The Waterwheels of Lizzafusina: Technological Innovation, Patenting, and Practical Necessity in Sixteenth-Century Venice

David Gentilcore

Technology and Culture, Volume 66, Number 1, January 2025, pp. 107-133 (Article)

Published by Johns Hopkins University Press
DOI: *https://doi.org/10.1353/tech.2025.a951052*

The Waterwheels of Lizzafusina: Technological Innovation, Patenting, and Practical Necessity in Sixteenth-Century Venice

DAVID GENTILCORE

ABSTRACT: This article explores the reliance of watermen (*acquaroli*) in early modern Venice on increasingly sophisticated waterwheels, designed, produced, and patented by competing inventors during the sixteenth and early seventeenth centuries, to load fresh water supplies that supplemented the rainwater on which the city otherwise depended for its freshwater needs. Using a range of archival and printed sources, this article examines the tools that delivered water to the watermen's barges and the state-sponsored competition this spurred among inventors. More broadly, the article investigates how Venice's patent process compared to those elsewhere in sixteenth-century Europe, with specific attention to the status of petitioners, contemporary notions of expertise, knowledge flows, and the role of the state.

KEYWORDS: hydraulic machinery; patenting of inventions; freshwater supply; Venice; hydraulic expertise; waterwheels; early modern

Introduction

In the early modern period, Venice was uniquely dependent on rainwater capture—which fed thousands of underground cisterns located in the city's public squares (*campi*), courtyards, private homes, and religious institutions—for nearly all its freshwater needs. This technology fascinated the Stuttgart architect Heinrich Schickhardt, who visited the city in 1598. He drew a cross section of a cistern (see figure 1), described its construction, and

Citation: Gentilcore, David. "The Waterwheels of Lizzafusina: Technological Innovation, Patenting, and Practical Necessity in Sixteenth-Century Venice." *Technology and Culture* 66, no. 1 (2025): 107–33.

0040-165X/25/6601-0005/107-133

JANUARY
2025
VOL. 66

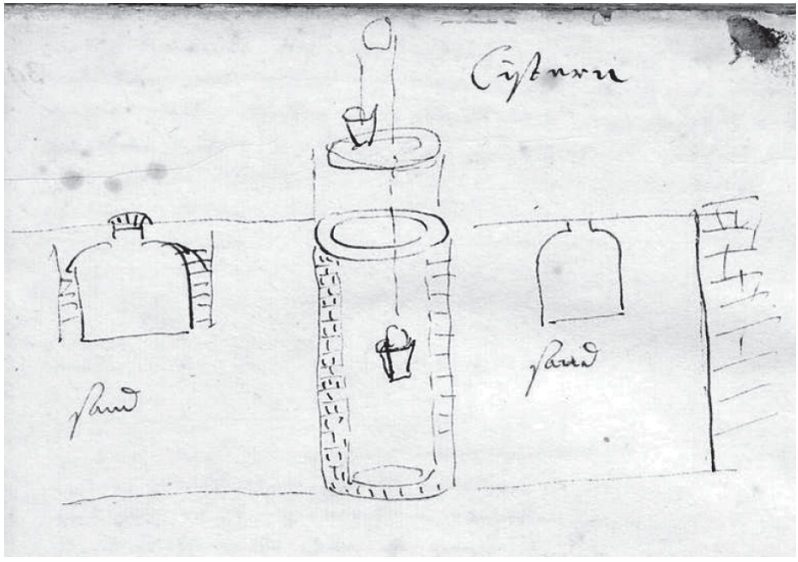

FIG 1. Capturing Rainwater. Heinrich Schickhardt's 1598 sketch of a Venetian-style well-cistern. Until the late nineteenth century, Venice relied on rainwater capture for most of its fresh water needs. Rainwater cisterns, identifiable by their well heads, were scattered throughout the city. Schickhardt, a Stuttgart architect, documented one of these well-cisterns in this cross-section, showing two underground vaults for rainwater collection and the sand layers filtering it into the well shaft below. (Source: Schickhardt, "Raiss in Italia," fol. 39v., WLB)

reported that almost every house had one.[1] This was far from true, but even if it had been, the cisterns would not have been enough to meet demand, given the vagaries of rainfall throughout the year, the heavy demands of certain trades and manufactures, and the city's growing population. As a result, the supply of fresh water to the cisterns had to be periodically replenished by barge loads of fresh water sourced from the Brenta River at Lizzafusina (today Fusina), brought across the lagoon to Venice, and poured into the cisterns. The watermen of the city, known as *acquaroli*, were responsible for transporting the water in flat-bottomed barges called *burchi*.[2]

In February 1588, the watermen complained about the dire situation they and the city were facing. Venice was desperately short of fresh water, "both for the daily use and the needs of its inhabitants . . . and for the support of dyers, for the cleaning of wool, for soap-makers, bakers, public hospitals, the Arsenale, and many other places." This deficit was caused by the watermen's inability to take on loads of water, "now that the machinery [*edifitii*] that had previously served to load water is burnt and abandoned." The watermen complained that they were forced to use their own arms to lift water into their barges and even proposed developing a device themselves for their needs.[3]

Using a variety of archival and print sources, this article focuses on the waterwheels that inventors created to solve the problem of getting water into the watermen's barges, analyzing the designs, technologies, and strategies they employed, as well as the state-sponsored competition among inventors that resulted. Patent applications for water-lifting devices came to the Venetian authorities from across Europe, and the applicants themselves represented a wide range of skills, professions, and social ranks, including famous names like Galileo and Janello Torriani, as well as local artisans. The applicants framed their proposals in ways that made them more convincing to the authorities, who sought ideas that would meet particular local needs. Although the applicants employed the language of innovation and originality, this article argues that practical considerations significantly shaped their efforts. More generally, it compares the Venetian example with patenting processes elsewhere in sixteenth-century Europe, highlighting what it reveals about the status and strategies of petitioners, contemporary notions of expertise and knowledge flows, and the role of the state.

1. Heinrich Schickhardt, ms., "Raiss in Italia (1598)," transcription and notes by Davide Martino, Cod.hist.qt.148.a, fol. 3r., fols. 12r. and 39v., WLB, https://digital.wlb-stuttgart.de/index.php?id=6&tx_dlf%5Bid%5D=16555&tx_dlf%5Bpage%5D=1.

2. Gentilcore, "The Cistern-System of Early Modern Venice: Technology, Politics and Culture in a Hydraulic Society."

3. *Collegio, Risposte di dentro*, b. 8, no. 196, February 16, 1587 (*m.v.*=1588), ASVe, cit. in Molà, "La Repubblica di Venezia tra acque dolci e acque salse: Investimenti tecnologici a Lizzafusina nel Rinascimento," 466. All translations are by the author unless indicated otherwise.

Venice's Patent Process and Hydraulic Devices

JANUARY
2025
VOL. 66

In 1474, the Venetian Senate passed a resolution that institutionalized and established an administrative procedure for granting *privilegi* (literally, "privileges"): patents that recognized inventions and protected inventors from unauthorized copying for a set period of time.[4] One patent described this process as "a useful expedient to aid and assist the creators of new inventions."[5] Over the course of the sixteenth century, the Venetian approach to patenting spread throughout Europe.

Anyone who claimed to have a new and useful invention could apply to the Venetian authorities for a patent. In a written "petition" (*supplica*), inventors or applicants would stress the novelty and usefulness of their invention and ask for certain conditions in return, most commonly protection for a set period of time. Privileges were usually granted by the Venetian Senate after hearing the opinions of the relevant elected magistracies on the invention. In the case of water-lifting devices, the relevant magistracies were usually the Provveditori di Comun (a public works office responsible for the construction and maintenance of streets, bridges, and wells) and the Savi alle Acque (which had authority over the maintenance of the lagoon, canals, and related waterways).[6]

By the middle of the sixteenth century, Venice was producing a wide range of goods for its own market and for trade, including silk, wool, leather, glass, ceramics, enamels, precious metals, and printed books.[7] Important hydraulic works were undertaken to defend the lagoon, improve navigation, and drain large areas of uncultivated land on the mainland. All these activities created an insatiable demand for the latest machinery. Patents were granted in what Luca Molà has identified as three main categories: large and small machines and devices, such as mills, pumps, and cauldrons; technical processes, such as chemical and dyeing formulas; and objects and consumer goods, such as textiles, glass, and ceramics.[8]

According to the documents painstakingly collected by Roberto Berveglieri, patents and goods were granted at a fairly constant rate over the three centuries of the procedure, from 1474 to 1789, with the exception of those for

4. *Senato Terra*, reg. 7, fol. 32, March 19, 1474, ASVe, cit. in Costantini, *L'acqua di Venezia: L'approvvigionamento idrico della Serenissima*, 60; Mandich, "Venetian Patents (1450–1550)."

5. *Senato Terra*, reg. 92 (filza 258), fol. 300v, January 4, 1622 (*m.v.*=1623), ASVe; Berveglieri, *"Ingegnosi arteficij": Trecento anni di storia della scienza, della tecnica e dell'innovazione (1474–1788)*, 490–91.

