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Castelli, Benedetto

(*b*. Brescia, Italy, 1578; *d*. Rome, Italy, 19[?] April 1643),

hydraulics, astronomy, optics.

Antonio, eldest son of Annibale and Alda Castelli, took the name Benedetto upon entering the Benedictine order at Brescia in September 1595. At some time before 1604 he moved to the monastery of Santa Giustina, at Padua, where he studied under Galileo. In 1607 he was at Cava, and in 1610 had returned to Brescia. Shortly after receiving from Galileo a copy of the *Sidereus Nuncius*, he applied for transfer in order to work with Galileo. Late in 1610 he wrote to Galileo, expressing Copernican convictions and suggesting telescopic observation of Venus to detect its phases, observations which were then being made by Galileo.

In April 1611 Castelli was moved to Florence. In 1612 he suggested to Galileo the method of recording sunspot observations by drawing them on a paper screen parallel to the eyepiece of a telescope. Galileo's controversy with philosophers over bodies in water and the phenomena of floating resulted in the publication of several polemics in 1612; it was to Castelli that Galileo entrusted the publication of replies (largely written by Galileo himself) in 1615.

Late in 1613 Castelli was present at the table of the grand duke of Tuscany at Pisa when Galileo's Copernican views were attacked; Castelli defended them and notified Galileo, who replied at length concerning his views of the relation between science and religion. This letter to Castelli was later important in Galileo's dealings with the Roman Inquisition, and in an expanded form it became the famed *Letter to the Grand Duchess Christina*, circulated in 1615 and eventually published at Strasbourg in 1636.

At Galileo's recommendation Castelli became professor of mathematics at the University of Pisa in 1613, a chair to which he was confirmed for life in 1624. In 1626, however, he resigned the post. At Pisa for want of a Benedictine monastery, he lived in one belonging to the Jesuate (not Jesuit) order. There he met the young Milanese student Bonaventura Cavalieri, whom he introduced both to the study of mathematics and to the personal acquaintance of Galileo. Cavalieri's "geometry by indivisibles" was an important step toward the infinitesimal calculus. Later, at Rome, Castelli was the teacher of Evangelista Torricelli and of Giovanni Alfonso Borelli; he was also the instructor of Galileo's son, Vincenzio.

While Castelli was still at Pisa, he became interested in the study of water in motion. Early in 1626 he sent to Florence, for Galileo's comment, two treatises on the motion of rivers, in one of which he corrected the classic work of Frontinus, *De aqueductibus urbis Romae*. About this time he was called to Rome by Pope Urban VIII as papal consultant on hydraulics, tutor

to Taddeo Barberini, and professor of mathematics at the University of Rome. In 1628 he published the book *Delia misura dell'acque correnti*, considered to be the beginning of modern hydraulics. Its fundamental propositions related the areas of cross sections of a river to the volumes of water passing in a given time. He also discussed the relation of velocity and head in flow through an orifice. A posthumous edition included the proposition that where a stream was dammed, the velocity of flow over the top was in direct proportion to the depth of water so flowing. Castelli's defective "proof" of this was deleted in most copies as a result of his dissatisfaction with it, expressed in some of his letters. Castelli's pioneer work in hrydraulics was carried on much further and with greater accuracy by his pupil Torricelli.

Some writers have declared that Castelli owed his knowledge of hydraulics to the manuscripts of Leonardo da Vinci and in particular to the compilation of Leonardo's writings on that subject by Luigi Maria Arconati, now in the Barberini archives. In fact, however, that compilation was dated 1643, and the manuscripts of Leonardo did not pass to the Biblioteca Ambrosiana, where Arconati consulted them, until 1637. Castelli's correspondence shows quite clearly that his studies of hydraulics were chiefly of an experimental character. It is of interest in this connection that he obtained from Galileo the length of an approximate seconds pendulum for use in his experiments and devised a cylindrical rain gauge.

