, prior to Huygens having done so, that augmenting the number of lenses of the ocular did not augment or increase the coloration of the image. In the *Ragguaglio*, Giuseppe stated that: "This last telescope is 55 palms in length, having 4 lenses, but with two contrivances which may be said to have been my invention. The first is, that with the mutation of two other objectives, that I had constructed one of 52 palms and the other of 50 palms, without varying the distance of the eye from the ocular lens, that had 5 *oncie* and 1 minute, remaining all three astronomical telescopes, taking away only the two lenses in the middle. . . . The other is, that in the circumference of the ocular lens there is no color, that appeared to be inseparable in the telescopes of four lenses".[499] Huygens, therefore, having personally examined the Campani telescope, reported an optimum impression to his brother for constructing a similar one. In a letter to de Sluse dated 11 Seprtember 1665,, Huygens wrote that he was going to congratulate Campani for the quality of his lenses, and that he was going to try to craft similar ones:

[498] Ibid., no. 1553, 68. *Pollice* is the Italian word for thumb, an old measurement equivalent to 1 inch; Nicodemo Jadanza, "Per la storia del cannocchiale," *Memorie del R. Academia delle Scienze di Torino* Serie 2, no. XLVI (1896): 253-270.

[499] Campani, *Ragguaglio di due nuoue osseruazioni*, 23-25.

"*Gratulabor Campano de prestantia perspicillorum suorum, et tentabo an similia perficere quem*".[500]

Giuseppe's little volume contained a drawing of the planet Saturn that he reproduced as it had appeared to him. The system was inverted because the image was obtained by a telescope having two biconvex lenses. His telescopes of 17 and 25 palms enabled him to see the planet encircled by a ring in elliptical form. Before publishing the final results of his observations, he had taken some precautions to make certain that he had seen it well and correctly and had not fallen into error. At this point, to confirm the accuracy of his own observations, he sought out well-known competent individuals and invited them to join him in observing, begging them to declare separately what they had seen. From a summary of the various observations, each drawn upon a sheet of paper, it was possible to establish the veracity of a certain observation. In this manner, Giuseppe obtained confirmation from individuals of indisputable competence and impartiality. This was a valid precaution.

Despite all these precautions, however, Campani wrote that he had not hastened to publish "his invention" of the system of Saturn any sooner for fear that some other could give it out as his own, as had already happened, he said, with other of his inventions. Furthermore, he noted, he was on the point of completing a large telescope of 55 palms, the perfection of which would have dispelled any doubt. In substance, Campani spoke incorrectly of "invention," inasmuch as what he had observed was none other than that which Huygens already had discovered some time ago.[501]

A somewhat dubious example of Campani's mechanical ability was presented by himself in his *Ragguaglio.* After he had made observations of Saturn and had observed and designed the various positions in which the planet's ring occurred, he elaborated a theory on the motion of the planet. To confirm that theory, he proceeded to devise a mechanical model consisting of a circle and of a iron string that he made of diameter and that he passed through the center to raise and lower it. Observing this little mechanism

[500] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, no. 1456, 477.
[501] Campani, *Ragguaglio di due nuoue osseruazioni*, 17-23.

that Campani called a "*macchinuccia*" from a distance with a telescope, it was possible to observe the appearance of Saturn and all its phases, which were verified years later.[502]

Campani presented his model to Prince Mattias de Medici as one of his own inventions. In actuality, a similar model had been produced 4 years earlier, in 1660, by Giovanni Alfonso Borelli, a member of the Accademia del Cimento. In reporting this, the nineteenth century Italian historian Caverni spoke bluntly of usurpation and that it was recognized as such in that period by the Academicians who had assisted Borelli with his invention.[503]

Borelli simulated a certain detached indifference, as Caverni suggested, possibly from fear of finding himself engaged in polemics with Cassini who doted on Campani. On Borelli's behalf, Michelangelo Ricci wrote to Prince Leopold, brother of Prince Mattias to whom Campani had dedicated his *Ragguaglio*, in the hope of inducing Campani to recognize the prior author of the model of Saturn. In other circumstances, Borelli let it go with a heavy appraisal in confrontation with Campani. In replying to Prince Leopold, who had sent him a sheet with the latest observations of Saturn made by Campani, Borelli declared himself ready to show an evident inexactness in one of the figures; however, he did not feel like bringing it directly to Campani's attention because to award "these persons, who hold adulation more dear than sincere advice, it is best to leave them alone."[504]

It is not known whether these words were said simply due to resentment because of the usurpation or possibly as the consequence of a feeling of envy for the major successes collected by Campani even with the Medici princes. The fact remains that the usurpation had been made and noted in the publication of the *Ragguaglio* by all. Why Campani had tried to claim for himself an invention that was not his is a puzzle, for he did not need additional acknowledgment. Perhaps he was unaware of what Borelli had discovered, or else he hoped to gain advantage with the prince by presenting him with a new invention even though it was not his own. It must be observed, however, that this

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[502] Ibid., 19–20.

[503] Giovanni Alfonso Borelli (1608–1679) was an Italian physicist and astronomer, founder of the iatrophysical school, credited with discovering the parabolic path of comets, and attempted to explain the motion of Jupiter's satellites by laws of attraction. [Middleton, *Experimenters*, 259–62, 304; Raffaello Caverni, *Storia del metodo sperimentale in Italia*, vol. 2 (Firenze: Civelli, 1892), 395.]

[504] Ibid., 492.

question of priority in invention was always a subject of discussion in the seventeenth century. Partly because of fear that an invention would be copied by others, one kept to oneself a strict reserve. As a consequence, it was not always clear who in fact was the first to conceive an idea. Inasmuch as Borelli had made his mechanism public in 1660, as Caverni reported, there was no question of priority.[505]

In 1664, Giuseppe Campani wrote to Huygens enclosing a drawing of Jupiter. "On the 30th day of July," he wrote, "in the second and half hour of the night, two rather obscure spots moved across the face of Jupiter which the famous astronomer Cassini immediately pointed out to this writer, and said these were shadows of satellites going under Jupiter; they then seemed to emerge from its lower margins.[506]

The nineteenth century Italian mathematician Nicodemo Jadanza also reported how Huygens had judged the various images of Jupiter and Saturn that had been produced by Campani in 1664 and greatly praised those designs "that give a precious proof of the excellence of Campani's telescopes, [drawn] with the exactness and the most marvelous method of this admirable observer." There could not have been greater praise from such a notable competitor.[507]

Huygens's praise for Campani's instruments was shared by Prince Leopold, who reassured Huygens in 1666 that his hypothesis on the Saturnian system had received strong confirmation from Campani's observations. When Campani's telescopes had been tested in Florence with other instruments, the Prince added, they always had proven to be the best. This letter is of importance because it also contained Prince Leopold's opinion concerning the lathe that Campani claimed to have invented. On this subject Leopold wrote, "But concerning his Lathe even here it is believed by many that it is no more than a most competent artifice permitted since others do not walk the same true road of fabricating lenses well." Apparently, Leopold believed that this was the general opinion. Jadanza concluded that the invention of the terrestrial telescope with an eyepiece combining three lenses such as Huygens described in Proposition LIV of his *Dioptrics* must be attributed to Campani. Jadanza found it surprising that Huygens did not admit

[505] Ibid.

[506] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, no. 1305, 195, Appendix II to no. 1303 (1890), letter from Guiseppe Campani to Huygens, July 7, 1664 (Nones), including drawing.

[507] Jadanza, "Per la storia del cannocchiale", 253-270.

the true paternity of the invention, commenting only that it was invented in Rome, noting "*Romae nescio a quo primum fuit inventa*".[508]

Jadanza then reported on a study of achromatic ocular lenses that had been made, which demonstrated that Campani's eyepiece satisfied the test for achromatism. It was clear that Campani had found the means if not of eliminating then of reducing chromatic aberration, even if he did so in an empirical manner. Jadanza held that great merit was due to Campani because his works furnished Huygens with a means of fathoming certain problems, and that it was Campani's telescopes that provided Huygens with the opportunity to contribute to optical science.[509]

The questions about Jupiter's "belts" and the comparison of lenses made by Divini and Campani also were of interest to the members of the Royal Society of London, and in September 1664, Henry Oldenburg reported to Robert Boyle the subject of discussions that had taken place in a meeting of the Royal Society held the previous day, noting"

> As to ye observations of Jupiters belts, another letter from Paris to me mentions, yt there having been a challenge for ye excelency of Optick Glasses betwixt Eustachio and Campani, those of ye latter were found better, yn those of ye former; and yt ye 1st of July st. n. 1664, there was discovered in Rome 4. belts in Jupiter moste obscure, and 2 in ye same, more clear than ye rest of his Discus. So yt in stead of 2. or 3. we have now 05. belts in Jupiter. I am also desired by yt Virtuoso, who imparted me these things, to inquire here, how our observers saw Jupiter yt day (vid. July 1, st., n) and how they saw ye Satellites on ye 25th of this month, st. n. But I can meet with none yt can satisfy this Quaere [query].[510]

Notable among Huygens's correspondents was the abovementioned René François Walter, Baron de Sluse. Unaware that Huygens already had been informed of these circumstances, he took this opportunity of bringing to his attention that Carlo Dati, in providing him with two copies of Campani's broadside, had requested that one copy be forwarded to Huygens. Nothing similar about Jupiter had yet been observed, he wrote, with even the finest telescopes of the Medici princes. He noted that Dati had worked with

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508 Ibid., 19 (1896).

509 Ibid., 19 (1896).

510 Henry Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 2 (Madison: University of Wisconsin Press, 1966), 239–41, letter from Oldenburg to Robert Boyle on September 29, 1664. Henry Oldenburg (circa 1615–1677) was born in Bremen. He served as official representative of Bremen to Cromwell's Commonwealth, and after the Restoration, he remained in England and was a founding member, and the first secretary, of the Royal Society. Oldenburg was a prolific correspondent with European men of science.

the mathematician and hydraulic engineer Famiano Michelini on a treatise for publication "On the Direction of Rivers," as well as on a first volume of the experiments of the Accademia del Cimento.[511] Some months later, Sluse again addressed Huygens, "this time with Campani's answer, which I, as a third party, received from his friend, the very famous mathematician Famiano Michelini." He enclosed another print of Campani's broadside illustrating his observations of Jupiter and Saturn.[512]

Although during the years 1662 and 1663 Campani occasionally presented examples of his telescopes to friends, it was not until the autumn of 1664 that he began to market his telescopes commercially; prior to that time, only three instruments are known to have left his hands. It was at this point that Giuseppe fulfilled the first commissions for telescopes that he received from Grand Duke Ferdinand II and Prince Leopold, for which he was generously compensated.

The *Ragguaglio* succeeded beyond all of Matteo's and Giuseppe's expectations in making Giuseppe's name familiar in scientific circles by means of published reviews of the work. The very first issue of the *Journal des Sçavans*, which appeared in 1665, contained a summary of the *Ragguaglio*'s content.[513]

One correspondent in France had offered to provide Oldenburg with news of scientific activities in France and Italy, as he informed Boyle, wishing nothing in return except news concerning any books that were being published in England. "He hath already promised to send me ye observations, w[hi]ch one of ye very best Philosophers of Paris hath made upon ye new book of Optick Glasses, yt are so much cried up, as far excelling those of Divini." The new correspondent probably was Auzout, and the book in question was Giuseppe Campani's *Ragguaglio*. Auzout's critical discussion of it in his

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511 Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, 117–18 (1890), letter from Sluse to Huygens on October 2, 1664, with enclosure. Famiano Michelini (circa 1593–1666) taught physics and mathematics to Prince Leopold and later lectured on mathematics at the university of Pisa. His work with Sluse was entitled *Trattato delle direzioni de' fiumi* (Florence, 1664). Rene Francois de Sluse (1622–1685), after studying at the University of Louvain, received a degree in law from the University of Rome in 1643. In 1650, he became a canon of the Roman Catholic church and, in 1659, served on the privy council of the Bishop of Liege. In 1666, he became abbot of Amay. Author of numerous books on mathematics, Sluse was elected a foreign member of the Royal Society and corresponded widely with men of science.

512 Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, no. 1303, 117–18, letter from Sluse to Huygens on January 2, 1665.

513 *Journal des sçavans: 1665/1666* (Amsterdam: Chez Pierre le Grand, 1685), 3–5.

Lettre a M. P. Abbé was written on October 13, 1664, although not published until the summer of 1665.[514]

Two months later, even wider attention was brought to Giuseppe's little book in the lead scientific article to appear in the first issue of the *Philosophical Transactions of the Royal Society*, of which Henry Oldenburg was the editor. The newly founded Royal Society of London had been eagerly seeking information in its efforts to keep abreast of scientific activities wherever they occurred in Europe and to report them in its new journal. As the very first issue of the *Transactions* reported:

> There came lately from Paris a Relation, concerning the Improvement of Optick Glasses, not long since attempted at Rome by Signor Giuseppe Campani, and by him discoursed of, In a Book, Entitled *Ragguaglio di nuove Osservazione*, lately printed in the said City, but not yet transmitted into these parts; wherein these following particulars, according to the same Intelligence, which was sent hither, are contained.
>
> The *First* regardeth the excellency of the long *Telescopes*, made by the same *Campani*, who pretends to have found a way to work great *Optick Glasses* with a Turne-tool, without any Mold. And whereas hitherto it hath been found by Experience, that *small* Glasses are in proportion better, to see with, upon the Earth, than the *great* ones, that Author affirms that his are equally good for the Earth, and for making Observations in the Heavens. Besides, he useth three Eye-Glasses for his great *Telescopes*, without finding any *Iris*, or such Rain-bow colors as do usually appear in ordinary Glasses, and prove an impediment to Observations.
>
> The *Second*, concerning the *Circle of Saturn*, in which he [Campani] hath observed nothing, but what confirms Monsieur *Christiaan Huygens de Zulichem* his Systeme, of that Planet, published by that worthy Gentleman in the year, 1659.
>
> The *Third*, respecting *Jupiter*, wherein *Campani* affirms he hath observed by the goodness of his Glasses, certain *protuberancies* and *inequalities*, much greater than those that have been seen therein hitherto. He addeth, that he is now observing, whether those sallies in the said *Planet* do not change their situation, which if they should be found to do, he judgeth, that *Jupiter* might then be said to turn upon his *Axe*, which, in his opinion, would serve much to confirm the opinion of Copernicus. Besides this, he affirms, he hath remarked in the *Belts of Jupiter*, the Shaddows of his *Satellites*, and followed them, and at length seen them emerge out of the Disk.[515]

Featured in the second issue of the *Philosophical Transactions* was an account of Campani's observations of Saturn's ring, in which he claimed having been able to distinguish the shadow cast upon the planet by its ring. As the account noted, Campani's telescopes had considerable power.[516]

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[514] *Mémoires de l'Académie Royale des Sciences depuis 1666 jusqu'à 1699*, vol. IX, n.d., 5–65; Oldenburg, *The Correspondence of Henry Oldenburg*, 1966, 2:291–93.

[515] "Giving Some Accompt of the Present Undertakings, Studies, and Labours of the Ingenious in Many Considerable Parts of the World", Hutton, Shaw, and Pearson, *Philosophical Transactions of the Royal Society of London, Vol. 1, 1665-1672*, I, from 1665 to 1672:2–3 (Monday, March 5, 1665).

[516] "An Account of the Improvement of Optick Glasses," *Philosophical Transactions of the Royal*

The next issue of the *Philosophical Transactions*, published June 5th of the same year, featured "A Further Account, touching Signor Campani's *Book and Performances about Optick glasses*," by Adrien Auzout. The French astronomer voiced his opinion about that which he considered to be new in the *Ragguaglio* "concerning both the effect of the telescopes after a peculiar way by the said *Campani* at *Rome*, and his new Observations of *Saturn* and *Jupiter*, made by means thereof." After Auzout had raised some "scruples" concerning Campani's method of grinding and polishing lenses on a lathe without molds, he reviewed the observations that Campani had made with those lenses. At first commending "*Campani*'s sincerity in relating what he thought to have seen in *Saturn*, without accommodating it to M. *Hugens Hypothesis*," Auzout then went on to affirm that if one assumed that there was a ring around Saturn, *Campani* could not have seen the same appearance on the several different times that he claimed to have actually observed. "For, having seen it sometimes in *Trine Aspect* with the *Sun*, and *Oriental*," Auzout reasoned, "sometimes in the same *Aspect*, but *Occidental*, sometimes in *Sextil Aspect*, and *Occidental*, at another time, again in *Trine*, and *Oriental*, this Author cannot conceive, how *Saturn* could in all these different times have no difference in its *Phasis*, or keep always the Same *Shadow*: seeing that, according to the *Hypothesis* of the *Ring*, when it is *Oriental*, it must cast the *Shadow* upon the *left* side of the *Ring* beneath, without casting any on the *right* side: and when it was *Occidental*, it could not but cast it on the *right* side beneath, and nothing of it on the other."

"Concerning the upper *Shadow*, which *Campani* had indicated had been made by the *Ring* around Saturn's body," Auzout judged, "there could be no such Phenomenon, by reason of its *Northern Latitude* at the times, wherein the *Observations* were made, *vid*, in *April 1663*; in the midst of *August*, and the beginning of *October*, next following, and in *April 1664*, except it were in *October*, and the *Shadow* strong enough to become visible." He agreed with Campani concerning the shadow below, however, that it did in fact appear but not as had been noted, since he believed it must be on the one side sometimes and sometimes on the other. Following Auzout's comments and observations concerning Cassini and Campani, he went on to state that he "doth find no reason to doubt any more

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Society of London 1, no. 1 (March 6, 1665); Arthur Ernest Bell, *Christiaan Huygens and the Development of Science in the Seventeenth Century* (London: E. Arnold, 1947), 56.

of the excellency of the Glass used by them, above his, except this difference may be imputed to that of the *Air*, or of the *Eye*. But yet he is rather inclined to ascribe it to the goodness of their Glasses, because he would not be thought to have the vanity of magnifying his own. . . .”.[517]

Auzout’s “Account” was followed in the same issue of the *Transactions* by another article entitled “Signor Campani’s Answer: and Monsieur Auzout’s Animadiversions thereon,” which began

The other part of this *French Tract*, conteining *Campani*’s Answer, and Mr. *Auzout* his *Reflections* thereon, begins with the pretended *Shadows* of the *Ring* upon *Saturn*, and of *Saturn* upon the *Ring*. Concerning which, the said *Campani* declareth, that he never believed them to be *Shadows*, made by the *Ring* upon the *Disk* of *Saturn*, or by the body of *Saturn* upon the *Ring*, but the *Rimms* of these bodies, which being *unequally* Luminous, did shew these appearances. In which Explication, forasmuch as it represents, that the said *Campani* meant to note only the *Inequality of the Light*, which, he *saith*, his Glasses did discover. Mr. *Auzout* doth so far acquiesce, that he only wishes, that his own Glasses would shew him those differences. Next to the Objection, made by Monsieur *Auzout*, against Signor *Campani*, touching the Proportion of the Length of the *Ring* to its breadth, *Campani* replyeth that the Glasses of Monsieur *Auzout*, show not all the particulars, that his do, and therefore are unfit for determining the true Figure and breadth of the apparent *Ellipsis.* To which Mr. *Auzout* rejoyns, that he is displeased at his being destitute of better Glasses, but that it will be very hard for the future to convince *Campani* touching the *Proportion* of the *Ring*, being that the breadth of the *Ellipsis* is always diminishing although if the declination of the *Ring* remains the same, one can at all times know, which may have been its greatest breadth. But he assures, that the breadth of the *Ring* is not the half of its length, and that it doth not spread out so much beyond *Saturn*’s Body as he hath alleged. And withal desires to know, what can be answered by Sig. *Campani* to Mr. *Hugens*, who being persuaded, that the Declination of the *Ring* is not above 23 degr. 30’ having seen the Ring to spread out above the Body of *Saturn*, concludes, in a letter to Mr. *Auzout*, that the length of the *Ring* is more than treble the *Diameter* of *Saturn*’s body, which, according to *Campani*, is only about 67 to 31. What difference yet does not appear to M. *Auzout* to be so great; but that M. *Hugens* perhaps will impute it to the Optical reason, which he (*Auzout*) hath alleged of the Advance of the light upon the obscure space, although he is of Opinion, he should not have concluded so great a Length if he had not seen the Breadth spread out more, than he hath done: for (saith he) if the Length of the Ring be to the body of Saturn, as 2-1/2 to I. and the *Inclination* be 23 degr. 30’ the *Ring* will be just as large, as the body, without spreading out, but if the *Ring* be bigger, it will a little spread out; and if it were treble, it must needs spread out the half of its breadth, which hath not so appeared to him.

Further, to M. *Auzout*’s change of Opinion, and believing, that the *Advance* or *Sally*, seen by him in *Jupiter*, was the *shadow* of one of his Moons, *Campani* declares, that he would not have him guilty of that change: Whereupon M. *Auzout* wonders, why *Campani* then hath not marked it in his *Figure*; and would gladly know, whether that *Sally* be more easie to discover, than the *Shadows* of the *Satellites*, which *Campani* believes *Auzout* hath not seen; and whether he be assured, that those obscure parts, which he there distinguishes, do not change: for if they should not change, then *Jupiter* would not turn about his *Axis*, which yt, he saith, it doth,

[517] ‘A Further Account, Touching Signor Campani’s Book and Performances about Optick-Glasses’, *Philosophical Transactions of the Royal Society of London* 1, no. 4 (and 1666 1665): 69–73.

according to the *Observations* made by Mr. *Hook*, *May 6, 1664*. inserted in the first papers of these *Transactions*. The full Discovery of which particular also he makes to be a part of *Cassini*'s and *Campani*'s work, seeing that they so distinctly see the inequalities in the *Belts*, and as seen also sometimes other *Spots* besides the *Shadows* of the *Satellites*; where he exhorts all the Curious, that have the conveniency of observing, to endeavor the discovery of a matter of that importance, which would prove one of the greatest *Analogies* for the *Earth's Motion*.[518]

A discussion of Campani's lenses in "An Account of the Tryalls, Made in Italy of Campani's New Optick Glasses" appeared in the 8th issue of the *Philosophical Transactions* and purported to have been reported to correspondents in London by an "Inquisitive Parisian":

We received lately news from *Rome*, from a very Curious Person of our acquaintance, importing that *Campani* hath had the advantage of *Divini*. The Great Duke of *Toskany*, and Prince *Leopold*, his Brother, upon Tryal, made of both their Glasses, have found those of *Campani* excel the other, and with them they have been able, easily to distinguish people at 4 Leagues distance: Of which I intend you more particulars hereafter.

Among them are expected the *Length* of these *Telescopes*, and the Largeness of the *Aperture* of their *Object-glasses*. In the mean-time, the *Parabolical-glasses*, formerly mentioned to be in hand here at *London*, are finishing with all possible care and industry.[519]

In the meantime, Huygens had responded to Matteo's communication, but that letter has been lost. Early in December 1664, Matteo again wrote to Huygens, noting he had received his "exceedingly refined letter" several days ago from the hands of Michelangelo Ricci, with whom he joined in congratulating Huygens upon his most ingenious hypothesis concerning Saturn that had become manifest as a consequent of Matteo's brother Giuseppe's telescope. Addressing the Dutch savant as "The Most Renowned and Learned Master," although in fact Huygens was 9 years his junior, Matteo went on:

You ask of me now about the so well-known ring which the very famous Father Fabri has seen. I answer naturally, that he has long denied writing the truth of our phenomenon: nay, rather from the same place I find a writing, that this phase is reputed as false and as a trick of the eyes, of a lens badly rounded; and therefore that your hypothesis likewise falls apart; the argument taken from the difference of latitude between the ellipses of Saturn and the phases delineated by you and by us. He then, after having been proven wrong by the authority of several witnesses and great men and princes, clearly considered the newness of our phase, sang the same song; and this was he who before had constantly denied your system of Saturn and the most certain observance of my brother; recently (for so I hear), even now that the ring is obvious by means

[518] 'Signor Campani's Answer: And Monsieur Auzout's Animadversions Thereon', *Philosophical Transactions of the Royal Society of London* 1, no. 4 (and 1666 1665): 74–75. (June 5, 1665).

[519] "An Account of the Tryalls, Made in Italy of Campani's New Optick Glasses," *Philospohical Transactions* 1, no. 8 (1666 1665): 131–32 (January 8, 1665).

of our telescope, he did not cease declaring it publicly, and also through the same instruments of his friend [Divini] that, at the moment, look slightly less powerful [then our telescopes], had even established for certain that between these limits (of the ring) around Saturn an offshoot quite rich in little spheres, or of satellites was to be seen. But I do not know by what secret of the art of dioptrics such telescopes are made, which draw the eyes and hearts of friends looking through them into such different things; a marvelous invention, indeed!

You again demand my word of honor concerning the lathe, happily invented by my brother, for forming very exact lenses without using spherically concave forms. I guarantee it not once, but a thousand times, if it were necessary, God forbid, indeed, if I should hold you with many empty fiction, and hold others deceived as well.

One thing I warn, most learned Sir: that since my brother's [telescope] tube does not exceed 25 palms, or 16 of your feet, that not only is the ring of Saturn clearly and distinctly apparent, but also that of the Medicean clouds moving across the face of Jupiter were not only annotated by the most renowned Master Cassini, but he will bring it to light with some of his other very accurate observations.

I am sending another "leaf" to you containing the new observations of Saturn and Jupiter; because in the other copy, which I received from the eminent Slusio, the errors made by some one who attempted to conceal them had crept in, which the author took pains to correct with his own hand according to the form of the phases delineated by him at the time of the observation.[520]

Matteo concluded his letter by forwarding the good wishes of Cassini and Bartoli as well as from his brother. The "leaf" with new observations he sent to Huygens was the broadside produced for Giuseppe Campani and accompanied his published "Letter" to Cassini concerning "the shadows of the Medicean stars in the face of Jupiter and other new celestial phenomena discovered with his telescopes, directed to Sig. Giovanni Domenico Cassini, first astronomer of the famous observatory of Bologna".[521]

Within the next several weeks, Huygens informed Baron de Sluse that Matteo Campani had shown him another view [*voie*], presumably referring to the revised broadside. He also mentioned to Auzout that Giuseppe Campani had written to him and provided him with an observation corrected as to the diameter of the planets about which Auzout differed not only from him but also from Riccioli, Hevelius, and others, and that Campani's method was the same with which Huygens measured the diameter of Mars.[522] Huygens also wrote to Gregoire de St. Vincent, the Jesuit astronomer, acknowledging his

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[520] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, no. 1304, 193–94, letter from Matteo Campani to Huygens on December 2, 1664 (the letter from Huygens has not been found but possibly may be letter no. 1248).

[521] Campani, *Lettera di Giuseppe Campani*; see also the table reproduced with the letter by Matteo Campani to Christiaan Huygens: Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 5, no. 1304, 193–94,

[522] Ibid., n. 1308, 196: letter to Sluse on January 5, 1665; no. 1310, p. 198:,letter from Huygens to Auzout on January 15, 1665..

letters and enclosing a drawing of the planet Jupiter. Huygens informed him that Fabri had confessed his mistake, as confirmed in a letter he had received that day from Matteo Campani.[523]

Giuseppe's confirmation of Huygens's Saturnian hypothesis brought congratulations to Huygens from others. In a letter to Huygens, J. Chapelain mentioned in passing that he took great pleasure in the fact that, as a result of Campani's observations, Father Fabri was reduced to confessing his debt to Huygens concerning the Saturnian system. "That effectively closes the mouth to Envy", he commented, "and Huygens had met well against the oppositions. He was unable," he went on, "to speak of the experiences of Campani as I do not yet know of what they consist".[524]

It was not until later in February that Huygens acknowledged Matteo's letter, thanking him for his observations, and made mention in passing of a lathe for grinding lenses as reported by Robert Hooke in his *Micrographia*.[525]

It was at this time that Huygens noted to Auzout, "Your consideration on the little work that Campani produced [the *Ragguaglio*] gives one to think [...] Fabri endorses now my hypothesis of the ring &c., something that Campani whose brother makes the fine lenses also later confirmed to me".[526]

A report in the *Journal des Sçavans* of February 22, 1666, described a letter written from Rome concerning new discoveries Cassini had made on Jupiter. "Monsieur Cassini", it stated, "after having discovered by means of excellent lenses of 50 palms, or of 55 feet, made by the Sieur Campani, the shadows that the four moons or satellites of Jupiter cast on its disk, when they meet between it and the sun, after one has distinguished their bodies upon the disk of Jupiter: they gave the past year predictions for the months of August and of September, and marked the days and the hours that the bodies of the moons and their shadows will appear to us on Jupiter, so that the curious are able to be convinced of this fact by their own observations".[527]

[523] Ibid., no. 130, 195, letter from Huygens to Gregorius a St. Vincentio on January 5, 1665.
[524] Ibid., 231–233, letter from Chapelain to Huygens on February 13, 1665.
[525] Ibid., no. 1332, 240–41, letter from Huygens to Matteo Campani on February 24, 1665.
[526] Ibid., no. 1352, 266–67, letter from Huygens to Auzout on March 12, 1665.
[527] 'Extrait d'une Lettre écrite de Rome (February 22, 1666)', *Journal des sçavans: 1665/1666* 18 (1685): 294–98.

