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The Silesian Impact of Hero's Treatise. Salomon de Caus and the Wrocław Garden of Laurentius Scholz

In the existing literature, Salomon de Caus has been credited as the inventor of a device where water circulation was driven by pneumatic tanks equipped with lenses. The identification of such a device in the garden of Laurentius Scholz in Wrocław nearly two decades earlier prompted the necessity to verify this belief. The authors attempted to elucidate the functioning of the device based on available texts, analogies, and iconography. They also presented the contemporary technologies of water devices in gardens, including their sources, functions, and cultural significance. The methods of supplying water to gardens were analyzed, along with the likely connection between the garden and the water supply network in Wrocław. The discussion incorporated the perception of water, encompassing preferences and the assessment of water quality based on its origin (rainwater, well water, river water, lake water, etc.). The symbolism and intricate depiction of the manifestation of the water element in gardens were explained. Based on preserved treatises and accounts, the authors determined that individual elements of the device could be found in works dedicated to hydraulics, pneumatics, distillation, or medicine. They speculated that both Scholz and de Caus may have become acquainted with the solar pump in one of the gardens in Italy, such as Tivoli, or most likely in Pratolino, where numerous automata could be found, primarily inspired by the works of Heron of Alexandria.

Keywords: Wrocław, Laurentius Scholz, modern gardens, Renaissance hydraulics, history of technology

Słowa kluczowe: Wrocław, Laurentius Scholz, ogrody nowożytne, hydraulika renesansowa, historia technologii

Introduction

Among the researchers dealing with both the history of science and gardens of the late Renaissance, Salomon de Caus[1] remains one of the most recognizable figures. To a similar extent, this inventor, constructor, occultist, and 'Leonardo of garden art' owes his popularity to the inventiveness of the 19th-c. dramatists[2] and historians of science[3] who effectively constructed the enduring image,[4] as well as to the devices he created and whose ingenuity and mysterious principles of operation continuously fascinate us to this day. Among the presented works by de Caus[5], there were machines not only relatively easy to recognize – as water mills, bucket pumps and wheel and axle machines – but also sophisticated automata, among which we can find moving sculptures, water-driven instruments, portable fountains and figurines of singing birds. Particularly noteworthy, however, are pneumatic devices from the work entitled *Les Raisons des Forces Mouvantes* (Francfort 1615), which utilized the power of compressed air and steam.[6] Thanks to these devices, de Caus earned recognition in the history of science as one of the progenitors of the steam turbine.[7] Nevertheless, this perspective has been scrutinized in recent literature, and the famous *Theoresme V* has been recognized as Hero of Alexandria's *aeolipile* variant only, a device without practical application.[8] However, other pneumatic devices are treated differently, which refers to those previously recognized – according to Salomon de Caus'[9] own descriptions – as his own achievements.[10] Earlier works did not include extended systems in which the pressure of steam formed in containers thanks to the energy of

1 On Salomon de Caus (1576–1626) see: L. Morgan, *Nature as Model: Salomon de Caus and Early Seventeenth-Century Landscape Design*, Philadelphia 2007; S. Schweizer, *Salomon de Caus. Die Einheit von Kunst. Wissenschaft und Technik in der Höfischen Gesellschaft um 1600*, [in:] *Wunder und Wissenschaft. Salomon de Caus und die Automatenkunst in Gärten um 1600. Katalogbuch zur Ausstellung im Museum für Europäische Gartenkunst der Stifung Schloss und Park Benrath 17. August bis 5. Oktober 2008*, ed. by G. Uerscheln, Düsseldorf 2008, p. 11–28.

2 A. Joly, *Salomon De Caus à Bicêtre! Monologue dramatique en 1 acte et en vers*, Paris 1849; A. Munch, *Salomon de Caus. Dramatisk Digtning*, Christiania 1854; A. de Balathier Bragelonne, *Les mystères des prisons*, Paris 1858.

3 A.N. Baillet du Belloy, *Notice historique sur les machines à vapeur, machines dont les Français peuvent être regardés comme premiers inventeurs*, "Journal des mines" 1813, vol. 33, no. 197, p. 321; F. Arago, *Notice historique sur les machines a vapeur*, "Annuaire du Bureau des Longitudes" 1828, p. 234–236; *Nouvelle Biographie Générale*, ed. J.-Ch.-F. Hoefer, Paris 1852–1854, s.v. CAUS, CAULS ou CAUX (Salomon DE).

4 Myths and assumptions about de Caus's inventive activity have been outlined by L. Morgan, *Nature as Model*, p. 7–31.

5 Projects in the field of plumbing, pneumatics and other *automata* are included in two works, i.e. S. de Caus, *Les Raisons des Forces Mouvantes avec diverses machines tant utiles que plaisantes*, Francfort 1615; idem, *Hortus Palatinus: A Friderico Rege Boemiae, Electore Palatino Heidelbergae Exstructus*, Francofurti 1620.