In 1634, as a result of discussions with friends about the mutual illumination of the earth and the moon, Castelli arrived at the conclusion that the illumination given by any two lights of different intensity and surface area is directly proportional to those two factors and inversely proportional to the squares of the distances of the lights from the illuminated body. (This photometric law, in a less detailed form, had been given by Johannes Kepler in 1604 but seems not to have been noticed elsewhere until 1638, when it was published by Ismael Boulliau at Paris.) Proceeding with his lunar observations, Castelli wrote to Galileo in 1637 that he was convinced of the existence of large land bodies in the South Seas, a conclusion approved by Galileo in his reply and confirmed later by the vast extent of the Australian continent.

Castelli's optical investigations were continued in a treatise sent to Giovanni Ciampoli in 1639 and published posthumously in 1669. Included are many observations and conclusions with respect to the persistence of optical images, by which Castelli explained the perception of motion, the illusion of forked tongues in serpents, and other phenomena. In the same treatise he recommended the use of diaphragms in telescopes to impede transverse rays, anticipating Hevelius. His discussions of the camera obscura, the inversion of images on the retina, and of cataract (from which Galileo had recently lost his sight), although less novel, are not without interest.

More celebrated is Castelli's discussion of heat in a series of letters to Galileo (1637–1638) and particularly his experiments with the absorption of radiant and transmitted heat by black and white objects. Two of these letters, in which the pursuit of experimental science is even more clearly described than in Galileo's work on bodies in water, were published in 1669. Castelli was also interested in algebraic researches, particularly on the use of negative quantities in the solution of problems in the theory of numbers.

Castelli's importance to science lay not only in his extension and dissemination of Galileo's work and methods, but also in his long and faithful service to Galileo during the two periods of crisis with the Inquisition. It was to Castelli that Galileo addressed his first discussion of religion and science, and it was on Castelli's advice in 1630 that Galileo transferred the

printing of the 1632 Dialogue from Rome to Florence, a maneuver without which that important work might never have issued from the press.

BIBLIOGRAPHY

I. Original Works. With Galileo, Castelli wrote Risposla alle opposizioni del S. Lodovico del le Colombe e delS. Vincenzio di Grazia… (Florence, 1615). Delia misura dell'acque correnti (Rome, 1628) includes, as the second part, Demonstrazioni geometriche deila misura dell'acque correnti; to the 2nd ed. (Rome, 1639) are added two appendixes and a letter to Galileo relating to hydrology; to the 3rd ed. (Bologna, 1660), several hydrological treatises. An English trans, of Castelli's works on hydraulics and hydrology, based on the 3rd ed., was published by Thomas Salusbury in *Mathematical Collections and Translations, the First Tome* (London, 1661; repr. 1967). A French trans, of the work on hydraulics is contained in *Traité de la mesure des eaux courantes de B. Castelli par Saporta*… (Barcouda, 1664). The Italian text has been frequently reprinted. Alunci opuscoli filosofici.., (Bologna, 1669) contains Discorso sopra la vista, Del mode di conservare i grani, and Due lettere.., sopra'l differente riscaldimento…. Castelli's short commentary on Galileo's La bilancetta was first published in Opere di Galileo Galilei (Florence, 1718), III, 309–311. Castelli's lectures on geometrical pavement and on questions of algebra were published in an appendix to A. Favaro, "Amici e corrispondenti di Galileo Galilei, XXI.,—Benedetto Castelli," in *Atti del Reale Istituto veneto di scienze, lettere ed arti*, **67** , pt. 2 (1907–1908), 1–130. Most of Castelli's correspondence was published in *Opere di Galileo Galilei*, Edizione Nazionale, A. Favaro, ed. (Flor-ence, 1890–1910; repr. 1929–1939, 1964–1966), which also contains his commentary on Giorgio Coresio's polemic against Galileo over floating bodies (V, 245–285).

II. Secondary Literature. The principal source is A. Favaro, "Amici…" cited above; see also Favaro, "Intorno al trattato di Leonardo da Vinci sul moto e misura dell'acqua." *Reale Accademia dei Lincei. Rendiconti*, **27** (1918), 17 Nov., and "Galileo Galilei, Benedetto Castellie la scoperta delle fasi di Venere," in *Archeion*, **1** (1920), 283–296. See also G. L. Masetti Zannini, *La vita di Benedetto Castelli* (Brescia, 1961), which includes an extensive bibliography of works by and about Castelli.

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