Early in 1666, Oldenburg informed Boyle that he had received news of Tito Livio Burattini, Grand Master of the Mint of Poland, who was "rich, curious, and a good Mechanician," and about a French gentleman, M. dela Son, "who promises to be in Paris soon and to fashion glasses there." Burattini had affirmed to Oldenburg that he had developed a method "to polish his Optick Glasses perfectly in his Forms, without ye interposition of any Linnen, or Woolen cloath, or paper, etc. and to give them an admirable polish. The other, M. dela Son, affirmed to have found a Turne [lathe], whereby he can give what figure he pleases to Glasses; and seems to excell Campani at Rome".[528]

At Cambridge, Isaac Newton also had experimented with the production of lenses for use in his optical experiments. In about 1666, he proposed a device for figuring hyperbolic lenses, of which only a sketch of this apparatus has survived, and nothing more is known about it. Newton noted, "Y^e glass *a* may be ground Hyperbolical by y^e line *cb* if it turns on y^e Mandrill *e* whilst *cb* turns on y^e axis *rd* being inclined to it as was shown before".[529]

Three years later, in 1669, Sir Christopher Wren proposed to the Royal Society the construction of a working model of a lathe for polishing hyperbolic lenses, and the Society assigned Hooke to the project. He reported, however, that it did not appear to be possible to produce a working model of the machine and, furthermore, that he had already invented an apparatus for the same purpose. When subsequently he presented his own completed machine, it was justly criticized by a number of the members.[530]

Although the defect of spherical aberration was not critical for lenses of long focus such as were used in the seventeenth century in larger telescopes, because the difference between a spherical and parabolic surface was very small, nonetheless several attempts to figure aspherical surfaces were made. In 1637, René Descartes had proposed

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[528] Henry Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 3 (Madison: University of Wisconsin Press, 1966), 45–48, letter from Oldenburg to Boyle on February 24, 1665.

[529] Isaac Newton, *Opticks, or, A Treatise of the Reflections, Refractions, Inflections, and Colours of Light* (London: Printed for W. and J. Innys, 1718), 83.

[530] R.T. Gunther, *Early Science at Oxford*, vol. 6 (Oxford: Oxford University Press, 1930), 352.

several methods for making parabolic or hyperbolic lenses, but none of these proved to be practical.[531]

In a letter to Huygens on September 6, 1669, Oldenburg reported on a second lens made by Cock that turned out to be only a 50-foot glass; it had a 6-inch diameter and allowed a 3-inch aperture, but was deemed to be sufficiently good enough to send to Hevelius, They tested it by making observations of the moon and found it satisfactory. Later, in observations on Saturn made on August 2, it showed the planet in the shape that Huygens had designated in the second of his *Systema Saturnium*. Oldenburg wrote that he assumed that Huygens had seen and had tried some telescope made by Campani, and the Society wished to learn the results.[532]

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[531] Descartes, *Discours de la méthode pour bien conduire sa raison*, 19–21.

[532] Henry Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 6, 13 vols. (Madison: University of Wisconsin Press, 1966), 202-24, letter 1280: letter from Oldenburg to Huygens on September 6, 1669.

Chapter X

DUELING TELESCOPES

(1664–1666)

> *We received lately news from Rome, from a very Curious Person of our acquaintance, importing that Campani hath had the advantage of Divini. The Great Duke of Toskany, and Prince Leopold, his Brother, upon Tryal, made of both their Glasses, have found those of Campani excel other, and with them they have been able, easily to distinguish people at 4 Leagues distance ...*
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> "An Account of the Tryalls, Made in Italy of Campani's New Optick Glasses", *Philosophical Transactions*, v. 1, no. 8, pp. 131–132 (January 8, 1665).

By the end of the summer of 1664, the results of the repeated trials made of the telescopes of Divini and Campani that had been held in Rome proved to be inconclusive, much to the disappointment of Grand Duke Ferdinand II and Prince Leopold. Despite repeated attempts, the comparisons had failed to resolve the important question for potential purchasers of which were the superior instruments, those made by Divini or by Campani. They were unable to rely on their agents in Rome for a comparison of their telescopes, nor was an estimate from Michelangelo Ricci any more conclusive. The 18th of August 1664, Ricci responded that he was not aware whether a comparison had yet been made that could form a clear judgment because Divini claimed his instrument had "the disadvantage of the less clear air or the small distance. And because of these objections," Ricci went on, "Divini continues to maintain that his does not yield to the other. . . . These two artisans and *virtuosi* are in such strong competition that others cannot open their mouths in approval of one without the other being offended. So, everyone refrains from speaking his mind".[533]

The Grand Duke realized that it would be quite out of the question to attempt to transport the contending instrument makers to Florence for further trials. Finally, he concluded that an impartial solution could be achieved only by arranging new trials to be

[533] Bonelli and Van Helden, "Divini and Campani," 87.

held in Rome but under the strict supervision of members of the respected Accademia del Cimento, who were adequately experienced in resolving questions relating to scientific observation. Accordingly, arrangements were made to schedule another competition to be held in Rome, carefully planned and managed from Florence by members of the Accademia.

The purpose was to be two-fold: to establish the relative merits of telescopes made in Florence by Evangelista Torricelli and by Vincenzo Viviani, which had never been resolved, as well as of those produced in Rome by Divini and by Campani. For the past decade and more, the superiority of Divini's instruments had remained relatively unchallenged in that they had dominated the market not only in Italy, but they were sought from elsewhere in Europe as well. The Medici princes also had somewhat of a vested interest, for undoubtedly they were aware that Divini almost certainly had learned lenscrafting at their court in Florence with Torricelli. Until now, the Divini telescopes had been preferred by the Medici brothers, although their inventories revealed that they also owned and used telescopes by several other Italian makers, including Ippolito Francini, Gian Battista Magnelli, Francesco Fontana, and Paolo Belletti as well as by foreign makers, notably Johann Wiesel of Augsburg and John Marshall of London.[534]

Recently, however, after having repeatedly received accounts of the apparent success of Campani's telescopes, Grand Duke Ferdinand II and his brother Prince Leopold had become eager to determine whether the quality of the telescopes made by the relatively unknown young newcomer Campani was in fact superior to that of those made by Divini. Both the Grand Duke and Prince Leopold had read a copy of the *Ragguaglio* with considerable attention and interest, and furthermore, they had been impressed when informed that, in July, while using a Campani telescope, Cassini had observed the passage of Jupiter's satellites across the planet's disk. Consequently, they had become anxious to determine whether Campani's telescopes were as had been reported.

Through Monsignor Paolo Falconieri, their agent in Rome, the Medici princes had commissioned telescopes to be made by Campani, which they planned to test. Two weeks

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[534] Albert Van Helden, *Catalogue of Early Telescopes* (Firenze: Instituto e museo di storia della scienza, 1999), 6–67, 68–71.

passed, however, before Falconieri was able to inform Prince Leopold whether Giuseppe had completed making the telescopes they had ordered. Finally, they were ready, Falconieri reported, and he added that Giuseppe said he was shipping them by means of the Torino courier. Falconieri also mentioned that Cardinal Borromeo was partial to instruments made by Divini and referred to the trial that had been made to compare the lenses.[535]

Monsignor Paolo Falconieri, who was to serve as the contact between the court at Florence and the contestants in Rome, was a man of considerable distinction. He and his brother Ottavio had been born of a distinguished Florentine family residing in Rome. Paolo had pursued an ecclesiastical career that was to take him to Brussels as papal internuncio in 1673. He was a distinguished poet and a member of the Accademia della Crusca. He also was learned in antique languages and maintained an interest in the natural sciences.[536]

As a correspondent of the Accademia del Cimento, although not a member, Monsignor Ottavio Falconieri attended some of the meetings and participated as well in some of the experiments. In the absence of Lorenzo Magalotti, the Accademia's secretary, it was Falconieri who had made the final revisions of the galley proofs of its published record, the *Saggi di Naturali Esperienze*. Among his friends and correspondents, he numbered Cassini as well as many other learned men of his time. The Medici princes especially relied upon his acknowledged expertise on antiquities and fine arts.[537]

In early December, Ottavio Falconieri wrote to Magalotti concerning a variety of items and enclosed two letters from Auzout to the Abbé Charles that had been sent by the

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[535] ASF, *Carteggio di Artisti*, filza X c. 35 (127), Letter from Paolo Falconieri to the Grand Duke, August 30, 1664, Carteggio; c. 36, letter from Paolo Falconieri to Prince Leopold on September 20, 1664; BNCF, Gal. vol. 283, cc. 162–163, letter from Giuseppe Campani to Prince Leopold on September 6, 1664; Mario Bencivenni, "Falconieri, Paolo", *Dizionario Biografico Degli Italiani* (Roma: Istituto dell'Enciclopedia Italiana Giovanni Treccani, 1994).

[536] Maria Luisa Bonelli, "Unpublished Letters on Campani's and Divini's Telescopes," in *Proceedings of the Tenth International Congress of History of Science (Ithaca)*, vol. 2 (International Congress of History of Science, Paris: Hermann, 1964), 699–700; Daumas, *Les instruments scientifiques*, 50–51.

[537] Bonelli and Van Helden, "Divini and Campani," 87, footnote 1; Maria Luisa Bonelli, "Delle prime lavorazioni dei cannocchiali in Italia e della loro fortuna," *Giornale di Astronomia*, 1977, 153–61; Accademia del Cimento, *Saggi di naturali esperienze fatte nell' Accademia del Cimento ... descritte dal segretario di essa Accademia* (Firenze: Per Giuseppe Cocchini, 1667), 12–15; Middleton, *Experimenters*, 99–101.

latter to Giuseppe. He also enclosed an extract of a letter from "an English astronomer" brought to him by a friend. The letter appears to have been written by Henry Oldenburg to a correspondent in France, and consisting largely of an extract from a letter Huygens had written to Sir Robert Moray, dated October 10, 1664 that praised Cassini's new observations made with a Campani's telescope: "I do not know if you have heard mention of that beautiful observation of Jupiter that they have been able to make in Rome," the unidentified writer stated, "across whose disk they have seen pass the shadows of two of his satellites that were passing between him and our eyes, and [which shadows] a little later disengaged themselves from the disk. M. Huygens says that he had never thought that such an observation could be made in view of the smallness of his companions, and that surely their glasses would be of an extraordinary perfection".[538]

Giuseppe Campani, meanwhile, already was well-acquainted with Ottavio Falconieri, having dealt with him in his capacity as agent/correspondent of the Medici court in residence in Rome. It had been through Falconieri that commissions for his clocks from Grand Duke Ferdinand II and Prince Leopold had been negotiated.[539]

After deliberating over the existing inconclusive state of telescope superiority, the Grand Duke and Prince Leopold finally determined to proceed with their plan to schedule a series of new trials to be held in Rome under the direction of the Accademia del Cimento. Responding to granducal urging, the Accademia's members set themselves the task of formulating a set of rules and requirements for the trial. The Academicians were experienced with conditions for making observations and of variation in human vision, and they had proven they were capable of impartiality. Several years earlier, the Accademia already had managed to resolve problems successfully among other men of

[538] Bonelli and Van Helden, "Divini and Campani," 94–101, letter from Ottavio Falconieri to Magalotti, December 9, 1664, with extract of letter from Oldenburg to an unknown correspondent; also see Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 4, 119–20, letter from Huygens to Robert Moray on October 10, 1664; Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 2, 262–64, letter from Oldenburg to Robert Boyle with copy on October 20, 1664.

[539] It was at just about this same time that Ottavio, Paolo Falconieri's brother, was able to forward a telescope made by Campani from Rome to Florence by means of the *ordinario* from Lyons. He noted that, before shipping it, he had taken the liberty to take the instrument out of doors and tested it himself. He made his final observations during the two previous nights with several other of Campani's telescopes that the Grand Duke had ordered. Falconieri also enclosed a new publication describing the appearance of Saturn and of Jupiter, in the first part of which, according to what Giuseppe told him, were included various errors that inadvertently had been made by the engraver. Falconieri, "Letter from Paolo Falconieri to Prince Leopold", vol. X, f. 128.

science; this related to the competing hypotheses of Huygens and Honoré Fabri concerning the appearance of Saturn. A resolution had been reached by making use of models, which were observed through telescopes. It was extremely doubtful, however, that this expedient would be useful in the present situation.[540]

It became apparent immediately that any attempts to manage such a competition among *virtuosi* in far-off Rome from Florence would be fraught with problems. Despite the acknowledged competence of the Accademia's members in formulating the requirements, the problem would be in assuring fair results that would be acceptable to both combatant participants.

The method that generally was applied at that time for testing focal lengths of telescopes was to use the instruments to observe printed placards mounted upon a rigid board with a selection of letters randomly arranged on the cards. These test cards generally contained 10 successive lines printed with letters of decreasing size. The card was placed at a specified distance from which the competitors were stationed to observe it with their instruments.

The method used by Campani to measure the focal length of a lens is not known with certainty, but it appears that he used the direct method, namely, of observing at what distance from the lens parallel rays were formed. This was the method typically used in the seventeenth century, for example, by the optical maker Hartsoeker who worked the two superficies of the lenses until making the sun's rays converge together at a predetermined point. The distance of the lens was equal to the focus desired.[541]

In designing a placard or sheet suitable for the test, the Academicians in Florence had selected 10 lines of text taken at random from various poems, which then were printed in decreasing size, the letters ranging from 12.8 mm to 1.1 mm on successive lines. Belatedly, it was realized that several problems might be inherent even in such a random selection. If the observer was a person of learning, or at least was well-informed in literary works, it was probable that he might recognize entire segments. Furthermore, if

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540 Albert Van Helden, "The Accademia del Cimento and Saturn's Ring", *Physis* 15, no. 3 (1975): 244–48.

541 Bonelli, "Unpublished Letters on Campani's and Divini's Telescopes"; Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 15, 227, 274–75, plate; Middleton, *Experimenters*; Bonelli and Van Helden, "Divini and Campani," 32–34.

an observer tested several instruments by using the same sheet, it was likely that he would recall some of the words or phrases.[542]

It was agreed, therefore, that the solution was to arrange the letters on the placard in meaningless groups. Although these precautionary measures resolved the more obvious problems, it was soon was realized that an observer might recognize certain letters merely by their shapes and sizes; consequently, words having ascenders and descenders had to be eliminated. Finally, a close examination of the surface of the placards or test sheets revealed that in the course of the printing process faint grooves had been impressed upon the paper by the typefaces, resulting in recognizable shadows that affected the outlines of the letters, and these too had to be avoided.[543]

During the competition, two lanterns were required to illuminate the placard or test sheet, placed one on either side and arranged so that as their light fell upon the writing, in order that it was made fully visible while at the same time not reflecting into the eyes of the observers. The trial was based upon being able to read the lines of the smallest type that could be successfully read with each of the telescopes, which ranged in length from 2 to 10 *bracci*.

Lorenzo Magalotti, secretary of the Accademia, was assigned the task of preparing and providing a sufficient number of copies of the proposed placard and an account summarizing the results of the tests that already had been made with it in Florence. He was a natural choice, as an extremely handsome courtier, a good dancer, and fine horseman. Born in Rome, after studies at a Jesuit seminary until the age of 18, in 1656, he went to Pisa to study law. More interested in science, however, he soon left to study in Florence with Viviani for 3 years, becoming his friend.

Magalotti had delayed until late September or early October 1664 before forwarding to his friend Paolo Falconieri in Rome the results of the tests that had been made at Florence. He included several copies of the test sheet and enclosed with them an

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[542] Ibid., 66–71.

[543] 'Minute di lettere, risposte, et altre scritture intorno al paragonedegli occhiali del Divini, e del Campani con quelli del S.A.S. (Drafts [or copies] of letters, replies, and other writings about the comparison of the telescopes of Divini and of Campani, with those of His Most Serene Highness)' (1664), Carte Magalottiane, Formerly in Archivio Venturi-Conti. First item of summary (*minute*) of a letter, reply, and other writings about the competition of the telescopes of Divini and Campani with those of the Grand Duke. [*Codice Cartaceo* sec. XVII and Bonelli and Van Helden, "Divini and Campani", title page of Section II.]

undated letter of the Grand Duke's specific instructions for similar comparative tests to be performed in Rome with the telescopes of Divini and Campani.[544]

"His Serene Highness the Grand Duke," Magalotti advised, "wishes to ascertain the degree of perfection to which some of his [Campani's] telescopes have attained, inasmuch as a consequence of the concurrence of so many artisans, it is estimated that the art of shaping lenses has been so much refined. He has ordered me to send you the enclosed sheet displaying different characters, to use as I shall indicate, in accordance with what already has been done here".[545]

Magalotti proceeded then to explain. The placard was to be placed upon a board at a distance of 100 *bracci* (58.3 meters) at one end of a series of rooms, the doorways of which were aligned. The board was to be illuminated by means of two lanterns, one on either side of it. Two stubs from candles of white wax were to be used for fuel and placed in a clay flask containing oil. There was to be no apparent difference in the lighting from one observation to another. The selection of candle stubs for illumination was to provide a light that would be the same for both contestants, to avoid the possibility of disputes.

"We succeeded by this means in keeping the illumination very uniform," Magalotti wrote. "We observed with telescopes of different lengths from the other end (this end meaning not the extremity of the telescope but where the eye is placed). We should now like to know which characters can be read from the same distance of 100 Florentine *bracci* [while] having the sheet illuminated in the same manner, with telescopes of both Divini and Campani of equal length (according to the measure of the threads that we enclose herewith)".[546] The lengths of the threads were based upon the lengths of the telescope tubes, which have been adjusted for daytime viewing of terrestrial objects that were approximately 3 miles distant (the Florentine mile was 1,778 meters).

The Grand Duke's instructions went on to caution that reports made by others were not to be trusted, particularly any reports from the contenders, Divini and Campani. They were to be aware that, "knowing in your mind what the lines say, you are not

[544] Bonelli and Van Helden, "Divini and Campani", 46–53, letter from Lorenzo Magalotti to Paolo Falconieri, with Appendix, undated, from September or October 1664.

[545] Ibid.

[546] Ibid.

deceived into believing that you read with the eye what you read with the imagination. It will be wise, therefore, to call upon individuals who have not seen the sheet previously because they will be more apt to judge up to what point [the characters] can truly be distinguished".[547]

Magalotti had sent along an Appendix containing the results of the tests that already had been performed in Florence. In the first test, the entire fifth line had been read in these tests with a telescope of 2 *bracci* (1.2 meters), and in the sixth line, the capitals and the letters having strokes had been read as well. With a telescope of 5 *bracci* (2.9 meters) used for observing in the countryside, "Per" and the letters with strokes had been read. (This annotation later was deleted.) The entire eighth line and the capital letters of the ninth line could be read clearly with a telescope of 4 *bracci* (2.3 meters). With a telescope of 10 *bracci* (5.8 meters), the entire ninth line was read, as well as the capitals and those letters having strokes of the last line. The second test was conducted at a distance of 100 Florentine *bracci* (58.3 meters). It was not possible to distinguish any letters in line two with a telescope of 1/4 *braccio* (14,5 cm). The shortest words of the fifth line could be read with a telescope of [undecipherable] *bracci*, but the longest could not be distinguished. The sixth line could be read with a telescope of [undecipherable] *bracci*.[548]

The arrangements the Grand Duke had required for making similar tests in Rome had been more easily described than implemented, however. Paolo Falconieri had not as yet found telescopes that were equal to the measures that had been provided to him; the Campani instruments were of greater length and had a stronger ocular than the Divini instruments. Because Falconieri had been unable to find telescopes equal to the measures that had been sent to him, he was forced to observe only with instruments that approximated those measures most closely, as he noted on an enclosed memorandum. As a consequence, Falconieri was forced to conduct the tests on two separate occasions, one time with Divini's instruments and at another time with the Campani telescopes. Nonetheless, the trials proved to be unsuccessful for several reasons, primarily because

[547] Ibid.

[548] Ibid., letter from Lorenzo Magalotti to Paolo Falconieri, with Appendix, undated, from September or October 1664.

the telescopes were not equal in length, type, or having the same power of the eyepieces.[549]

To add to the confusion and inconclusiveness of the comparison, in one of their tests one of the Campani brothers (almost certainly Matteo!), moved the lanterns closer to the test sheet. The 6th of November 1664 Paolo Falconieri wrote: "in sum, there was not an advantage that the Campanis did not obtain, to the point that it became tedious, while Eustachio, the other evening, never approached the lights and never said a word".[550]

The prospect of engaging in yet another duel with the telescopes was not welcomed by either of the would-be competitors, and the responses elicited were less than cooperative. Despite the persistent hostility between the contenders, Falconieri did his best to arrange an amicable competition, although he was greatly preoccupied with other official business for the Grand Duke at the time so that he was unable to direct his full attention to the project.

He reported that he had spoken first to Giuseppe Campani, who had expressed willingness to make the test. "He raised some difficulty, however, about knowing whether concave or convex lenses had been used in the trials in Florence," Falconieri wrote, "and whether those telescopes had been equipped with two or with more lenses".[551]

When Paolo Falconieri asked the Campani brothers whether they wished to be present at the trial with Divini or did Giuseppe wish to be alone, Matteo and Giuseppe both answered vehemently that they wished to be there by themselves. Matteo obviously was concerned by the prospect of having his brother's telescopes compared unfavorably with those in Florence, and thus he raised another question. "Because the air in Florence is thicker than in Rome", he stated, "the medium that interposes itself between the eye and the object consequently is more opaque, and in Rome the observation would be made with prejudice against the quality of the telescope".[552]

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[549] BNCF, Gal, vol. 284, cc. 161–164; ASF, *Carteggio di Artisti*, filza X, cc. 44–45; Bonelli and Van Helden, "Divini and Campani", 54–65, letter from Paolo Falconieri to Magalotti in October 1664.

[550] BNCF, Gal. vol. 284, cc. 161, 164; Bonelli and Van Helden, "Divini and Campani", 66–71, letter from Paolo Falconieri to Magalotti on November 6, 1664.

[551] Ibid., 54–63, letter from Paolo Falconieri to Magalotti in October 1664, including Falconieri's reports of the tests (copy in BNCF, Gal. vol. 284, c. 163).

[552] Ibid.

"With Eustachio exactly the opposite transpired", Falconieri continued, "because, after having promised to come, it had entered his head that, although this order comes to me from Florence, it was perhaps a trick of Don Matteo, of whose cunningness he was extremely frightened. He informed me that he wanted Campani to be there with him, and that it must be with telescopes that were equal and mounted at the same time. In addition to the reading, he wished also the definition and the magnification be considered, because otherwise he would send a friend with his telescopes, leaving the opinion to whomsoever wanted [to express one], for he did not wish to know anything".[553]

Upon being so informed, Paolo Falconieri traveled by carriage the next morning to pay a visit to Divini at his home to assure him that the trial actually was no more than a simple desire of the Grand Duke. He explained that it was impossible to make an exact test because Divini did not have telescopes of the same measures as those of Campani, nor in fact did Campani have instruments equal to those of Divini, and that every small difference was sufficient to render inadequate any advantage that could be drawn from the trial.

Divini then ventured to ask Falconieri to inform the Grand Duke that, in order to please His Highness, he would be willing to make telescopes conforming to the measures that His Highness had sent. Divini would forward the instruments to His Highness in Florence, he said, and would arrange for the Grand Duke to retain them as long as he wished in order to study or to compare, as he was inclined. Divini assured Falconieri that if the Grand Duke were to do him this honor, as far as he was concerned, it would not be necessary to arrange other trials of his telescopes in Rome, only those with Campani.[554]

Paolo Falconieri explained that he gave Divini many other reasons for participating in this trial, in addition to his obligation to the Grand Duke. Divini finally appeared to be mollified, Falconieri reported, and made an appearance, although reluctantly, in time to engage in the experiment with the test sheet on the evening of the trial.[555]

Reports of the separate tests made with the telescopes of Divini and Campani had been filed together with this letter from Falconieri, and attached in the midst of it,

[553] Ibid.
[554] Ibid.
[555] Ibid.

apparently by accident, was a portion of another letter from Falconieri to his friend Magalotti, believed to be dated November 3, 1664. In it Falconieri explained that because "the Master" (by whom Falconieri meant the Pope's nephew, Don Agostino Chigi) planned to go hunting at noon on the following day, Falconieri was obligated to accompany him and would be unable to give the matter of the test sufficient attention if he were to write later tomorrow. He considered, therefore, that it was essential that he record his thoughts before retiring that same evening while his memory was still fresh. "I tell you this so that you will sympathize with me and continue your support," he added. "As to the trial of telescopes that had been held," he commented, "it is difficult to provide a judgement other than as indicated in the enclosed sheet." Falconieri then asked for other characters to be used on test sheets for experiments to be made later, if any.[556]

Falconieri continued, "If, after he has heard about the offer made by Divini [to send a telescope conforming to the Duke's specifications], Campani also wishes to send [a telescope], you can be greatly pleased. On this subject, however, please be advised not to promise the Grand Duke [a telescope] as a gift, because from the little that I have been able to find out, he [Campani] does not intend to give or sell [a telescope] to the Grand Duke if the latter has no wish to compare [it] but only wishes to demonstrate his confidence and promptness. Furthermore, he intends to consign it to the [Florentine] ambassador in order, I think, that in case the lenses or something break, the ambassador will be held responsible. Knowing this, see whether you wish that I have him send [a telescope] to you, which I shall do. This, too, is mere speculation on my part, however". Falconieri's comments about Giuseppe—with whom he had had many dealings and knew well—are revealing of Giuseppe's business acumen; he did not need to seek favors.[557]

It is apparent from Falconieri's comments that Giuseppe's instruments were of somewhat greater length than those of Divini and were equipped with eyepieces that were more powerful. The Campani brothers also had the additional advantage of the presence at the tests of their friend, the sharp-sighted Cassini. Cassini and Giuseppe had been able to read much more of the test sheet than the others were able to do, which had led Falconieri to raise the problem of the content of the test sheet in that a learned person

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[556] Ibid., 64-65, letter from Paolo Falconieri to Magalotti on November 3, 1664.
[557] Ibid., the Florentine ambassador to the Holy See was Carlo di Pierfrancesco Rinuccini.

might recognize a line of the poetry in its entirety, and that while testing several telescopes using the same sheet, an observer could memorize the words. Falconieri thereupon had arranged to have a sheet printed that contained combinations of letters in meaningless groups and lacking ascenders or descenders, taking into account shape, width, and spacing of the letters. On one of the test sheets, the letters were arranged in groups, and in the other, they were spaced uniformly. It had been noticed that when observed in oblique lighting, grooves resulting from the typefaces created shadows that affected the outlines of the letters; accordingly, the paper was beaten flat to eliminate the grooves.[558]

Accordingly, when the trials in Rome were to be repeated using the same telescopes equipped only with objectives and concave eyepieces, another test sheet was devised, which was to be observed from the same distance and provided with the same lighting for illumination. Magalotti explained how this alternate test sheet had been designed, on which:

> each line is composed of two types of letters, those having strokes and those without. And when it comes to reading them, those that are taller, being distinguished more easily, give away those that are less well-distinguished, if not to read them then [at least] to identify them. Therefore, it has seemed preferable to take unconnected words—and for the most part those having no meaning—all equal, that is, without strokes, in order to avoid not only the risk of memorizing them, reading them by heart, but also of guessing. . . . I send you herewith another [test] sheet . . . with which we should like you to repeat the observations with the same telescopes equipped only with object lenses and concave [eyepieces], and [observations are to be made] from the same distance and with the same light. You should not be ashamed when your vision appears to have been worsened in the course of this, for we are aware that such things happen very easily, particularly in the present season, and much more [happens] to you who are unfortunately immersed in thick air of which Campani rightly suspected that, assuming that the telescopes were of equal quality, ours would always be on the winning side, as is said, thanks to the more pure and transparent air in which we live [in Florence].[559]

Whether Magalotti was mocking Falconieri in the comparison of weather is not certain. Magalotti went on to comment that there was a distinct disadvantage in using words not having letters containing strokes because when certain letters are combined the proximity of strokes created a confusing image that did not occur with other letters having more body and which were more readily distinguished.[560]

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[558] Ibid., 34.
[559] Ibid., 32, 72-85, letter from Magalotti to Paolo Falconieri in November 1664.
[560] Ibid.

Falconieri's report of the trial held in Rome was read and much appreciated by the Grand Duke. Members of the Accademia, realizing that identification of individual letters was affected by shape, width, and spacing, prepared two new sheets that Magalotti forwarded to Falconieri to use for a new trial. One had been prepared with letters spaced in groups and the other with letters arranged with uniform spacing upon paper that had been beaten accordingly to eliminate the appearance of the outlines of the letters. The observations made with the first sheet were to be repeated with observations made with this second test sheet, Magalotti explained, and he reminded them that notes would be taken of which lines had been read on one and on the other with the same telescope, identifying which line could be read clearly with each telescope; those lines of which only some characters could be read were also to be noted.[561]

Although in the past, the competitions of the dueling telescopes had been held at the Collegio Romano, from the 13th of December 1664 the contestants were forced to seek another meeting place. Because the start of the civil day was 1 hour after sunset, the doors of the Collegio were closed at 3 o'clock. Because of the Collegio's distance, that left only very little time available for observing. Instead, they selected as the new meeting place the recently completed Pamphili palace in Piazza Navona. It had been built by Prince Giovanni Battista Pamphili (1574–1655), who later became Pope Innocent X, and had been completed as recently as about 14 years earlier.