6 S. de Caus, *Les Raisons des Forces Mouvantes*, p. 1, 2 (*Theoresme premier*), 4 (*Theoresme V*), *Problesme IX, XIII, XIIII* and *Problesme XV*.

7 On de Caus as an alleged steam engine inventor see: L. Morgan, *Nature as Model*, p. 17–20.

8 R. Thurston, *A History of the Growth of the Steam-Engine*, New York 1878, p. 16.

9 'The creation and cause of permanent movement was presented in the previous problem, from the invention of which I took the presented machine and which can be assigned the name of the permanent fountain', after: S. de Caus, *Les Raisons des Forces Mouvantes*, *Problesme XIII* (transl. by Katarzyna Błażewicz). De Caus mentions the 'previous problem,' i.e. a device, however, it is not clear which device he writes about because none of the preceding 'fixed fountains' is a continuous operation device.

10 The view on the innovative nature of this device in the case of de Caus was expressed by M. Valleriani, *The Garden of Pratolino: Ancient Technology Breaks Through the Barriers of Modern Iconology*, [in:] *Ludi naturae. Spiele der Natur in Kunst und Wissenschaft*, ed. by N. Adamowsky et al., Paderborn 2010, p. 175 and Ph. Steadman, *Renaissance Fun: The Machines behind the Scenes*, London 2021, p. 188–189.

sunlight focused by means of lenses was used to supply fountains and other mechanisms with water.[11] Implementations of this idea are not known either. That is why there was no obstacle to recognizing de Caus as an inventor of such a device. Only the discovery – in the graphics depicting the Wrocław Garden of Laurentius Scholz (1552–1599) – of the twin-like object which resembled those known from the works of de Caus made it possible to determine that this idea was successfully put into practice.[12] In light of the popularity of *Les Raisons des Forces Mouvantes*, the Wrocław machine could be regarded as a reception of de Caus' work, were it not for a chronological discrepancy. Namely, the *editio princeps* of the work is dated 1615, whereas the drawing depicting the Scholz Garden dates back to 1598, with the garden having been established a decade earlier. Given the above premises, it is worth re-analyzing the findings regarding the discussed device in order to determine its possible origins.

Method

When preparing the article, we first analyzed source texts, which consisted of dissertations presenting the state of knowledge in mechanics, plumbing, and pneumatics in the early modern period until the beginning of the 17th c. Among them were modern translations of the works of a Greek mathematician, physicist, mechanic and constructor, Hero of Alexandria (c. AD 10–70),[13] as well as other treatises,[14] including the already mentioned Salomon de Caus' *opus magnum*. Numerous studies on the reception of the findings and proposed theoretical solutions were also analyzed. Within this scope, special attention was paid to their role in the shaping and functioning of Italian gardens (in particular, Pratolino). The collected material was compared with the findings regarding Scholz's Wrocław Garden. Not only were the iconographic materials related to it thoroughly re-analyzed and the previous findings verified, but all other source documents were also examined. Probable parameters of the device and limitations connected with its functioning were also considered separately. This enabled us to draw conclusions that add new information to the current understanding of the Scholz Garden, going beyond the existing research fields in which this garden had previously been analyzed.

11 Among de Caus' works on mechanical and hydraulic topics, which preceded his studies, Hero's of Alexandria Treatise in the English translation was also taken into account. See: B. Woodcroft, *The Pneumatics of Hero*, and historic editions of the work: F. Commandino, *Heronis Alexandrini*; A. Giorgi, *Spiritali di Herone Alessandrino ridotti in lingua volgare da Alessandro Giorgi da Urbino*, Urbino 1592. Other modern editions were mentioned in M. Valleriani, *Ancient Pneumatics Transformed during the Early Modern Period*, "Nuncius" 2014, vol. 29, no. 1, p. 135–138.

12 M. Jagiełło, *Ogrody epoki renesansu i manieryzmu*, [in:] *Ogrody na Śląsku*, vol. 1, *Od średniowiecza do XVII w.*, ed. by M. Jagiełło, W. Brzezowski, Wrocław 2014, p. 127.

13 *Automata* (i.e. the book about machines) and *Pneumatika* (i.e. the book about pneumatics and plumbing).

14 A. Ramelli, *Le diverse et artificiose machine del capitano Agostino Ramelli*, Parigi 1588; G. della Porta, *Magiae naturalis libri XX in quibus scientiarum naturalium divitiae et deliciae demonstrantur*, Neapoli 1589, p. 260–291 (*Liber XVII, Liber XVIII*).