6. Zaggia, "'Far la città': Il ruolo dei Provveditori di Comun nell'evoluzione dell'ambiente urbano di Venezia; Strade, ponti, pozzi, case"; Bevilacqua, *Venezia e le acque*, 91–92; Ciriacono, "Management of the Lagoon and Urban Environment in 18th-Century Venice."

7. Pezzolo, "The Venetian Economy."

8. Molà, "Inventors, Patents and the Market for Innovations in Renaissance Italy," 12.

hydraulic pumps, which peaked in the second half of the sixteenth century, when forty-three of a total of sixty-six patents were granted, as well as those for mills (mostly hydraulic), with thirty-eight of the seventy-two patents of this type dating from that period.[9] Hydraulic machinery itself—wheels, gears, screws, shafts, pulleys, etc.—had been part of manufacturing technology for centuries, but its operational capacity increased enormously throughout Europe during the sixteenth and early seventeenth centuries. Italy was at the forefront of hydraulics.[10] The Venetian authorities in particular, as Salvatore Ciriacono has noted, actively promoted hydraulics as an empirical science capable of predicting the effects of diverting rivers, digging canals, and dredging lagoon openings.[11]

It is not always easy to identify patent applications, partly because the terminology of the time was fluid, with terms like *edificio*, *macchina*, and *strumento* applied to a wide range of devices, machines, and apparatuses, and partly because certain processes were multifunctional. Water mills are a case in point, as they could be used in many different areas, and gear drives could be adapted in other types of mechanical devices.[12] Consider the water mill proposed to the Venetian authorities in 1559: Powered by river, spring, or tide, it could (according to the petitioner) perform a bewildering variety of activities, including grinding flour, pressing olives, refining sugar, polishing weapons, grinding gunpowder, making paper, tanning leather, milling wood, draining ditches and marshes, fulling cloth, irrigating vineyards, and supplying fresh water.[13]

In their basic principles, waterwheels were similar to other irrigation and drainage devices that were in great demand on the Venetian *terra ferma* from the sixteenth century onward, as evidenced by the boom in patent applications. Venice welcomed inventions that promised to consume less fuel or rely less on human or animal power, which would directly benefit the public purse in activities such as shipbuilding, land reclamation, dredging, fortification, and freshwater provision.[14]

In his 1568 petition to the Venetian Senate, Torriani—whose first and last names were spelled in various ways, roughly corresponding to the number

9. Berveglieri, *"Ingegnosi arteficij": Trecento anni di storia della scienza, della tecnica e dell'innovazione (1474–1788)*, 42–43.

10. Biswas, *A History of Hydrology*, 202.

11. Ciriacono, *Building on Water: Venice, Holland and the Construction of the European Landscape in Early Modern Times*, 119.

12. Popplow, "Hydraulic Engines in Renaissance Privileges for Inventions and 'Theatre of Machines,'" 79.

13. Petition made by Giovanni Battista Antonelli, "engineer to his Catholic Majesty" Charles V, March 16, 1559, *Senato Terra*, reg. 42 (filza 29), fol. 23v., ASVe; Berveglieri, *Ingegnosi artificij*, 223–24; Howard, "Invention and Reality: Patent Applications Presented to the Venetian Senate," 77.

14. Howard, "Invention and Reality," 78; Popplow, "Hydraulic Engines," 80.

JANUARY
2025
VOL. 66

of his inventions—defined himself as "clockmaker and mathematician to his Catholic Majesty [King Philip II]."[15] A well-traveled Cremona native and polymath, more craftsman than scholar, he was one of the most talented inventors and machine builders of his generation. He held numerous positions at court, all of which required knowledge of practical mathematics, including bell smelter, automaton maker, and instrument maker.[16] Torriani undoubtedly benefited from the well-established link in his native country between the practical mathematical knowledge used in clockmaking and hydraulic expertise.[17] As Cristiano Zanetti has noted, both clockmaking and hydraulics were informed by "the same rotary mathematical principles involving set controlled concatenated motion."[18] In his adopted home, at the time of his petition to Venice, Torriani was building, in addition to planetary clocks, the so-called "Artificio" of Toledo (1565–69), an ingenious hydraulic system capable of transporting large quantities of water from the Tagus River to the Alcázar.[19] He applied for and was granted patents for water-lifting devices in Rome, Mantua, Milan, and Venice, following a scattergun strategy employed by other inventors to ensure maximum protection and visibility (and when possible, to be able to sell the rights to the invention in specific locations).[20] Like many others, Torriani's device was never built.

In 1593, the year after accepting the chair of mathematics at the University of Padua and offering private lessons in mechanics, Galileo petitioned the Venetian authorities with his own "machine for lifting water and irrigating land."[21] He boasted that his waterwheel was "very easy and practical" and that "with the movement of a single horse, the twenty spouts it contains will pour water continuously."[22] Although no model of the device was presented to the Venetian authorities, Galileo eventually built one. A young Nicolas-Claude Fabri de Peiresc, later an antiquary and astronomer, admired it in action in 1602 while studying law in Padua—by which time Galileo intended the

15. *Senato Terra*, reg. 46 (filza 50), fol. 211, February 7, 1567 (*m.v.*=1568), ASVe; Berveglieri, *Ingegnosi artificij*, 267–68.

16. Zanetti, *Janello Torriani and the Spanish Empire: A Vitruvian Artisan at the Dawn of the Scientific Revolution*, 323–37.

17. Maffioli, "Hydraulics in the Late Renaissance, 1550–1625: Mathematicians' Involvement in Hydraulic Engineering and the Mathematical Architects."

18. Zanetti, *Janello Torriani*, 329.

19. Zanetti, *Janello Torriani*, 362–401; García Tapia and Carrillo Castillo, *Tecnología e Imperio: Ingenios y leyendas en el Siglo de Oro; Juanelo, Lastanosa, Herrera y Ayanz*; Shulman, *A Tale of Three Thirsty Cities: The Innovative Water Supply Systems of Toledo, London and Paris in the Second Half of the Sixteenth Century*, 115–36; Merlos Romero and Soto Caba, "Toledo: The Thirsty City."

20. Zanetti, *Janello Torriani*, 142–43, 238–51.

21. Poni, "Scenari e fuori scena di un teatro di macchine," xvi.

22. *Senato Terra*, reg. 64 (filza 133), fol. 128v., December 28, 1593, ASVe; Galilei, *Le opere*, 19:126–29; Berveglieri, *Ingengosi artificij*, 380.

full-scale version to be used in the ornamental gardens of the Contarini rather than to help load water from barges.[23]

While one might expect petitions from such famous names to contain fascinating technical details, the written patent applications to the Venetian Senate, as well as the magistrates' responses to them, rarely provide more than the briefest descriptions of the devices and how they worked. The authorities were more interested in the purpose, contribution, and expected performance of the device. Detailed technical information on how it worked was not deemed necessary at the application stage, since the granting of the privilege depended on the successful testing of the invention, which could include the presentation of drawings, a scale model, or its implementation in situ. The privilege became valid only when the device was fully operational. The Venetian authorities were, of course, eager to attract the latest manufacturing technologies and remain competitive, but they could also afford to be enthusiastic because a patent only became valid once the invention was up and running.

It was important for applicants to reveal no more than was strictly necessary at the application stage. Part of the value of an invention lay in its secrecy; information was withheld so that only informed technical experts could replicate the device. Instead of detailed technical information, petitioners emphasized the novelty of their devices, which often meant only that they were new to the Venetian Republic. These devices may have already been patented elsewhere in other Italian states or in Europe, and the fact that they had been patented elsewhere could even serve as a selling point. Petitioners also expected that their inventions would provide them with economic returns. For example, Guglielmo di Grandi, the *proto* (consultant expert) and engineer of the Savi alle Acque, proposed to "execute and put in operation" his device at his own expense "for my benefit and that of my heirs."[24]

Some petitioners attached scale models of their proposed devices to their applications, though this was not required. According to Giuseppe Ceredi, court physician to the Dukes of Parma and Piacenza, the "secret rooms of the Provveditori di Commun in Venice" at Rialto were filled with scale models of hydraulic machines submitted by petitioners, with notes recording the creator's name and the date of submission, enabling comparisons between earlier and later submissions.[25]

Ceredi claimed that the machines represented by these models were destined to remain "perpetually hidden" because their inventors had deluded themselves into believing that "they had found some ingenious and valuable

23. Letter from Aix-en-Provence, January 26, 1634, Galilei, *Le opere*, 16:27.

24. Savi ed Esecutori alle Acque, b. 271, fol. 59r., July 20, 1584, ASVe.

25. Ceredi, *Tre discorsi sopra il modo d'alzar acque da' luoghi bassi: Per adacquar terreni; Per levar l'acque sorgenti, & piouute dalle ca[m]pagne . . . Per mandare l'acqua da bere alle città*, 19. None of these models survived the fall of the Venetian Republic in 1797.