The competitors were able to continue their observations in the palace using three telescopes by Campani until 5 o'clock. During the tests, the entire space of the rooms—an area nearly twice as large as the tests required—was maintained almost completely in darkness. There was no other light except that of the two lanterns placed one on either side of the test card, and behind the observers there was also a revolving lantern that could be opened from time to time just long enough to enable the observers to write down what they had seen. As Paolo Falconieri reported:

> This darkness was deemed absolutely better by Don Matteo and Sig. Cassini, and if you wish me to tell you, the difference seems sensible to me. I am unable to report on Eustachio's opinions, for as I wrote to you, he never speaks. One window of the room in which the lanterns were placed was slightly open; Don Matteo had adjusted it in this manner so that the smoke of the torches could escape. I thought it a good thing to determine whether the night was misty or clear during the experiment; it was in fact always very clear. Please note that the measure of the telescope was

[561] Ibid.

written down by the hand of Don Matteo without him having given me scarcely any cause to suspect that he marked it down on the low side. For he believes that every little difference in length matters substantially. Furthermore, the lights were closer than the last time, and not all the words of the lines that were read clearly were written down, because the [concave] eyepiece takes in a small field, and manipulating the long telescope on the thin supports on which we arranged the instruments was not very easy. Therefore we were content with just those [words] seen with the telescope, thinking that the other [words on the same line] would be read in the same manner. We have measured the distance from the eye to the object in *bracci* and not in palms. I shall send you what we will have seen with the telescopes of Divini, by the ordinary Lyons courier, hoping to make the observation with greater accuracy than that which was made this evening.[562]

Although Falconieri had promised to forward results of the test of Divini's telescopes as well, he was unable to do so because Divini had not succeeded in borrowing back the instruments from their owners. "And I can not risk trying to make the experiment [trial] tomorrow," he wrote, "for even if I have time, as usual I must go hunting with Don Agostino [Chigi]. Pity me, and be content to receive the report on Saturday by the Genoa courier. I take this opportunity to inform you that those telescopes of Campani with which we had observed on Saturday, were the same as [those used] the other time.

He continued, "It is possible, however, to adhere to those measures first made by me personally with total accuracy, and not those measures marked by Don Matteo, which are, in my opinion, not very precise. Moreover, I forgot to mention to you that I thought it was a good idea to determine roughly how much the first telescope with which we observed multiplied my natural sight; it seems to me that it was 67 times. Look on the back of the sheet on which the observations are printed, because I seem to remember that I wrote it there. If you hear should criticism of this involuntary tardiness of mine, I beg you to come to my defense".[563]

Falconieri's report subsequently was summarized to Forzoni by Magalotti, who noted that Paolo had been unable to send the observations as promised by the Lyons courier because he had been hunting with Don Agostino. Magalotti continued:

We do not need, therefore, to be so awed by their excellence," he went on, "since that to which the good Don Matteo has given the measure of 1 *braccio* 19 *soldi* [1.14 meters] should be of 3-1/8 *bracci* [1.82 meters]. That of 6 *bracci* 3 *soldi* 2 *punti* [3.59 meters] should be of 6-1/2 *bracci* [3.79 meters], and that of 8 *bracci* 14 *soldi* [5.08 meters] which caused amazement here, should be of 10 *bracci* [5.84 meters]. It can be seen from this that the good man spoke the truth when he

[562] Ibid., 118–33, letter from Paolo Falconieri to Magalotti on December 13, 1664.
[563] Ibid., 134–37, letter from Paolo Falconieri to Magalotti on December 15, 1664.

said that as far as he was concerned it seemed that every tiny advantage of length made a big difference, and in order not to err, he subtracted from his telescopes here a *braccio* and there two. Signor Paolo also told me that he had made a rough observation of how much the second Campani telescope, the one of 6-1/2 *bracci*, multiplied the object, and that it appeared to him that there was an increase of about 67 times. This can easily be tested with those of His Highness.[564]

During the past 2 days, Falconieri went on, there had been much talk of a comet that it had been said "would be seen in its entirety during the hours to increase in I do not know how many degrees of Scorpio. I do not think it is possible to give better information than what I have received on this subject, first from Sig. Cassini, who will send you the same note he had written in response to one of mine. . . . If the weather is fine this night (which until now is hardly to be expected) I will not fail to satisfy my curiosity by observing it together with Cassini and other friends. At least I hope to have given a better report to you".[565]

When Paolo Falconieri next wrote to Magalotti, he expressed his frustrations with the progress of the observations and his inability to forward the promised results of observations with Divini's telescopes. "Considering that in eight days I have been unable to settle any of the things [of which he who must bestow them, i.e., Divini] has as much desire, so to speak, as I [who searches for them] commanded me by you, and by you in turn to serve His Most Serene Highness. . . . It seems a paradox, but it is as follows: popes, queens, cardinals, and princes have united to give work now to Eustachio and now to me, in such a way that, although I was twice about to leave the house to go to the observations, I have not succeeded in doing so".[566]

He then mentioned having observed the great comet; after having become visible earlier that month, it passed in perihelion on December 4th. "Yesterday, at the setting of the Moon," he wrote, "the conjunction of the same with Jupiter and Venus was seen, and do you know how skillful Jupiter was? He placed himself in the middle, as he and Venus were both to the south of the Moon, and while at the beginning of the observation, he was distant from the Moon by a diameter, then, as it appeared to him that [Venus] was positioned lower than [the Moon], he made himself approach her by half [a lunar

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564 Ibid., 138–41, letter from Magalotti to Forzoni on December 20, 1664.

565 BNCF, Gal., vol. 277, c. 67, letter from Ottavio Falconieri to Grand Duke Ferdinand II on December 16, 1664.

566 Bonelli and Van Helden, "Divini and Campani," 142–49, letter from Paolo Falconieri to Magalotti on December 20, 1664.

diameter] and left Venus [perhaps because of his dissatisfaction], who stayed at her initial distance of two lunar diameters [south of the Moon]. Sig. Cassini thinks that the conjunction of such benign aspects may perhaps even be an antidote against the malignant influences of the comet".[567]

Falconieri went on to inform Magalotti that "no telescope longer than 50 palms (11.2 meters) had been produced in Rome, that is, of the [palm] I sent you recently (the Roman *palmi di passetto* (22.34 cm) divided into 12 *oncie*, was the palm used by all architects and artists of Rome in that period). And of these [telescopes], there are three: the first was made by Eustachio Divini, and after he had printed that 'little book' that I sent you [Divini's *Lettera* of 1663], Campani did not wish to appear to be the lesser so he produced one equal in length, but equipped with simple lenses instead of composite ones such as in Divini's telescope. And through a certain test that was made in the garden at Montecavallo [Quirinal palace], it [Campani's] was thought to be the better." The only effect of this experiment was that it succeeded in motivating Divini to make another instrument, "exactly like that of Campani," so that later he would be able to compete in "a most exact test without any excuse being made about whether the lenses were simple or composite".

"And I now have inclined Cardinal Chigi and Don Agostino to have this comparison made in their presence, so that respect for them will prevent [Campani and Divini] from coming to blows. Moreover, it can happen easily to arrange since the telescopes are already at San Pietro Montorio, waiting for clear weather and the convenience of these gentlemen. The first [instrument] is in the hands of the said Cardinal, who paid 500 *scudi* for it, as you have seen from the prices in the note. The other two are with their makers, who, in my opinion," Falconieri presumed, "apparently plan to sell them since they were not made to order and I think that they like the 500 *scudi* more than their telescopes. I cannot tell you what can be observed with these because for someone who could not be there on the day that the test was made, it is not easy to see [the same] under other weather conditions. But if this trial ever comes about, I shall make accurate observations in order to report [to you]".[568]

[567] Ibid., 145.
[568] Ibid., 142–49, letter from Paolo Falconieri to Magalotti on December 20, 1664.

Determined at all costs to obtain the information that the Grand Duke and his brother had requested, Falconieri eventually persuaded the Pope's nephews, Cardinal Flavio Chigi and Prince Agostino, to participate in another competition, which was to be a test of the longest telescopes produced by Divini and Campani. During the past few months Divini had constructed another telescope of 50 palms without composite lenses in the compound eyepiece which consequently was comparable in every way to the Campani telescope of 50 palms.

Forzoni, the Grand Duke's secretary, informed Magalotti that His Highness ordered that "I must tell you how much His Highness approves that Your Lordship informs Mr. Paolo as well as the others in Rome of the naked truth about the observations with our telescopes. The instructions for making tubes for the telescopes are in the hands of His Highness, who wishes to make I do not know what test. And I have nothing more to tell you on this subject. Each time I receive your letters, I read them over and over in order to prepare the answer, but never do I see the beginning of our duel. Therefore, when you decide to begin it, I shall pretend not to be aware of it. Our return to the fray will be sooner".[569]

It was not until late in December that Falconieri was able to report at last on the comparison of the telescopes and on the test on the Divini's ones, which finally had taken place. "But as things that begin badly end badly," he noted, "there has been no lack of obstacles to the observations we were able to make, so that what I am sending you, I cannot send you with any pleasure. And if the difficulties and the impediments we experienced, together with the fear that you would take it for a pretext, had not dissuaded me, I would not have sent it".[570]

Just as the observation with Divini's telescopes was well in progress, he complained, Prince Panfilio Pamphili, the owner of the palace, had arrived with two of his sons and three others. This necessitated a great waste of time and a needless tiring of the eyes of the observers. To such a degree, in fact, that after Pamphili and his friends had left and the observers returned at last to making serious observation, they discovered that the pupils of their eyes had contracted considerably. Now they were able to see only

[569] Ibid., 156–61, letter from Pierandrea Forzoni to Magalotti on December 31, 1664.
[570] Ibid., 162–71, letter from Paolo Falconieri to Magalotti on December 23, 1664.

hesitantly what earlier they had seen easily, even with the same weather conditions. Upon opening a window, they discovered that the air outside had become foggy and hazy since by then it was well into the night. However, since they had stayed so long, Cassini, Divini, and Falconieri decided to observe by themselves, using sheet B only so as not to tire their eyes even further in the confusion of letters on sheet A.

"Here immediately is thus a difference in the observation, and not the only one," continued Falconieri. Having been overcome by all the confusion, Divini proceeded to add "an ordinary candle in a candlestick at the middle of the object [the sheet with lettering], the center of which, because it was very wide, remained rather dark due to the distance of the lanterns from the sheet. It seemed to him and to Signor Cassini that it helped greatly, but I confess that I am of the contrary opinion, as it seemed to me, that owing to the smallness of the flame, [only] a few [additional] letters were illuminated. Because of this light and the light from the torch in my eyes, the same confusion remained as before." The only telescope used was the one of 12 palms (2.7 meters), and the subsequent observations proved to be better than expected since, in the meantime, the air had cleared. The room was filled with smoke from the lanterns, which had been burning for 6 hours, and the light had become extremely dim.[571]

The comparison of the two instruments of 50 palms (11.2 meters) was made with two other observations during the 22nd of Dicember at Palazzo Panphili in the presence of Prince Agostino Chigi, Cardinal Flavio Chigi, Cardinal Borromeo, Carlo Pio di Savoia (1622–1689), and other interested *virtuosi*. The first observation was made of the Villa Mondragone situated in Frascati, some 22 km from Rome. The long telescope by Divini, with the composite lenses they saw "less clearly, but it covered a larger field and was freer from colors". Falconieri also reported that with the small telescope by Divini of 2 palms, they were enabled to distinguish many details of the Villa and could see all the windows so clearly that they could be counted, but nothing else. Next they turned their telescopes to one of Giuseppe's broadside of Saturn and Jupiter that had been posted upon one of the windows of the Quirinal palace on Monte Cavallo They discovered that "it could be distinguished very well, except for the discrimination of the ring in front of

[571] Ibid.

Saturn's disk and the bands of Jupiter, but [they were] unable to discern the letters that appeared on the broadside".[572]

After the trial had been completed, the cardinals declined to discuss it, and the others likewise feigned indifference. They refused to state their opinions publicly, but when questioned privately, they agreed that they favored the Campani instrument. Falconieri noted that the trial had not been made with the thoroughness required to detect the smallest differences. Campani, he wrote, had more or less given up and did not accept the wager of 100 doubloons (200 *scudi*) that had been proposed by Divini's brother and did not agree to an exchange of the lenses of the eyepiece by combining his lenses with Divini's object lens and those of Divini with his own objective. It was concluded, however, that the trials made in Rome were unable to provide sufficiently definitive answers to what the Grand Duke had proposed.[573]

Meanwhile, the final duel of the telescopes that occurred in Rome was reported widely in scholarly circles, including an account in a correspondence between a writer in Paris to the recipient in London, both unidentified, published in the *Philosophical Transactions* of the Royal Society in England:

> We received lately news from Rome, from a very Curious Person of our acquaintance, importing, that Campani hath had the advantage of Divini. The Great Duke of Toskany, and Prince Leopold, his Brother, upon Tryal, made of both their Glasses, have found those of Campani excel the other, and with them they have been able, easily to distinguish people at 4 Leagues distance: Of which I intend you more particulars hereafter.
>
> Among them are expected the Length of these Telescopes, and the Largeness of the Aperture of their Object-glasses. In the mean time, the Parabolical-glasses, formerly mentioned to be in hand here at London, are finishing with all possible care and industry.[574]

As news of the competitions being held in Rome reached London, meanwhile, Campani's name became increasingly familiar to English savants: "As to y^e^ observations of Jupiters belts, another letter from Paris to me", wrote Oldenburg to Robert Boyle in late 1664, "mentions y^t^ there having been a challenge for y^e^ excellency of Optick Glasses betwixt Eustachio and Campani, those of y^e^ latter were found better, y^n^ those of y^e^

[572] Ibid., 163–69, letter from Paolo Falconieri to Magalotti on December 23, 1664.

[573] Although Divini's brother is not identified by name in the letter, it probably was not Vincenzo Divini, whose interests were literature, history, and medicine. It was more likely Cipriano Divini, who cultivated the fine arts and probably had assisted Eustachio in producing his broadside of the moon in 1649. Mantio Bianchedi, 'Eustachio Divini, ottico matematico del secolo XVII', *Bollettino dell'Associazione Ottica Italiana, serie storica* 1, no. 2 (1946): 2–3.

[574] "An Account of the Tryalls, Made in Italy of Campani's New Optick Glasses," 131–32.

former; and y^t^ y^e^ lst of July at n. 1664, there were discovered in Rome 4. belts of Jupiter more obscure, and 2. in y^e^ same, more clear, than y^e^ rest of his Discus. So y^t^ in stead of 2. or 3. we have now 6. belts in Jupiter".[575]

As previousle noted, by late 1665, rumors already had begun to circulate in London concerning the invention that had been made in Rome of some new method for lens-making in addition to reports about the Divini–Campani trials that had been held there. Oldenburg, as the Royal Society's secretary, felt obliged to learn more about these events and wrote to Sir John Finch in Florence requesting more details. Finch had been a member of the council of the Royal Society since 1663, had lived at Padua, and presently was a professor at the University of Pisa. "We have of late heard much of y^e^ new way of Grinding Optic Glasses, invented and practised by Campany [sic]," Oldenburg wrote, "and of y^e^ Contest risen thereupon between him and Eustachio, We have also been informed of y^e^ printing of y^e^ Florentin Experiments, of an Italian treatise. . . .". The latter reference was to the *Saggi di Naturali Esperienze* of the Accademia del Cimento that were being prepared for publication.[576]

The Accademia del Cimento's publication, *Saggi di Naturali Esperienze*, had already gone to press by the autumn of 1664 during the period that these tests using printed texts were being held, so that it was too late to include reports of them in the publication. Magalotti's file on the comparative tests of the telescopes held in Rome and Florence, instead of being added to the archives of the Accademia, inadvertently had been relegated to his family archives, the Ginori-Conti Archives. There the entire file had remained hidden and forgotten in his family's hands for more than 300 years until modern times. It was discovered by the late Dott.ssa Maria Luisa Bonelli in the early 1960s. The head of the Ginori-Conti family subsequently sold the files to the late Alain Brieux, the antiquarian librarian in Paris, who in turn sold them to the University of California at San Diego, where they are presently held.

As a consequence, the correspondence and documents related to the tests had not become known to Giovanni Targioni Tozzetti, the noted eighteenth century historian of

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575 Oldenburg, *The Correspondence of Henry Oldenburg,* vol. 2, 240, letter from Oldenburg to Robert Boyle on December 19, 1664.

576 Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 2, 631–33, letter from Oldenburg to Sir John Fitch on December 7, 1665. Reply from John Finch (1624–1682) in January 1666.

Tuscan science and one-time assistant librarian of the Magliabecchian Library. Nor was the information about the tests included in his account of the physical sciences in seventeenth century Tuscany published in 1780.[577]

As a consequence, regrettably the tests remained unknown also to the pioneers who contributed to the development of the optotypes: V. Becker in 1805, Tauber in 1816, and Kuckler in 1835. Kuckler's optotypes were not successful, and titles of books instead were preferred and continued to be used. In 1854, Eduard Jaeger produced tables consisting of printing types of various numbers and sizes to be used for reading, and these were printed by the Dutch ophthalmologist Herman Snellen and his associates. Many of the experiments that had already been performed by those who were testing telescopes in the seventeenth century in Florence were repeated by the pioneers in the nineteenth century. In fact, the Snellen version, the optotype of 1862, ancestor of the modern ophthalmological test types, did not vary greatly from the ones that had been devised by the Accademia del Cimento two centuries earlier. There had been no standards for reference for the Italian predecessors, and they were limited to a direct comparison of the two instruments. Snellen's quantitative approach expressed visual acuity as a numerical ration of a standard.[578]

Two weeks later, on December 19, 1665, Oldenburg inquired from Robert Boyle concerning observations that were being made in England with Richard Reeve's instruments, and commenting on the trials made in Florence with a Campani telescope, he wrote, "The performance of Mr. Reeve's glas, of seing y^e shape of windows, and y^e differing colors of y^e stones, and y^e weathercock upon the Harrow-steeple, I suppose to have been done by his 60. foot Glasse; but, I believe, y^t of Campani's, tryed at Florence, was not above 35. Foot; whereof I expect, more particulars shortly. As to y^e sale of his longest glasse to some Virtuoso abroad, y^t is not like to be, because himself has obstructed it, by what I find printed by M. Auzout, whom saith, y^t a while agoe a person of some quality, having told Reeves, y^t at Paris there were glasses drawing y^e same length

577 Giovanni Targioni Tozzetti, *Notizie degli aggrandimenti delle scienze fisiche accaduti in Toscana nel corso di anni LX. del secolo XVII, raccolte dal dottor Gio. Targioni-Tozzetti ...* (In Firenze: Si vende da G. Bouchard, 1780).

578 Herman Snellen, *Test-Types for the Determination of the Acuteness of Vision* (Utrecht: P. W. van de Weijer, 1862); Arthur Linksz, 'The Development of Visual Standards: Snellen, Jaeger, and Giraud-Teulon', *Bulletin of the New York Academy of Medicine* 51, no. 2 (1975): 277, 285.

with his, y^t did not bear a greater Aperture, and of stronger Oculars [*et des Oculaires plus forts*] (leaving him thereupon to judge, whether they were better) y^t person received no other answer from him, but y^t his Glas was exceedingly good, and y^t those, who did not think the same, should not think to have any of them. In y^e same place y^e said M. Auzout takes notice, y^t y^e Telescope, sent by His Majesty to y^e Duke of Orleans, made by Reeves, bears no more aperture than 2. Inches and 3. *Lines French* [...] ".[579]

By the end of December 1664, Giuseppe Campani's telescopes were being purchased by the Medici princes as well as by clients in Rome and elsewhere, and in the course of the following year, the Grand Duke and Prince Leopold both purchased a number of telescopes from Campani as well as Divini.[580] Despite the frustrations arising from the physical competitions and the verbal conflicts between the contenders, Divini's work nonetheless continued to receive appropriate and due acknowledgment. In October 1666, Grand Duke Ferdinand II sent his emissary, Paolo Falconieri, to Rome to present Divini with tangible evidence of his esteem. It was in the form of a gold chain having a large gold medal bearing the Grand Duke's portrait.[581]

During the year 1665, Campani's telescopes were tested in Florence, the long instruments being selected to make observations of Saturn and Jupiter. Campani made a 50-palm instrument for Cardinal Antonio Barberini and had it forwarded to Florence for testing. It was declared to be finer than any other telescope of similar length. As Prince Leopold wrote to Campani: "the perfection and quality of this telescope, superior to all

[579] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 2, 240, letter from Oldenburg to Robert Boyle on December 19, 1665.

[580] In April 1665, the Grand Duke instructed Magalotti to communicate with Paolo Falconieri in Rome concerning disposition of some of the instruments made by Campani or Divini. Accordingly, Magalotti informed Falconieri that he had "received the command from His Highness, just now, to send back to you the telescope of 20 palms [3.8 meters], that is, the objective only, as we are keeping all the other concave [oculars] with the objective of 12 palms [2.7 meters] (which has succeeded entirely satisfactorily). The one that we send back is also very good, but since His Highness has two other ones of the same length, he wants to have this one of 12 [palms] for comparison with another one of about 5 *bracci* [2.9 meters], so that for this reason, and for the satisfaction of having a perfect work from such an excellent master, His Highness has resolved to keep it together with all the [ocular] lenses also judged to be of a most beautiful polish. You will, therefore, please pay him the total; the price that will be suitable and is usually paid for telescopes of similar lengths; as well as the cost of the concave [lenses] considered to have been accepted. And when you inform me of the sum, I shall promptly send you an allowance for your reimbursement". Bonelli and Van Helden, "Divini and Campani," 174–75, letter from Magalotti to Paolo Falconieri on April 27, 1665.

[581] Divini, *Lettera*, 22.

others made up to now, was recognized by all".[582] A few days earlier, Giuseppe Campani wrote to Prince Leopold:

The silence I have maintained with your Highness until now was advised by reverence, but now the other day Cardinal Chigi indicated that he had sent to a Cavalier of your court, the telescope that I made for the service of Cardinal Antonio Barberini, and this gave me inspiration to offer a memorial to you, as I am doing with the present writing, petitioning from your benign patronage, which is recognized by all the literati, your efficient universal protection, not only of virtue but also of all its supporters.

I, Most Serene Prince, have no virtue but I continually work to acquire some. My personal inclination brings me ultimately to the application of dioptrics in which I do not know whether I have made myself any profit. For the past year I had occasion to note that Saturn appeared to fly encircled diversely to the various spectators who were using different telescopes in all of Europe. In due course, especially in Rome and Florence, two vigorous controversies developed, the first related to the system of this planet, and derived from the disputes arising from it was the controversy concerning the value of the telescopes.[583]

Giuseppe told the Prince that it had been he who had been able to dispense justice in the cause. He pointed out that the secant shadow on Saturn's disk that Huygens claimed to have seen with his telescopes, "which appeared to confirm at the same time its own ingenious system, and the imperfection of the telescopes of the other part that constantly negated the said shadow, and to assert another very different system, composed entirely of white and black globes, because in this manner they gave manifest indication of the appearance observed with his finest lenses in Saturn". He continued:

These disputes, inasmuch have greatly provoked various sentiments, in this manner they also challenged my mind and the hand to make such lenses, with which it would be possible to demonstrate by the eye the truth of one of the systems; It would have been no little achievement, if I […] were able to show to the world, either that ring, and that shadow, or other particulars that under this same Roman sky had not yet been seen with other lenses, not even during those past years when they were much more visible, which they are not at present.

If indeed Your Highness has listened to all these things and had seen my printed observations [...] I am petitioning Your Highness, that immediately after having made the observations of Saturn, and of Jupiter, with the other Roman telescopes [of Divini] you will do me the honor of observing these planets with my telescope as well, raising however, the two ocular lenses most distant from the eye, and then will be served by the proper ocular lens of this telescope will be able in place of this serve yourself of another lens more acute that I have sent to this purpose [end], with which on Friday night in the garden of the Pope at Monte Cavallo were seen marvelously distinct, the ring and the globe of Saturn without shadow [. . .] I therefore beg Your Highness to make use of every exact diligence and adjustment of the glasses, thus with mine, as with other telescopes in all the tests, and in all the comparisons that will be made, and do not permit that using any lens of one in another telescope, because this would ruin the good one, and improve the bad one, because the shaping of convex lenses is a most delicate procedure and

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582 BNCF, Gal. vol. 282, c. 120, letter from Prince Leopold to Giuseppe Campani on July 12, 1665.

583 Ibid., vol. 277, c. 198, letter from Giuseppe Campani to Prince Leopold on June 30, 1665.

any minimal error, particularly in a telescope having several lenses–and even in the work in only two lenses. I do not deny for this that if you wish to examine the objective, *v.g.* of my telescope, and the objective of another of the same length, you can remove all three ocular lenses from both telescopes, and put in their place an acute concave for each, of equal acuteness. I actually wish that this is done, because in this manner it will be clearly seen the differences of both their objectives, and of the ocular lenses […]As to the manner of testing them, Your Highness be the arbiter. If after the test Your Highness would wish to give full report by a recommended letter to Monanni so that someone else who has my name and cognomen would not be recovered from the post, I would receive it by the special grace of Your Highness".[584]

It was at this time that Giuseppe proposed a solution for testing telescopes that he believed would establish the question of superiority once and for always. He suggested to Prince Leopold that a large piece of glass of the finest quality be obtained from Venice and sent to Rome. There, under careful supervision and safeguards to prevent substitution of another piece, it was to be split into two equal parts, one piece to be given to Campani and the other to Divini to convert into object lenses of specified focal length. At no point were they to be allowed to test the curvature of the lenses while their production was in progress. Upon completion, the lenses were to be sent to Florence to be compared and assessed, and an impartial body of judges would determine whether or not the success of the lenses was due to luck or to skill.Campani also enclosed a copy of his *Lettera* addressed to Cassini, which had been published in 1665, in which he also described the same proposal. Divini also presented a challenge of his own, but Prince Leopold did not act upon either proposal, inasmuch as there was no further question but that the Campani instruments unquestionably were superior.[585]

In the following year, Auzout wrote to Oldenburg stating that until then he had been unable to learn "the Aperture Campani gives to his Glasses, nor what Eye-glasses [ocular lens] he makes use of. His longest, draw 50. or 51. palms which is about 34 or 25 of our Feet […] Until we see the instrument he has made for Cardinal Antonio Barberini, which was still in Rome", Auzout commented, "we shall hardly be satisfied of the excellency of his Glasses above others, nor consequently of y^{e} truth of y^{e} Observations,

[584] Ibid.

[585] Ibid., c. 204, vol. 313, cc. 51–52, letter from Giuseppe Campani to Prince Leopold on July 14, 1665; included also in Campani, *Lettera di Giuseppe Campani*, 6.

made by y^{m}. It is with that Glas of 50. Palmes, y^{t} Cassini has seen the Shadows of y^{e} Satellits, and y^{e} permanent spot in Jupiter".[586]

Huygens had an opportunity, while visiting at the home of the Abbé Charles a month later, to examine the 3-foot telescope Campani had made for the Cardinal, which Huygens greatly admired and which may have been the instrument about which Auzout had written.[587]

Although Matteo and Giuseppe were well-acquainted with the Jesuit polymath Athanasius Kircher, it is surprising that there appears to have been little if any continued association and direct communication between them, at least that has survived in the form of correspondence. The Campani brothers had become personally acquainted with him in 1657 when Kircher had participated in the Collegio Romano's judgment in the controversy over the silent night clock. Kircher had in fact obtained copies of Giuseppe's broadside with engravings of Saturn and Jupiter that had appeared as the frontispiece of Campani's *Lettera* published in 1665. Kircher sent these broadsides to Duke August of Brunswick-Lüneberg as well as those by Gottignes relating to the new comet that appeared in the same year.[588]

As a consequence of Matteo's careful planning and of Giuseppe's continued production of instruments of increasing superiority, Giuseppe by now had become firmly established and acknowledged as the maker of the finest lenses and telescopes being produced in Europe at that time. Furthermore, within the next two decades, between 1665 and 1685, his telescopes were responsible for important astronomical discoveries that were being made with increasing frequency by Cassini, by himself, and by others. In reviewing their numbers, it proved that the discoveries of Giuseppe Campani and Cassini were the ones that dominated and were reported in the scientific periodicals.

With the increasing fame of Campani's telescopes throughout Europe, they were also being favorably considered in England. The London instrument makers did not have access to *cristallo*, the finest quality of optical glass used by Italian makers, nor

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[586] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 3, 110–16, letter from Auzout to Oldenburg on May 18, 1666.

[587] Huygens, *Oeuvres Complètes de Christiaan Huygens*, vol. 6, no. 1546, 48.

[588] Herzog August Bibliothek, Wolfenbüttel, BA n. 362; John Fletcher, "Kircher and Astronomy: A Postscript," in *Enciclopedismo in Roma Barocca : Athanasius Kircher E Il Museo Del Collegio Romano Tra Wunderkammer E Museo Scientifico*, ed. Maristella Casciati, Maria Grazia Ianniello, and Maria Vitale (Venezia: Marsilio, 1986), 136; Campani, *Lettera di Giuseppe Campani*.

apparently had they developed the techniques required to compete with the lens and instruments of the Italian makers being imported. London artisans were sufficiently stimulated by these imports to copy them, however, and by the end of the seventeenth century, English makers had begun to produce finer instruments.[589]

Among the miscellaneous papers of Vincenzo Viviani, filed under the rubric of "Experimental Physics. Optics," is a rare price list revealing a comparison of the prices charged by Divini and by Campani for their telescopes. Presumably it had been compiled by Viviani for informing the Grand Duke and Prince Leopold. The compilation appears to be of the period 1665–1666:

Rate of the Prices for Telescopes

	Tube Only	
Palms	Divini	Campani
N. 3	s 3.50	s 4.50
N. 5	s 10.-	s 40.-?
6 in. 7	s 10.-	s 48.-
8 in. 9	s 20.-	s 25.-
10 in. 11	s 25.-	s 36.-
12–13	s 25.-	s 40.-
15–16	s 30.-	s 55.-
	With 4 lenses	
No. 1–2	s 20.-	s 45.-
3	s 30.-	s 40.-
4–7	s 35.	s 36.-
8–10	s 40.-	s 40.-
12–13	s 55.-	s 55.-
14–15	s 60.-	s 60.-
16–17	s 65.-	s 65.-
18–20	s 60.-	s 50.-
25	s 90.-	s 110.-
30	s 100.-	s 150.-
40	s 200.-	s 300.-
50	s 350.-	s 500.-

589 King, *History of the Telescope*, 61–64.

Whereas Campani's prices for telescope tubes without lenses were consistently higher than those of Divini, his prices in several instances were otherwise the same or almost the same for telescopes with four lenses.[590]

[590] BNCF, Gal. vol. 133, c. 159, *tariffa de prezzi de gli Occhiali del Divini ed de Campani*.