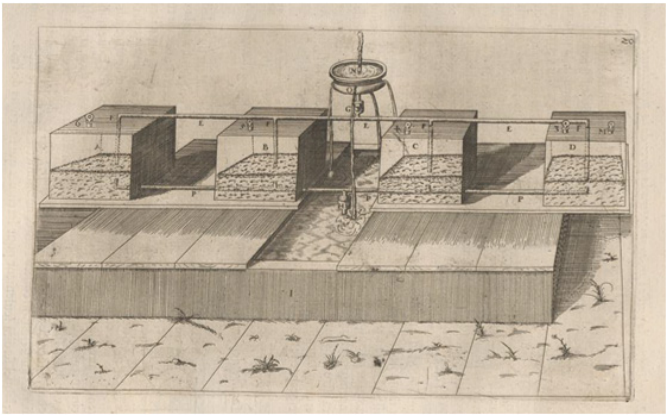

Fig. 1. A fountain in which the water circulation is forced by four pneumatic reservoirs, *Problesme XIII* (source: S. de Caus, *Les Raisons des Forces Mouvantes avec diverses machines tant utiles que plaisantes*, Francfort 1615, pl. 20)

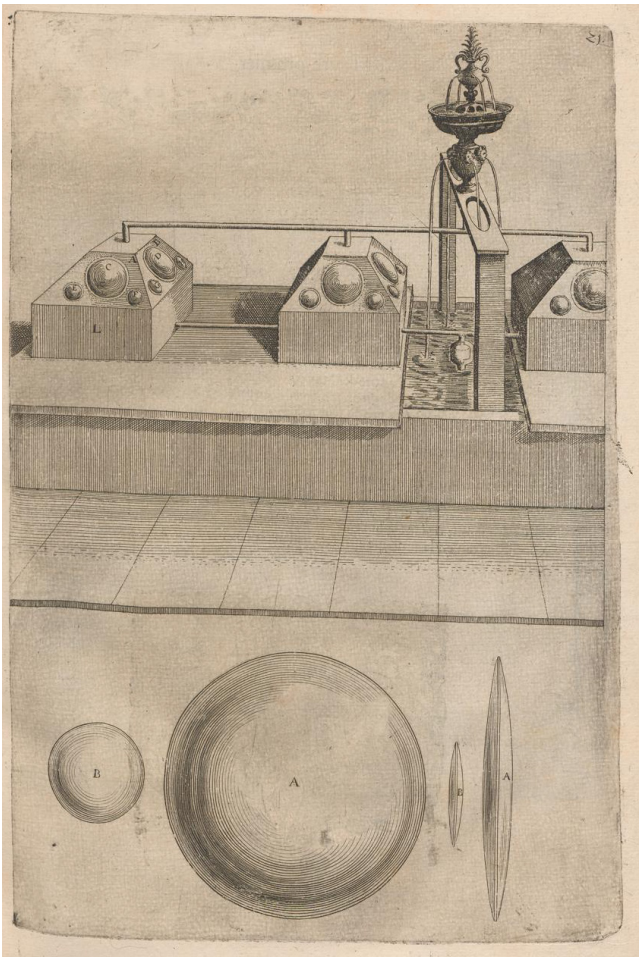

Fig. 2. A fountain, in which four pneumatic reservoirs with lenses force water circulation; lenses detail, view and cross-section, *Problesme XIIII* (source: S. de Caus, *Les Raisons des Forces Mouvantes avec diverses machines tant utiles que plaisantes*, Francfort 1615, pl. 21)

Salomon de Caus' *Problesme XIII, XIIII* and *XV*

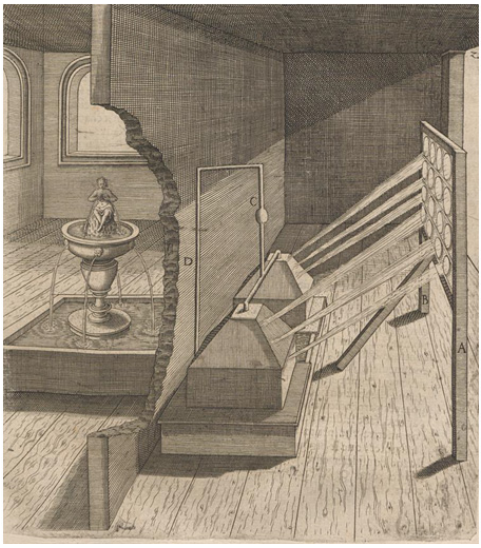

Fig. 3. A fountain, in which water circulation is forced by two pneumatic reservoirs, warmed by a screen with lenses, *Problesme XV* (source: S. de Caus, *Les Raisons des Forces Mouvantes avec diverses machines tant utiles que plaisantes*, Francfort 1615, pl. 22)