JANUARY
2025
VOL. 66

addition," when in fact their devices were "no better or more useful than others" already in existence. However, Ceredi did not categorize his own hydraulic machine this way.[26] In February 1566, he submitted a Venetian petition for a "machine for lifting water, draining valleys, irrigating fields, and doing other things with water," for which he was granted a forty-year patent, on the condition that he make it work within four months.[27] He had applied to the Milanese authorities several months earlier, in September 1565.[28] His device was based on the efficient use of an Archimedean screw for various applications, making it quite different from the waterwheels commonly used at Lizzafusina—and never built.[29]

Contemporary Representations of the Waterwheels at Lizzafusina

Given the absence of detailed descriptions in the petitions and the lack of surviving models, it is necessary to turn to other sources to depict the devices used at Lizzafusina. Two visitors to Venice, Michel de Montaigne and Heinrich Schickhardt, and one local expert, Vittorio Zonca, can help. Their descriptions were written on either side of the watermen's 1588 complaint with which this article began. The first account comes from the French humanist and traveler Michel de Montaigne, who, during his first visit to Venice in 1580, saw boats being loaded with fresh water at a place he called "Chaffousine" (i.e., Lizzafusina). He noted "how the water was taken from a stream and turned into a canal by means of a wheel driven incessantly by horses. The aforesaid boats lie under the mouth of the canal and are there loaded with water."[30] Montaigne used the term *canal* in the French original, which the English translator has rendered "canal," but conduit would make more sense in this context.

The second account comes from Heinrich Schickhardt, who visited northern Italy for the first time in 1598. Schickhardt was already interested in hydraulics, having designed a house with hydraulic pump to supply water to the castle at Montbéliard and a bathhouse at Bad Boll near Stuttgart for his patron Friedrich I, Duke of Württemberg. He produced a sketch showing the water-raising device in operation at Lizzafusina—a horse-drawn bucket

26. Ceredi, *Tre discorsi*, 19.

27. *Provveditori di Comun*, b. 5, "Scritture" 1562–67, February 10, 1565, ASVe, cit. in Popplow, "Hydraulic Engines," 81, 83n23; *Senato Terra*, reg. 45 (filza 45), fol. 234, February 18, 1565 (*m.v.*=1566), ASVe, cit. in Berveglieri, *Ingegnosi artificij*, 259.

28. *Acque Parte Antica*, b. 6, September 24, 1565, ASM.

29. Ceredi, *Tre discorsi*; Traetta, "Giuseppe Ceredi: A Hydraulic Engineer in 16th-Century Italy."

30. Montaigne, *The Journal of Montaigne's Travels in Italy by Way of Switzerland and Germany in 1580 and 1581*, 3:35. For the French original: Montaigne, *Journal du voyage de Michel de Montaigne en Italie, par la Suisse et l'Allemagne en 1580 et 1581*, 2:32.

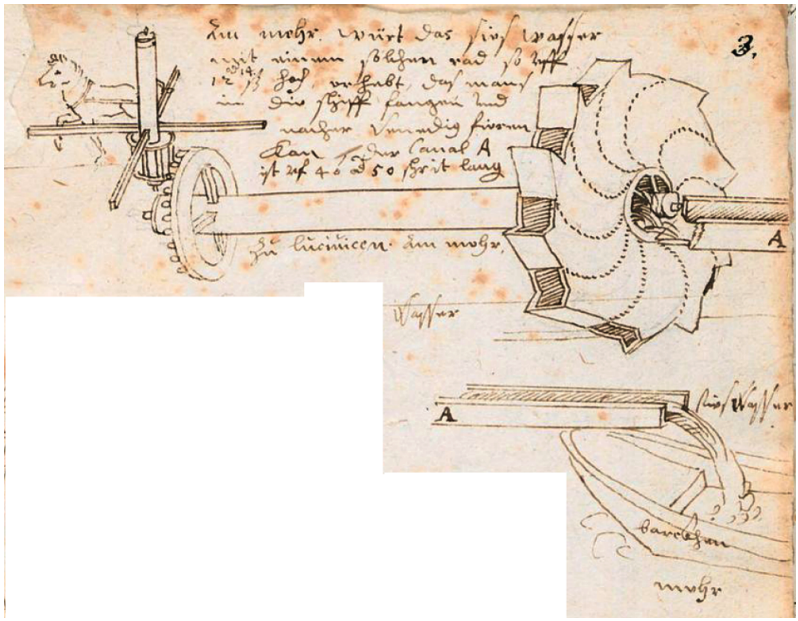

FIG 2. Water on the Move. Heinrich Schickhardt's 1598 sketch of the water-raising device in operation at Lizzafusina. During his 1598 visit, Schickhardt captured this essential technology for the thirsty city of Venice's water supply—a horse-powered waterwheel along the Brenta River. To fit the entire scene, he illustrated the trough (labeled A) twice, first as it exits the waterwheel and then as it empties into a waiting waterman's barge. An arduous task, during droughts, watermen transported water from Lizzafusina to Venice, where it would be poured into empty well-cisterns. (Source: Schickhardt, "Raiss in Italia," fol. 3r., WLB)

JANUARY
2025
VOL. 66

wheel lifting water into the sluice and from there into the waiting barge—and a barge used to transport the water (see figure 2). He captioned the sketch by noting that "at the sea-weir the fresh water is raised by such a wheel 12 or 14 feet, so that it can be collected in the boat and taken to Venice."[31] Both Montaigne and Schickhardt were equally fascinated by the nearby boat-lifting mechanism, called *carro*, that had carried their boats over the barrier separating the Brenta River (which had brought them from Padua) from the lagoon and on to Venice.[32]

At the time of Schickhardt's visit, there were two main types of water-lifting devices: The more complex ones lifted water continuously, relying either on the power of the water or on animal labor, while the simpler ones relied on muscle power as needed. The former required considerable organizational, technological, and financial effort, both for installation and for the constant maintenance and repairs they required. As a result, they were only viable in specific contexts: elite houses and gardens, religious institutions, for irrigation and drainage, crafts and industries, and urban water supplies.[33] No early modern Italian city made systematic use of water-lifting devices to augment its water supply except Venice.[34]

The third account, dating from before 1602, comes from Vittorio Zonca, a Paduan "painter, mathematician, sculptor, and building superintendent [proto]."[35] His *Novo teatro di machine ed edificii*—published in 1607, five years after his death, and reprinted in 1621 and 1656—depicts and describes various water-powered devices in situ in and around Padua and in Venice, including a "wheel for raising water," which he claimed was used at Lizzafusina to supply water to Venice (see figure 3).[36] Zonca's book was part of the then-popular genre of "theater of machines," where authors used full-page illustrations, accompanied by explanatory text, to explain the devices depicted.[37] However, these books were more ornamental than practical, focusing on spectacular and idealized mechanical devices, such as improbable water-lifting devices proposed by Agostino Ramelli in his 1588 collection. Such books aimed to impress courtly readers, city councils, or fellow authors and rarely addressed

31. Schickhardt, "Raiss in Italia"; Eckoldt, "Der Brenta-Kanal bei Venedig in der deutschen Reise- und Fachliteratur des 16–19. Jahrhunderts"; Kluckert, *Heinrich Schickhardt: Architekt und Ingenieur*. For his second Italian trip: Schickhardt, *Voyage en Italie: Reiß in Italien (novembre 1599–mai 1600)*.

32. Schickhardt calls it the "Careten" (Schickhardt, "Raiss in Italia," fols. 1v–2r). On the carro: Hatinguais, "Shakespeare's Tranect and the Traghetto of Lizzafusina."

33. Popplow, "Hydraulic Engines," 73–75. For background: Duarte Rodrigues and Merlos Romero, "*Noras*, *Norias* and Technology-of-Use."

34. Shulman, *Three Thirsty Cities*, 94–95.

35. Poni, "Scenari," ix.

36. Vittorio Zonca, *Novo teatro di machine et edificii per varie et sicure operationi, con le loro figure tagliate inrame e la dichiaratione e dimostratione di ciascuna, opera necesaria ad architetti et a quelli che di tale studio si dilettanto*, 61–63, 58–60.

37. Popplow, "Hydraulic Engines"; Marchis, "I teatri delle macchine."

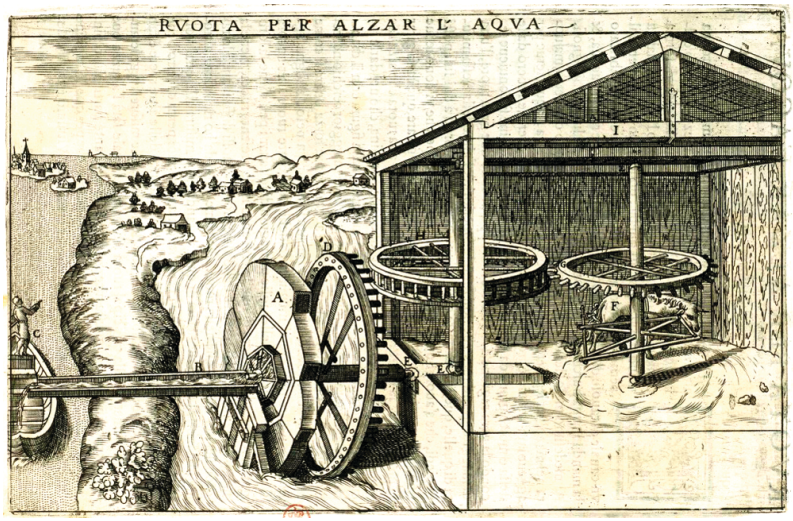

FIG 3. Zonca's Practical Engineering. Vittorio Zonca's depiction of a "wheel for raising water" at Lizzafusina. Zonca's illustration, conceived before his death in 1602, portrays existing technology rather than a theoretical wonder, distinguishing it from the fanciful genre of the "theater of machines"—a representation that is useful to historians of technology and mechanics. His image and text reveal the device as a horse-powered scoop wheel, housed in a custom-built wooden structure. (Source: Zonca, *Novo teatro di machine*, 61–63).