Chapter XI

VAGARIOUS MERCURY

(1664–1666)

> *That famous experiment with the quicksilver, which rose up before the great intellect of Torricelli in the year 1643, is now known in every part of Europe, as is also the high and wonderful thought that he derived from it, when he began to speculate on the reason.*
>
> *Saggi di Naturali Esperienze fatte nell'Accademia del Cimento* (Per Giuseppe Cocchini, Firenze, 1667).

By this time Giuseppe Campani had turned his shop into a veritable factory, where he worked long hours to fulfill commissions for lenses and telescopes while at the same time maintaining his clientele for his silent night clocks. His tract on silent clocks published in 1660 had intrigued many who avidly sought the innovation of a timepiece having a sturdy mechanical movement that was practical for indicating the time during the night hours and was also silent. Then the publication and distribution of his *Ragguaglio* several years later, in 1664, coupled with the favorable reviews it had generated in all the scientific journals of the day combined to make his name and his work better known in the European world of astronomy. The invariably favorable comparisons being made of his telescopes with those of Divini and others brought him an unceasing stream of orders from amateur astronomers not only in Italy but also from elsewhere in Europe.

Despite the fact that Giuseppe's claim that he ground and polished his lenses upon a lathe without prior casting or use of molds was questioned again and again by his peers and others, the evidence lay in the unquestioned superiority of his lenses. As a consequence, it gave rise to insatiable curiosity on all sides, followed by efforts to discover the secret of his technique, much to Giuseppe's constant annoyance and frustration, and perhaps amusement as well. From the very beginning, he had been excessively protective about his work methods, forcing him to become increasingly a recluse, locked away in his workroom to which no one was allowed access except possibly his brother Matteo and members of his immediate family.

Although Giuseppe undoubtedly kept in contact with other members of his family throughout this period, particularly his father in Castel San Felice, he and his brother Pier Tommaso had become estranged from about 1657. This may have been partly because of their disagreement over the distribution of income from the sale of the silent night clocks with mercury escapement, on which they had been jointly engaged. This breach was widened when Giuseppe was granted a papal patent for his invention of the crank lever escapement for silent night clocks, which he had developed while working privately without Pier Tommaso's knowledge. Although Pier Tommaso immediately proceeded to devise another form of the same escapement, which was a breach of the conditions of the patent, Giuseppe never objected to the violation, but the alienation was never totally healed in their lifetimes.

It was during this particularly active period of Giuseppe's life, when he had reached the age of about 28, that he contemplated domestic life and was married. His wife, Theopista Santori, was a native of the nearby tiny hill town of Albano, a community officially named Albano Laziale, high in the Alban hills above Rome. The exact date of Giuseppe's wedding is not known, but it occurred in the early spring of 1664. Their first child, a daughter they named Giulia Francesca Felice, was born on December 16, 1664. She was baptized on December 18 of that year in Giuseppe's parish church, San Lorenzo in Damaso. One of the child's sponsors was none other than the incumbent governor of the city of Rome, Don Giannicolò Conti.[591]

Matteo, meanwhile, no longer having to be engaged in vindication of the inventions by his brothers and now assured that his younger brother had been launched successfully upon his dual careers, turned to developing personal interests that he had put aside. Now he could give more attention to his parochial responsibilities as well as to the pursuit of several scientific projects of his own that he had been eager to develop.

In 1656, while experimenting with mercury as a power source for the silent night clock invented jointly by the brothers, Matteo had become intrigued by the vagarious characteristics of the mysterious silvery metal. Although all three brothers had been

[591] ASVR, *S. Lorenzo in Damaso*, *anime* (December 1664).

experimenting with various substances, it had been Matteo who had, after having familiarized himself with various liquids, provided a successful solution with the liquid metal, suggesting an escapement consisting of mercury within a container.

Matteo was fairly well-grounded in the general state of the sciences of his time, although as a parochial priest he was not part of a teaching community nor formally involved in any scientific activities. Made familiar with Galileo's writings through his association with Vincenzo Viviani, he also had become well-informed about the work in which some of his acquaintances in the Jesuit faculty of the Collegio Romano were engaged.

It was at the time that Viviani had made a visit to Rome in the summer of 1663 that Matteo's interest in mercury and its characteristics had become actively revived. During the several summer months while Viviani remained in Rome, he and Matteo met with frequency while sharing mutual interests. Matteo discussed the experiences with mercury that he and his brothers had had during their development of the silent night clock, and Viviani told Matteo about having witnessed early experiments with water and mercury made by Gasparo Berti in the early 1640s. He related that these demonstrations had been attended also by several notable men of science, including Emmanuel Maignan, Rafael Magiotti, Athanasius Kircher, and probably Nicola Zucchi. Undoubtedly Viviani also provided Matteo with details of how, in about 1644, he had been the first to have made the experiment with mercury and to have observed the effect forecast by his great friend Evangelista Torricelli.

Elsewhere other than in Florence, the Torricellian experiment had been performed privately in Rome in February 1645 for Cardinal Gian Carlo de' Medici (1611–1663), at his residence. The young brother of Grand Duke Ferdinand II had just been named cardinal in 1644, and it was early in the following year that he had become host to the Torricellian experiment.[592]

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[592] Favaro, *Amici e corrispondenti di Galileo Galilei. Vincenzo Viviani*, 20–148; Maria Luisa Bonelli, "L'ultimo discepolo: Vincenzio Viviani," *Saggi su Galileo Galilei*, 1972, 656–88; Giovanni Mario Crescimbeni, *Le vite degli Arcadi illustri*, vol. 1 (In Roma: Nella stamperia di Antonio de' Rossi ..., 1708), 123–39; Pierfrancesco Tocci, "Vita di Vincenzo Viviani fiorentino detto Erone Geonio," in *Le vite degli Arcadi illustri*, vol. 1 (In Roma: Nella stamperia di Antonio de' Rossi ..., 1708), 123–39; W. E. Knowles Middleton, *The History of the Barometer* (Johns Hopkins Press, 1964), 10–11, 19–25. Gasparo Berti (1600–1643) was a mathematician and astronomer born in Mantua. Nicola Zucchi (1587–1670) was an excellent mathematician and physicist and rector of the Collegio Romano from 1646–1659. Rafael Magiotti

Although noted for being of less than disciplined instincts, Cardinal Gian Carlo nonetheless was considered to be a man of taste. Young, wealthy, handsome, and always exquisitely dressed, he consumed food in monumental quantities and had an equally insatiable lust for women. He dedicated himself totally to pleasure in a beautiful villa he had built for himself in the midst of a great garden in the Via della Scalas. There he maintained and entertained a number of mistresses and had arranged to eliminate at least one tiresome rival by having him drowned in a pond used for cultivating carp on his premises.

Cardinal Gian Carlo d'Medici had been expelled from Rome for refusing to allow himself to be accompanied by older and less libidinous cardinals on his visits to Queen Christina of Sweden soon after her arrival in the Eternal City. Pope Alexander VII expressed the opinion that "the society of young prelates and Christina's attractions became so agreeable to all parties that he considered it desirable to appoint a cardinal of more mature years as the Queen's spiritual director." Concluding that Gian Carlo was too young and handsome for such an office, he accordingly requested Grand Duke Ferdinand to recall his brother to Florence.

After having met the painter Salvator Rosa in Rome, the Cardinal had invited him to Florence where he was paid to paint for the Medici court while still being allowed to accept independent commissions. The Cardinal also subsidized one theater being constructed by a company of actors, and another in a rented palace. The Grand Duke had become so frightened of his younger brother that he made no effort to curtail the Cardinal's excesses and expenditures, and he permitted him freedom to pursue his inclinations. Apparently, it was with relief when subsequently the Grand Duke received the news that the young Cardinal had died of apoplexy.[593]

Cardinal Gian Carlo's varied interests did not appear to have allowed him much time to indulge also the sciences, but presumably he had become interested in the Torricellian experiment from having learned about it at his brother's court. The demonstration, which took place in his private chambers in Rome, had been attended by two Jesuit professors, Athanasius Kircher and Nicola Zucchi, and by Emmanuel Maignan

(1597–1658) was an Italian scientist and employed in the Vatican Library.

[593] Christopher Hibbert, *The House of Medici: Its Rise and Fall* (New York: Morrow, 1975), 285, 332.

of the Minims Order. At least these three witnesses attested to the fact that the experiment had taken place in Rome. Kircher indicated that the experiment had been performed for him as a special mark of favor. He agreed with Zucchi unequivocally on the date, while Maignan's account was mostly circumstantial. In his *Cursus philosophicus*, Maignan reported having witnessed the experiment "in Rome six years ago," stating definitely that the experiment was made in tubes of widely different shapes. There is no evidence indicating that the event was open to the public, and although Marin Mersenne was in Rome at the time, he was not present. The event appears to have been kept secret for several years.[594]

During the next several years after Viviani's return from his sojourn in Rome, Matteo maintained a fairly constant correspondence with him on the subject of the Torricellian experiment, on which Matteo continued to conduct extensive experiments by means of air pressure on mercury in glass tubes that he attributed to Nature's dislike of a vacuum.

In a letter dated May 24, 1664, he then proceeded somewhat facetiously to inform Viviani that he had discovered the name of the inventor of those telescopes that he, Viviani, and Candido del Buono had seen in Rome some time previously. That inventor, he wrote, was in fact none other than his own brother Giuseppe, whom he then praised for the success of his studies in optics, reporting that he had made great progress in that field.

As proof of it, Matteo recounted how on April 30th, two of Giuseppe's telescopes, each equipped with four lenses and the focal lengths of which were 51 and 55 palms, respectively, had been tested against a telescope of 52 palms made by Divini. In the trial

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[594] Emanuele Maignan, *Cursus philosophicus concinnatus ex notissimis cuique principiis*, vol. 4 (Tolosae: Raymundum Bosc, 1653), 1888 : "*cum enim ego Romae haec omnia sim expertus*". Although published in Rome in 1653, the date of the "approbation" of the *Cursus* is dated 1650, so it may have been the de' Medici's experiment that was described; Niccolò Zucchi, *Experimenta vulgata non vacuum probare, sed plenum, et antiperistasim stabilire* (Romae: Ex typogr. L. Grignani, 1648), 4; *Nova de machinis philosophia* (Romae: Typis Haeredum Manelphij, 1649), 4, 102 et seq.; quoted by Cornelis de Waard, *L'expérience barométrique: ses antécédents et ses explications; étude historique* (Impr. nouvelle, 1936), 177–81; Athanasius Kircher, *Musurgia universalis sive ars magna consoni et dissoni* (Romae: Corbelletti, 1650), 11; Jacobus Pierius, *Ad experientiam nuperam circa vacuum, R.P. Valeriani Magni demonstrationem ocularem et mathematicorum quorumdam nova cogitata, responsio ex peripateticae philosophiae principiis desumpta* (Parisiis: Apud S. Cramoisy, 1648) dedicated to Petit; Middleton, *The History of the Barometer*, 32–34; *Invention of the Meteorological Instruments* (Baltimore, Md.: Johns Hopkins Press, 1991), 16–17.

the latter proved to be much less precise than those of Giuseppe, and in fact Giuseppe's instruments made it possible for one to read a text perfectly from a distance while Divini's instrument enabled one to read only the capital letters of the first line. Divini himself, who was present while the three telescopes were being tested, confessed that the ones made by Giuseppe were much better.

Matteo then went on to comment on Torricelli's experiments with mercury and asserted that he would soon send Viviani descriptions of some experiments he had undertaken. These experiments, he claimed, proved that Torricelli's theory was correct. As soon as he could, he would send Viviani also a copy of a lecture he planned to present soon in the house of Father Lanci concerning these same experiments.[595]

Matteo's correspondence with Viviani on his Torricellian experiments, had started the previous summer, when in August 1663, Matteo agreed to comply with the request from Viviani and Lanci to describe the experiments with mercury that he had made in an attempt to assess the Torricellian theory. Of course, he added, his doctrine paled in comparison with that of such distinguished scholars. Nevertheless, he would do his best and begged their pardon in case his reasoning was not sufficiently clear. Recalling their discussions in Rome during Viviani's visit, Matteo wrote:

> To your most kind request, which you expressed upon leaving Rome, about those fantasies of mine that I described to you concerning the wonderful experiments with mercury that had been carried out by Signor Torricelli, you have now added another one through the service of the most Reverend Father Lanci, a man endowed with notable knowledge to whom I owe a great deal of gratitude. I then concede to both of you, although unwillingly, since I know that I may only demonstrate my ignorance, which deserves sympathy. Yet I find consolation in the knowledge of your extreme kindness, which will prevent you from making fun of me in public. This being so, the foolish reasoning of mine that I am about to relate to you will not come to the ears of others. I know that things will go this way, both because I kindly ask you to act so and because I am writing to you only in order to comply with your request, and not to make an appearance on the stage of some academic theater.
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> I then state that having admired the invention, and the effects that can be seen in those most clever vials of Sig. Torricelli, and having pondered the reason which, in his opinion, lies behind the experiment, I held it to be true for a long time. Later, however, I began thinking that those phenomena that one sees in that experiment—namely, the rising of mercury in the vials, which varies according to the different places and positions—may have been caused by the external pressure of the atmosphere, as the author of the experiment holds, or by internal attraction. This internal attraction could be regulated by Nature through proportionate means in order to prevent the separation of bodies, which she (Nature) always tries to keep together in the most clever ways to achieve her awesome schemes, I then took to thinking about other similar experiments concerning the rising of mercury to be performed in several and more numerous

[595] BNCF, Gal., vol. 254, cc. 264-65, letter from Matteo Campani to Viviani on May 24, 1664.

glass tubes by force of water pressure. I wished to see whether the glass tubes, once pulled out of mercury (on which water had to exert pressure) would keep the mercury that had risen inside them out of the external pressure of water as I had seen happen in some smaller vials.[596]

Thus, at first, Matteo had no reason to suspect that the cause of the rising and falling of mercury in the vials could be different from the reason brought forth by Torricelli himself. Afterward, however, he started pondering that there could be another reason for such reactions; instead of being the outcome of the pressure exerted by the atmosphere, those changes in the mercury could be caused by some form of internal attraction operating within the vials. Accordingly, Matteo began experimenting by making use of vials that were much narrower than the one they all had seen hanging from the ceiling in the apartment of *Abate* Lanci in San Pietro in Vincoli. He noted that the vial in Lanci's apartment retained all its mercury even when turned upside down and immersed in the basin. Matteo then described the experiments:

Now, these tubes of mine, as you are aware, were open. One was straight, the other was bent like a siphon. I put both of them inside a glass cylinder, at the bottom of which was a small quantity of mercury, and then I filled them with water. Afterwards, the mercury began to rise in the tubes as much as it should have. After this was done, I removed the straight tube from the mercury in which it had been placed, so that the mercury inside the tube, which had previously risen, began to flow out of it. I then immersed the upper end of the bent tube in a bowl filled with water, and having raised it just as I had done with the first one, I noticed that not only the mercury was flowing out of it but I saw the water rising inside the tube through that end that had been immersed in the bowl.[597]

Matteo commented that this experiment raised doubts in his mind about the explanation that Torricelli had offered for his experiments. Actually, among other things that he had been led to believe, including the reason for the various reactions that differed from those occurring with the vial suspended in air, it led him to wonder almost to the point of turning to the other opinion and disagreeing with the conclusions reached by Torricelli. For a time, he believed that the risings in Torricelli's vial was to be found in the vial itself, not outside it. Then he recalled that Viviani and others had pointed out to him that it was air pressure that was the proven cause of the mercury's fall and that such pressure entered through the opening on the upper end of the tube. Matteo's response at the time was that this air pressure at the top of the tube had to be the same as the pressure

[596] BNCF, Gal., vol. 254, cc. 250-54, letter from Matteo Campani to Viviani, August 11, 1663.
[597] Ibid.

exerted upward through the lower opening of the tube. Since his opinion was not appreciated by Viviani or by others as well, Matteo sought to make other experiments that would support his theory.

In his account, Matteo admitted that his previous speculations had been in error, and his aim now was to reconstruct the entire story. He went on to relate how Viviani had tried in vain to show him the correctness of Torricelli's thesis. At the time, however, Matteo had been determined on finding results that would confirm his own theory regardless of the advice of such famous men of science. In due time, however, Torricelli's well-deserved fame and the opinions of such renowned scholars as Viviani led him to have doubts about his much-disputed theory. He thus decided to undertake a new experiment, which he described as follows:

> I took a new tube, a larger one, yet its lower end was smaller than all previous tubes, so narrow that nothing thicker than a regular needle could enter it. I immersed it in a basin filled with mercury; then I raised it up as usual, and much to my surprise, I saw that, contrary to what had happened in my previous experiments, the mercury in the tube was kept up by the pressure exerted by the water, just as had happened in the said vial [in Father Lanci's apartment]. Furthermore, as I kept raising the vial up, both the water in the cylinder and the mercury in the vial went down proportionately.
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> This is a most striking phenomenon, which (besides showing, as I was saying, that the air cannot exert any considerable pressure downward in such open tubes, for as much pressure, due to the water pressed by the same air, is exerted upward) seems to provide visual evidence of the veracity of Torricelli's thesis. Having observed this, I again took the first narrow tube, the diameter throughout of which was about the size of a *piastra* [a coin used in seventeenth century Rome] about 2 *bracci* high, in the attached drawings shown as Figure ABC.[598]

Matteo then proceeded to describe experiments that he was to present in greater detail in his treatise published 3 years later. To make certain and to find further proof of the correctness of Torricelli's theory, Matteo then made another experiment, which he described:

> I stopped up the opening A of vial AC with a finger. Afterwards, I inserted two fingers of mercury in it through opening C. This done, I filled the remainder of the vial with water, ensuring that no air entered it. I then turned it upside down and immersed most of it in a cylinder LMN filled with water like the one shown in the illustration. I then moved my finger away from the opening A so as to let the air come in and in order to see what the reaction of the mercury in the vial would be. And so I saw that the mercury went down the tube all the way to point B, parallel to point M in the cylinder. After a few small vibrations, the mercury stopped and remained still,

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598 Ibid.; Giovani Battista Lanci, O.P., was pastor of the Church of S. Pietro in Vincoli. The church had been built by Sixtus III in the fifth century to house the chains that had bound Saint Peter in Jerusalem. To these were later added the chains with which Saint Peter is believed to have been bound in Rome.

just like a magnet that had reached its destination. No matter how much I moved the cylinder up and down, right and left, after a few little vibrations the mercury returned to the same position, that is, point M on the cylinder.[599]

This convinced Matteo once and for always of the veracity of Torricelli's explanation. Yet atmospheric pressure was certainly the main reason for the status of the mercury, although it might not be the only one. He continued to believe that some form of internal attraction may be at play, thus cooperating, so to speak, with atmospheric pressure in determining the movements of mercury. He suspected that some form of attraction may be operating within the mercury itself, expanding and reducing its volume. An answer to this hypothesis, Matteo felt, may come from experiments made with tubes of differing sizes and shapes.[600]

These experiments confirmed Torricelli's theory, as Matteo noted in the closing of one of his letters to Viviani: "Meanwhile, I will await your kind lordship to confirm the veracity of these impressions of mine, so that, free from any shadow of doubt, that it being the truth, I may once again, praise, as I used to do, that most clever and convincing opinion put forth by Torricelli and your Lordship, whose worth I admire and whose knowledge I worship. This said, I wish God may grant you all prosperity".[601]

In response, Viviani thanked Matteo for his letter but reported that he was unable immediately to verify the results of Matteo's experiments described therein because he did not have at hand neither glass tubing available nor mercury that he could use. He planned to obtain supplies of these as soon as possible, however, and he promised to report the results of his experiments after he had made them. In any case, he added, whenever the level of the mercury rises in a tube, the reason it does so is due to external pressure, for external pressure always seeks to achieve a balance with internal pressure. He added that he did not intend to deprive Matteo of the pleasure of invention.[602]

It was not until a week later that Matteo received Viviani's reply, he reported to him, because he had neglected to check the mail after the *ordinario* had passed. As for

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[599] Ibid.

[600] Matteo Campani, *Nova experimenta physico-mechanica pro demonstranda genuina causa elevationis aquae et mercurii* (Romae: Typis I. de Lazaris, 1666), folding plate with 20 figures.

[601] BNCF, Gal., vol. 254, cc. 250-54, letter from Matteo Campani to Vincenzo Viviani, August 11, 1663.

[602] BNCF, Gal., vol. 253, c. 212, letter from Vincenzo Viviani to Matteo Campani, undated but sent in response to Matteo's letter of August 11, 1663.

what Viviani had written, that when mercury rose in the tube as had occurred in Matteo's experiment, the reason was external pressure, he found it difficult to accept inasmuch as in those experiments he had made, he had closed all access to external air. Perhaps, he wrote, Viviani was referring to that little amount of air that remained above the mercury in the second tube, more precisely, the air remaining in the large cylinder. This possibility had to be discarded, he felt, as soon as one made the tube that is inserted in the cylinder larger and more capacious than the cylinder itself. In any case, he wished to make certain of the effect, then search for the cause. He added that if Viviani wished to expedite his research and to communicate Matteo's efforts to others, although it was of little moment, he was to be free to do so. "As a matter of fact", he added, "the desire to find the truth must come before any personal interests".[603]

Viviani was occupied with other matters at the Medici court so that once again time passed before he could reply. He sent a letter in late September and then another one on the 2nd of October 1663.[604] In this message, Viviani wrote commenting that the other day (when he wrote the previous letter to Matteo), as a man was waiting for him at his door with his litter [*lettiga*], it made him forget to comment on what Matteo had said concerning the freezing he had suggested doing in his experiments once the tubes had been closed. Viviani expected that the results would be the same, however, even after the operation as he had already dared to foretell because if, in the first experiment, the warming of the tube FE would be such as to expel all internal air there was no doubt that, once the neck was closed and the heat was gone, that will remain either completely empty, full only of ether, or that amount of fiery atoms that the surrounding atmosphere will provide. Consequently, the freezing will prove to be useless. If, moreover, some extremely rarified air will happen to remain, that surrounding the closed neck with ice that you suggest will not have any greater effect, he thought, than warming it up once open and then close it immediately afterwards.

Viviani informed Matteo that he shared the same opinion concerning the tubes of Matteo's second experiment. This experiment, he added, further confirmed Viviani's

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[603] BNCF, Gal., vol. 254, c. 259, letter from Matteo Campani to Vincenzo Viviani on September 8, 1663.

[604] BNCF, Gal., vol. 252, c. 90, letter from Viviani to Matteo Campani on September 25, 1663; c. 91, letter from Viviani to Matteo Campani on October 2, 1663.

belief that the rising of the mercury took place inside the tube "in which the air will be more rarified as a consequence of the heat or in which (provided that there has been a uniform rarefaction in both vases) the ice will have condensed the air," or, as he saw it, "in which the air will have been rarefied the most as a result of its fiery spirits [*ignicoli*] having been left out, and as a consequence, the departure of those that were disseminated there once the air in the other tube will be in condition to exert its motion more freely and to expand itself so as to restore balance in that vase." He underscored once again that such rising of mercury in the large vase will be almost unnoticeable, whereas it will be easy to see in the little pipe [*cannellino*]. Now that he was back home again, returned from the countryside, he promised to try to clear up the entire matter and asked Matteo not to hesitate to tell him about the experiments he was making in Rome.[605]

Matteo wrote to Viviani on the same day he had received his letter, stating, "In order not to bother you any longer with my letters, I had thought of waiting for the results of your two experiments and for your other two kind letters, thus postponing to another occasion thanking you for all of these things. Afterwards, however, I thought it unkind, and I have thus resolved to write to you to tell you at least that I have received all these materials from you and that I, as well as everyone here, am very pleased to learn that your hypothesis has proven to be correct".[606]

As for the other details Viviani had touched upon, Matteo decided not to say anything on the subject for the time being, for he had not kept copies of any of his own letters that he had sent, except for part of the first one. Consequently, he did not recall exactly what he had written, although he remembered that it had been his intention to find out whether there was such a thing in nature as what was commonly being called "attraction." In connection with this, it brought to his mind an experiment that might be better and more precise than all the others:

Let us imagine that we have a vial ABCD one and one half *bracci* high. Let us pour mercury in the vial through the opening B so as to have sections AB and CD (the latter is narrower than the other) full of mercury. To do so we must stop up the spout indicated with an E in the sketch.

Let us then practice the usual immersion and let us fill the mercury in the thin section of the vial all the way down to C, which we can do by opening spout E. Let us then stop up opening B, either with wax or whatever else will do, before dipping the whole vial once again in the usual

[605] Ibid.

[606] BNCF, Gal., vol. 257, cc. 244r-v, letter from Matteo Campani to Viviani, undated but posted on October 2, 1663, with sketch.

basin filled with mercury. While the vial is thus immersed, let us dispell all the air within it and the sphere DE through spout E by warming it up with fire. This done, let us stop up the said spout E. In warming up the tube filled with air, however, we must pay the greatest attention so as not to warm up the tube filled with mercury. In order to do so, we may insert a thin film of iron or something like that.

If, while cooling off, the mercury in the larger section of the vial will come down, thus rising in the other section until it will stop upon reaching the same level in both sections, this will be the indisputable proof of the following fact: the reason why at the beginning of our experiment the mercury in section AB was all the way up in that section of the vial was air pressure, namely, the pressure exerted by the air upon the mercury in the basin. This experiment has the peculiarity of showing persons like myself and these gentlemen how things take place before our very eyes.[607]

Matteo commented that this experiment raised doubts in his mind about the explanation that Torricelli had offered for his experiments. Actually, he indicated that he had been led to believe that the reason for the various reactions of mercury was to be found in some kind of internal attraction, that is, an attraction within the vial itself. His doubts were rebutted by Viviani and other distinguished scholars; the latter confuted his thesis by asserting once again that the cause of the changes of the level of mercury was the pressure exerted by the air upon the upper opening of the tube. Matteo tried to confute these assertions by stating that the same amount of atmospheric pressure must have been exerted from the bottom up through the lower opening of the tube.[608]

Matteo's treatise was published in 1666 in a volume entitled *Nova experimenta physico-mechanica.* He dedicated it to Sigismondo Chigi, nephew of the late Pope Alexander VII who had newly been named Cardinal by Pope Clement IX.[609]

Sigismondo, brother of Prince Agostino, was the younger son of the Pontiff's late brother Augusto Chigi. He had not become a member of the ecclesiastical hierarchy as had his late uncle Pope Alexander VII and his cousin Cardinal Flavio Chigi, yet he was sufficiently closely associated to serve Matteo's purpose as sponsor of his published work. His uncle the pope had assigned Sigismondo the position of Prior of Rome of the Knights of Malta, however, and in 1667, when the youth had reached the age of 19, Pope Clement IX created him cardinal with the diaconal title of Santa Maria in Domnica. This

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[607] Ibid.
[608] Ibid.
[609] Campani, *Nova experimenta physico-mechanica*.

rather pale adolescent figure was to die a decade later, in 1678, without having any notable accomplishments to perpetuate his name.[610]

At about the same time, Viviani received a report informing him that Carlo Dati (also a pupil of Galileo and Torricelli)[611] wished to tell Matteo that "the Cardinal" (whom was not named but in all probability was in fact the papal nephew Sigismondo Chigi) had expressed the wish, after having spoken with Abbot Stefano Gradi, to read Matteo's treatise. Dati added that he planned to visit Viviani on the 16th of the month, at which time he desired that Viviani would provide him with a copy of Matteo's writings to present to the Cardinal.[612] Dati, using a pseudonym, had published a small volume defending the memory of Torricelli; this was the first publication of the famous letters of 1644 describing the Torricellian experiment. Stefano Gradi (1613–1683), born in Ragusa of a patrician family of Dalmatia, was an erudite poet and diplomat. Through his uncle Pietro Benessa, secretary of Pope Urban VIII, he had been called to Rome where he completed his studies in theology. After receiving holy orders, Gradi returned briefly to Ragusa. Alexander VII subsequently sent him to France as secretary to Cardinal Chigi, and later in Rome, he became a consultant to the Congregation of the Indices and for more than two decades served as prefect of the Biblioteca Apostolica Vaticana.[613]

Matteo, on the verge of publication once again, vividly recalled his unpleasant experience in 1658 when his *Dell'Horologio Muto* on silent clocks had been censored by the Vatican's office of censorship, and thus he had taken steps to avoid the same fate for his new work, *Nova experimenta.* As previously noted, by using the device of dedicating it to a notable personage in the Church's hierarchy, it became possible to express, in a published form, ideas that officially the Church might frown upon. Matteo's book, the title of which may be translated as "New Physico-Mechanical Experiments to Assess the True Cause of the Rising of Water and Mercury", was published in Rome in 1666 with Church approval. It bore the imprimatur of none less than the Reverend Hyacinthus

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[610] Paschini, *I Chigi*, 37–38.

[611] Magda Vigilante, 'Dati, Carlo Roberto', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 1987). Carlo Roberto di Cammillo Dati (1619–1676) was a native of Florence and an officer of the Accademia della Crusca. Primarily a literary scholar, he was informed on some of the sciences.

[612] BNCF, Gal., vol. 257, cc. 206-207.

[613] Tomaso Montanari, 'Gradi, Stefano', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 2002).