In *Les Raisons des Forces Mouvantes* de Caus presented three fountains with different details in which the water circulation was provided by compressed air.[15] *Problesme XIII* contains a description and drawing of a fountain consisting of four sealed cubic containers connected by two sets of pipes; one was brought to the pool with water, whereas the other was in the fountain. One-way valves prevent natural movement down. During the day, under the influence of the heat of sunbeams, the air pushes water in the containers under pressure, which spills from the pipes upwards and flows into the pool. At night, when the cooling air shrinks, the decreasing pressure opens the valve and sucks the water from the pool, which automatically complements the container which was empty during the day. In subsequent descriptions, de Caus presented other variants of the device described above. In *Problesme XIIII*, metal containers were equipped with round lenses which were designed to ensure the appropriate 'sun power' necessary to produce steam.[16] The third variant – *Problesme XV* – also contains lenses; however, they are mounted on a frame standing in front of containers. As a result, a device forcing water movement was obtained, constituting a *novum* against the background of other fountains, which required a connection to the source of accumulated water or complicated and expensive pumps and buckets. At the same time, it should be emphasized that the fountain's performance was relatively low. Assuming a value of 15° as a daily summer air temperature difference, a container with a volume of 1m^3 of air would make it possible to force out about 50 liters of water during the warm part of the day, which estimates the capacity of approximately four liters per hour.[17] De Caus was aware of the low performance of the device because he claimed that it would work better in countries where the sun shines more strongly and all day – in Spain and Italy.[18] The given water volume can be made bigger – without changing

15 S. de Caus, *Les Raisons des Forces Mouvantes*, *Problesme XIII, XIIII*, and *XV*.

16 'If we want to have water at five or six feet of height; the machine will not work if the sun does not light up with great violence, and in order to enhance the power of the sun, there will be a need for copper receptacles to be done in a shape as can be seen in the illustration presented', S. de Caus, *Les Raisons des Forces Mouvantes*, *Problesme XIIII* (transl. by Katarzyna Błażewicz). Let us add that the results of research on the role of lenses in focusing solar energy and their optimal shape for this purpose were already described in *De Luce et Lumine* by Girolamo Cardano: G. Cardano *De Subtilitate rerum*, Nuremberg, 1550, p. 165–166.

17 The air changes its volume by 3.4% to each 1°C temperature change.

18 'The machine discussed here will achieve huge results in hot places such as Spain or Italy, to the extent that the sun rises there almost every day bringing great heat; especially in summer,' after: S. de Caus, *Les Raisons des Forces Mouvantes*, *Problesme XIII* (transl. by Katarzyna Błażewicz).

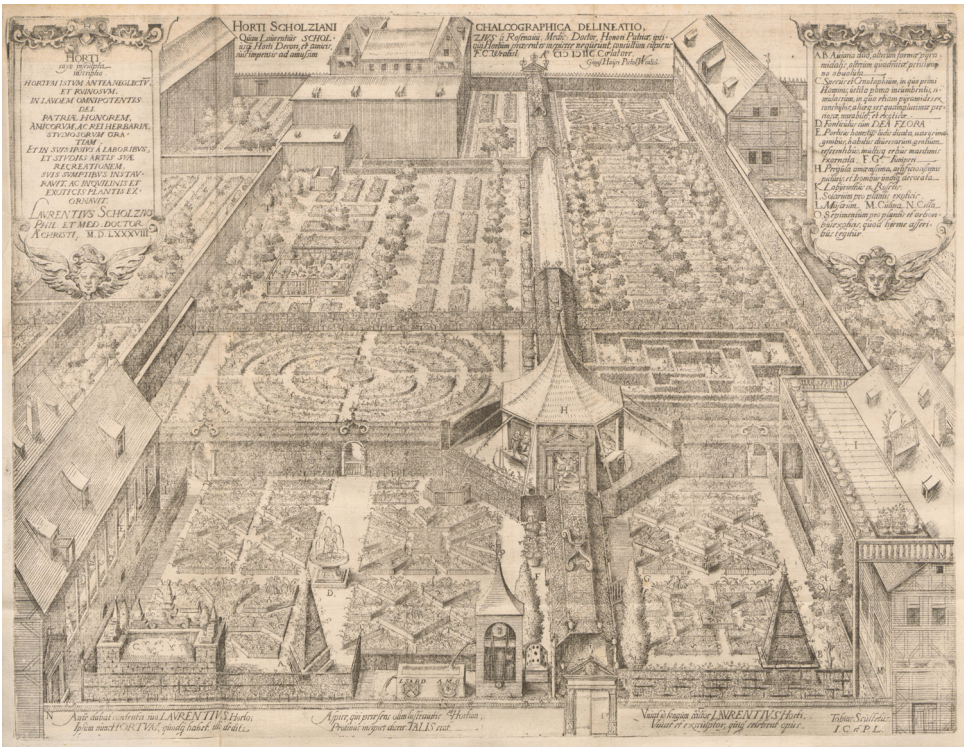

Fig. 4. Garden of Laurentius Scholz, a view from the east. Engraving by Georg Hayer from 1598 (source G. Hayer, *Horti Scholziani Chalcographica Delineatio* […], chalcography, Vratisl[avia] 1598)