JANUARY
2025
VOL. 66

how the machines were used or practical concerns like materials, friction, measurements, or gear ratios.[38] Lay readers and potential investors did not need such technical information.

Zonca's book stands out because, in representing the water wheel at Lizzafusina, he depicts something already in use, tried and tested, rather than an idealized novelty or innovation yet to be built. Zonca, who never claimed to be an inventor and never submitted a patent petition to the Venetian authorities, consulted for the Venetian Magistrato e deputati sopra le acque del Tartaro, for whom he drew a detailed scale map of the river and its environs in 1599. This explains his attention to proportions in *Novo teatro*, a text that Alex Keller argues documents "the closest to the actual mechanical practice of the time."[39] The illustrations offer a conventional, single-point perspective, while his text combines a humanistic and technical vocabulary to explain how the machines worked. At the same time, Zonca occasionally tweaked his depictions, as with his drawing of the boat-lifting carro at Lizzafusina, which he modified to improve its functioning and "not to overcomplicate the right-hand part."[40]

Zonca's image and accompanying text show that the device used at Lizzafusina was a scoop wheel in form and function, housed in a specially constructed wooden structure. He notes that the machine's purpose was to lift water "but not very much," only half the diameter of the two wooden wheels. This was because it discharged water at or near its hub rather than from the top—though Zonca does not mention this. The outer wheel (labeled A in figure 3) had triangular boxes that scooped the water into the sluice (B in figure 3), and the inner wheel (D in figure 3) rotated to move the water. The "main difficulty with this machine," he notes, was "to make it easy to move," as it was a heavy structure, made mostly of wood with metal used for the teeth, and required regular maintenance as well as a horse to power it. According to Zonca, the diameter of the scoop wheel determined how high the water could be lifted, and the size of all parts, including the two horizontal wheels, was proportional to this main wheel.

Zonca emphasized the simplicity of the mechanism, which was unusual in a genre that often favored complexity and a certain degree of obscurantism. What interested Zonca was the machine's practical usefulness, allowing water to be transported by barge (C in figure 3) "to places that need it." Its practical purpose, combined with its curiosity value, likely explains Schickhardt's

38. Ramelli, *Le diverse et artificiose machine*.

39. Archivio Segreta, Archivio Zendrini, reg. 30, ASVe, cit. in Poni, "Scenari," x; Keller, *A Theatre of Machines*, 4.

40. Archivio Segreta, Archivio Zendrini, reg. 30, ASVe, cit. in Poni, "Scenari," x; Keller, *Theatre of Machines*, 60.

interest in it and its continued appearance in other theater of machines books, long after the waterwheels of Lizzafusina had disappeared.[41]

Zonca's description of the building that housed the mechanism is similarly direct. It highlights how the structure protected both the machinery and the animal driving it from the elements, while also providing security, privacy, and a recognizable facade for the activity being performed.[42] Although many of Zonca's mill buildings, with their rusticated arches and classical columns, reflect a humanistic artistic license typical of the theater of machines genre, this is not the case with his covered waterwheel. This unadorned, simple wooden structure (I in figure 3) reflects its purely utilitarian function.

Zonca ends his account with a brief nod to antiquity, pointing out that a similar device is described by Vitruvius. Vitruvius's *De architectura*, first published in illustrated form by the Veronese engineer Fra Giovanni Giocondo in 1511, was the foundational text for Renaissance engineering. Zonca's wheel is, in fact, a more complex version of Vitruvius's tympanum for raising water. Like Zonca after him, Vitruvius notes that the device does not raise water very high—only to the level of the axis—but adds the important detail that it raises a large quantity of water very quickly.[43] Vitruvius also refers to the human power needed to operate the device, the wooden trough and pipe underneath that carried the water, and mentions that the entire device had to be smeared with pitch, much like a ship. This cannot have done much for the taste of the water, but Vitruvius's tympanum was intended for irrigating gardens or supplying saltworks, where taste was not a concern.

While Vitruvius's device features one vertical and one horizontal wheel, Zonca's version has two of each. This doubling of weight, which did not significantly increase pulling power, may have been Zonca's way of adding his own imagined twist to the device actually in operation. It is possible, in other words, that this was more of an artistic embellishment, rather than a representation of a functioning waterwheel. In this regard, Schickhardt may be a more reliable guide to the devices located along the banks of the Beverador Canal—the small canal (*abbeverare* means to supply with water) that ran parallel to the Brenta River at Lizzafusina.

While the fact that these devices were patented suggests that they were novel, it remains unclear in what ways they were truly innovative. In his brief survey of the water-lifting devices represented in the theater of machines genre, Marcus Popplow concludes that the innovations mainly concerned the types of gears used to drive them, rather than the methods of lifting the water.[44] This point is supported by a remark in Ceredi's short treatise on a

41. On the afterlife of Zonca's images: Poni, "Scenari," xl.

42. Howard, "The Proto-Industrial Architecture of the Veneto," 37.

43. Giocondo, *M. Vitruvius per Jocundum solito castigatior factus cum figuris et tabula*; Vitruvius, *The Ten Books on Architecture*, 293–94.

44. Popplow, "Hydraulic Engines," 79.

JANUARY
2025
VOL. 66

device designed by "several learned men," unfortunately unnamed, in Lizzafusina. These inventors sought to improve upon Vitruvius's model by ensuring that "the radius where the motor is located is somewhat longer than the radius receiving the weight; this directs a horse which, with a turn wider than the tympanum, and with a toothed wheel beating inside the spool of a spindle cast on pivots, moves not only with greater ease but also much faster."[45] Few patent applicants were as specific as Ceredi in their technical descriptions.

Technical Innovation or Practical Concerns?

Two decades following the incorporation of the watermen into a guild and the beginning of the patenting process in Venice, both in 1474, the first patent application was made for a water-raising device. Clearly, the watermen were dependent on some sort of water-lifting device long before their complaint in 1588. On May 21, 1492, Antonio Gislardo requested a fifty-year patent for his "most useful and already tested devices, both for raising water from the Brenta Canal and for drawing it."[46]

Gislardo's application provides an early reference to the Beverador. Patents specifically mentioning the extraction of water from the Brenta or the filling of burchi are otherwise a small subset of those granted for hydraulic machinery in general (eight out of sixty-six) and are mostly limited to the period between 1551 and 1600. Each device had to cope with the particularities of the water supply at Lizzafusina, which included navigating the Beverador, bringing water from the Brenta to the wooden sluices or troughs (*gorne*), and filling the boats. The water from the Beverador channel did not flow with enough force to feed the troughs, which were positioned high to allow the water to flow into the waiting barges, as depicted by both Schickhardt and Zonca. Thus, a water-lifting device was necessary.

The applicants generally claimed that their particular device (edificio, ingegno, strumento) was novel. In 1542, the Bergamasque Mattio di Andrea di Zoi, writing directly to the Savi alle Acque, boasted of having discovered "a most beautiful (*bellissimo*) and easy means and device for drawing and loading water from the Brenta for the use of Venice, especially in times of need," which was fast and would save both expense and effort.[47] In 1555, the "master artisan" Florio de' Paternostri of Vicenza claimed to have "discovered a new way of building mills capable of working both in fresh and salt water and on land without water, draining marshes and flooded fields and loading

45. Ceredi, *Tre discorsi*, 17.

46. *Senato Terra*, registro 11, fol. 110v., ASVe, cit. in Berveglieri, *Ingegnosi artificij*, 159 (though he erroneously cites fol. 112v.).