Libellus of the Apostolic Palace, whom Matteo also had named in the work as a participant in Matteo's experiments. Matteo also was well-acquainted with Ignazio de Lazzari, the publisher or printer of the work, who maintained his printing shop nearby Matteo's church on Via Parione.[614]

From the very inception of his treatise, Matteo emphasized the importance of the experiments with mercury made by Evangelista Torricelli, which had made a great impression upon the men of science throughout Europe. The experiment, as he described it, consisted of placing a vial partially filled with mercury into a bowl which also was filled with mercury, As soon as the vial was lifted out of the bowl, free of the mercury, the mercury in the vial would overflow and spurt out of the vial's lower end. A number of different explanations to account for it were offered. In seeking an explanation of the phenomenon, Matteo Campani wrote that men of science debated over the nature of the void and of the air and other related topics, stirring a vast and wide-ranging dispute.

In the work at hand, he advised, he would limit himself to considering only the basic points, because a thorough and meticulous discussion could be accommodated only in a very thick volume. Accordingly, he divided his treatise into three parts—a review of the terminology being used, a description of Torricelli's experiment, and Matteo's own opinions concerning what Torricelli had done.

In setting out to define a series of concepts relating to Torricelli's experiment, Matteo began by considering the nature of a "body". A body was something tangible, even if only to a very small degree. He visualized an impalpable and impermeable space to be inane or empty. An inane and empty space was an area that could be occupied by various bodies. He went on to note that, therefore, whatever was inane could not be subject to tension, and then he moved on to discuss the nature of tension. Tension, he concluded, was directly proportional to the weights applied, and then he provided several examples with gears and other mechanisms to emphasize the direct relationship between tension and weights, as illustrated in his Figures 18 and 19.

[Figura dall'opera di Matteo Campani]

[614] Saverio Franchi, 'Lazzari, Ignazio', *Dizionario biografico degli italiani* (Roma: Istituto Giovanni Treccani, 2005).

He proceeded to produce another series of examples to serve the same purpose, relating to scales and balances, as exemplified in Figure 20. He emphasized that in making such experiments, it was necessary to pay attention not only to the weights that were being applied but also to the weights of the scales or balances and the lengths of their beams. This was important, he anticipated, also in relating to Torricelli's experiment with mercury, although he did not provide an explanation.

Matteo devoted the second part of his treatise to descriptions of the details of Torricelli's experiment, supplemented with Figures 1 to 10, inclusive. As illustrated in Figures 1 and 2, upon removal from a bowl filled with liquid (i.e., mercury), the mercury half-filling a glass vial starts spurting at the opposite end. A similar experiment was illustrated in Figure 3 in which, however, the vial half-filled with mercury was sealed at one end. To be noted was that the other end of the vial had a smaller diameter than the one used in the previous experiment. The consequence of these changes in the vial was that once it had been lifted from the bowl, the mercury did not spurt out of the vial.

Then, in Figure 4, Matteo illustrated it with a brief digression in which he recalled that he had first been introduced to these mercurial studies by Viviani. He commented that it had been while Viviani had been spending an extended period in Rome during the summer 3 years earlier, in about 1663, that he had described the experiments with mercury that were being undertaken in Florence by members of the Accademia del Cimento. Thus, Matteo became aware of the Accademia's activities, which he proceeded to cite in his text. Nor did he pass up the opportunity at this point to praise Prince Leopold, the Accademia's patron, and the Accademia's recent achievements, particularly the invention of the barometer. Then Matteo commented on having seen an unusual instrument, which he then described in some detail:

> Amongst the most remarkable inventions of this admirable genius is a most elegant and clever instrument that I had recently seen in the bedroom of Our Most Holy Lordship. The instrument allows us to know the degree of humidity of the air we breathe at any time of the year. It does so by means of a pointer, or a needle, the same as in a clock, that is placed at the center of a sphere (or semi-sphere) that is divided into many sections. All such sections, or better stated, of degrees, are of the same length. The aforesaid needle stops at one of these sections on the circumference, moving most swiftly from one to the other depending on the weather. It then remains in one point until a change in the air forces it to move either up or down.[615]

[615] Prototype of barometer shown to Alexander VII; Campani, *Nova experimenta physico-mechanica*, 21–22. From "*cuius eximi ingenii inter alia cuiusque difficilioris* to *ultra vel citra moveri contingat*."

Matteo's reference to "the bedroom of our Most Holy Lordship," [*in cubiculo Sanctissimi Domini nostri*] referred to the bedroom of the Pontiff, Alexander VII. After having described this prototype of a barometer, Matteo referred the reader to his Figures 4 and 5, pointing out that the mercury in the vial moved up (from BS to SA, the full length of the vial being AB) if it was moved slightly to one side. Then the mercury resumed its initial position when the vial had again been restored to a perfectly perpendicular position. Anyone could see for himself, Matteo commented, the consequence of these experiments, but the difficulty lay in attempting to explain them.

What, then, he asked the reader, was the reason for these puzzling effects? The difficulty in providing an answer to this question rested upon the fact that one should not seek a general cause, but rather that he should be searching for a specific one. It would not be sufficient to provide general answers, he wrote, and a precise reason for these effects must be found, specifying why that would be the cause as opposed to another reason.

In attempting to resolve the question, Matteo Campani wrote that many men of science had provided opinions in answer to the question, most of which can be said to originate from two main principles. One school of thought that was held followed Torricelli's own view, that the reason that mercury acted as shown in Torricelli's experiments was to be found in air pressure. It claimed that it was the pressure exerted by air that made mercury overflow. The other popular opinion held was that mercury spurted out of the vial because of the joining of two bodies in the same vial. The advocates of the latter view claimed that an absolute void did not exist, and consequently the touching together of two bodies in the vial caused the reaction described in the foregoing.

Matteo stated that many contrasting views had been given voice among the advocates of this last explanation concerning the nature of the two bodies involved. What kind of body, in fact, would occupy the space in the vial that was not occupied by the mercury? Some, among whom was the Jesuit Stefano Natali, believed it to be occupied by an extremely thin type of ether, some sort of extremely pure air. Others, among them Nicola Zucchi, the Jesuit Honoré Fabri, and Francesco Lino, held that this second body did not come from the outside but was something contained within the vial itself.

However, the advocates of this last explanation (whom Matteo called "tensionists" [*tensionistae* in Latin]) did not agree as to the nature of this body that would be contained within the vial. Zucchi stated that it consisted of spirits or exhalations [*spiritibus seu halitibus*] emanating from the mercury contained in the vial. Fabri and Lino, instead, held that the section ADS in the vial was occupied by a thin, tense body. It was the pressure of mercury, they asserted (once it has reached its highest point of tension), that made this body act as it did in the various experiments that had been described in the foregoing.

Yet, Matteo wrote, these two most illustrious men of science did not agree as to the nature of this body. On the one hand, Lino believed that this most thin of substances was nothing but the byproduct of the rarefication and the exhalation of the surface of the mercury contained in the section BS of the vial. Fabri, on the other hand, held that this substance was squeezed out of the vial's glass by the force of the mercury moving in, as he had written in his *Dialogues on Physics* published in Lyon in 1665. The pressure of the mercury was such that it made this substance flow out of the glass and occupy the entire section AS.[616]

Matteo believed that all of the possible explanations that the tensionists had put forth to be false, as he intended to demonstrate by describing the experiments he had carried out on this subject. In his view, it was only by virtue of new, sound experiments that the answer to these questions was to be found.

The final section of Matteo's treatise[617] was dedicated to description of his own experiments. He began by stating that Torricelli's experiments did not support the existence of the Aristotelian void, that is, of a void conceived of in a Peripatetic sense. Nor did they support the existence of the so-called "Lucretian inane," i.e., pure void. Actually, Matteo argued, Torricelli's experiments did not show the reason why mercury acted as shown in the foregoing, nor did "the wonderful experiments most cleverly conceived and carried out by the most renowned Robert Boyle in his excellent book, '*On experimentis physico mechanicis de aere*,' nor by Francesco Lino's objections to Boyle's

[616] Ibid., 29-30.
[617] Ibid., 34-79.

work." In order to answer this question, Matteo wrote, one must undertake a series of utterly new experiments.[618] This is exactly what Matteo proceeded to do.

His experiments, Matteo noted, allowed one at least to find out the cause of such effects by means of analogy. The first analogy he set out to illustrate was that between water and air. Here he pointed out that a body immersed in water would be attracted to, and eventually would be sucked up, by a concave body, such as a rod or a vial, that also was immersed in the water and the upper end of which emerged from it. Matteo used the example of a finger that, being underwater, was made to approach close to a tube, the upper part of which stuck out of the water. The closer the finger approached the tube's opening under water, the greater would be the force attracting it toward such an opening, until eventually it would be sucked up by the tube. He then underscored the similarity between water and air. The pressure, he wrote, exerted by the water upon even heavier liquids is well known. Matteo further stressed this obvious point by inviting the reader to look at Figures 6, 7, and 8 in his treatise. They illustrated three vials of differing sizes filled with mercury, all of them inserted in a glass cylinder. Once water was poured into the cylinder, the mercury contained in the three vials began to rise owing to the water's pressure, until it reached the same level in all three vials. Water was thus useful, Matteo asserted, to demonstrate the reason for mercury's behavior in most of Torricelli's experiments.

At this point, Matteo made haste to emphasize that it was possible to account for most, although not all, of the results of Torricelli's experiments by using this analogy between water and air. As a matter of fact, he commented, we would have to be surrounded by water instead of by air to give an answer for all of Torricelli's experiments through the analogy between water and air. Nonetheless, he affirmed, the importance of this analogy was not to be overlooked. For instance, it provided the opportunity to note that the section in the vials that was free of mercury was not occupied by any kind of particularly pure air. To urge his point, Matteo referred the reader to Figures 9 and 10 of his treatise, in which were visible two vials that were inserted into a basin of mercury. Both vials contained the same amount of mercury, yet the one in Figure 10 was enclosed

[618] Robert Boyle, *Nova experimenta physico-mechanica de vi aëris elastica et ejusdem effectibus, facta maximam partem in nova machina pneumatica* (Roterodami: Arnoldi Leers, 1669).

in a larger cylinder-shaped vial filled with water. Once both vials were lifted slightly from the bottom of the basin, the mercury they contained began to descend at the same pace, and it stopped flowing upon reaching the same level in both vials. The difference between these two vials, Matteo asserted, and the identity of their behavior, demonstrated that the reaction of the mercury contained therein had nothing to do with the quality of air.[619]

Furthermore, Matteo continued, water was helpful also in showing that the vial sections free of mercury were not occupied by some kind of exhalation or spirits given off by mercury while moving within the vial. The very foundation of this thesis, according to Matteo, was false, for there was no substance whatsoever pushing the mercury up or down within the vial. The advocates of this thesis had conceived an analogy between the vial filled with mercury in Torricelli's experiment and a syringe. Yet this analogy was groundless, Matteo claimed, as shown by his Figure 11. This figure also, as in Figures 9 and 10, illustrated an experiment carried out by Matteo. It showed a long, wide tube open on one side (B) and closed by a thin film on the other (A). A small glass bell, with a narrow opening at the top, was placed on top of side A. Water was poured down the opening of the glass bell surrounding side A, thus filling the section to the top and eliminating all air from it. The bell thus filled with water was then sealed, in order to make certain that no air remained within it. The tube was then half-filled with mercury and stuck in a basin. Once inserted in the tube, mercury began going down until it reached level S, halfway through the tube. His point was that no tense body could be said to be contained in the upper part (AS) of the tube, that is, in the section free of mercury. If a tense body occupied that section, Matteo argued, the tension exerted by mercury would make it break the thin film closing the upper part of the tube (end A), thus making the water contained in the glass bell on top of it fall.[620]

Matteo then illustrated a curved vial, the upper part of which was in the shape of a small sphere, in Figure 12. This sphere was filled with water, whereas the remainder of the vial was filled with mercury. If the vial's opening was stopped with a finger until the vial had been placed in a basin, he wrote, and then the finger was removed, the reaction

[619] Campani, *Nova experimenta physico-mechanica*, 39.
[620] Ibid., 41.

of the components within the vial were to be observed. All such reactions, he asserted, confuted the opinions of the tensionists. In point of fact, he wrote, one saw the water descending from the upper sphere until it joined with the mercury contained between the vial's first and second curve (section BCD). This quantity of mercury moved upward toward the descending water. On the other hand, the rest of the mercury, that which was originally contained in the section past the second curve, moved down until it reached the usual level S, without bringing along any of the mercury originally kept in section BCD. Such a diversified motion of the elements contained in the vial, Matteo asserted, proved that, contrary to the opinion of the tensionists, there was no tense body contained in it.

Figures 13–15 illustrated other experiments that Campani carried out to confute the tensionists. The main principle, which in his eyes ruled this experiment and rebutted the opinion of the tensionists, was that a would-be tense body exerting some kind of tension within these vials would make the mercury distribute itself evenly in the same direction. Experience, however, as Matteo pointed out indicated otherwise. Figure 13, for instance, featured a two-legged vial topped by a small sealed sphere filled with mercury. Once the two legs of the vial had been inserted in two cylinders filled with mercury, the mercury in the vial began to descend, until it reached level S in Figure 13. It was also to be noticed, Matteo added, that the mercury that originally occupied section BD would not follow the mercury of the right hand leg ending in Cylinder X, instead it would proceed down toward D, filling the lower part of the glass sphere at level C. Furthermore, an upward motion of the mercury contained in either leg of the vial would be caused by raising cylinder T or X.Eventually, the mercury thus raised would flow into the upper glass sphere and fill it. Finally, if the sealed top of the glass sphere was pierced with a needle, the mercury contained therein (section CD) would move up toward B and then fall toward F, until the glass sphere has been completely emptied out.[621]

Matteo stressed the fact that, once again, if there were a tense body exerting some kind of tension on the mercury, the latter would spread and move evenly, just as would happen with the liquids contained in a syringe once the piston was moved either up or down. This not being so, Matteo asserted, the theory of the tensionists was proven to be

[621] Ibid., 44–45.

false.[622] The same conclusion, he added, was reached on the basis of the experiments illustrated in Figures 14 and 15.[623] Here also he stressed the same point, namely, mercury's uneven reaction once one of the two cylinders in these pictures was raised or lowered.

This having been said, Matteo Campani moved on to confute another point held by the tensionists. Figure 8 illustrated a very thin tube containing both water and mercury. This tube was so thin, he wrote, that the two liquids contained in it could not move up or down at the same time. The tube was immersed in a cylinder filled with water from E to C and mercury on the bottom (EG). Once the tube was slightly raised from the bottom of the cylinder, the mercury, which initially stretched from B to S, moved up the tube, reaching point ZT in the section RT. Matteo then suggested that the tube should be weighed on a scale, marking the two ends R and T of the section now occupied by mercury. Then, he wrote, if the tube were out of the water, keeping a finger on the upper opening (A), whatever amount of water had been lost in the process was then added, so as to bring the mercury back to its previous level (RT). Then the lower opening (B) was to be sealed with wax and the tube put back in the cylinder filled with water and mercury, just as it was in the beginning. If the whole thing was again weighed, he wrote, one would notice that the total weight has remained the same.[624]

Unfortunately, Matteo did not always specify what he aimed to demonstrate by means of this last experiment. Probably the entire matter seemed to him to be self-explanatory, and as such, not deserving of further comment. Yet he illustrated another experiment in order to make his confutation of the tensionists even clearer. Figure 7 illustrated an experiment, the result of which, he claimed, confirmed those previously illustrated through Figure 8. This time the tube was large, so that its contents could move freely. Just as before, the tube was immersed in a cylinder containing water with mercury on the bottom. This time, he wrote, the mercury contained in the tube moved down slowly but inevitably, so much so that even if the tube was raised, the mercury in the tube would continue to descend toward the mercury lying on the bottom of the cylinder. In Matteo's opinion, this once again confuted the theory of the tensionists, bearing witness,

[622] Ibid., 51–52.
[623] Ibid., 53–58.
[624] Ibid., 49–50.

on the other hand, to the veracity of Torricelli's explanation. The cause common to all the phenomena hereto discussed, he wrote, is the one already indicated by Torricelli, namely, air pressure. "Following Torricelli," he wrote, "we assert this common cause to be air, the same air we all breathe. It is air which, by virtue of its weight, presses and pushes all other fluid bodies, making them move about every empty space, not unlike a piston whose motion encompasses the whole volume in question".[625]

In order to prove the veracity of Torricelli's assertion, Matteo resolved to undertake various experiments. He immediately underscored the novelty of such experiments, for no other scientist, he remarked, had hitherto set out to accomplish such a task. From among his experiments, Matteo chose the one that he considered best to illustrate the exactness of Torricelli's thesis. He noted that only a chosen few, all of whom were his close friends, had been previously informed of this experiment. Among them he had included the Reverend Hyacintho Libello, censor of the Apostolic Palace; Mario Albericio, secretary of the Sacred College of Propaganda Fide; Giovanni Maria Lanci of Fano, Abbot General of the regular canons of San Salvatore; Tommaso Retano, procurator general of the Congregation, Michelangelo Ricci, Gian Domenico Cassini and Francesco Eschinardi.[626]

A new kind of balance [or scale, *libra*] invented by the same Matteo Campani, was central to this experiment. He thus reminded the reader of the importance of what he had said in the initial pages of his tract about tension and scales. The scale he had invented would prove that no body subject to tension was to be found in the vials filled with mercury. Instead, it would demonstrate the existence of a proportion between the weights of the various amounts of mercury employed in the experiment and also between the volumes of the vials.[627]

To explain his experiment, Matteo referred the reader to Figure 16. He provided the following instructions for making his experiment:

Take a long and narrow vial, so narrow that mercury and water cannot up down it at the same time. Then take a thin piece of iron and use it to insert mercury in the vial. Slowly remove this thin piece of iron being careful not to allow any air become mixed with mercury. Then stop up End B of the vial with a finger and turn the vial upside down until it is perfectly perpendicular

[625] Ibid., 59–60.
[626] Ibid., 64–65.
[627] Ibid., 66.

above a basin. Slowly remove your finger from End B, until mercury will have reached the usual S level, at 29.5 inches. Afterwards place the vial in the basin filled with mercury until End B touches its bottom, tilt the vial until mercury reaches the Level T, i.e., rising a little above level S, approximately 1 inch [*uno digito*]. Stop up End B with your finger while the vial is in the basin, then lift it, keeping it tilted, and remove your finger from the lower opening. You will then see the mercury move all the way toward End A of the vial.[628]

In Matteo's opinion, this experiment proved two things. First, it showed that when the vial was perpendicular to the basin, mercury would fall below End B for the length of the space indicated as TS in Figure 16. Secondly, once the ratio between mercury and air has been re-established, mercury would stand still, provided that one was slowly removing one's finger from End B. On the contrary, if one opened End B too abruptly, the mercury would fall quickly down through that end into the basin underneath, leaving only as much mercury in the vial as indicated by the letters B and R in Figure 16. This last quantity of mercury occupying section BR of the vial would then be attracted to the other end of the vial (i.e., opening A) by the pressure of the air, just like a light scale pan is pushed upward by a heavier scale pan. Matteo insisted on the parallel between the vial used in the experiment and a scale by noting that the speed with which the lighter scale pan was moved upward was proportionate to the difference in weight between that pan and the heavier one. Likewise, he affirmed, the greater the amount added to the mercury originally contained in the vial, the faster would be its descent into the basin. For the same reason, the less mercury that would remain in the vial, the faster would be its ascent toward the other end of the vial once most mercury had fallen into the basin.

In conclusion, Matteo wrote, the way in which one tilted the vial and the speed at which one stopped up and then opened End B would make the mercury kept in section BS either rise to T or fall down to R. The tilting of the vial and the motion of the finger alternately stopping up and opening End B alters the weight of the mercury in the vial and the amount of air in it. On the same page, he also pointed out that both the rise of the mercury when the vial was tilted and its fall once the vial had been restored to its upright position were continuous, until the mercury has reached either End A or End B of the vial.

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[628] Ibid., 67–68.

The results of the experiment carried out, thanks to his newly invented scale, Matteo asserted, dismissed the first principle of the tensionists, namely, that when moving down the vial, the mercury would make room for some kind of substance subject to tension. No such substance could be said to occupy section AS of the vial in Figure 16, for, as Matteo pointed out on p. 75, it was typical of stretchable bodies to spring abruptly whenever possible and then come to a complete stop. The motion of mercury in the vial in his experiment, Matteo observed, was of a different nature, much more similar to that of falling weights, whose speed increased as they kept falling. Many other conclusions, Matteo wrote, could be drawn from his experiment and from the use of his recently invented *statica fistula* (literally, "static vial" unless he erroneously connected the term *statica* to *stadera*, in which case the translation would be something like "scale vial").

Leaving them aside for the time being, Matteo resolved to illustrate just one more motion drawn from this experiment. He then referred the reader to Figure 17. As he pointed out, the two-legged vial in the illustration was very similar to the one in Figure 13. This time, however, the entire vial was immersed in water within a large glass cylinder. His purpose here was to show that the same results obtained in the experiment illustrated in Figure 13 would be obtained now, even though now the vial was surrounded by water instead of by air (except for its two ends, A and B, sticking out of the cylinder). In Figure 17, he noted, mercury acted just as in Figure 13. Although he does not specify why, Matteo asserted that this fact further confuted the tensionists' thesis. It is likely that, in Matteo's eyes, mercury's identical reaction in a volume surrounded by either water or air proved the thesis of the tensionists concerning spirits and exhalations to be wrong.[629]

In June 1666, Viviani wrote to Ottavio Falconieri in Rome stating that the latter must have become aware that for some time past there had been a practice introduced, which he could not decide whether it was laudable, of what he called the despicable custom or habit that seemed to be spreading throughout Europe of publishing scientific treatises and letters containing concepts, opinions, details, and experiences—sometimes with accuracy but at other times stupidly or foolishly—without obtaining the author's consent and without fear of reprisal. He complained bitterly about the practice and enjoined Falconieri to induce Matteo Campani not to publish any of his, Viviani's,

[629] Ibid., 77–78.

treatises or letters on scientific matters that he may have sent him. Viviani went on to state that he was even willing to pay the costs of having such writings of his, if published and were about to be circulated, withdrawn from the market and destroyed.[630]

Falconieri responded promptly, informing Viviani that he had just arrived in Rome after having spent the entire previous month at Castel Gandolfo with the Pontiff and the papal court. Immediately after returning to Rome, he had visited Matteo Campani to do what Viviani had charged him in his most recent communication concerning the text Matteo was planning to publish concerning his experiments with mercury. Falconieri reported that the work was already completed, and he sent Viviani a copy so that he could see for himself.

"At first I was sorry to learn that the work already had been finished," Falconieri wrote, "and fearing that I had not been in time to fulfill your orders and that something displeasing to you may have been part of the text. I was much comforted later when assured by Campani himself that you were not mentioned in his work except for that paragraph in which he praises you highly as one of those who attended the experiment held in San Pietro in Vincoli. Therein Campani has not written anything about your opinion concerning the experiment nor does he mention anything for or against you. He showed that passage to me and I must confess that I found nothing in it that could give you the least concern".[631]

He was grateful to Falconieri for having delivered the copy of Matteo's work in which the author had insisted on so honoring him. He apologized for having reacted somewhat rudely in his letter, requesting Falconieri to contact Matteo to prevent his work from circulating without Viviani's consent.[632]

After receiving this copy of Matteo's newly published volume, by hand of Ottavio Falconieri, Viviani lost no time in making gracious acknowledgment. "I have just received from the Most Illustrious *Signor Abate* Falconieri, who is a very dear friend of mine", Viviani wrote, "a copy of your beautiful and most curious book. I thank you, not only for the publication but also for the extremely kind and laudatory mention of me that you have included in its pages. Actually, my only merit is to have had the honor of being

[630] BNCF, Gal., vol. 252, c. 164: letter from Viviani to Ottavio Falconieri ante June 5, 1666.
[631] BNCF, Gal., vol. 255, c. 17: letter from Ottavio Falconeri to Viviani, June 5, 1666.
[632] BNCF, Gal., vol. 252, c. 111v, letter from Viviani to Ottavio Falconieri on July 22, 1666.

admitted to your clever speculations during that brief period of time in which I have had the opportunity to enjoy your company and to serve you. I profess myself to be most obliged, therefore, by your kindness and look forward to reciprocating it. In the future, please feel as free in requesting favors of me as you have been in lavishing praise upon me".[633]

It was not until 1670 that the subject of Matteo Campani's publication on mercury occurred again in Falconieri's communications from Rome to the Grand Duke, and then it was an evaluation of Matteo's *Nova Experimenta*. After reporting that he had observed an eclipse, during which Falconieri noted that the observers lacked an astronomical clock, he added:

I too hold the impression that in his little book [*Nova experimenta*] Campani has dared to promise more than he is able to keep in practice, and if he had shown me this work before, I would have suggested to him that he keep himself more than a step behind [be more cautious], especially since in this case one has to deal with quite outstanding men such as [Robert] Boyle. That which I had already mentioned to Your Highness immediately after I had seen the book for the first time is that, to put it this way, frankly it had seemed to me that he did not demonstrate much, so that I had the impression that there would be objections and opinions contrary to the conclusions that he expressed in that book. I still have not seen Signor Michel Agnolo [Michelangelo Ricci] after his return from Frascati, which occurred two days ago, so that I am unable to say anything to Your Highness concerning his opinion of this small book; neither has Father Davisi [Urbano Davisi, S.J.], whose opinion I asked about the same matter the other day, had as yet seen the book. The other day [Matteo] Campani himself showed me a letter from Cassini from which it is clear that he appreciates and esteems this book in an outstanding way, especially that part which Your Highness considered to be praiseworthy, i.e., the part containing the critique of the old theories he enumerated sustaining the theory of tension and who generally are opposed to the theory of the pressure of air.[634]

Sometime later, Matteo Campani performed these experiments with mercury at the residence of Sigismondo Chigi, to whom he had dedicated his book. The performance of the Torricellian experiment at the residence of the Cardinal Chigi, and the presence in the collections of the Biblioteca Apostolica Vaticana of Prince Sigismondo's copy of Matteo's volume, bound in full leather and bearing the Chigi arms on the cover, supports the fact that a receptive attitude toward the new science did in fact exist among members of the highest ecclesiastical circles.[635] Among the participants who witnessed the

[633] BNCF, Gal., vol. 252, cc. 111r, letter from Viviani to Matteo Campani on July 20 or 30, 1666, autographed minute.

[634] 'Memo to the Grand Duke from Ottavio Falconieri' (10 March 1670), filza X, cc. 322r-v-323r, Carteggio di Artisti, Archivio di Stato di Firenze.

[635] Sigismondo's copy of *Nova experimenta* is in the Biblioteca Apostolica Vaticana.

Torricellian experiment in the residence of Prince Sigismondo Chigi had been the Abbot Francesco Nazzari. A native of Bergamo and professor of philosophy at the university La Sapienza in Rome, Nazzari became editor of the new periodical *Giornale de' Letterati*, initiated in January 1668 in Rome in imitation of the *Journal des Sçavans*, which first had appeared in Paris 3 years earlier.

In the June 1677 issue of the *Giornale de' Letterati*, in an entry alluding to Matteo's *Nova experimenta*, the editor Nazzari wrote: "Signor Matteo Campani, in the presence of Cardinal Sigismondo Chigi and others among whom I had the honor to be present, made the following experiments that demonstrated . . ." and it was there Nazzari's statement ended, without explanation![636]

In the same June 1677 issue of the *Giornale*, Nazzari again alluded to the selfsame Torricellian experiments organized by Matteo Campani in the palace of Cardinal Sigismondo Chigi. In an entry entitled "Experiments that demonstrate that the pressure of air causes the raising of mercury in the Torricellian tube", Nazari wrote, "he sustained mercury in glass tubes closed at one end, of which I have spoken many times in the *Giornali* and later in [No.] II of this year, it was Torricelli who made the first experiments, believing the effect was due to the pressure of air, and by others attributed to Nature's horror of a vacuum or to the tension of the ether [*Etere*] remaining in the tube. Before the Cardinal Sigismondo Chigi and others with whom I had the honor to participate, Sig. Matteo Campani made the following experiments that demonstrated the truth of the first and the falsity of the other opinions concerning this effect". Nazari went on to comment that Matteo had never been mentioned in the *Giornale* edited by Ciampini, "although he was honored by having been mentioned two other times in that of Nazari, for his publication on the "Restrained Scale, that is, A Useful and Happy Invention that Obligates the Weigher To Give Correct Weight" and above all, for his treatise of the *Horologium solo naturae*, no less distinguished for its dedication to Louis XIV".[637]

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[636] 'Collegium experimentale, sivè curiosum, in quo primaria huius saeculi inuenta, & experimenta physico-mathematica &c. continentur, edidit Ioannes Christopharus Sturmius Norimbergae 1676. In 4.', *Giornale de' Letterati* 1678, no. vii (1678): 109–11. Describes the experiments that demonstrate that the pressure of air causes the raising of mercury in the Torricellian tube.