the size of the container – by increasing the temperature difference of the air which fills it. This volume, however, is so small that it practically excludes the possibility of supplying a larger fountain with water or continuous operation of the device. Hence, it is also likely that it was switched on temporarily by twisting the valve after prior gas compression in the morning. It is uncertain whether de Caus made a working model of the solar fountain he described. Apart from the treatise, it did not occur among the well-known projects that he implemented and in which other methods of setting water in motion were used.[19] However, we have proof of the existence of a similar device, used to force water flow, before the end of the 16th c. in the most famous of the Silesian gardens of that time, established by Laurentius Scholz in Wrocław.

19 In the gardens of the Coudenberg Palace in Brussels, de Caus used a pump with four pistons driven by the accumulated waters of the Maalbeek River, and in the Richmond Palace a gravitational system with a cistern situated higher; see: L. Morgan, *Nature as Model*, p. 74–76 and 102–103. Due to their location on the slope, this last solution was adopted also for the gardens in Heidelberg, where except for the complex of the palace and garden with grottos, four 'Brunnenstuben' were founded, probably a kind of cistern with sieves and settlers which stopped contamination. Further water flowed in sealed pipes from lead and ceramics, and therefore ensured adequate pressure. Cf. W. Metzger, *'Wasser-Kunst' und 'Krottenwerk' – De Caus' Hortus Palatinus im 17. Jahrhundert*, [in:] *Magische Maschinen. Salomon de Caus' Erfindungen für den Heidelberger Schlossgarten 1614–1619*, ed. by F. Hepp et al., Neustadt a.d. Weinstraße 2008, p. 68.

Laurentius Scholz and his garden

Scholz, a Wrocław doctor, botanist, and collector, can be included in the group of the most important Silesian humanists of the late Renaissance.[20] He received a thorough education between 1572 and 1578, studying in Wittenberg and then at the universities of Padua, Bologna, and Valence (France), where he defended his doctoral dissertation in 1580. In his biography, it is also worth noting that his travels around Italy in 1579, which had a Grand Tour character, were undertaken with a group of three young Wrocław patricians. These travels focused on four cities – Florence, Rome, Milan, and Naples – the main centers of science and art at that time. Additionally, during his stay abroad, Scholz began collecting books, primarily on medicine (initially in the form of hand-made copies), which became the foundation of his later rich book collection. Scholz also had a sketchbook, as evidenced by a very detailed plan of the botanical garden in Padua, which contained a taxonomy of all plant species.[21] Social contacts established abroad, which led to the appearance of many exotic plants in his garden (including tomatoes, potatoes, tobacco, and calamus), also turned out to be of great significance. After his return, Scholz spent the first years practicing medicine in Kożuchów and then in 1585 he settled permanently in Wrocław, where he was the central figure of the city intellectual elite until his death in 1599. Scholz's research and collector's passions resulted in – apart from the already mentioned library – rich collections of native and exotic plants,[22] works of art, and various types of curiosities, all of which integrally connected with the functioning of the garden.

Scholz began preparations for the establishment of the garden already before arriving in Wrocław.[23] Apart from providing herbs which were necessary in medical practice, the garden was also extended in order to include a part for implementations of the above-mentioned collectors'[24] interests as well as to serve recreation and entertainment.

20 About Scholz and the garden at Wierzbowa Street see, for example, K. Eysymontt, *Ogród Laurentiusa Scholza we Wrocławiu i jego europejskie parantele*, "Biuletyn Historii Sztuki" 1989, vol. 51, no. 1, p. 3–12; P. Oszczanowski, *Wrocławski ogród Laurentiusa Scholza St. (1552–1599) – sceneria spotkań elity intelektualnej końca XVII wieku*, [in:] *Śląska Republika Uczonych*, ed. by M. Hałub, A. Mańko-Matysiak, Wrocław 2004, p. 98–145; M. Jagiełło, *Ogrody epoki renesansu i manieryzmu*, p. 113–137; Ch. Lauterbach, *Der erzählte Garten des Laurentius Scholz: bürgerliche Gartenkultur des Späthumanismus in Breslau*, Worms 2018.

21 During that period, creating drawings was a common practice among artists and scientists, exemplified by architects such as Heinrich Schickhardt, who produced some during his trip to Italy in 1599, and Valentin Säbisch, who copied treatises and made drawings from nature.

22 For which Scholz developed the catalog: L. Scholz, *Catalogus arborum, fruticum et plantarum, tam indigenarum quam exoticarum, horti medici Laurentii Scholzii medici Vratisl.*, Vratislaviae 1594. As indicated by Szafrańska, garden descriptions consisting of lists of the plants growing in them, which attest to their collector's character, appeared in Italy as early as the 15th c. M. Szafrańska, *Ogród jako kolekcja. XVI-wieczna geneza idei*, "Kronika Zamkowa" 2009, vol. 1–2 (57–58), p. 73.