47. *Savi ed Esecutori alle Acque*, reg. 344, fols. 29v–30v, May 15, 1542, ASVe; Costantini, *L'acqua di Venezia*, 61; Molà, "Acque dolci," 463.

water into barges."[48] The 1559 petition by the carpenter Polo de Gabriel is more modest, promoting his device merely as something "no longer made in this way."[49] In 1560, Antonio da Ponte, proto for Venice's Magistrato al Sal and architect of the Rialto Bridge, straightforwardly described his plan as a "device newly discovered" by him "to load barges and boats with water in Lizzafusina."[50] In 1561, Michiel Basilij of Curzola (today's Korčula, an island off the Dalmatian coast) "and associates" (*compagni*) petitioned for their "new means and device discovered for filling boats and barges with water from the Brenta, with ease and little cost."[51] A few months later, di Grandi boasted that his own "invention and method" would save one *soldo* for each barge filled with fresh water, prevent the mixing of fresh and salt water by using leather-covered sluices, load several barges at once, and be transported to different locations as needed.[52] In 1591, the Venetian Senate granted the last patent for a waterwheel at Lizzafusina to the watchmaker Gherardo Lucanio from Friesland in the Dutch Republic, the Milanese Giovanni Pietro Orello, and the Sienese Enea Piccolomini, who promised to build and operate a new "device to conduct water from the Brenta to the barges and boats of this city . . . at the same price granted to the watermen" and claimed that their device would speed up the loading of barges.[53]

No technical explanations were provided to justify these claims of innovation and improvement. In his 1571 application, Giovan Battista di Trinini of Brescia boasted that "by long study we have discovered a method of raising water as high as the human intellect can imagine," but he does not explain what the method was.[54] It would be exciting if the devices presented in the petitions to the Venetian authorities represented true novelty in the context of technological innovation in late Renaissance Italy. But there was little innovation in the water-lifting devices over the century or more that they were proposed for use along the banks of the Beverador Canal. Nor did patent holders necessarily promise absolute innovation; rather, many proposed

48. *Senato Terra*, reg. 40 (filza 22), fol. 85v., September 26, 1555, ASVe; Berveglieri, *Ingegnosi artificij*, 206; Molà, "Acque dolci," 464.

49. *Senato Terra*, reg. 42 (filza 29), fol. 23v., March 16, 1559, ASVe; Berveglieri, *Ingegnosi artificij*, 222.

50. *Senato Terra*, reg. 42 (filza 31), May 9, 1560, ASVe; Berveglieri, *Ingegnosi artificij*, 227–28; Costantini, *L'acqua di Venezia*, 62.

51. *Senato Terra*, reg. 43 (filza 33), fol. 76, March 15, 1561, ASVe; Berveglieri, *Ingegnosi artificij*, 234; Costantini, *L'acqua di Venezia*, 62.

52. *Savi ed Esecutori alle Acque*, b. 271, fols. 59r.–60v., July 20, 1584, ASVe; Molà, "Acque dolci," 465–66.

53. *Senato Terra*, reg. 61 (filza 119), fol. 43, March 30, 1591, ASVe; Berveglieri, *Ingegnosi artificij*, 367–68; Costantini, *L'acqua di Venezia*, 63; Molà, "Acque dolci," 468.

54. *Senato Terra*, reg. 48 (filza 57), fol. 134v., July 14, 1571, ASVe; Berveglieri, *Ingegnosi artificij*, 283; Popplow, "Hydraulic Engines," 81, 83n25.

JANUARY
2025
VOL. 66

to make an existing device suitable for a wider range of uses, improve its efficiency, or save costs.[55]

Shifting focus from the patent records to the embankment at Lizzafusina, it can be seen that working waterwheels at Lizzafusina came and went, much like the patent proposals. In the 1540s, there were "twelve or thirteen sluices" of "both wood and stone," which in August 1548 were reduced to seven, of which only five were operational.[56] Ceredi, writing in 1567, states that there were only two machines in Lizzafusina: a smaller one that "lifts the water that so often gushes out in certain plowed fields and conveys it to the neighboring valley" and a larger one that "lifts water from the Brenta to convey it beyond the dike that exists between the Brenta and the sea [i.e., the lagoon], so that it can fill the barges that bring the water to the city to be used in cisterns."[57] By July 1584, insider Guglielmo di Grandi was surprised that only two water-lifting machines were in operation—yet they were deemed sufficient to meet the needs of Venice's watermen.[58] By 1587, however, there were none, as the 1588 watermen's complaint noted. Three years later, on June 19, 1590, the Savi alle Acque, frustrated, gave the owners of the edificio, the Pesaro family, two days to repair and reactivate the machinery.[59] In addition to collecting the tolls from the acquaroli for the loading of fresh water, the Pesaros also earned rent from a tavern (*osteria*) and wool-washing facilities used by the wool-makers' guild, providing them with a significant annual income.[60]

Rather than "new and improved" devices, the authorities would have been satisfied with any machine that simply worked! In fact, the petitioners may have sought patents not to publicize or protect innovation but to gain access to the often rather crowded canal bank—permissions to build their device and charge fees for its use—privileges the authorities were happy to grant.

The practical nature of the patenting process of wheels is illustrated by the cooperation of the Savi alle Acque. Julio di Massimi and Iseppo Gaiato were allowed to test (*far la experientia*) their proposed device in situ.[61] The Savi alle Acque also favored certain devices by occasionally exempting patentees from paying the water toll for a year (a tax paid on each barge load of fresh water). The inventor saved money, and the authorities got a new water

55. Howard, "Invention and Reality," 78.

56. *Archivio Pesaro*, b. 43 (LI no. 4B), "Inventario di scritture attinenti alli beni di Lizzafusina," November 30, 1543, and August 21, 1548, ASVe; cf. Molà, "Acque dolci," 463.

57. Ceredi, *Tre discorsi*, 17.

58. *Savi ed Esecutori alle Acque*, b. 271, fols. 59v–60v, July 20, 1584, ASVe, cit. in Molà, "Acque dolci," 465–66.

59. *Savi ed Esecutori alle Acque*, reg. 347, fol. 9v., June 19, 1590, ASVe, cit. in Costantini, *L'acqua di Venezia*, 62.

60. *Savi ed Esecutori alle Acque*, b. 343, "Capitolare" no. 2, fols. 46v–48r, September 1, 1535, ASVe, cit. in Molà, "Acque dolci," 458.

61. *Savi ed Esecutori alle Acque*, reg. 344, fol. 52v., April 8, 1549, ASVe.

wheel. For example, in 1542, in response to Mattio di Andrea di Zoi's patent application, the Savi alle Acque granted his request to choose where to place his device in Lizzafusina, provided that it did not interfere with the work of others already in operation. He also requested "a suitable payment" for a period of thirty years, on the grounds that only an inventor rewarded in this way could build a machine like his, and asked for exemption from paying the water toll for one year, requests that were granted.[62] This clearly shows the practical benefits of applying for a patent. Likewise, the granting of the patent to the Fleming Lucanio and his associates in May 1591 was accompanied, the following November, by a grant of public land at Lizzafusina by the Council of Ten for the construction of their waterwheel.[63]

The process was also open to negotiation. Michiel Basilij and associates promised to donate six soldi for every ducat "the device will provide" in alms to the Venice Hospital of Incurables for the duration of the patent, an offer that clearly pleased the authorities. Indeed, both the Provveditori di Comun and the Savi alle Acque responded favorably to the Senate's request for an opinion, despite the fact that they had never "seen the device or a model of any kind." As a result, the Senate issued a patent valid for thirty years.[64]

Of course, as with all Venetian patents, the design monopoly did not take effect until the device was built and fully functional. This brings us to a third aspect of the project's realization: financing. The implementation of water-lifting devices required the contribution of a wide range of craftspeople—millwrights, carpenters, and metalworkers—and the material costs were considerable. Florio de' Paternostri's petition, in which he promised to invest three hundred ducats "in one or more devices to be built in Lizzafusina to load the boats and barges as to meet the demand," was only made possible by a business partnership he formed with the Venetian patrician Zuane Lippomano and the surgeon Agostino Gratia ten years after his first request.[65] When Gratia left the association in 1566, his place was taken by the lawyer Galeno Bellobuono, who had received a patent for a similar water-raising device in 1565, likely to avoid a dispute over "some similarities between the two devices."[66] In 1567, five years after his application, the carpenter Polo de Gabriel entered a partnership with an Augustinian monk, Lunardo da

62. *Savi ed Esecutori alle Acque*, reg. 344, fols. 29v–30v, May 15, 1542, ASVe; Costantini, *L'acqua di Venezia*, 61; Molà, "Acque dolci," 463.

63. *Senato Terra*, reg. 61 (filza 119), fol. 43, March 30, 1591, ASVe; Berveglieri, *Ingegnosi artificij*, 367–68; Costantini, *L'acqua di Venezia*, 63; Molà, "Acque dolci," 468.

64. *Senato Terra*, reg. 43 (filza 33), fol. 76, March 15, 1561, ASVe; Berveglieri, *Ingegnosi artificij*, 234; Costantini, *L'acqua di Venezia*, 62.

65. *Notarile Atti*, b. 8280, notary P. G. Mamoli, fols. 76r–80r, February 22, 1566, ASVe, cit. in Molà, "Acque dolci," 464.

66. *Senato Terra*, reg. 45 (filza 44), fol. 174, August 20, 1565, ASVe; Berveglieri, *Ingegnosi artificij*, 256–57; *Notarile Atti*, b. 8280, notary P. G. Mamoli, fols. 76r–80r, February 22, 1566, ASVe, cit. in Molà, "Acque dolci," 464.