[637] Matteo Campani, "La Stadera Imbrigliata, ovver inventione utile e facile che obliga il pesatore a dare il giusto peso, di Matteo Campani"; "Esperienze che mostrano la pressione dell'aria cagionar il

Matteo Campani's interest in the experiments on the pressure of air on mercury was considerable, reflected in his expression of gratitude to Viviani and concerning the Torricellian studies for which, in 1663, he had provided inspiration and assistance.[638] Matteo's endeavor to interpret the Torricellian experiment was in fact a major undertaking in that time, in which he was supported by a work subsequently published by none other than Daniello Bartoli. The acknowledgment Bartoli made therein of Matteo's contribution is of considerable importance, as the question continued to be debated and elaborated in Jesuit circles, above all with the theory of space, in which Matteo's work had particular influence. Matteo's publication is of value primarily because it again exposed and documented a large part of the diverse and numerous experiments that were being conducted over three decades on this subject. Bartoli's intention was to illustrate the two theses contrasted eventually in order to furnish the simple story of the experiment.[639]

Bartoli's tract, translated as "The Tension and the Pressure Disputing on which of them sustains the quicksilver in the Tubes once the Vacuum has been produced in there. . . ", was reviewed in the *Giornale de' Letterati* in 1677, soon after its publication, noting that in his work Bartoli had gathered together comments by other *letterati*, presenting first a simple account of the experiments, then the universal principles of the two major opinions "Pressure" and "Tension," and finally supporting one of the two as being the better one.[640]

The results of Matteo's experiments concurred with those of others in furnishing the proofs of sustaining the pressure that already in manifest manner had conquered the favors of Bartoli. He assigned the role of most evident proof to the experiment with the air pump of Robert Boyle, but a function in his adherence to the theory of atmospheric

sollevamento dell'argento vivo nella Canna Torricelliana," *Giornale de' Letterati*, 76, IV, 77, V. (June 1677); vide: Gardair, *Giornale de' Letterati de Rome*, 92, 249-50.

638 Campani, *Nova experimenta physico-mechanica*, 21: "*Cuius tamen observationis non parvi ponderis . . . occasionem mihi dedit vir clarissimus Vincentius Viviani, Serenissimi Magni Ducis Etruriae Primarius Mathematicus, ac Torricelli, studiosissimus: quique ad haec studia me vertit, ut primum supradicta experimenta tribus circiter ante annis hic in urbe exhibuit*".

639 Daniello Bartoli, *La tensione e la pressione disputanti, qual di loro sostenga l'argento vivo ne' cannelli dopo fattone il vuoto [...]* (Roma: N.K. Tinassi, 1677).

640 Daniello Bartoli, 'La tensione e la pressione disputanti, qual di loro sostenga l'argento vivo ne' cannelli dopo fattone il vuoto. Discorso del P. Daniello Bartoli della Compagnia di Gesù', *Giornale de' Letterati* X (1677): 152–54.

pressure had of course been performed and asserted by Matteo. As Bartoli wrote, "Other [objections to the pressure] passed off as valid evidences, are contradicted by the factual evidences: and some of those are well illustrated in the tract of the physical-mathematical experiments by Signor Matteo Campani". Finally, noteworthy is the fact that Bartoli ended his text, as had Matteo, with the doubt as to which was the cause of the failure of cohesion of two plates [*lastre*] to adhere perfectly. Even from this text, therefore, emerges confirmation of the conspicuous role exercised by Matteo in one of the first experimental disputes of modern science.[641]

The treatise *Nova experimenta* was reprinted some three decades later, in 1692, in a compilation by Gaudenzio Roberti (1655–1695). Between 1686 and 1690, Roberti had edited the publication *Giornale de' Letterati di Parma* in collaboration with Benedetto Bacchini; it was modeled after the *Giornale de' Letterati* initiated in 1668 in Rome. Roberti's *Miscellanea* furnished documentation of Italian scientific publication during the second half of the seventeenth century. Roberti considered Matteo's work to be of sufficient importance and interest to be included with that of his better known contemporaries in the field of science. In addition to Matteo's work on mercury, the volume contained *De sphaerea et solidis sphaeralibus* by Guglielmi, texts by Cassini and Montanari, and *Discorsi su osservazioni cometarie* held at the Accademia Fisica Matematica of Ciampini.[642]

It is surprising that the late Dr. W. E. K. Middleton, in his exhaustive works on the barometer and other meteorological instruments, had made no mention of Matteo Campani's book *Nova experimenta*, nor had he been aware of it until it was brought to his attention by the present author. As Middleton subsequently commented, one of the reasons that Matteo Campani's book on the Torricellian experiment was of interest was primarily because it demonstrated how it was possible in his time to express ideas that were unpopular and officially frowned upon in Church circles by dedicating the work to an important personage. Matteo had written, "With the ancient philosopher Lucretius, I call an intangible and permeable space empty, or a vacuum, for the reason that things can

[641] Bartoli, *Tensione e la pressione disputanti*, 1677.

[642] Campani, *Nova experimenta physico-mechanica*, 21; Bonelli, 'Ultimo discepolo', 664–65; Giorgio Abetti and Pietro Pagnini, eds., *Le opere dei discepoli di Galileo Galilei*, vol. 1. Accademia del Cimento (Firenze: Barbera, 1942), 271–78.

exist, be produced, be moved, and act in it. And on this account I believe that such empty spaces are diffused through all bodies".[643]

Matteo's *Nova experimenta* dealing with the Torricellian experiment confirms that he was more than merely another minor figure in the sciences in his time, although his progress toward a major role had been stringently limited by his parochial responsibilities and appears to have been at least to some degree impeded by his lack of a solid basis in mathematics.

Filed away among the papers of the Medici princes is a critique of Matteo's little volume by an unidentified writer. Although the manuscript report is unsigned and undated, it obviously was a report compiled for the Accademia del Cimento:

Having examined the tract by Campani, I am pleased to see that, thanks to the exposure to the experiments of our Accademia, shown to him here by Viviani, he has turned into the right direction. Or to what is generally considered as such by those who, in the study of Philosophy (Science), follow the experience and the rationality, more than their own passions or someone else's authority. But with respect to what he afterwards so strongly states, i.e., that all the experiments and explanations produced thus far to affirm the positive truth of the air pressure in the quicksilver experiment, or [to state] the falsity of the usual subterfuges of the peripatetic philosopher, are insufficient and ineffective, and that he has been the first one to achieve such a result with new experiments, and that, having discovered the real truth, he has defeated the entire peripatetic school, I will not deny that those are enterprises worthy of one who possesses a great mind, but I do not know to what extent his outcomes are equivalent to his good will. In fact, as to the first point, on the one hand he himself states that the experiments and reasons produced by Liera and other Peripatetics against those of Boyle and of all the others who affirm the question of the air in relation to the Torricellian phenomenon, or suspension of the quicksilver, are of no moment. On the other hand, I see that he himself does not present any evidence against them which might in some way show their insufficiency and ineffectiveness. And finally, we know that besides our Accademia, those of France and England, which practice the experimental method, as well as many others among the most excellent minds of Europe, have considered the above mentioned experiments and explanations so effective, and sufficient to prove that the air pressure is the real cause of the already mentioned phenomenon, that at present they have no doubt concerning this matter. Having said this, I therefore, cannot understand how one could make those experiments and explanations insufficient by simply saying so.

Moreover, as to the second point, I do not think to have noticed in the proposed experiments any novelty of any importance, but only things which either Boyle lately, or Pascal, Roberval or others after Pacqueto, or before anyone else Tommaso Cornelio, have either accurately described, or briefly mentioned, or that can easily be inferred from them. And with the only exception of Boyle, it would not be a great thing if Campani had never had the opportunity to see their experiments. In which case he could be excused for having considered many things as his own inventions, even if they are not such except for some external and accidental aspects of the experiment itself. And that will be well evident by means of a comparison, since it would be too annoying to examine now those aspects one by one.

[643] W. E. Knowles Middleton, 'Science in Rome, 1675–1700, and the Accademia Fisicamatematica of Giovanni Giustino Ciampini', *The British Journal of the History of Science* VIII, 2, no. 29 (July 1975): 140.

It is true, however, that as for the specific subject of those who have done so, he has expressed some good and some original thoughts, moving from the ideas of Liera and Father Fabri, which lived after the times of the above mentioned authors. However, he seems to consider too easy a task to persuade and completely convert a peripatetic who is unwilling to believe (or to change his mind). If the experiments were enough for that purpose, we would have nothing more to desire right now, since the ones invented thus far are of the strongest evidence.[644]

As Vincenzo Antinori commented in 1841 in his notes related to the history of the Accademia del Cimento, "The discovery of the barometer . . . made it necessary to change the essence of physics, as the telescope did that of astronomy, as the circulation of blood did those of medicine, and Volta's pile did that of molecular physics".[645]

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

[645] Vincenzio Antinori, "Notizie storiche relative all'Accademia del Cimento," in *Saggi di naturali esperienze fatte nell'Accademia del Cimento: preceduta da notizie storiche dell'Accademia stessa e seguitata da alcune aggiunte*, Terza edizione fiorentina (Firenze: Dai Torchi della Tipografia Galileiana, 1841), 27; [*La scoperta del barometro . . . fece cambiare l'aspetto della fisica*, *come il telescopio quello dell'astronomia*, *la circolazione del sangue quello della medicina*, *la pila del Volta quello della fisica molecolare.* Mauro Recenti, "Il Caso Campani" 1994 (unpublished manuscript), unpaginated]; Campani, *Nova experimenta physico-mechanica*, 9.

Chapter XII

CLOCKWORK IN A VACUUM

(1663–1672)

“What do you think of the new kind of clock whose motion takes place in a vacum to avoid inequalities produced by the air?”

Letter from Henry Oldenburg to Christiaan Huygens, November 11, 1669[646]

In the years preceding Matteo Campani’s engagement with mercury’s experiments in 1663—that will lead to the publication of his *Nova experimenta* in 1666—his thoughts kept reviewing in his mind other scientific matters. Repeatedly, his mind returned to the subject of time measurement, a dominating interest he had shared with his two brothers, Pier Tommaso and Giuseppe, since their arrival in Rome. He was pleased by how both had moved on to win one accolade of praise after another for their horological achievements. In the interim, meanwhile, ruminated Matteo ruefully, he had remained stalled in their shadows in a subdued sustaining role even though he had been equally dedicated to invention.

The recent visit from Pierre Guisony, the French physician from Rouen, kept coming to mind, and Matteo remembered how the visitor had admired Giuseppe’s clocks and discussed the pendulum and silent clockwork. He recalled his own discussions with Giuseppe after the visitor’s departure, and then his thoughts leaped back to his own visit to Florence some years earlier. There he had seen Galileo’s “measurer of time”, which his son, Vincenzio Galilei, had unsuccessfully attempted but had failed to complete. That had been the aging sage’s last attempt to develop a timekeeper for determining the longitude

[646] Christiaan Huygens, *Oeuvres Completes*, v. 6, pp. 532-535.

at sea, Matteo reflected, and thereafter had been totally ignored following Huygens's success with clockwork regulated by a pendulum.

After Guisony's visit, the Campani brothers individually continued to give serious thought to their visitor's comments, which apparently led them eventually to separately undertake new experiments that the meeting had inspired. Each of the brothers pursued his own ideas, without communicating with the other, apparently each hoping to be the first to succeed. Giuseppe kept his customary silence as he went about his work, while Matteo's mind frequently kept returning to Guisony's comments. Deciding finally to venture upon the project, it would be a double success, he thought, if he could achieve it without informing or involving Giuseppe.

Nothing more is known of the status of the projects of the two brothers until in the spring of 1663, when the Grand Duke's urgent interest proved to have been generated by word of the existence of such a project that had come to him early in May 1663. It had originated with associates in Florence of Niccolò Simonelli in Rome. Simonelli was a distinguished dealer and consultant in fine art and antiquities who had served in these capacities for Camillo Pamphilj, Cardinal Brancacci, and then for Cardinal Flavio Chigi as well as for Pope Alexander VII. He was largely responsible for developing the collections for Cardinal Chigi's museum, first at Ariccia and later at his Casino delle Quattro Fontane.[647]

This tantalizing bit of news about such a prospect had quickly found its way to the Medici court, whereupon Simonelli's Florentine associates were then instructed to contact Simonelli and request that he immediately investigate the matter further. His instructions came in a communication delivered by the Grand Duke's equerry, Bruto della Molara. Obviously the possibility that a successful nautical timekeeper had been invented, an endeavor that Galileo had failed to accomplish, was of considerable interest and concern to the Grand Duke. Simonelli promptly contacted Matteo Campani, and after meeting with him, communicated to della Molara what had transpired. He wrote

> Finally today I spoke with that Campani about the clock that he has invented; he states that it will not be completed for a while, given that it is a certified original invention by means of which he hopes to obtain a considerable premium that has been promised to him by those Lordships of the States General of Holland. He says also that this clock will be useful not only for navigation and

[647] Giovanni Battista Passeri, *Vite de pittori, scultori ed architetti: che anno lavorato in Roma, morti dal 1641 fino al 1673* (In Roma: Presso Gregorio Settari, 1772), 420.

that these Lordships promised *scudi* that will be paid in Rome immediately after completion of the clock, inasmuch as it will be used for great enterprises that will yield considerable fortunes to the States. What I have just reported to Your Illustrious Lordship is all that I have been able to glean from him thus far. Just out of curiosity, I thought that he was demented, given that he thinks he can obtain huge fortunes by making clocks, and this is all; however, considering that nowadays I see so many crazy people becoming extremely rich, I must assume that this one also to be true.[648]

Simonelli had not given Matteo's boast much importance and had neglected to mention to his friends from Florence which one of the Campani brothers it was that he had interviewed. As a consequence of which, Viviani had been forced to proceed to Rome to interview Pier Tommaso and Giuseppe Campani, since he knew that both were clockmakers and that it would be a matter of which one was the source. It subsequently became apparent that it had been neither, that it had been Matteo who intentionally had leaked the information in late April or early May while boastfully describing his project to Simonelli, anticipating that word of it would filter its way along to Florence. Undoubtedly, he anticipated that when it became understood in Florence that it had been he who was the supposed inventor of a clock for determining longitude, the Grand Duke would be anxious to provide sponsorship. There can be no doubt that from the very beginning, following Guisony's visit, Matteo had been dreaming constantly of discovering a solution of the problem of determining the longitude at sea, with grand visions of fame and gain that its success would bring.

Being unaware of his friend Matteo's horological aspirations, it had not occurred to Viviani to contact him regarding this matter when he had made his trip to Rome. Viviani assumed that it had to be either Pier Tommaso or Giuseppe, both of whom he knew to be active clockmakers and both of whom had produced timepieces for the Medici princes. If so, it became a matter of immediate interest to the Grand Duke, and in order to make certain and obtain the required information as quickly as possible, Viviani had no recourse but to travel at once to Rome. There his mission was to interview each of the two Campani clockmaking brothers personally. He did so, and upon his return 4 days

[648] BNCF, Gal., vol. 276, c. 190, letter from Simonelli addressed to "Cav. . ., May 5, 1663." Although the addressee is not named, the use of the title "Cavalier" or "Knight" confirms that the recipient was Bruto della Molara. The letter is part of a file consisting only of letters sent to Prince Leopold between 1660 and 1663.

later, he reported to Bruto della Molara at some length. He had spoken with the two Campani clockmakers, he wrote:

whom the Grand Duke had ordered me to contact, concerning the particulars of that clock [for determining longitude at sea], of which His Serene Highness had by your most recent communication commanded me to obtain information. I can report that neither Pier Tommaso Campani, inventor of the clock about which I wrote to you in the last weeks, nor Giuseppe Campani his brother, had received precise orders from the Dutch to think about the invention of timekeepers of the greatest precision, such as are required for use in determining the longitude, and even less were they promised any prize.

It is quite true that from each of them, interviewed by me separately and in the best manner, I have obtained the following unanimously confirming information, that I esteem to be truthful because today these two are divided between themselves, and consequently are more brothers than friends. They tell me, therefore, that three or four years earlier [i.e., 1660], while they were still working together, a certain French gentleman who happened to see one of their pendulum-regulated clocks, told them that if all of its [the pendulum's] variations were exactly equal, they would have discovered that precision measurer of time that is so greatly desired by the Dutch for the certainty of navigating by longitude, but that he could not see that it could be achieved by this means, estimating that in two such clocks there would be found perceptible disparity and inequality of motion.

He encouraged the brothers, however, to think of some other clockwork invention that, even though agitated by the rising and falling of the ship, would not suffer even the slightest alteration, and, he added, that it is possible to make many of them that would maintain an invariable accord between themselves for a long time, because he had always heard that there still might exist an ancient deliberation about it by the States General of Holland, and that there [still] existed relating to it a deposit of many thousands of *scudi* (he did not know then whether it is 60 or 80 thousands), for anyone who presented them with such an instrument or another certain [absolutely reliable] invention for such a purpose. Not only these States [General], but also the kings of Spain, of England, and of Portugal had since a long time ago until now, promised the greatest reward. Based upon these reports (that later had been confirmed by others, including English and Germans and by some Jesuit priests), since then, the one and the other of these artisans began to speculate.

The older one, Pier Tommaso, finally concluded that at the present time it would be impossible to achieve such precision of more equal hours of a timepiece, not only during movement aboard a ship, but even when the timepiece was stable and fixed upon a table. He stated that he had found that in the course of a few days there always was in any case some difference of one or two minutes with which ever application of the pendulum [he made], and that therefore he considered it to be unavoidable.

The other brother, however, the said Giuseppe, who had been there [in Florence] [called] by His Highness some years ago [i.e., 1659], reckons that the invention is entirely possible, not only with stationery [fixed] clocks, but even with moveable clocks [clocks in motion] as well. As regards the former, he said he had ascertained, although not experienced, since it has been about two years that he has been working on it on stolen time [i.e., since 1661] and expects to complete the work soon, which after many tests he already had reduced to the most facile and most simple form (that which makes me believe it) and that a new particular [peculiar] invention, but without having a pendulum, however, (that which makes me doubt), stating that he found substantial disparity between the large and the small vibrations, having observed those to be longer than these.

But I answered him that perhaps such would follow [be true] in spring-powered clocks, because the spring, having more force at the beginning when wound, raises the pendulum even more and as a consequence encounters major impediments in cleaving the air with its motion, which [motion] happens to have greater velocity than with the lesser vibrations, being an effect that it seems to me can occur in weight-powered clocks in which the motive power is always constant and uniform, and therefore the vibrations are of equal length and consequently of equal duration; if, however, [two words incomprehensible—appear to be "it happens"] that the continued mutation of the air now becoming of greater density, and now less dense, could cause some circumstance [alteration] also with time.

That which seems certain is that he [Giuseppe] asserts that it is impossible to achieve this invention with the pendulum, but that a different invention is required. He states that he has found it with certainty for [use with] the stationery clocks, and he hopes [to find the invention] for the mobile timepieces [clocks in motion] on shipboard, but that the former [stationery clocks], after the passage of 20 days, of a month, and possibly even of a year, will not vary by a half minute second. But for now he does not venture to promise as much if he does not first complete its construction.

This is as much as I have learned from the two persons in order to obey the orders of the Serene Grand Duke our Lordship. Try to determine whether His Highness feels that until this point he has been adequately informed [received an adequate response], and advise me if there is more I need to do, because if so I would not spare my energies.[649]

In the following days, Viviani received in Florence new instructions from the Grand Duke, who was vacationing in the Tivoli countryside. The instructions came in the form of a postscript to a letter to Viviani from Bruto della Molara, also in Tivoli, where the equerry was attending the Grand Duke. "The Most Illustrious Grand Duke ordered me to tell you to write and inform us about the proposal made by the Dutch to the clockmaker in Rome for the production of a clock that some say is to be used to navigate by means of the longitude. Please undertake some research in order to determine whether this thing is something good or not; when you locate him, find out what he has promised and what is the reward. Please try to send me some good news, writing either to me or to Prince Mattias also; I would really appreciate your sending me some information about this matter". Despite his jocular tone, his use of the word "us" in the letter was equivalent to the royal "we", indicating that the Grand Duke was seriously interested.[650]

That at some time in the past a reward had been offered by the States General of the Netherlands was internationally well known, and it is probable that Matteo had indeed approached a representative of the States General with his promised invention. It would

[649] BNCF, Gal., vol. 252, cc. 82r-v-83r-v. Letter from Viviani to Bruto della Molara on May 15, 1663.

[650] Ibid., vol. 162, cc. 101r–102r, letter from Bruto della Molara in Tivoli to Viviani on May 19, 1663.

have been an informal personal application, however, and not through channels of state. As well as can be determined, Matteo's identity in this connection had not become known to the Medici court, and consequently he received no response from there. There can be no doubt that Matteo was greatly chagrined that his ploy had failed. A search made of the filed resolutions of the States General in the Netherlands failed to reveal the existence of any record of contact with Matteo Campani, however, and it is likely that it may have been one of many informal applications that were made of which no mention survives.

The Grand Duke, after having been alerted to the prospect of someone under his sponsorship having succeeded in producing the desired timekeeper, endeavored meanwhile to pursue the matter further. Accordingly, 2 months after having interviewed the Campani brothers in Rome, Viviani prepared a memorandum, presumably addressed to Prince Leopold. It contained the text for a letter to be sent from the Medici court in Florence to an addressee identified therein only as a certain "Hippolyte de Wich". In the text of the communication, Viviani requested information concerning the specifications required by the States General of the Netherlands for timekeepers to be used at sea for determining the longitude. In a surviving draft minute, filed without identification of addressee but with the noted indication that it or a copy was to be sent to "de Wich," Viviani wrote:

Given that in order to obtain at sea the difference of the meridians—otherwise known as the longitude of places—it is said that the General Maritime Assembly of the Sea of the General Orders of the United Provinces of Holland is known to have asked for the invention of automata, some new kind of mechanism that may demonstrate the hour of the natural day with the greatest precision and without departing from the truth, and given that it is said that the above-mentioned States have promised a great prize and have already deposited a great sum for the invention, for all these reasons we are seeking to know the following specifications precisely:

1. First of all, to what degree of precision do the States expect this invention to attain, and for how many days consecutively, two, three, or many more, are these clocks expected to run and calculate the time in the exact same manner, with their index [clock hand], without showing the difference of even one minute—amongst themselves, being always the same and comparable with each other—both the stable ones which are on land and the mobile ones placed on ships at sea rocked by rough weather (the mobile clocks and the stable clocks always agreeing in the calculation of time)?

2. [We wish to know] whether such clocks that are placed on ships are expected to calculate time and longitude precisely, notwithstanding even in the most fierce and tempestuous commotions of the sea?

3. On the supposition that such an invention has been invented, we wish to know where, how, and with whom the inventor must deal, and when and by whom would the invention be tested and approved, and such being the case, who would be the judge?

4. When is the amount of money deposited for that purpose, or what is the reward that has been promised?

5. If such a clock should prove not to be extremely precise in the great agitation suffered by ships, but showing, on the other hand, to be extremely accurate on land and therefore to be useful for correcting the longitude on geographical charts, such being the case, we wish to know whether the invention would be desirable, and what prize could be expected for it.[651]

The recipient "Hippolyte de Wich" subsequently has been identified as Jan De Witt (1625–1672), one of the greatest statesmen of his age and in Dutch history. From 1653 until shortly before his death, he had served as the Grand Pensionary of Holland, the first minister and magistrate of the state of Holland and Zeeland in the Seven United Provinces of the Netherlands. By virtue of his office, he was president of the provincial legislature and permanent deputy of the States General.

Viviani's query unquestionably was intended for the States General of the Netherlands, and in this instance, De Witt was being addressed not in his official capacity as councilor pensionary of Holland but as the unofficial factotum of both the government of the province of Holland and of the central government of the States General, as well as a mathematician.[652]

The communication to De Witt from the Grand Duke or Prince Leopold requested the specifications prescribed by the States General for a prize-winning timepiece for determining longitude at sea, presumably for the purpose of providing guidance for anyone whom the Medici court might enlist to engage in the development of a solution to the longitude problem. Inasmuch as none of the clockmakers known to the Medici court was at work on such a project at that time, the Grand Duke was curious to learn the identity of the source of the rumor from Rome. A search of Viviani's surviving papers and of the archives of the *Mediceo principato* has failed to bring to light either a reply from De Witt or other related correspondence.

The prospect and its possibilities tempted Matteo Campani for several reasons. First of all, he visualized the great universal acclaim that would come to him if he succeeded in an endeavor in which so many others had ventured and failed, and he had

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[651] Ibid., vol. 252, cc. 84r-v, *Minuta* of a letter from Viviani without identification of addressee with a copy to Jan De Witt (Hippolyte de Wich) on July 9, 1663. The communication, marked as a copy sent to De Witt, survives as a *minuta autografa*, or file copy, of a letter that has been expedited.

[652] Herbert H. Rowen, *John de Witt, Grand Pensionary of Holland, 1625-1672* (Princeton, (N.J.): Princenton University Press, 1978).

full confidence in his own abilities to achieve it. No less appealing was the monetary prize that had been offered by the States General of the Netherlands, which still remained unclaimed. Perhaps what appealed to Matteo most of all was the challenge of competing with his talented brothers Pier Tommaso and particularly Giuseppe and the prospect of succeeding.

The comments made by Guisony during his visit to Giuseppe's shop that had stirred Matteo's interest, and a supplementary communication to Matteo from the French physician that had followed, had ignited and fueled the fires of invention even more. That Guisony had in fact been Matteo's primary source of inspiration was confirmed later in a letter he had received from Guisony several months after the French physician's visit.[653]

It may have been with the cooperation of Cardinal Gian Carlo in Rome that, in 1659, Matteo had gained entrée to the Medici family museum,[654] and it may in fact have been the Cardinal who had first brought about Matteo's introduction to Viviani. At the Medici court, as already noted, Matteo had been shown the unfinished Galileo clockwork model, the Huygens clock made by Salomon Coster, and the operating pendulum-regulated public clock on the Palazzo Vecchio based upon the Galileian principle that had been produced by Johann Philipp Treffler. Matteo had been further encouraged in his decision upon learning details of Galileo's pendulum experiments. Galileo's efforts subsequently had been duplicated by the Accademia del Cimento and were described and illustrated in the Accademia's *Minutes* for August 11, 1662. A copy of the minutes may have been furnished to Matteo by either the Grand Duke's brother, Cardinal Gian Carlo de' Medici, or possibly by Viviani.[655] Whatever the circumstances may have been, Matteo appears to have become well-informed of Galileo's experiments with vibration

[653] BNCF, Gal., vol. 279, letter from Guisony to Matteo Campani copied in:Matteo Campani, *Proposizione d'orioli giustissimi tantoche il loro misuratore necessariamente debba muouersi con periodi eguali, & vniformi sotto qualunque intemperie d'aria, & anche data ne i medesimi orioli inegual potenza motrice. Inuenzione vtile à nauiganti per prender le longitudini, come anche à geografi, & agli astronomi. Dedicata alla sacra maestà del re christianissimo Luigi 14. dall'inuentore Matteo Campani de gli Alimeni ... spoletino ...* (In Roma: per Ignatio de' Lazari, 1673) letter from Matteo Campani to Cardinal Leopold, March, 1670, foll. 1-18. sent to Cardinal Leopold in March 1670.

[654] Campani, *Horologium solo naturae motu*, 9-10.

[655] BNCF, Gal. vol. 260, V, Posteriori, Accademia del Cimento, *"Minute d'esperienze fatte nell'anno 1662"*, c. 196.

counters and possibly also of his negotiations with the States General and correspondence with the Dutch Admiral Laurens Reael.[656]

As Matteo later explained in his published work, it had been the early experimentation with the self-winding sphere he and his brothers had undertaken in 1655, during which they had enclosed their self-winding sphere within glass, that suggested to him the idea of sealing a nautical clock within a vacuum.[657] Although Matteo let it be known generally that he was so engaged, he worked alone on his new project. Despite the fact that both of his brothers were talented clockmakers, Matteo did not consult with them or utilize their services. Or he may have asked for advice and assistance and had been refused. Determined to keep his project secret and not to share its success, during the next several years, he employed a local clockmaker to work privately with him in the construction of the clock mechanism for his nautical timekeeper.[658]

As the work progressed from designs developed by Matteo, much time was being consumed during which they experimented with various aspects of the invention. More time was being wasted while Matteo kept providing additional detailed instructions and variations to his clockmaker. Matteo had particular difficulty in devising a satisfactory means for sealing the mechanism. It was not until almost 5 years later that he felt that he had made sufficient progress with the completion of the nautical clock to warrant venturing into print about his timekeeper, even though it had not yet been quite completed.

No additional documentation has been found relating to the progress of the project during the 5 years that had elapsed since Matteo's meeting with Simonelli in 1663, when he had boasted about the clock he was constructing. Then, in October 1668, Matteo's first publication about his nautical clock sealed within a glass globe appeared in Rome, in a small volume of several pages.[659] The little volume, the title of which may be translated

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[656] Galileo Galilei, *Le opere di Galileo Galilei*, vol. 14 (Firenze: G. Barbera, 1966), chap. Carteggio 1637-1638 letters letters n. 3462*, 3468**, 3531**, 3755; 'Copia del registro delle resoluzioni degl'illustrissimi e potentissimi ordini generali delle Provincie Unite Belgiche. Sabato 25. Aprile 1637', in *Opere di Galileo Galilei divise in quattro tomi*, Nuova edizione, vol. Tomo secondo, 4 vols (In Padova: nella Stamperia del Seminario, 1744), 470–71.

[657] BNCF, Gal., vol. 279, cc. 5r-14v, Campani, *Proposizione d'orioli giustissimi,* Letter from Matteo Campani to Cardinal Leopold, March, 1670, foll. 1-18.

[658] Ibid., 18.

[659] [Scientific Editor 2: Except for the following documents: in fact there is evidence that Matteo Campani had sought Leopold's patronage for his new project already at the end of 1667: BNCF, Gal., vol.