23 The oldest orders for plants, probably healing ones, come from 1581, see: M. Fleischer, *Späthumanismus in Schlesien: Ausgewählte Aufsixtze*, München 1984, p. 147. Based on Scholz's own words in the preface of the catalog from 1594, where he mentions seven years of work on the garden, it is possible to determine that its foundation was in the year 1587. The entrance gate was one year younger. Still in the 19th c. there was an earlier catalog from 1587. It is probable that before establishing a garden of a representative character, Scholz had a garden which was connected to his medical practice; see: Ch. Lauterbach, *Der erzählte Garten*, p. 43.

24 Apart from books, reliefs, musical and physical instruments, Scholz's collection consisted of paintings and other artifacts, among which there was a copy of the waterpot from Cana of Galilee and an Egyptian mummy. We must also mention painted depictions of plants growing in the garden, as well as animals and people representing various regions of the world, which were executed on the wall of one of the garden buildings (*porticus honestis*) by a Wrocław painter Georg Freyburg.

Moreover, this very part of the garden became a meeting place for the elite educated group of Scholz's friends (doctors, professors of Wrocław gymnasiums, poets, and city officials), including those who commemorated the Roman celebration of the feast of the goddess Flora (*Floralia Wratislaviensia*). The nature of these meetings was regulated by written rules, the so-called *Leges Convivales* (Feast Laws), and the so-called *Leges Hortenses* (Garden Laws)[25] for staying in the garden, which were likely modeled on those from the *hortus botanicus* in Padua.[26] The appearance of Scholz's garden is known thanks to the aforementioned drawings made by Georg Hayer in 1598, commissioned by Scholz, as well as to descriptions, mainly a poetic text by Andreas Calagius (1549–1609), a humanist and professor at Wrocław St. Mary Magdalena's Gymnasium.[27] Epigrams, which were dedicated to Scholz by his friends, including Valens Acidalius (1567–1595), a poet and doctor of medicine and philosophy after his studies in Bologna,[28] also bring additional information.

In the current literature, the botanical and artistic aspects of the garden have been widely analyzed,[29] in contrast to the issues related to the technology of supplying it with water, which was crucial for the garden's functioning. Archaeological research carried out in 2012 showed that no hydraulic installations[30] were preserved because they were destroyed when subsequent structures were erected on this site, particularly during the thorough transformation of the garden into a Baroque layout.[31] In this situation, we have been forced – although largely remaining in the sphere of hypotheses – to analyze this issue using available sources.

Before delving into this, let us first consider the ambiguous role of water in contemporary gardens. This step is necessary for understanding – by releasing ourselves from a modern perspective – and helpful in interpreting the functioning of mechanisms and devices that were supported or even driven by water at that time. Apart from its obvious role in watering plants and creating a habitat for birds and fish, water also played a significant cultural role as a subdued element open to various interpretations and cultural influences.[32] According to Aleksandra Jakóbczyk-Gola, 'at the moment when the element turned into an aesthetic fountain, it lost its dangerous properties. It ceased to be a source of moist and 'cold' humor – *phlegm* – and gained the attribute of embellishment, *ornamentum*, which decorates the space of gardens.' She hastes to add that 'water was also an element and

25 L. Scholz, *Leges hortenses*, [in:] *In Laurentii Scholzii Medici Wratisl. Hortum Epigrammata Amicorum*, Vratislaviae 1594, sig. G4r–H3v.

26 Similar paintings were hung at the entrance gate to the garden in Leiden, which belonged to another excellent humanist, philosopher, and philologist Joost Lips (Justus Lipsius). Cf. M. Szafrańska, *Ogród jako kolekcja*, p. 65.

27 A. Calagius, *Hortus Doct. Laurentii Scholzii Medici et philosophi Quem ille colit Vratislaviae, situm intra ipsa civitatis moenia celebratus carmine* […], Vratislaviae 1592.

28 V. Acidalius*, Ianus quadrifrons custos Hortii Scholtziani ad hospitem*, [in:] *In Laurentii Scholzii Medici Wratisl. Hortum Epigrammata Amicorum*, Vratislaviae 1594, sig. G1r–G3v.

29 Ch. Lauterbach, *Der erzählte Garten*. See the extensive bibliography.

30 T. Kastek, R. Mruczek, *Dawny pałac Oppersdorfów przy ul. Wierzbowej nr 30 na Starym Mieście we Wrocławiu: badania architektoniczne*, "Śląskie Sprawozdania Archeologiczne" 2013, vol. 55, p. 345–366.