JANUARY
2025
VOL. 66

Venezia, and Iseppo de Longhi, who held the contract for the "carro, canal, and tavern in Lizzafusina" of the Pesaros.[67] Interestingly, Polo also joined another association led by the Neapolitan philosopher and mathematician Fabrizio Mordente and the doctor Decio Bellobuono, Galeno's brother. The fact that the Bellobuonos had left Naples under controversial circumstances decades earlier and that Decio—an aspiring distiller and printer, an active member of the city's short-lived publishing project, the Accademia della Fama—was accused (and later acquitted) of heresy, suggests a restless entrepreneurial spirit not uncommon among the petitioners.[68]

What is striking about the petitioners—both technician-inventors and financial backers (and those who were both)—is their sheer diversity. Their geographic and social origins offer insights into the circulation of technical expertise and knowledge at the time. Geographically, the petitioners came from various parts of Italy and Europe, though between 1551 and 1600 more than half came from Venice and the Venetian terra ferma. Among the 265 patentees whose backgrounds are detailed in petitions from all fields, forty-eight (18 percent) were from Venice and the lagoon islands, ninety-nine (37 percent) from the Venetian terra ferma, and eighty-six (33 percent) from elsewhere in Italy. Twelve were German and ten Flemish.[69] A number of petitions for hydraulic machinery in particular came from residents of the Low Countries, unsurprising given their expertise in land drainage and water pumps.[70] The few experts capable of installing complex machines were in high demand, traveling to different regions to present new inventions to potential customers using drawings or scale models.[71]

Socially, those who initiated the waterwheel patenting process were typically craftsmen like the carpenter Polo de Gabriel, the goldsmith Alvise Rizzi, and the watchmaker Gherardo Lucanio, whose technical expertise in mechanisms and machines was crucial.[72] The skills of carpenters were vital to waterwheel construction, while the case of Torriani exemplifies a clockmaker

67. *Notarile Atti*, b. 8281, notary P. G. Mamoli, fols. 288r–289r, June 16, 1567, ASVe; *Archivio Pesaro*, b. 46, fasc. 17, fol. 25r., ASVe, cit. in Molà, "Acque dolci," 465.

68. *Notarile Atti*, b. 11631–32, notary F. Renio, fol. 496r, September 12, 1566, and notary F. Renio b. 8280, notary P. G. Mamoli, fols. 380r–381r, October 10, 1566, ASVe, cit. in Molà, "Acque dolci," 465. This time the patentee was Mordente, with no reference to Polo in the petition: *Senato Terra*, reg. 46 (filza 48), fol. 138, February 28, 1566 (*m.v.*=1567), ASVe; Berveglieri, *Ingegnosi artificij*, 263–64. On Decio Bellobuono, who would die of plague ten years later: Eamon, "The Canker Friar: Piety and Intrigue in an Era of New Diseases"; on his role and that of his brother Galeno in the Accademia della Fama: Guarna, *L'Accademia veneziana della fama (1557–1561): Storia, cultura e editoria*, 43–44.

69. Berveglieri, *Inventori stranieri a Venezia (1474–1788): Importazione di tecnologia e circolazione di tecnici, artigiani, inventori; Repertorio*, 42.

70. Also Ciriacono, *Building on Water*, 164–68.

71. Popplow, "Hydraulic Engines," 75.

72. Senato Terra, reg. 55 (filza 90), fol. 37, March 20, 1584, ASVe; Berveglieri, *Ingegnosi artificij*, 334.

turned hydraulic engineer. At a later stage, experts in the field—engineers like Guglielmo di Grandi and architects like Antonio da Ponte—submitted applications. Finally, eager investors like the Bellobuono brothers and Venetian patricians like Lippomano, with their deep pockets and useful connections, entered the process.

Characterizing Knowledge Flows

Hydraulic knowledge, like water, flowed freely during this period to meet the demand for hydraulic devices, which was not limited to the Republic of Venice. Castile began issuing patents in the 1520s, including for water-raising devices and other machines designed by hydraulic inventors like Torriano in Toledo and Juan de Herrera in Vallodolid.[73] In England, of the fifty-five patents granted for inventions between 1561 and 1599, seven or eight were for water-raising devices, while from 1617 to 1642, 18 out of 127 were for such devices.[74] In the Dutch Republic, unsurprisingly, one-third of the patents granted between 1580 and 1719 were for hydraulic equipment and installations, including water-raising mills, pumps, water-supply systems, dredges, bridges, and sluices.[75] In certain periods, such as 1580–99, 1620–39, and 1700–1719, 40 percent of all patents were related to hydraulics. As Karel Davids has documented, a key development in Dutch drainage technology was the shift from animal to wind power that began in the late sixteenth century and was evident in Friesland and elsewhere.[76] In contrast, there was relatively little technological development in Lizzafusina—perhaps wind-powered water mills or Archimedean screws were considered superfluous.

One commonality among Europeans attempting to build water-raising devices was the need for funding. The flows of knowledge came at a cost. Throughout Europe, patent holders had to finance their invention, find a market to attract investment, or license their products.[77] Successful exploitation of an invention often required financial capital that the patentee lacked, leading to partnerships, as in the Dutch hydraulic examples cited by Davids.[78] Another approach was to seek potential buyers, which in the Dutch Republic

73. García Tapia, *Técnica y poder en Castilla durante los siglos XVI y XVII*, 195–96; García Tapia, "Privilegios de invención."

74. E. W. Hulme, *The Early History of the English Patent System* (1909), cit. in Jenkins, ed., introduction to *R. D'acres's The Art of Water Drawing . . . 1659 and 1660*, ix.

75. Davids, "Patents and Patentees in the Dutch Republic between c.1580 and 1720," 266; Davids, *The Rise and Decline of Dutch Technological Leadership: Technology, Economy and Culture in the Netherlands, 1350–1800*, 408–9.

76. Davids, *Rise and Decline*, 72–75, 239–41.

77. MacLeod, *Inventing the Industrial Revolution: The English Patent System, 1660–1800*, 90.

78. Davids, "Patents and Patentees," 275.

JANUARY
2025
VOL. 66

could include public or semipublic institutions like municipalities or water boards.[79] This option was not available to petitioners in Venice, who had to rely on other financing mechanisms. On the other hand, petitioners to the Venetian authorities were not required to be resident, as in the Dutch system. Nevertheless, the Dutch Republic attracted a large proportion of foreign applicants: 20 percent during the years 1580 to 1600.[80]

The diversity of petitioners in terms of social origins and occupations also reflected the flow of knowledge. Expertise benefited from the growing links between different traditions, high and low, theoretical and practical. As in the Venetian case, a wide range of origins and occupations were represented in the Dutch Republic. Craftsmen-inventors predominated: about a quarter of patentees were woodworkers, followed by merchants, metalworkers, engineers, and physicians.[81]

Since there was as yet no specific course of study for aspiring engineers, hydraulic or otherwise, applicants from various backgrounds were able to make their mark by providing technical solutions to practical problems. The trades and professions represented had different knowledge bases, training regimes, social statuses, and patronage opportunities. In this preprofessional era, artisans "followed somewhat fluid careers and were not locked into a traditional craft," as Pamela Long has remarked.[82] What they shared was "practical knowledge," which they codified in petitions, plans, drawings, and scale models and translated into in their actual devices.[83] Like the fortification engineers in sixteenth-century England studied by Steve Walton, the Venetian petitioners were all "experts in context," balancing practical knowledge, theoretical learning, and access to power (not to mention funding) in order "to make things happen."[84] As a result, their expertise had to be "(re)negotiated anew, every time it came up"; that is, with every project petition, a position faced by practical experts across Europe, in the words of Eric Ash.[85]

At Lizzafusina, the risk was almost entirely borne by the petitioners themselves. They would only benefit if and when the proposed waterwheel was up and running, putting petitioners—including insiders—on equal footing with authorities. There was little in the way of coordinated state support or patronage, as seen in Jean-Baptiste Colbert's France or even in

79. Davids, "Patents and Patentees," 275.
80. Davids, *Rise and Decline*, 230–31.
81. Davids, *Rise and Decline*, 420–24.
82. Long, "Trading Zones in Early Modern Europe," 842–43.
83. Valleriani, "The Epistemology of Practical Knowledge."
84. Walton, "State Building through Building for the State: Foreign and Domestic Expertise in Tudor Fortification," 83.
85. Ash, "By Any Other Name: Early Modern Expertise and the Problem of Anachronism," 16–17.

the Republic of Venice's institutional promotion of the silk industry.[86] Such support was not deemed necessary to meet the specific and limited needs of Lizzafusina. However, an alliance of sorts emerged—a bottom-up process of "self-organization" by individual actors and groups of inventors and petitioners, met with institutional openness and encouragement from authorities.[87]

The cluster of patentees proposing to build water-raising devices along the bank at Lizzafusina differs significantly from the "projectors" who have captured the interest of historians of science and technology in early modern England. The label "projector," which began to appear in England in the 1590s, was often used derisively, with projectors seen as speculators at best and parasites or fraudsters at worst.[88] While Venetian petitioners were not entirely free from this ambivalence, the specific nature of the machinery needed at Lizzafusina, the social origins and craft-based occupations of many petitioners, the high cultural status of invention, and the expertise associated with it combined with a bureaucratic process that placed nearly all the risk on the petitioners, meant that the state had little to lose. As a result, the applications and the petitioners were taken seriously. The records simply refer to the petitioners by their trade or place of origin (or both). The loaded and contested term "projector" did not exist in sixteenth- and seventeenth-century Italian, and a similar term—*progettante*—does not appear until the second half of the eighteenth century in the very different climate of the Enlightenment, a parallel development seen in both French and German.[89]

The petitioners in this case study can be seen as practical experts and Lizzafusina as a limited kind of "trading zone," as Long suggests: "arenas in which artisans and other practitioners . . . and learned men . . . engaged in substantive communication and shared their respective expertise."[90] Lizzafusina can be seen as a place where artisanal skills and practical and theoretical knowledge converged, encouraged by the Venetian state's efforts to ensure the city's supply of fresh water. However, this was a "limited" form of "trading zone"—not only because the scale of the enterprise was small but also because it was not formalized or institutionalized beyond the state-sponsored

86. McClellan and Regourd, "The Colonial Machine: French Science and Colonization in the Ancien Régime"; Molà, *The Silk Industry of Renaissance Venice*, 186–214.