"The Precision Clock of Antimo Tempera Most Useful to Navigators", was dedicated by Matteo to "the Most Eminent and the Most Reverend Prince de' Medici, Prince Cardinal Leopold". Following an elaborate salutation to His Eminence, which he dated March 15, 1668, was the foreword in which he informed the Prince that his work was about his "invention of clocks made variable by changes of atmosphere". Matteo went on, "Under the most felicitous auspices of Your Eminence was born and created the invention of clocks that were not made variable by the changes of air, and of which I reverently presented advice to Your Eminence in the month of October 1667. Having, as I hope, the same maturity and perfection of your high patronage, particularly today as I marvel to appraise the excellency of your virtue, I feel myself disposed to receive the benefits infused by greater cognizance than perhaps I need for the entire completion of the project. That being so, and for a debt of gratitude, and to increase its speciousness and beauty, I consecrate it to Your Eminence. But with this ingenuous confession, that this is more of yours than of mine; inasmuch as having the regal munificence of the advisers of Your Serene Highness and of you personally, and of the most knowledgeable reigning Grand Duke your brother, creative persons in every profession of letters and art, excellent and singular, that in this manner of things are the great workers who have brought great light to the world, to the same one must, as part of their sovereign beneficence, when the same Science and Arts produce each day. With these live feelings of real ingenuity, and gratitude I offer to you, and present this invention, and implore your very potent protection". It was with a copy of this book that Matteo subsequently forwarded his nautical clock to Florence to the Grand Duke. In the text Matteo discussed pendulum clocks he had devised and Galileo's experiments with the pendulum.[660]

It is surprising, therefore, also to find therein as part of the book a description of the latest horological invention made and patented by his brother Giuseppe Campani. This invention, according to the description, was a clock "that measured time not by the turning of its wheels, but by the natural continuous descent of two most perfect spheres,

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278, cc. 104-105, letter sent to Prince Leopold from Giovan Francesco Raimondi, secretary to the Duke of Altemps, on a friend's behalf who used the pseudomim of Antimo Tempera (December 5, 1667), and c. 106: letter from Matteo Campani to Prince Leopold on December 6, 1667].

[660] Matteo Campani, *L'oriuolo giusto d'Antimo Tempera vtilissimo a' nauiganti* (In Roma: per Michele Ercole, 1668); dated March 15, 1668, Matteo's preliminary dedication to Cardinal Leopold of his book.

from two most elegant spires, which however suffered as well from the variation of time".[661] Only a single signed example of this falling ball clock by Giuseppe Campani is known, one he had made for the Landgrave of Hesse as well as an example in Florence that is unsigned but attributed to him.[662] The appearance of this description, which served as an advertisement of his brother's work in a text describing Matteo's own invention, is puzzling and appears out of place.

In his historical bibliography, G. H. Baillie provided a description of Matteo's nautical timekeeper, derived from his translation of the Italian text, noting that it "was regulated by means of a pendulum having 7,200 swings per hour. The first wheel with 90 teeth made one turn per hour, driving a pinion of 5 on the arbor of the second wheel which had 80 teeth, which in turn drove a pinion of 5 on the arbor of the escape wheel of 25 teeth. Don Matteo proposed to enclose the clock in a Torricellian vacuum and estimated he could avoid any friction in the escape wheel by counterbalancing its weight "by the magnetic needle".[663]

Instead of using his own name as author of his *L'Oriuolo Giusto*, or "Clockwork of the Greatest Precision", Matteo resorted to the use of the pseudonym "Antimo Tempera", which he created and claimed was based upon an anagram of his own name.[664] He distributed copies of the book to selected recipients without identifying himself, presumably to arouse curiosity about the new invention described therein by this mysterious inventor. He obviously cherished the confusion aroused by the anonymity of the book's authorship.

Matteo had forwarded a copy of *L'Oriuolo Giusto* to Grand Duke Ferdinand II, who may have known of Matteo Campani's existence but only as a brother of Giuseppe the clockmaker. Not having been informed of his pseudonym, however, he consequently had no clue to the identity of the author of the book. When he received the copy from

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661 Ibid., 11.

662 Friedrich C. Schminke, *Versuch einer genauen und umständlichen Beschreibung der Hochfürstlich-Hessischen Residenz- und Hauptstadt Cassel nebst den nahe gelegenen Lustschlössern, Gärten und andern sehenawürdigen Sachen* (Cassel: Gedruckt bey H. Schmiedt, 1767), 165; Rudolf Hallo, 'Von alten Uhren im Hessischen Landesmuseum und von der Uhrmacherkunst in Kassel', *Uhrmacherkunst* 58, no. 32 (1930): 657–66; Franz M. Feldhaus, 'Kugellaufuhren', *Deutsche Uhrmacher Zeitschrift* 11, no. 61 (November 1957): 487–88; Maria Luisa Bonelli, 'Un oriolo o strumento detto moto perpetuo', *La Clessidra* 1 (1957): 11–14.

663 Baillie, *Clocks and Watches*.

664 Campani, *Proposizione d'orioli giustissimi*, 11.

Matteo, it was with some bewilderment, and in November 1668 he sent a request to Ottavio Falconieri in Rome to obtain any information he could find about this man named Tempera. Falconieri had been away at Frascati during October and found the request awaiting him upon his return. In several letters he sent to the Grand Duke in the course of the next few weeks, he kept reporting unsuccessful results of his continued efforts to identify anyone of that name.[665]

Falconieri responded that in fact the name had been unknown to him also, but that upon consulting one of the Campani brothers with whom he was acquainted, he had the feeling that there was no doubt but that the latter knew to whom the book referred. Falconieri had been unable to obtain any more details, however. "He simply told me only that not long ago he had overheard something about a foreigner who had arrived in Rome who pretended to have discovered such a clock. I will continue, however, to make further enquiries about this name during the coming week and report to you what I have learned". [666]

It appears that the Campani brother he had contacted had been none other than Matteo himself, who was intent upon playing his game of nonentity. A week later Falconieri reported, "With renewed diligence one more time this week I sought to obtain information about Antimo Tempera but I had no more success than in the past; I will not fail, however, to communicate when I can". Another week passed, until in late November, Falconieri was able to report progress, if not success. "After having taken much care to obtain some information concerning the identity of Antimo Tempera, finally I have found out with certainty what I had been suspecting myself, i.e., that this is a fictitious name, as the person himself who had written the letter to Your Highness on his [Tempera's] behalf told me. I was unable, however, to obtain any other information from this person, except that thus far the author of the alleged clock wishes to keep secret his identity and information about his invention, moreover, in order better to protect himself in this matter, he does not even want to venture to write in his proper name".[667]

[665] Paolo Falconieri, 'Letters from Ottavio Falconieri to Grand Duke Ferdinand' (Letters, 5 November 1668), Carteggio di Artisti, Archivio di Stato di Firenze.
[666] Ibid.
[667] Ibid.

Once again Matteo had engaged in playing the same game as he had in 1662 when identifying Giuseppe's first telescope as having come from Holland, this time suggesting that his clock had been brought to Rome by a foreigner. What he hoped to gain by means of this concealment is unclear. The only explanation appears to be that Matteo was using it as a means of generating publicity for the purpose of building up recognition and acclaim for himself. The matter finally must have been resolved, however, and Tempera's true identity disclosed, because it was in September 1669 that Matteo's invention of the nautical clock was delivered to the Grand Duke Ferdinand II.

At some point during that autumn 1668, Matteo departed from Rome to Castel San Felice. It was a sojourn to his family home in the Umbrian hills for unspecified reasons, possibly to resolve matters relating to members of his family or because of personal health problems. On October 24, 1668, Matteo may have sent his letter through the Grand Duke's secretary, Abbot Giovan Filippo Maruccelli,[668] with whom he had developed a friendship. In the letter, Matteo sought to explain how:

> Due to various domestic vexations, I had been unable to apply myself to complete the discourse undertaken about that artifice about which Your Illustrious Highness was aware. I hope nonetheless to finish it immediately upon my return to Rome, departing at this point for that purpose from Spoleto. It is quite true that in this time I have not entirely abandoned the speculation and the examination of it: from which other [than] to have simplified and improved the equilibrium of the balance, that Your Serene Highness has already seen, having from the humidity of the shaft brought to the center of its disk or circle, it seems to me thus to have invented another artifice that is entirely satisfactory to everyone. And were it not that there were other thoughts concerning it, those which when called to reckoning it seems to me to have proven to be defective, one might say that this last were to succeed accurately, all the more as I succeeded with such to make counts with its weight, number and measure. In spite of all that, because I doubted of its possibility, as did others some time ago, I cannot assure it of other if not the principles and the means I tentatively proposed, or to say better, my thoughts seem very plausible.
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> At the first opportunity I will attempt to make the experiment but first it is necessary for me to learn to work a little with my hands, as I was thinking of making this balance [*tempo*] while I was staying in my home country [Castel San Felice], when my brother might have wished to please me with a lathe that he had promised to send me, but I am still hoping by means of the divine spirit I can overcome even this difficulty. And therefore Your Illustrious Highness either knows that which is this thing to confer with Your Highness, in case of happy outcome, or at least will have seen the design, that I hope will please you. I beg for the continuation of your good graces.[669]

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[668] Vanna Arrighi, 'Marucelli, Giovan Filippo', *Dizionario Biografico degli Italiani* (Roma: Treccani, 2008).

[669] BNCF, Gal., vol. 284, cc. 20r-v, letter from Matteo Campani without address but believed to be to Cardinal Leopold through Giovan Filippo Maruccelli (?) on October 24, 1668.

Matteo offered no additional explanation of the "domestic vexations" to which he had referred, but the mention of his brother, presumably Giuseppe, from whom he had wished without result to obtain a lathe, suggests that a rift between the brothers still continued. Time passed, and two weeks later Matteo again addressed Maruccelli, informing him that he had finally returned to Rome, "in order to keep alive my obligation and devoted service".[670]

It was not until early in November 1668 that Matteo was able to return to Rome, and he then again invited someone from the Medici court (perhaps the selfsame Marucelli) to request any favors he needed to have done for him in Rome. He also asked that any letters that may have arrived in Florence addressed to him were to be directed to him in the care of a certain Andrea Mauri in Rome, whom he described as one of his good friends. He specified that such letters before being forwarded should display on the envelopes a certain symbol to be added, which he illustrated, that would immediately alert the addressee Mauri that these letters were intended for Matteo. Then Matteo went on:

> Your great kindness induces me to tell you about a most miserable disgrace I happen to suffer, namely, the bad fortune I have had with my brothers notwithstanding my best efforts to enhance their status and reputation [...]. In this connection I would like to urge you to think over what has been said about the Christmas crib [*praesepio*] with the magic lantern during that evening that you and other distinguished gentlemen spent at my house. On that occasion you saw that lantern made by my brother Giuseppe. I urge you to remember what I told you then about that attractive project. I told you that it would be easy to make a Christmas crib of that kind if it worked like a clock, i.e., with the same devices and mechanical parts as a clock. I also urge you to remember what I told you and the Abbot your brother [Francesco Marucelli?] on another occasion, when we met shortly afterwards, but I do not remember where precisely. During that meeting we spoke also of other things and we did not mention this topic any more afterwards.[671]

Matteo then reminded Marucelli that on an occasion some time ago the latter had asked him about Giuseppe's project relating to a clock to be installed upon a public building that was to be illuminated at night by means of a magic lantern. On that occasion Matteo said he had not pointed out that the first project of that sort had not in fact been Giuseppe's, but his own. Now, however, he felt that he has to be clear about it, and thus informed the Florentine that he, not Giuseppe, had been the first to design such a clock.

[670] Ibid., cc. 21-22, letter from Matteo Campani to Giovan Filippo Marucelli (?) on November 10, 1668 from Rome.

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

Unfortunately, Matteo added, his break of relations with Giuseppe was still far from being healed. He said that this deeply rooted feeling of enmity between them began because of such inventions and their different opinions concerning their operation. He thus requested Marucelli to convince Giuseppe, whenever he may happen to meet him, of the correctness of Matteo's opinions, and also to tell him about the discussion that he had had with him about the public night clock and the magic lantern.[672]

In August 1669, while again in Spoleto, the city in which formerly he had been pastor of his first church, he wrote to Cardinal Prince Leopold concerning his nautical clock. He mentioned a new principle that he had invented 10 or more years earlier but that in his manuscript, he went on to write, "neither of the above-mentioned methods proved to be adequate to liberate the clock sufficiently from any failings because it would have required improved [*here appears a section of unreadable text*] of great length. Thus it was for the same reason that the knowledgeable Grand Duke had not brought the same fine principle to the same Vincenzo [Galilei], and to other intelligent persons".[673]

Matteo was not one to overlook any opportunity to promote himself or his projects, and it is not surprising that as the work on his new timekeeper had been nearing completion, he managed to make the Pontiff aware of his invention. As a consequence, Matteo had been asked by Pope Clement IX, successor to Pope Alexander VII, perhaps only as a matter of courtesy, to bring the clock when completed to the Apostolic Palace to show it to him. Greatly excited by this summons, Matteo did so, and apparently the clock remained at the Vatican on display at the disposition of the Pontiff for a brief period. As a consequence, after having promised it earlier, Matteo experienced an embarrassing delay in bringing it to Florence to the Grand Duke.[674]

Meanwhile, at the time of the publication of the book describing his invention, Matteo had, for reasons unknown, neglected to provide a copy to Cardinal Prince Leopold, the patron to whom it was dedicated. It was an awkward oversight. In the above-mentioned letter sent in mid-August 1669 from Spoleto, Matteo informed the Cardinal that the first accounts of his "Invention of the Nautical Clock" had been printed, although he realized that no copies had been transmitted to the Cardinal. He had intended

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[672] Ibid.
[673] Ibid., vol. 278, c. 271, letter from Matteo Campani to Cardinal Leopold on August 17, 1669.
[674] Ibid.

to have copies accompany the clock itself, he explained, but had not done so because he would not be able to remove the clock from Rome until after the Pontiff had seen it. For the time being, therefore, he was forwarding an illustration of the clock that had appeared in the book, hoping that with his elevated benignity, the Cardinal would discover in one or the other much that will please him. He went on:

> to the first indications from His Highness, I have printed the earliest accounts of "The Invention of the Nautical Clock," although it does not seem that any Copy has as yet been transmitted to Your Highness. I wish that I had been able to accompany it with the same original of the work, the clock itself, which by the grace of God will prove to result successfully. But because (this due to certain obligations not obtained by me) I cannot remove the clock from Rome before His Holiness has seen it; hence it is, that only now am I presenting an image from the obligated small book, to offer it next when I present its above-mentioned original, extending [holding out] that in one or the other will discern the additional benignity of Your Highness, much that sympathize with me […].[675]

A week later, the 24th of August 1669, Matteo took pride in informing the Cardinal that on the previous Monday he had the honor at last of having been invited to the Vatican palace to demonstrate his nautical clock to Pope Clement IX. "His Holiness deigned to examine the invention part by part and approved it with many expressions; if there were then other means, the pleasure in hearing my resolution of presenting it to Your Serene Highness (as he also had written to the secretary Marucelli) that it would be extremely pleasing to Your Highness, that if I take the opportune proof of the benign protection of Your Serene Highnesses, for which I will attempt to arrive at all the things together, despite the great inferior lunge to the first, which I have been deigned to do. I confess ingenuously my little or absent knowledge, the innate weakness of my crude ingenuity, and my little talent that scarcely conforms the little books published before the illustration to understand the illustration, that I still have not finished to engrave in Rome, as will appear in the enclosed page". If the Prince Cardinal agreed, he went on, he would present the clock to him together with another of the same type, as he had already written to the Grand Duke's secretary, Marucelli.[676] After another week had elapsed, Matteo again addressed Cardinal Leopold, stating:

> At this point I have consigned to the *procaccio* [paid messenger] a small crate containing the clocks, but dismantled, so that they will arrive more safely. That [one] for the Cardinal Prince is

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[675] Ibid.

[676] BNCF, Gal., vol. 278, c. 273, letter from Matteo Campani to Prince Leopold on August 24, 1669.

without its case and ornaments, that I wish to say, and since they are thus until it can be determined the manner that could best please His Highness because during the coming week there will be arriving from Rome for his own pleasure my friend, who is knowledgeable about this material. Thus it will be possible to evaluate from the same state to reassemble said clocks; as much to repair as to improve that one, that is only saved from the dust but not from the air [atmosphere] at this time, but it is possible. Meanwhile, it will please His Esteemed Highness for them to be put together most easily. It can, however, be adjusted as one wishes. If, in the meantime, His Illustrious Highness wishes to have them assembled, it is something that can be done with the greatest facility. The hour is now already late and therefore I conclude with making my most humble reverence and remain your most humble and most devoted and most obligated servant.[677]

It is difficult to determine from this communication whether Matteo was sending the Cardinal de' Medici several clocks he had arranged to have made for him or that the latter had commissioned. Presumably, Matteo was responsible for a single clock at this time, his so-called nautical clock, and that clocks from other sources had been included in the shipment.

Within the same year, *L'Oriuolo Giusto* was reviewed in the pages of the *Giornale de' Letterati* by the editor, Nicol'Angelo Tinassi. The clock was described in a lengthy account summarizing current concerns about the determination of the longitude at sea. After mentioning various attempts to find a solution, including how Galileo had experimented with a pendulum but had been prevented by death from perfecting his invention, Tinassi pointed out the difficulty of producing a timekeeper that could maintain uniform motion at sea and which would not be altered by either heat or cold or humidity. The account stated that Don Matteo Campani, after having constructed this timekeeper and displayed it in his own home to diverse gentlemen, "had taken it to Florence to demonstrate to that Most Serene Highness, the Grand Duke, under whom fine inventions flourished and were protected. Campani wrote that there His Most Serene Highness had assigned the timekeeper to his court clockmaker [sic],[678] to have its operation compared with that of another that had been constructed as a supplement to other inventions".[679]

[677] Ibid., vol. 284, c. 53, letters from Matteo Campani to Marucelli or to Viviani on September 1, 1669.

[678] It was Viviani, as we shall see, who tested Matteo's vacuum clock.

[679] Michel Ercole, 'L'oriuolo giusto d'Antimo Tempera utilissimo a' naviganti', *Il Giornale de Letterati, per tutto l'anno 1669 (Tinassi)* 8, no. 29 Agosto (1668): 114–116 and illustration.

The reviewer then went on to describe how "now in the present work, this author describes a clock of his own invention, the precision of which is esteemed to be above that of all others, and in consequence is most useful for finding the distance of the meridian. The major and minor velocity of the *mobile* depends in part on the major or minor resistance in the midst of which it moves. Therefore, the air being exposed to a thousand mutations, renders it more or less resistant, even the motion of the clock, that is made in it, is more or less rapid, and cannot operate completely with precision. To remedy this defect the author has found a way to enclose the clockwork within a crystal container [vase] in such a manner, that air cannot enter in any way. From this one can derive two uses, one, the clock will be free of many mutations, that come from the exterior air, the other, liquid, or viscosity, deriving from the evaporation of humidity, will not be generated in the holes of the pivots necessary in these openings, and from the action of very small ship worms [*terei*; *Teredo navalis*] that gather there. As for this last-named defect, he has provided even with another artifice, that is, to carry in balance or almost in balance, in the form of a magnetic needle, one of those ultimate mechanisms of the clock, that is, the *serpentina* or the balance wheel".[680]

The reviewer also referred to the illustration contained in the book, which was reproduced in the *Giornale* and in which the editor Tinassi commented on its component parts:

The structure as to the order of the wheels is the same, as in other ordinary clocks, except for some differences in the situation and disposition of the locations that is, of the dial plate, and of the movement, as can be seen in the annexed illustration, in which the first figure shows the entire clock, and the other three, the parts of which it consists.

BCDEFG shows the enclosure or case, that is, BCD is a curved metal plate with a fitting inside; and DEFGB, a crystal container, which serves as a cover of the above-mentioned plate plastered inside the fitting.[681]

[Figure]

It was not long before news of Matteo's new invention of a clock having the unusual feature of being sealed in a vacuum became known not only in Rome but also outside Italy, the news reaching London and Paris and immediately arousing interest

[680] Ibid.
[681] Ibid.

there in its potential success. The prospect that a timekeeper would become available that was useful in determining the longitude at sea was obviously of considerable interest to many at this time, and Matteo's promise of such aroused general anticipation.

In a letter to Huygens (September 6, 1669) containing a discussion of a variety of scientific topics, Oldenburg at the Royal Society congratulated the Dutch astronomer on the success of his sea-going clocks and said he awaited with interest the report of the results of another test of them soon to be made. He wrote:

We are delighted that you have received good news of your sea-going clocks, but the trial which you will undertake 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, one of which weighed two pounds, which seems to me unbelievable.[682]

Two months later, Oldenburg again congratulated Huygens on the success of the trial of his nautical clocks:

which you say performed successfully on the voyage to Crete, reserving as yet the details to yourself although you believe them worthy of being known. They will be very glad to hear these details, when you think fit, and are convinced that you will not long postpone this communication.

No doubt you have learned that M. Campani has gone to Florence to show the Grand Duke a clock placed in a vacuum. You will oblige us if you should learn the details, of informing us how in what manner it is made, whether it has a pendulum or not, and how it is wound up, etc. The said Campani claims that it may be very usefully employed at sea, which no one here believes as yet. Moreover, a friend from Rouen [Pierre Guisony] tells me that the discovery of the longitude by the exact and reliable knowledge of the motion of the moon, and by means of an instrument made to take two or three observations of the sun and moon simultaneously, is at the present time under the scrutiny of your Academy. I beg you, Sir, to tell us about it; and particularly whether the table showing the hours, minutes, and seconds of the moon's arrival at the meridian of Paris during the whole of the month of November, prepared by the inventor, is confirmed by observations.

Mr. Boyle greets you very respectfully, and says that the difference in the effect when the water strikes the glass in the presence of air, and when it does so in the absence of air, is very considerable, the sound of the water falling against the glass without air being like that of a piece of wood or stone falling, very different from that of water shaken against the glass with air in it. He adds, that although the air slips by more noticeably in wider tubes and so offers a less noticeable resistance to the falling fluid, than it does in narrower pipes, nevertheless it is the case that he has found that resistance greater, than when the air was exhausted from them. He has not made this experiment in very wide tubes, because of the greater danger of breaking the glass.[683]

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[682] Oldenburg, *The Correspondence of Henry Oldenburg*, vol. 6,, letter 1280, 220–24, letter from Oldenburg to Huygens on September 6, 1669.

[683] Ibid., letter 1319, 310–15, letter from Oldenburg to Huygens on November 11, 1669.

The determining of the longitude by clockwork at sea was also the subject of a letter to Oldenburg in the same period from Cocheerel, who commented:

> I have waited until I could . . . let you know by what means the person I mentioned to you claims to find without mistake the longitude of whatever place he may come to, whether by sea or by land. I am well aware, Sir, that some have claimed that and the uniformity of pendulum clocks gives the time of the place one has left, if one knows the time of the place where one is, one can find his longitude. But since many things can occur to cause the pendulum clock to go irregularly and since this method is purely a mechanical one, it seemed to me that it would not satisfy the scientifically minded nor have all the desired utility. And I certainly think that the best and most certain method is to observe carefully the motion of the moon, not [compared] with the satellites of Jupiter whose motion is too slow, but [compared] with the sun, in order to find out the hour, minute, and second at which the moon will touch the meridian of the place whose longitude is sought, compared with the place one has left [. . .].[684]

In the course of time, Matteo had managed to make himself well known at the Medici court in Florence. In addition to his long friendship with Viviani, and his formal acquaintance with both the Grand Duke and Prince Cardinal Leopold, he had become a familiar figure with others at the court as well. Dr. Francesco Redi, the Grand Duke's physician and a famous biologist, mentioned Matteo in his best-known work, "Experiments on A Variety of Natural Items" [*Esperienze intorno a diverse cose naturali*]. Redi wrote that Matteo was "a *virtuoso* extremely well known by all the *letterati* of the world for his most noble and most useful inventions".[685]

During the late autumn months of 1669, Matteo visited the Medici court, either on his own initiative or possibly with an invitation from the Grand Duke, and during his sojourn in Florence, he became seriously ill. The Grand Duke arranged to have him attended by his personal physician, Francesco Redi, after which the Grand Duke had Matteo taken to Pisa to recuperate. While there, Matteo wrote to Viviani in Florence, asking him to inquire at the postal office in Florence to determine whether any letters had arrived for him. If they appeared to be of some importance, Viviani was to forward them to him at Pisa, otherwise to have them sent to his address in Rome. He then asked Viviani to return to their owners some objects that he had borrowed.[686]

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[684] Ibid., letter n. 1297, 262–67, letter from Coocherel to Oldenburg on October 5, 1669.

[685] "*Virtuoso molto conosciuto da tutti i letterati del mondo per le sue nobilissime ed utilissime invenzioni*." Francesco Redi, *Esperienze intorno alla generazione degl' insetti fatte da Francesco Redi Accademico della Crusca, e da lui scritte in una lettera all' illustriss. Signor Carlo Dati* (Napoli: Nella Stamperia di Giacomo Raillard, 1687), 9..

[686] BNCF, Gal., vol. 255, c. 124, letter believed to be addressed to Viviani in December 1669.

Late in that year (1669), Viviani presumably received instructions from the Grand Duke to proceed to make certain tests with Matteo's nautical clock. Although Viviani attempted to undertake the testing, he had been unable to do so because the clock had ceased operating, as he informed Matteo in Rome.[687] Found among Viviani's miscellaneous papers is an incomplete document in his handwriting that apparently was dated January 1670 containing the following statement:

This clock given by Don Matteo Campani as a gift [sic] to the Most Serene Grand Duke Ferdinand II, which His Most Serene Highness ordered me to take before he left for Pisa last year. He instructed me to keep this clock in my house in order to compare it with his own tower clock [or his clock in the tower—*col suo della torretta*]; he wished to know if there were any considerable differences in precision and uniformity as regards the calculation of the time between these clocks, considering that Campani's clock was enclosed by crystal and they were both exposed to the variations of both humid and dry weather.

When His Serene Highness returned [to Florence], I told him what I had observed during the past months. Given that I already had sent the tower clock back to the palace, His Serene Highness ordered me to keep this clock of Campani and to continue my observations, comparing it with mine, which is what I have done thus far; doing so I have always found. . .[following page missing] [688]

The potential success of Matteo's nautical clock understandably was a subject of interest also to Christiaan Huygens, who in the following January communicated with Oldenburg concerning it. He discussed various subjects, including the glass used for making lenses, Barrow's treatise on dioptrics, the forthcoming voyage to test his own sea-going timepieces, and another proposal from someone in Rouen of an invention for determining longitude predicated upon the motion of the moon. Huygens then went on, "I have heard nothing of the clock [operating] in a vacuum; I have seen only a description of that which is enclosed in a bottle or glass vessel, and about this there is nothing

[687] Ibid., cc. 127-128. Letter from Matteo Campani to Viviani on January 18, 1670.

[688] Bedini, *The Pulse of Time*, 48-49 [Scientific Editor 2: the archival reference provided by Bedini in his book is wrong. The correct one is: BNCF, *Gal*., vol. 248, c. 6]. In the same file is another unsigned document, the authorship of which is not indicated but appears to be in the handwriting of Matteo Campani. This document, filed with Viviani's miscellaneous papers under the category of "Clocks", relates to the discussion in which Matteo Campani's clock was compared with those of the Grand Duke. It states: "The clocks of the Grand Duke are not accurate; as a matter of fact, these clocks must be corrected often by means of observing both the sundial and the stars. The clocks are one minute slow each day, which means that by the twentieth day of this month, the author states they will be more than one third of an hour slow. He also noted that although these clocks strike the hour with only one or two minutes of difference of one from the other, this difference still is considerable in the long run. Moreover, he adds, it is not certain that these clocks are always slow and never fast.". BNCF, Gal., vol. 248, c. 5.

remarkable, because no air was removed. And I believe the thing is quite difficult, because unless the vessel were hermetically sealed, the air would, ultimately, find some way in. I do not doubt that Mr. Boyle closes up in this way the tubes in which he puts water, a thing about the truth of which I would, however, very much like to know".[689]

It was not until early in January 1670 that Matteo was able to return to Rome. In mid-January, Matteo informed Viviani that while he was at Pisa he had received four of the latter's letters that had been sent from Florence, and now he received another here in Rome, although the letter sent to Bruto della Molara had disappeared. Matteo apologized to Viviani for not having fulfilled his requests immediately because, as he explained, after his return he had been bedridden for a long period. He had been unsuccessful thus far in his search for the book by Father Guldini of Monte Biagio that Viviani had asked him to find, but he had not yet been able to search with diligence because of his physical indisposition.

He now was fully recovered, he reported, thanking God and the sacred image of the Blessed Virgin to whom he had prayed. He promised that now he would make haste to satisfy Viviani's request for books, and as his health improved, he would make certain to satisfy all of Viviani's needs. Meanwhile, he asked Viviani for a copy of the sketch that the latter had drawn. After having been bedridden for such a long period, he added, he was still suffering from an infection that gave him a minor fever continually. "Over there on that tower in the air," he wrote, "where (as you say with great distinction) 'Aeolus has his den.' My physicians give me little hope and little good judgement, however, so God's will be done".[690]

Matteo's reference to the den of Aeolus was to describe his own bedroom and study, which was situated on the second floor of the rectory in Via Parione. Apparently, the room was unheated, cold, and windy. Aeolus was the god of the winds, which were kept imprisoned in a cave in the Aeolian Islands and which Aeolus allowed to go free at will or upon commands he received from the other gods. The letter continued:

I conveyed greetings to Michel Angelo Ricci in your name and made him read the chapter in the memoirs you had given to me belonging to your Lordship and he sends you infinite thanks. With

[689] Oldenburg, *The Correspondence of Henry Oldenburg,* vol. 6, 424–27, letter 1365: letter from Huygens to Oldenburg on January 22, 1670, N.S.

[690] BNCF, Gal., vol. 255, cc. 127–128, letter from Matteo Campani to Vincenzo Viviani on January 18, 1670.

Abbot Gradi I will compare it as soon as I can, and I will serve also with Abbot Falconieri and deal with other things as well, God willing.

I also was extremely sorry that it was not possible to make the desired tests of the clock in a vacuum for the reason that it had stopped. In my opinion, the accident was caused by some curling or twisting of some teeth due to the temperature which changed after I had inadvertently turned the interior weight upside down one night. I am sending along the cords needed for demonstrating the clock.