31 The history of the plot transformations in the former garden are discussed in: W. Brzezowski, *Czy tylko zimny popiół? Barokowa rezydencja przy ulicy Wierzbowej 30 we Wrocławiu i jej otoczenie*, [in:] *Nie tylko zamki. Studia podarowane profesorowi Jerzemu Rozpędowskiemu*, ed by. M. Chorowska et al., Wrocław 2005, p. 353–367.

32 A. Chromik-Krzykawka, *Czystość linii. Higiena a renesansowy ogród*, [in:] *Przestrzeń ogrodu – przestrzeń kultury*, ed. by G. Gazda, M. Gołąb, Kraków 2008, p. 92.

a material for collecting as well as a collector's specimen.'[33] Her conclusion is important to our topic: 'Thanks to the pump machinery and closed circulation, there was no place for the fluids of unknown origin in these hydraulic systems.'[34]

It is also worth paying attention to the varied attitudes toward different types of water. The Renaissance inherited the general classification from a Roman scholar living at the turn of the new era, Aulus Cornelius Celsus (d. 50 AD), who developed an eight-degree hierarchy of water. At the top of this hierarchy was rainwater, which he deemed the purest and 'the lightest'. Following rainwater were waters from mountain and underground sources. Rivers came next, followed by well water, melting snow, lakes, and swamps. The hierarchy concluded with the sea.[35] Properties connected with these waters were not permanent. Even the purest water could become stagnant and stinking. As Tchikine has observed:

> The thing that allowed water to retain its properties was movement. Fountains, which due to their construction 'set' water in motion as well as some types of reservoirs, were intentionally designed to keep water in motion and circulation, which resulted in the fact that the task of saving water along with its supply became the foundation of the hydraulics of the Renaissance.[36]

Interestingly enough, fishes bred in garden reservoirs were also used to keep water in motion.[37]

For similar reasons, it is necessary to examine contemporary discussions about air, including its composition and the factors influencing its compression and decompression, as well as the concept of vacuum. These discussions were initiated in ancient times by figures such as Aristotle and Hero, and continued into the early modern period.[38] It was the subject of scientific inquiries, and the similarity of ventilation to breathing translated into attempts to actively provide buildings with air exchange systems[39] and thus ensure the health of their residents.[40]

From the above considerations emerges an image most vividly presented in the work of Giambattista della Porta (1535–1615), an Italian doctor, inventor, and scholar, renowned as the author of *Magiae naturalis*.[41] As described by Saito, in his work, he presented the

33 A. Jakóbczyk-Gola, *Gabinety i ogrody*, Warszawa 2019, p. 244 (transl. by Bugusław Setkowicz here and below).
34 Ibidem, p. 245.
35 A. Tchikine, *'L'anima del giardino'. Waters, Gardens, and Hydraulics in Sixteenth-Century Florence and Naples*, [in:] *Technology and the Garden*, ed. by M.G. Lee, K.I. Helphand, Washington 2014, p. 13.
36 Ibidem, p. 13.
37 Ibidem, p. 11.
38 A. Keller, *Pneumatics, Automata and the Vacuum in the Work of Giambattista Aleotti*, "The British Journal for the History of Science" 1967, vol. 3, no. 4, p. 339.
39 B. Kenda, *On the Renaissance Art of Well-Being: Pneuma in Villa Eolia*, "RES: Anthropology and Aesthetics" 1998, no. 34, p. 107–8. The so-called complex of Aeolian Villas in Costozza near Vicenza has a system of underground canals through which cool air in summer and warmer air in winter flows from the grottos to the living quarters. Another variant is the room described by Aleotti for the Villa d'Este in Tivoli, in which air movement was forced by alternately filling and emptying water tanks supplied with flowing water. See: G.B. Aleotti, *Gli artifitiosi et curiosi moti spiritali di Herrone*, Ferrara 1589, *Theorema IV*, p. 96; G. della Porta*, Io. Bapt. Portae Neapolitani Pneumaticorum libri tres. Quibus accesserunt curuilineorum elementorum libri duo*, Neapoli 1601, p. 59.
40 B. Kenda, *On the Renaissance Art*, p. 114.
41 G. della Porta, *Magiae naturalis sive de miraculis rerum naturalium libri IIII*, Neapoli 1558; idem, *Magiae naturalis libri XX*.