87. Davids, "On Machines, Self-Organization, and the Global Traveling of Knowledge, circa 1500–1900," 873.

88. Ash, "By Any Other Name"; Ash, *The Draining of the Fens: Projectors, Popular Politics, and State Building in Early Modern England*, 1–14, 141–78; Keller and McCormick, "Towards a History of Projects"; MacLeod, *Inventing the Industrial Revolution*; Ratcliff, "Art to Cheat the Common-Weale: Inventors, Projectors, and Patentees in English Satire, ca. 1630–70"; Slack, *The Invention of Improvement: Information and Material Progress in Seventeenth-Century England*; Yamamoto, "Reformation and the Distrust of the Projector in the Hartlib Circle"; Yamamoto, *Taming Capitalism before its Triumph: Public Service, Distrust, and Projecting in Early Modern England*, 1–67.

89. Keller and McCormick, "History of Projects," 437–42.

90. Long, "Trading Zones," 842.

patenting process.[91] And since secrecy was key to the patenting process, the petitioners shared expertise and practical knowledge without direct communication among themselves. Perhaps paradoxically, while the watermen themselves benefited from waterwheel technology, they are not recorded as having contributed to it directly.

JANUARY
2025
VOL. 66

Conclusion

By the time the second edition of Zonca's *Novo teatro* was published in 1621, both the water-raising wheels and the boat lift (carro) at Lizzafusina had ceased to exist. In April 1602, the Savi alle Acque accepted a plan proposed by its proto Giovanni Alvise Gallesi to build a canal that would divert the waters of the Brenta just beyond Mira and, with the removal of the dike at Lizzafusina, allow an expansion of the salt water of the lagoon. Gallesi's plan also included the construction of "a *seriola* to draw water from the Brenta to supply the city of Venice"—a seriola being a small, artificial canal along a natural watercourse, used for irrigation, land drainage, or in this case, water supply.[92] In 1611, the mouth of the seriola was moved from Mira to Dolo to increase water flow. A stone plaque, still present on the Dolo dike, marks the spot with the words *Hic urbis potus* (From here the city drinks). The losers in this new arrangement were the Pesaro family, who were deprived of the toll income from Lizzafusina.[93] Once compensation was agreed upon—at a significant rate of 581 ducats per year, about half of the family's regular income for the site—around 1615 or 1616, the devices were removed, and Lizzafusina's role as a transportation hub between Venice and the terra ferma, and as a supplier of water to Venice, came to an end.[94]

As a case history of knowledge flows and institutional responses, this article has focused on a cluster of Venetian patent applications from a specific time, place, and set of circumstances. It has explored the devices used to deliver water to the watermen's barges at Lizzafusina, the competition this generated among inventors encouraged by the state, the designs and technologies employed by the inventors, the social and occupational origins of the petitioners, and the key issue of funding. The petitioners pitched their patent proposals to make them more persuasive to the Venetian authorities, using the language of innovation and originality. However, practical considerations were equally important in shaping their efforts here—considerations that also guided authorities in their decision-making. Local realities, conditions and

91. Ash, "By Any Other Name," 11–16.

92. Savi ed Esecutori alle Acque, reg. 347, fols. 99r–101v, April 24, 1602, ASVe, cit. in Costantini, *L'acqua di Venezia*, 65–66.

93. Savi ed Esecutori alle Acque, reg. 384, fols. 158r–v, March 23, 1613, ASVe, cit. in Costantini, *L'acque di Venezia*, 68.

94. Caniato, "Commerci e navigazione lungo il Brenta."

requirements played a significant part in shaping both petitioners' proposals and the authorities' reactions to them.

David Gentilcore is full professor of early modern history in the Department of Humanities and board member of the New Institute Center for Environmental Humanities (NICHE) at Ca' Foscari University of Venice, and principal investigator of the European Research Council advanced grant "Water-Cultures: The Water Cultures of Italy, 1500–1900." He has published widely on the social and cultural history of early modern Italy. This article was written with support from the European Research Council under the European Union's Horizon 2020 research and innovation program, Grant Agreement no. 833834. An earlier draft was presented at the "Scientiae: Disciplines of Knowing" conference in Prague in June 2023, in a session organized by Gaia Bruno. The author is grateful to the two anonymous reviewers of this journal for their suggestions, and he is indebted to the generosity of Davide Martino for providing his notes and translation of the relevant parts of Schickhardt's manuscript, to Lavinia Maddaluno for providing images of Ceredi's Milanese petition, to Elisa Andretta for information on Bellobuono, and to Cristiano Zanetti for a copy of his thorough study of Torriani. He would like to dedicate this article to the memory of his friend and former colleague Dr. Alex Keller (†2020).

Bibliography

Archival and Unpublished Sources

Württembergische Landesbibliothek, Stuttgart, Germany (WLB)
Archivio di Stato, Milan, Italy (ASM)
Archivio di Stato, Venice, Italy (ASVe)

Published Sources

Ash, Eric. "By Any Other Name: Early Modern Expertise and the Problem of Anachronism." *History and Technology* 35, no. 1 (2019): 3–30.

Ash, Eric. *The Draining of the Fens: Projectors, Popular Politics, and State Building in Early Modern England*. Baltimore: Johns Hopkins University Press, 2017.

Berveglieri, Roberto. *"Ingegnosi arteficij": Trecento anni di storia della scienza, della tecnica e dell'innovazione (1474–1788)*. Sommacampagna: Cierre, 2020.

Berveglieri, Roberto. *Inventori stranieri a Venezia (1474–1788): Importazione di tecnologia e circolazione di tecnici, artigiani, inventori; Repertorio*. Venice: Istituto Veneto di Scienze, Lettere ed Arti, 1995.

Bevilacqua, Piero. *Venezia e le acque*. Rome: Donzelli, 1998.

Biswas, Asit. *A History of Hydrology*. Amsterdam: North Holland, 1970.

Caniato, Giovanni. "Commerci e navigazione lungo il Brenta." In *Il Brenta*, edited by Aldino Bondesan, Giovanni Caniato, Danilo Gasparini, Francesco Vallerani, and Michele Zanetti, 255–72. Sommacampagna: Cierre, 2003.

JANUARY
2025
VOL. 66

Ceredi, Giuseppe. *Tre discorsi sopra il modo d'alzar acque da' luoghi bassi: Per adacquar terreni; Per levar l'acque sorgenti, & piouute dalle ca[m]pagne . . . Per mandare l'acqua da bere alle città*. Parma: Seth Viotti, 1567.

Ciriacono, Salvatore. *Building on Water: Venice, Holland and the Construction of the European Landscape in Early Modern Times*. Translated by J. Scott. New York: Berghahn Books, 2006.

Ciriacono, Salvatore. "Management of the Lagoon and Urban Environment in 18th-Century Venice." *Water History* 10 (2018): 141–61.

Costantini, Massimo. *L'acqua di Venezia: L'approvvigionamento idrico della Serenissima*. Venice: Arsenale, 1984.

Davids, Karel. "On Machines, Self-Organization, and the Global Traveling of Knowledge, circa 1500–1900." *Isis* 106, no. 4 (2015): 866–74.

Davids, Karel. "Patents and Patentees in the Dutch Republic between c.1580 and 1720." *History and Technology* 16, no. 3 (2000): 263–83.

Davids, Karel. *The Rise and Decline of Dutch Technological Leadership: Technology, Economy and Culture in the Netherlands, 1350–1800*. 2 vols. Leiden: Brill, 2008.

Duarte Rodrigues, Ana, and Magdalena Merlos Romero. "*Noras*, *Norias* and Technology-of-Use." In *The History of Water Management in the Iberian Peninsula between the 16th and 19th Centuries*, edited by Ana Duarte Rodrigues and C. Toribio Marin, 331–50. Cham: Springer Nature, 2020.