If Sig. Bianchini or Sig. Cristofano or perhaps both of them together would agree to favor me with their assistance, they undoubtedly could repair it immediately. I ask you to beg them in my name. Also I wish that you give to each of them the ropes that are enclosed for display of the clock. The cord is in a separate wrapping, divided into two bunches, one cord in each one and stamped by the post.

I attempted repeatedly to serve Sig. Balatri, Sig. Paolo Magnali, as well as the Marquis Carbone, and with Cav. della Molara as best I could. I would also have done that with the Most Serene Grand Duke, but because His Highness never speaks to me about this clock, I thought it prudent for me to remain silent also. Besides providing lodging for me in Pisa and showing me around Livorno at his own expense, His Most Serene Highness provided me with a litter for my return to Rome. All this comes from his great generosity and at the same time all the favors to me by the aforesaid gentlemen.[691]

The Grand Duke's lack of response to communications, which Matteo had noted, despite his many favors to the priest visiting from Rome during his sojourn in Tuscany, apparently was a well-known characteristic, for Viviani did not comment on it.

In mid-February, Matteo reported to Viviani that finally he had purchased a number of the books that the latter had requested, including prose works by Ciampoli, the letters of Cardinal Pallavicini and of Guastaferri, a treatise on blood circulation, and the letters of Rayman donated by the author, a friend of Matteo. The name Cennini was often mentioned and appears to have been the book dealer or agent, and Matteo indicated that he had included a list of his expenses.

Matteo added a short note relating to his nautical clock: "I hope this one coming Saturday to be able to send you that little thing broken on my nautical clock. My other brother has promised me that he would do the work as I wish it to be done". The reference was to his brother Pier Tommaso. Apparently, the recent rift between Matteo and Giuseppe had not been healed so that he had recourse to his other clockmaker brother. Matteo complained that he had been suffering from a light fever, which had confined him to his bed for an entire week after having taken his laxative. The day on

[691] Ibid.

which now he was writing was the eighth day, and he felt somewhat better, although there was some variation of his pulse rate.[692]

At about the same time, Viviani received a letter from Francesco Eschinardi, informing him that Matteo had told him that Viviani was interested in acquiring some of his published works, and accordingly he had turned over copies of his publications to Matteo to be forwarded with his compliments. As a favor, he added, he would like to have Viviani read a little treatise he had written on the subject of mercury, in which he aimed to confute the theory of void, an opinion which he knew Matteo shared with him. He added a brief note reporting that Matteo had just visited him and told him about "the wonderful invention of the night clock that has been made there". There was no further explanation of this timekeeper and the comment is confusing. It may have been a reference to the projection night clock that Giuseppe had recently patented.[693]

Late in March, Matteo again reported to Viviani concerning books that he had acquired for the latter and included a copy of a letter that he had received from Guisony, which he planned to publish. He asked Viviani to translate it for him, since it was written in French. As part of his second publication about his nautical clock, Matteo then added the translation into Italian, "Proposal for Precision Clocks for Use in Astronomy, Cartography, and Navigation for Determining the Longitude". Adding a florid and elaborate dedication to the Cardinal Prince, he sent a copy to him, noting how Galileo had in 1637, with the support of the Grand Duke, proposed to the Dutch government his ingeniously simple yet easy method of measuring time by means of timekeepers utilizing the pendulum as regulator, which he had invented much earlier. This information Matteo had obtained from materials Viviani had furnished to him in addition to diverse letters between Galileo and the Dutch Admiral Reael. He wrote

That was a wonderful and most ingenious invention that Galileo himself, passing from one consideration to another, finally decided to apply the pendulum to the clock in order to avoid the tediousness of watching. It is not easy to establish whether the structure of the invention elaborated by him for the first time was similar to any of the later mechanisms constructed in various ways, beginning first with his son Vincenzo Galilei in 1649, followed then by the most erudite and most clever Christiaan Huygens in Holland, and finally by us [the Campani brothers] and by others here in Rome. As a matter of fact, both Galileo and his son Vincenzo were prevented from bringing their works to perfection and exhibiting them as completed because of impending death and of sickness. Therefore, we cannot be certain about either of the former's

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[692] Ibid., cc. 129–130, letter from Matteo Campani to Viviani on February 15, 1670.
[693] Ibid., cc. 131–132, letter from Francesco Eschinardi to Viviani on February 15, 1670.

invention or of the latter's complete design. I believe that this same opinion was held also by a most erudite French gentleman [Pierre Guisony], who because of a similar controversy that had come about between me and several other inventors, wrote as follows: *'Nowadays, neither Egypt produces men such as Ctesibius nor Sicily as Archimedes, nor England as Drebbel: invention is a kind of creation that requires souls of a higher standing and that it legitimately turns towards itself the immortal prayers of thanks that are due by all men for anything either outstanding or somehow important to our life. To the ones who believe time to be more precious than gold and hold the study of astronomy dear, the discovery that weights are necessary for the correct calculation of time is not a fact of little importance.*

Our age would not have discovered the method of measuring time perfectly if the previous age had not made a considerable progress through the discovery of pendulums' vibrations of equal duration [equitemporaneus] fit for gear-wheeled clocks. It is certain that already Galileo tried to construct such a mechanism in his old age. But he left it unfinished. Every scholar knows that eventually the Dutch Christiaan Huygens Zulichem was the first one to publish a complete design of this mechanism as an example of his great genius.

However, every scholar also knows both the fortune and the zeal of the most ingenious Campani's: they worked on this mechanism until they turned it into the most perfect of all mechanisms. The movement of a pendulum regulates the periods of the clock's geared wheels, and without any failure in the calculation of time, the weights are moved up twice [for the second time, denuo sursum elevantur podera] just as it happens in the clock of the Dutch [Huygens]. What is different between these two clocks, however, is that by means of a new device this one brings the correct hour in the middle of the sky and shows it so that the hour can be read immediately. One must also consider, however, that the friction between the gear wheel and the wings of the axis cause an unpleasant noise in Huygens's clock just as in every normal clock, whereas in Campani's clock no sound whatever can be heard. This is a quite relevant difference between Campani's clocks and those of Huygens, namely, that the former remain silent. I must admit that I have never seen nor heard anything like this either in France, or in England, Belgium, Germany, in the rest of Italy or in any other part of the world. I must say, therefore, that the Campani's have made the clocks mute with no less art and ability than that employed by Huygens to make them work precisely using vibrations of equal duration, and this is the only thing in which they are coincident.

Rome, 30 May in the year 1660 of the Christian Era,
/s/ Pierre Guisony.'

Although the reference in Guisony's letter was to the Campani brothers in general, and he described the rotating disk of the night clock, not to be overlooked is that his letter contained impressive praise for Giuseppe Campani's invention of silent mechanical clocks achieved by means of his crank lever escapement. None of the above systems has been useful, however, to set the clock free from any possible defect—although it has been considerably improved—and the reason was precisely that which already in the beginning the most wise Grand Duke pointed out to Vincenzio Galilei himself and to other inventors, namely, the fact that the impulses transmitted by the clock's geared wheels during the swinging were not equal. In fact, the vibrations of this movement do not happen to be equal in time with one another if they do not pass under equal arches; and experience shows that the short vibrations move faster than the long ones. That is why, finally, Huygens tried to render the vibrations of equal duration with the cycloid, as Your Excellency knows.[694]

[694] Ibid., vol. 279, cc. 5r-14v, Campani, *Proposizione d'orioli giustissimi*, fols. 1–18, Letter from Matteo Campani to Cardinal Leopold, March, 1670 .

Matteo corresponded with Viviani several times in the spring 1670, chiefly concerning books that he had purchased for Viviani at his request. In a letter to Viviani, not dated, Matteo urged him not to write to him in his own handwriting but to dictate his letters to a scribe in order not to strain his eyes, which Matteo held dear, he said, as indeed he did Viviani's health in general. He went on to report that he had received six copies of a published work by Viviani, the title or subject of which he did not identify, but of which he had distributed copies to Don Francesco Nazari for the *Giornale de' Letterati*, to Don Eschinardi, as well as to the secretary of the Duke of Altemps and to Monsignor Albrizio. He also related how he had spoken with a good friend, who was a man of letters, and asked him to obtain sections of the book by Guldini that Viviani had been seeking for a long time, and his friend had agreed to copy those sections for him against payment.

"As for [the manuscript of] that little treatise on the clock, 'Discussion on the Clock' [*Proposizione dell'Oriuolo*]", he added, "I beg your great benevolence to use it as you will, seeing to it, however, that no one else will read it except you. God forbid, in fact, that it should fall into anyone's hands except those of my copyist before you have corrected it".[695]

Later in the month of March, Matteo again reported to Viviani concerning books he was acquiring for him. Matteo informed Viviani that a problem had arisen with the printer concerning the publication of one of the latter's books. Viviani had sent Matteo a list containing a few alterations that were to be made in the text that then was already in press, but the printer appeared to have lost most of the changes requested. Michelangelo Ricci had loaned Matteo a copy of the book by Guldini so that Matteo now could transcribe the pages missing from Viviani's copy. Then Matteo discussed clockmakers in Florence. He noted that a certain clockmaker, Jacopo Melssen, who lived next door to the locksmith of the ducal guard [*magnano lanzo*], had been in Matteo's house, which he passed on his way to serve Monsignor Torregiani. He had written that he was returning to Rome to stay with him until he will have completed work on a clock for one of his friends. Matteo asked Viviani to find Melssen and to direct him on Matteo's behalf to repair the movement of the nautical clock, assuring him that Matteo would give him

[695] BNCF, Gal. vol. 257, c. 235, letter from Matteo Campani to Viviani, undated.

every satisfaction and that he could be assured that his possessions would be redeemed from the customs by Matteo as soon as they arrived. Matteo promised to open the packing case, remove the suit to be aired, and whatever else was required. Melssen was not to be troubled, Matteo added, and he was to stay as long as was required to repair the nautical clock.

Meanwhile, Matteo wrote, he was impatiently awaiting the sketch for the night dial that Viviani had made. Also, he wished to convey his respects to Sig. Balatri and Sig. Magnoli and to Viviani's brother. He added that in the meantime he had given the clock belonging to the *Signor* Goffredo to his brother (probably Pier Tommaso) to be completed. When he had gone to see whether it was ready, however, he discovered that it was still untouched. Therefore, he told Viviani, he would await the arrival of "the young man who worked extremely well (Melssen?). It is very true that the alignment of the teeth and of the *pinions* and of the wheels is so bad, that I hope to God that it will not be necessary to have to remake all the wheels of the movement as well as the barrel and the 'pyramid' [*fusee*] that were made in a very disproportionate manner, as had been noted by *Signor* Cristofano, to whom you may be able to tell that I have found that most gallant man who constructed the springs, but who denies being able to do so. So that I do not know how to find a remedy for the situation".[696]

During the following months, Viviani received several more letters from Matteo (sent on the 4th and 22nd of April, and on the 3rd, 10th and 31st of May), including a sketch of the clock that had been mentioned. Matteo acknowledged receipt on the previous Saturday morning of Viviani's letter accompanied by the sketch of the clock, which he greatly appreciated and for which he thanked him. He asked Viviani also to express his appreciation to *Signor* Balatri on his behalf because he had not yet had the time to do so personally owing to the many religious commitments he had last Saturday. He went on to speak of the clock, "I would greatly appreciate knowing about those small defects in the display of the hours at night. I would like to correct them, although I know for certain that because of the great affection you have for me that you, *Signor* Balatri and *Signor* Paolo, will easily mend these flaws—in particular those caused by my ineptitude.

[696] Ibid., vol. 255, cc. 135r-136v. Letter from Matteo Campani to Viviani on March 29, 1670. Jacopo Melssen is not recorded among seventeenth century clockmakers working in Italy.

Accordingly, I feel much obliged to you all. Here no one talks about the Pope any more; it must be taken for granted, then, that the conclave is still far from reaching a solution. Would you please tell that clockmaker whom I have mentioned in another letter of mine (Melssen), that his belongings are still safe in my apartment, just as are his clothes and tools. Finally, please thank Signor Bianchi for his kindness".[697]

Matteo again wrote to Viviani late in April 1670: "Most Singular Sir," he wrote, "The bearer of this [letter] is the young clockmaker who wrote to me from Florence that he wished to come and stay with me: and then he sent all his [trifling] personal possessions. Immediately after he arrived at my house, though, he told me that he had promised the Count Gonzaga, Master of the Chamber of the Most Serene Grand Duke, to return there, so that [the completion of] some of my drawings will be interrupted for some time. Dear Sir, my dear Viviani comes to me after I had asked him with all my heart to repair the enclosed [nautical] clock, as he promised me to be willing to do, given that he has seemed to me to have wished to see such an invention, and to try to repair it in order to understand it better. I also beg Your Lordship to please tell *Sieur* Cristoforo and *Sieur* Bianchini that, if it should happen that they have some willing youth of the trade who wishes to come to Rome, to send him to my house in San Tommaso in Parione, that here he would be well received".[698]Although not otherwise identified, Cristoforo and Bianchini were clockmakers, possibly employed in the Medici workshops in the Uffizi galleries.

In May 1670, Matteo decided to share with Viviani a mystery [secret, *arcano*] upon which he had been engaged in research for a long time. It was a startling report, which is best presented in his own words:

I would be going against the rules of a good and loyal friendship and contravening the laws of human confidence, if I did not confer with you concerning a particular secret [*arcano*] of mine about a principle which I have investigated for quite some time now and, once found, I have not revealed it to any body except Abate Filippo Marucelli, Secretary to His Serene Highness, on October 24, 1668. Regarding the nautical clock [clock in a vacuum] I once wrote to Marucelli that I thought I had made a most admirable discovery; on that occasion I wrote to him that the only reason to have doubts about this mechanism was because it was operating so marvelously. I had every reason to believe that it would work, especially since my reasoning rested upon a new principle which I had found and tested out some ten or twelve years before. At that time, I had based various conjectures on that principle; all such conjectures seemed plausible at first, but then

[697] BNCF, Gal., vol. 255 c. 137. Letter from Matteo Campani to Viviani, April 4, 1670.
[698] Ibid., vol. 255 c. 141 Letter from Matteo Campani to Viviani , April 22, 1670.

I discovered them to be wrong owing to the balance of forces. I came to this conclusion only by means of sketches of the mechanism and calculations of its motive power, resorting to paper, pen, and ink alone. As for the new machine I had invented, instead, I told Marucelli that I could find no flaw in it. Furthermore, I wrote to him that this new machine of mine appeared to demonstrate with new and greater force the causes of perpetual motion.

Having sent that letter to Marucelli and the latter having informed the Serene Lordships about the whole matter, as Marucelli himself told me, I thought I had aroused their curiosity. I expected them to ask me to give a demonstration of my discovery by using that old brass mechanism that I also had shown you when my teacher built the box of that clock. Realizing that no one paid much attention to it, however, I decided not to do anything for the time being. I thus resolved not to reveal what I knew nor the reason I had for building that small machine. After all, this invention of mine had to do with perpetual motion. Although perpetual motion is not there in action, yet it is there potentially so close that only a small variation, or the application of a few tools, is needed [to prove it]. On that occasion I resolved to apply these tools in a crafty and subtle way for two reasons: first, not to let the maker find out about the discovery; second, to show the learned that I had found, if anything, a new, more plausible and more reliable principle for the structure of perpetual motion. When I showed the functioning of that machine, one could see that the motive levers were always charged [armed] and horizontal, and, above all, substantially moving and with weights only on one side. I had intentionally and purposefully placed these weights on the side opposite the force and power of the levers in order to hide craft with craft. Consequently, instead of moving, the machine was forced to stop after reaching its balance. After all, you yourself can clearly see that, by changing the application of the aforesaid two powers—that is, once they have been united in order to move the machine, or, if you will, the sphere (which shows the perfection of the machine), apart from the other one I mentioned before, which I have shown here in Rome and in Florence before someone tampered with it—perpetual motion necessarily will follow. The speed of such perpetual motion will depend upon the two powers, which can be multiplied both in number and in quantity. The quality of the powers, too, can be changed; likewise, the adjustment of the clock can also alter them.

I know that in order to believe what I have just written, you would like to see the whole thing, or at least to hear from me that I have tested it myself. I can tell you that by using some small wooden models I have shown under oath to my dear Father Daniello Bartoli the veracity of my reasonings; I showed that to him and I convinced him completely [literally, "I made him touch it with his hands,"] and the levers put pressure on one side of the spinning spheres of the machine, and the lead weights; the latter were . . . put together to make the machine move in just one direction. Bartoli then was struck by this invention, and he gave me permission to mention him as witness and judge of this successful attempt. He said that he would testify that the experiment had been carried out properly, by resorting to natural principles, in a perfectly normal and undisturbed manner, but I must now return to my work.[699]

This letter provides the first inkling that Matteo had moved on to another invention, that of perpetual motion, a project that would continue to preoccupy him throughout his remaining years. The drawing he sent to Viviani survives, but no other details are known.

In late May 1670, Matteo wrote to Viviani in response to the latter's letter, stating that he held him in such high esteem that he would not fail to keep his promises. He

[699] Ibid., vol. 255, cc. 145r-146v. Letter from Matteo to Viviani, May 10, 1670.

assured Viviani that he had not shown to anyone that chapter of the unpublished manuscript with which Viviani had favored him to let him read, nor did he have even the least thought of publishing a word about it without Viviani's express approval as indeed he had promised. He wrote that he had persuaded himself that it would be appropriate for Viviani to look forward to publishing it "so as to give glory to Galileo". Matteo, about "the ingenious method imagined by Galileo to arrange the pendulum",asked Viviani not ever to believe of offending either Huygens or others by what he had written. He assured Viviani that he would obey him in all ways. Meanwhile he was grateful for his excellent counsel and begged him to put aside any doubts he may have had about him. He added that he had been greatly saddened by the recent death of the Grand Duke, to whose spirit he owed many obligations, and he inquired after Cavaliere Annibalo Bruto della Molara and whether he continued in the same service with the new Grand Duke.[700]

A week earlier, on May 23, the long-ailing Grand Duke Ferdinand II had finally expired at the age of 60. Failing with dropsy and apoplexy, he suffered incredible unceasing agonies throughout his final months, chiefly from the treatments he received from his doctors. Constantly bleeding him, they placed a cauterizing iron upon his head and forced *polvere capitale* up his nose. They applied four live pigeons to his forehead, the stomachs of which had been ripped open for the purpose. It was with considerable apprehension that his son, Cosimo III, entered upon his inheritance.[701]

Responding some weeks later to Viviani's request for more books to be acquired in Rome, Matteo reported that several months earlier he had given the book dealer Paolo Cennini some of the volumes that Viviani had requested. Cennini had promised to have the books delivered to Viviani, but apparently the latter had not received the package. Despite inquiries he had made, Matteo had been unable to obtain any information about the shipment. Finally, on July 5, Cennini wrote to Viviani concerning books he had with him and mentioned Matteo Campani in relation to them. Two weeks later, Cennini again wrote to Viviani, "I hear what you say and what you ask me, and I will promptly do that when *Sig*. Campani, who usually comes here, will happen to come by. Let me know if

[700] Ibid., vol. 255, cc. 150-151. Letter from Matteo to Viviani, May 31, 1670.
[701] Hibbert, *House of Medici*, chap. XXIII, p. 2.

there is anything else I can do for you, and feel free to ask specifying what and how much. And finally let me pay you my humblest homage, Rome”.[702]

On August 16, 1670, Matteo informed Viviani that as a consequence of his quarrel with a procurator, he did not have time that morning to visit Paolo Cennini, who had indicated that he was unable to obtain a certain volume that, however, Matteo could provide. As to other books Viviani has requested, Matteo reported, they could not be found in Rome but that perhaps a librarian could be commissioned to find them elsewhere. He had not yet been able to bind the book Viviani wanted. Matteo wrote again to Viviani concerning the purchase of books in mid-September.[703]

Several months passed before Matteo again wrote to Viviani, in March 1671: “I have not had the time to write to you before,” he explained, “and now I am writing a very short letter, owing to my many and different cares and commitments. I am much ashamed to tell you that the mechanism [artifice] of M. P. [perpetual motion?] has fooled me and some other persons around me of great intellect and learning. As soon as possible after Easter, I will send you a sketch of it. At first it seemed to uphold two plausible theories; once it had been carefully examined, however, it revealed the fallacy as well as the flaws [*equilibrio*] typical of such mechanisms”.[704]

In August 1671, Bruto della Molara wrote to Viviani from Foligno to acknowledge the arrival of a clock, which he neither described nor identified the maker. Because of the date, his communication apparently related to Matteo’s nautical clock. Molara wrote: “The clock that you sent me arrived here in excellent condition, and no less could be expected considering the care with which it had been packed. Please send me your other clocks in the same manner. Personally I did not have much opportunity to enjoy the clock, given that immediately I sent it betimes to show it to *Sig*. Carlo Conti who is fond of clocks.” Bruto della Molara went on to wish Viviani a quick recovery from his illness and stated he wished to see him in the best health possible according to the will of God. He added that he was his most loyal friend.[705]

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[702] BNCF, Gal., vol. 164, c. 45. Letter from Matteo to Viviani, July 5, 1670; c. 47. Letter from Paolo Cennini to Viviani, July 5, 1670; c. 49. Letter from Paolo Cennini to Viviani, July 19, 1670.

[703] Ibid., c. 55. Letter from Matteo Campani to Viviani, August 16, 1670; c. 66. Letter from Matteo Campani to Viviani, September 13, 1670.

[704] Ibid., vol. 255, c. 169. Letter from Matteo to Viviani, March 1, 1671.

[705] Ibid., Gal., vol. 164, c. 123. Letter from Bruto della Molara wrote to Viviani, August 8, 1671.

Viviani's responses to Matteo have not been preserved, but in September 1671, Matteo referred to them, noting: "I received your letters while writing the enclosed explanation of my theory on perpetual motion. I hope that at least it will help you to see whether my theory is plausible or not. Tomorrow I will see to it to have delivered that letter of yours to Monsieur Auzout, though I have not seen him in a while". The letter in question was a communication from Viviani to Auzout that Matteo was to deliver. Next followed Matteo's request for the baptismal certificate of Lucia Cecilia, daughter of Mariano Badeschi and Caterina Balduinetti, whom he was planning to adopt. In closing, Matteo added a postscript, "Please express my most humble greetings to the Marquis Vitelli, to whom I am much obliged for the great kindness he has shown me, and please do the same with the Most Excellent Doctor Francesco Redi, who took such good care of me, most wretched soul that I was, when I was sick."[706]

Following was Matteo's brief but incomplete explanation of his theory of perpetual motion: "The circle LMN represents the two plates *ubestate* at three columns LMN one of which and the other like a movement of etc…".[707]

Some 10 days later, Matteo once again wrote to Viviani, reflecting some aspect of the relationship that had grown between them over the decade and more of their acquaintance, as Matteo urged him to forego the use of ceremonial terms in future correspondence and to treat him *alla buona*. He requested that "you are not to stand on ceremony when you deal with me; instead, be simple and straightforward as I am your most humble servant". He reported that as for the small glass cylinder for leveling, Monsieur Auzout told him that he had tried many times to have it fabricated in Rome, "but he has never succeeded in having a piece made entirely the same way. He told me, however, that your request is more likely to be satisfied there [in Florence] if you have craftsmen to pull the small glass tubes, not too hot, upon an even and perfectly flat wooden table. He said that is the way they do it in France".[708]

Following Viviani's precise instructions, Matteo had "ordered the needle and the magnetic compass for measuring the declination". He had entrusted "a reliable and competent artisan there in Rome. It was not possible to determine the price; the cost in

[706] Ibid., Gal., vol. 255, cc. 181-182. Letter from Matteo to Viviani, September 13, 1671.
[707] Ibid.
[708] Ibid., cc. 195-196. Letter from Matteo Campani to Viviani, September 21, 1671.

Paris is 74, and ours is very expensive. This craftsman is very high priced. He told us, however, he would be glad to keep the work if, after having seen it, we will find it unsatisfactory, or if we deem the price to be too high. I would then like to know from you how much you are willing to pay. It is a little rectangular box, yet long enough to fit the nine-ounce needle of a Roman palm".[709]

As the end of the month neared, Matteo sent a letter to Viviani that he had dictated to an aide, because as he said, he did not have time to write it himself. He reported that he had been tremendously busy lately, and apologized for not having been prompt at times, in responding to Viviani's requests. He had just received Viviani's letter of September 26th and promised him that the very first thing next morning, he would send him the book by Guerini together with other items. He said he had waited 3 days before responding to the two letters because he wished to complete a few calculations concerning the eclipse and to include them as well. He thanked Viviani for having sent him the report of observations and was pleased to find that Viviani's and his own calculations about the eclipse coincided. They both agreed that regarding the observation of the eclipse there was a given minute difference between Florence and Rome.

Matteo then mentioned his clock in relation to the difference in the calculations, and later mentioned he had corrected the clock at noon by means of the sundial in Saint Peter's Square. He then complained about the envy and the wickedness of some scholars (probably from the Florentine milieu, but the names and specific reasons for his complaint are no longer legible).[710]

Late in October 1671, Matteo forwarded the compass needle to Viviani by means of the courier [*procaccio*]. He agreed that the needle was even more beautiful than that of Auzout, yet he could not help but express his disappointment concerning the high cost. The artisan demanded of him, as a friend, 5 *scudi*, so he did not know whether the matter of friendship caused the price to be reduced as the craftsman swore that it did, or to increase. "Kindly let me know if the needle has been made to your satisfaction," he

[709] Ibid., c. 195, Letter from Matteo Campani to Viviani, September 25, 1671.
[710] Ibid., vol. 164, cc. 150-151. Letter from Matteo Campani to Viviani, October 2, 1671.

wrote. “My master tells me that you could touch the needle with a powerful lodestone”.[711]

After Matteo had waited for several weeks and failed to receive a response on the matter of the baptismal certificate of Lucia Cecilia, daughter of Mariano Mariani and Caterina Balduinetti, he wrote again, suggesting that Viviani may not have replied because he had not expressed himself clearly enough. The baptism must have occurred between 1632 and 1638, he suggested. He was anxious to determine the exact dates of birth of various persons, particularly the girl’s mother. “As for Caterina Balduinetti,” he wrote, “since according to the above-mentioned certificate of 1648 she is said to be 56, she must have been born around 1592. When she was baptized she was called Caterina Cristina, daughter of Vincenzo Balduinetti and [*undecipherable*], both Florentines. The house of the said Vincenzo was on the corner by the alley right next to the Palazzo de’ Priori. The family served His Highness but I do not know precisely on what terms. I guess that he died when the plague wreaked havoc in the city, and his belongings must have been taken away. I imagine, though, that the said Caterina, while pregnant with Lucia Cecilia, must have gone back to Florence in the hope of putting a few things together. I will welcome any item of information you may be able to gather”.[712]

In December 1671, Viviani returned the needle to Matteo as unsatisfactory, and Matteo reported that he in turn had returned it to the artisan to have it modified in accordance with Viviani’s instructions. The artisan disagreed, however, claiming that he had produced a needle the same as the one owned by Auzout that had been given to him as a model and that in fact he had made his better. Finally, he promised to return Matteo’s money, but since Matteo had been out of town he did not as yet have time to go to the artisan’s house, he felt certain he would keep his promise.[713]

Early in 1672, Matteo informed Viviani that Monsieur Auzout claimed that “the magnetic compass that had been made for you was as good as his with three needles”. Matteo has resolved to return the compass to the artisan who made it and claim his money to be returned, and that would end the matter. He has been supplying Viviani with issues of Rome’s newspaper, the *Giornale,* and planned to acquire the particular issues

[711] Ibid., vol. 255, cc. 202r-203. Letter from Matteo Campani to Viviani, October 24, 1671.
[712] Ibid, cc. 206-207. Letter from Matteo Campani to Viviani, December 5, 1671.
[713] Ibid., c. 214, Letter from Matteo Campani to Viviani, January 16, 1672.

that Viviani wished from a *Signor* Renato. He apologized for not having done so sooner but had been unable to do so owing to an illness that has forced him to remain in bed for a number of days. In this letter, Matteo stated that he had finally resolved the matter of Caterina Balduinetti, the mother of the young woman he was planning to adopt.[714]

In the course of the development of his horological inventions over the past several years, Matteo had employed more than one of the local clockmakers in Rome from time to time, since it is clear that he did not confide his ideas to either of his brothers or seek to utilize their talents. Several days before Christmas 1674, in a letter now incomplete and apparently addressed to Cardinal Leopold, Matteo described the difficulty he was experiencing in completing his invention. A few days later, Matteo wrote to Viviani asking his friend to inquire about the Cardinal's opinion on his book's preface on the nautical clock.[715]

In the last years of his life, Matteo went on maintaining a frequent correspondence with the Medicean court, especially with Viviani; however, his vacuum clock did not bring him the fame and wealth he had expected.

[714] Ibid. Caterina Balduinetti, the daughter of Vincenzo and Ginevra. When Caterina was still young, Ginevra became a widow with a good patrimony from her deceased husband. Eventually Caterina married a Florentine shopkeeper who had to abandon everything after he had committed a murder. He fled Florence and went to Rome with his wife, and after the plague had brought disaster to Florence, Vincenzo's relatives in Florence died and their possessions were taken over by the local authorities. After the plague ended, Caterina returned to Florence to try to acquire some family belongings. There she was delivered of her daughter, and 3 months later, she returned to Rome, and then that her father died.

[715] BNCF, Gal., vol. 279, c. 5, c. 167, letter from Matteo Campani to Prince Leopold on December 22, 1674, concerning a clock on which he had been working for years. BNCF, Gal., vol. 256, cc. 25r. Letter from Matteo Campani to Viviani on December 29, 1674.