Eamon, William. "The Canker Friar: Piety and Intrigue in an Era of New Diseases." In *Piety and Plague: From Byzantium to the Baroque*, edited by F. Mormando and T. Worcester, 156–76. Kirksville: Truman State University Press, 2007.

Eckoldt, Martin. "Der Brenta-Kanal bei Venedig in der deutschen Reise- und Fachliteratur des 16–19. Jahrhunderts." *Technik Geschichte* 35 (1968): 90–103.

Galilei, Galileo. *Le opere*. 21 vols. Edited by A. Favaro. Florence: Barbera, 1890–1909.

García Tapia, Nicolás. "Privilegios de invención." In *Técnica e ingeniería en España*. Vol. 1, *El Renacimiento: De la técnica imperial y la popular*, edited by M. Silva Suárez, 545–76. Madrid: Real Academia de Ingeniería, 2004.

García Tapia, Nicolás. *Técnica y poder en Castilla durante los siglos XVI y XVII*. Valladolid: Junta de Castilla y León, 1989.

García Tapia, Nicolás, and Jesús Carrillo Castillo. *Tecnología e Imperio: Ingenios y leyendas en el Siglo de Oro; Juanelo, Lastanosa, Herrera y Ayanz*. Madrid: Nivola, 2002.

Gentilcore, David. "The Cistern-System of Early Modern Venice: Technology, Politics and Culture in a Hydraulic Society." *Water History* 13 (2021): 1–32.

Giocondo, Fra Giovanni. *M. Vitruvius per Jocundum solito castigatior factus cum figuris et tabula*. Venice: Giovanni da Tridentino, 1511.

Guarna, Valeria. *L'Accademia veneziana della fama (1557–1561): Storia, cultura e editoria*. Rome: Vecchiarelli, 2018.

Hatinguais, Catherine. "Shakespeare's Tranect and the Traghetto of Lizza fusina." *Oxfordian* 23 (2021): 267–314.

Howard, Deborah. "Invention and Reality: Patent Applications Presented to the Venetian Senate." In *Proto-Industrial Architecture of the Veneto in the Age of Palladio*, edited by Deborah Howard, 77–92. Rome: Officina Libraria, 2021.

Howard, Deborah. "The Proto-Industrial Architecture of the Veneto." In *Proto-Industrial Architecture of the Veneto in the Age of Palladio*, edited by Deborah Howard, 33–58. Rome: Officina Libraria, 2021.

Jenkins, Rhys, ed. *R. D'acres's The Art of Water Drawing . . . 1659 and 1660.* Cambridge: W. Heffer and Sons and the Newcomen Society, 1930.

Keller, Alexander. *A Theatre of Machines*. London: Chapman and Hall, 1964.

Keller, Vera, and Ted McCormick. "Towards a History of Projects." *Early Science and Medicine* 21, no. 5 (2016): 423–44.

Kluckert, Ehrenfried. *Heinrich Schickhardt: Architekt und Ingenieur*. Herrenberg: Stadt Herrenberg, 1992.

Long, Pamela. "Trading Zones in Early Modern Europe." *Isis* 106 (2015): 840–47.

MacLeod, Christine. *Inventing the Industrial Revolution: The English Patent System, 1660–1800*. Cambridge: Cambridge University Press, 1988.

Maffioli, Cesare. "Hydraulics in the Late Renaissance, 1550–1625: Mathematicians' Involvement in Hydraulic Engineering and the Mathematical Architects." In *Engineering and Engineers: Proceedings of the XXth International Congress of History of Science*, edited by Michael Claran Duffy, 67–75. Turnhout: Brepols, 2002.

Mandich, Giulio. "Venetian Patents (1450–1550)." *Journal of the Patent Office Society* 30, no. 3 (1948): 166–224.

Marchis, Vittorio. "I teatri delle macchine." In *Il contributo italiano alla storia del pensiero: Tecnica*. Rome: Istituto Treccani, 2013. https://www.treccani.it/enciclopedia/i-teatri-delle-macchine_%28Il-Contributo-italiano-alla-storia-del-Pensiero:-Tecnica%29/.

McClellan, James, and François Regourd. "The Colonial Machine: French Science and Colonization in the Ancien Régime." *Osiris* 16 (2001): 31–50.

Merlos Romero, Magdalena, and Victoria Soto Caba. "Toledo: The Thirsty City." In *The History of Water Management in the Iberian Peninsula between the 16th and 19th Centuries*, edited by A. Duarte Rodrigues and C. Toribio Marin, 25–48. Cham: Springer Nature, 2020.

Molà, Luca. "Inventors, Patents and the Market for Innovations in Renaissance Italy." In "Italian Technology from the Renaissance to the 20th Century," Anna Guagnini and Luca Molà, eds., special issue, *History of Technology* 32 (2014): 7–34.

Molà, Luca. "La Repubblica di Venezia tra acque dolci e acque salse: Investimenti tecnologici a Lizzafusina nel Rinascimento." In *La civiltà delle*

acque tra Medioevo e Rinascimento, Vol. 2, edited by A. Corona and D. Lambertini, 447–72. Florence: Olschki, 2019.

Molà, Luca. *The Silk Industry of Renaissance Venice*. Baltimore: Johns Hopkins University Press, 2000.

Montaigne, Michel de. *Journal du voyage de Michel de Montaigne en Italie, par la Suisse et l'Allemagne en 1580 et 1581*. 2 vols. Paris: Le Jay, 1775.

Montaigne, Michel de. *The Journal of Montaigne's Travels in Italy by Way of Switzerland and Germany in 1580 and 1581*. 3 vols. Translated by W. G. Waters. London: John Murray, 1903.

Pezzolo, Luciano. "The Venetian Economy." In *A Companion to Venetian History, 1400–1797*, edited by E. Dursteler, 255–89. Leiden: Brill, 2013.

Poni, Carlo. "Scenari e fuori scena di un teatro di macchine." Introduction to facsimile edition of Vittorio Zonca, *Novo teatro di machine et edificii*, edited by Carlo Poni. Milan: Il Polifilo, 1985.

Popplow, Marcus. "Hydraulic Engines in Renaissance Privileges for Inventions and 'Theatre of Machines.'" In *Arte e scienza delle acque nel Rinascimento*, edited by A. Fiocca, D. Lambertini, and C. Maffioli, 73–83. Venice: Marsilio, 2003.

Ratcliff, Jessica. "Art to Cheat the Common-Weale: Inventors, Projectors, and Patentees in English Satire, ca. 1630–70." *Technology and Culture* 53, no. 2 (2012): 337–65.

Ramelli, Agostino. *Le diverse et artificiose machine.* Paris: no pub., 1588.

Schickhardt, Heinrich. *Voyage en Italie: Reiß in Italien (novembre 1599–mai 1600)*. Edited by André Bouvard. Montbéliard: Société d'Emulation de Montbéliard, 2002.

Shulman, Jaime-Chaim. *A Tale of Three Thirsty Cities: The Innovative Water Supply Systems of Toledo, London and Paris in the Second Half of the Sixteenth Century*. Leiden: Brill, 2018.

Slack, Paul. *The Invention of Improvement: Information and Material Progress in Seventeenth-Century England*. Oxford: Oxford University Press, 2015.

Traetta, Luigi. "Giuseppe Ceredi: A Hydraulic Engineer in 16th-Century Italy." In "Explorations in the History and Heritage of Machines and Mechanisms," B. Zhang and M. Ceccarelli, eds., special issue, *History of Mechanism and Machine Science* 37 (2019): 17–27.

Vitruvius, *The Ten Books on Architecture.* Translated by M. H. Morgan. Cambridge, MA: Harvard University Press, 1914.

Valleriani, Matteo. "The Epistemology of Practical Knowledge." In *The Structures of Practical Knowledge*, edited by Matteo Valleriani, 1–20. Cham: Springer, 2017.

Walton, Steve. "State Building through Building for the State: Foreign and Domestic Expertise in Tudor Fortification." *Osiris* 25, no. 1 (2010): 66–84.

Yamamoto, Koji. "Reformation and the Distrust of the Projector in the Hartlib Circle." *Historical Journal* 55 (2012): 375–97.

Yamamoto, Koji. *Taming Capitalism before its Triumph: Public Service, Distrust, and Projecting in Early Modern England*. Oxford: Oxford University Press, 2018.

Zaggia, Stefano. "'Far la città': Il ruolo dei Provveditori di Comun nell'evoluzione dell'ambiente urbano di Venezia; Strade, ponti, pozzi, case." *Mélanges de l'École française de Rome: Italie et Méditerranée* 116, no. 2 (2004): 665–81.

Zanetti, Cristiano. *Janello Torriani and the Spanish Empire: A Vitruvian Artisan at the Dawn of the Scientific Revolution*. Leiden: Brill, 2017.

Zonca, Vittorio, *Novo teatro di machine et edificii per varie et sicure operationi, con le loro figure tagliate inrame e la dichiaratione e dimostratione di ciascuna, opera necesaria ad architetti et a quelli che di tale studio si dilettano.* Padua: Pietro Bertelli, 1607.