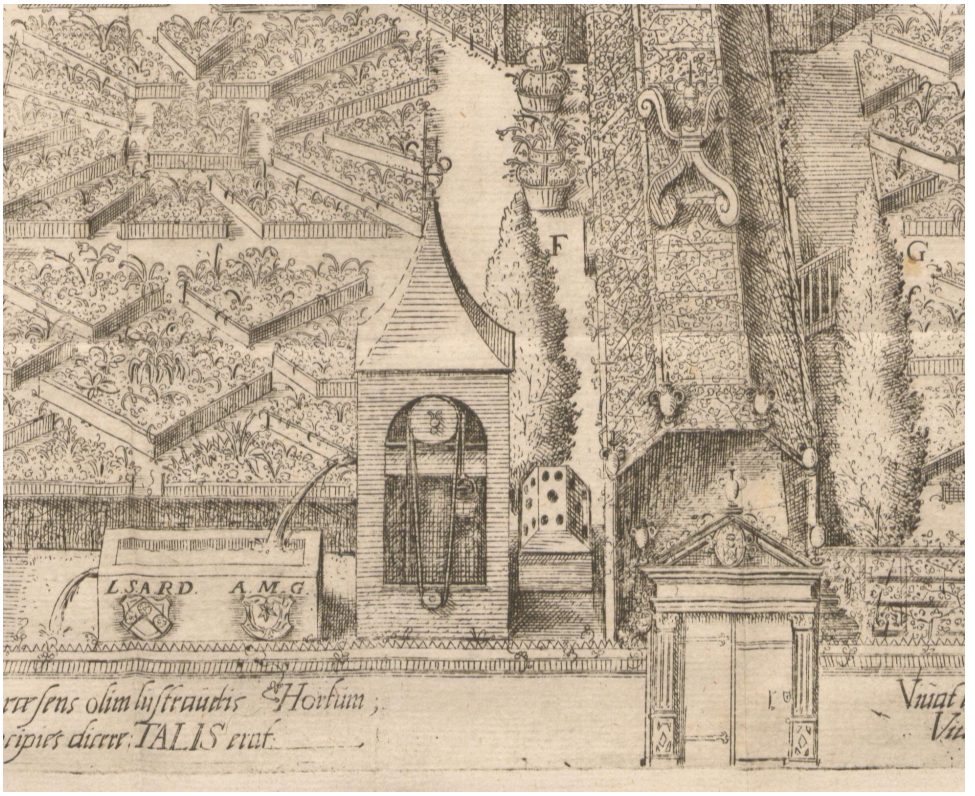

Fig. 5. Garden of Laurentius Scholz, detail with a water tower, an entrance gate and – most probably – a solar pump reservoir with lenses (source G. Hayer, *Horti Scholziani Chalcographica Delineatio* […], chalcography, Vratisl[avia] 1598)

'duality of the aspect of nature, which on the one hand appeared to human eyes, and on the other, was hidden under the curtain of appearances.'[42] Expensive water installations introduced into gardens not only surprised and amazed visitors but also served as a kind of 'scientific joke,' blending a 'joke of nature' with a 'joke of knowledge.'[43] For visitors, these installations were also a visible sign of the wealth and social status of the owners.

The existence of several water devices in the Scholz Garden was depicted in Hayer's drawing. The first of these devices served to irrigate plants growing in the functional part of the layout. Adjacent to the rear facade of the house, which may have been used for preparing medications from garden plants and possibly for distillation, there was a well surrounded by a square concrete support wall. We do not know whether the water taken from it came from an aquifer or whether it was supplied with the help of ceramic systems and wooden pipes from the so-called water craftsmanship (water pump).[44] In the second

42 F. Saito, *Knowing and Doing in the Sixteenth-Century Natural Magic: Giambattista della Porta and the Wonders of Nature*, "Circumscribere" 2014, vol. 14, p. 7–39.

43 Ibidem, p. 23.

44 The water pump, which was closest to the garden, was located by the River Oława at a distance of about 280 meters in a straight line, whereas a little closer, at 14 Kacerska Górka Street, there was a stone cistern which

part of the garden which was intended for recreational, representative, and collector's purposes, we can find a well (whose operation is connected with a water tower), two water reservoirs, a fountain (Flora's)[45] and – as we can suppose – a grotto supplied with water, in which apart from rocks we also see stalactites, shells, corals, and various plants.[46]

Let us add that rainwater was also used in the garden, as evidenced by an octagonal reservoir presented in the drawing by Hayer, to which, with the help of a decorative gargoyle – as we can suppose – rainfall from the roof of the nearby situated gazebo was delivered. Collecting rainwater from roofs in underground reservoirs constituted a common practice in Italy, both for economic reasons and due to the already mentioned high ranking among different types of water. In the Scholz Garden, a pond containing a sweet flag, an exotic plant from China at that time, was supplied with rainwater. The introduction of sweet flag into European gardens, imported from Constantinople, was first recorded in Prague in 1557 and later in Vienna in 1576. In the Scholz Garden, sweet flag was displayed near the Lusthaus. Considering the need for water circulation mentioned earlier, it can be inferred that small reservoirs in the garden must have had a system to facilitate such circulation.

Apart from the already mentioned box with lenses, the above list is also complemented by a mysterious device described by Calagius, to which we will return later in this article. It is all due to the fact that water in the Scholz Garden served not only to fulfill the basic needs of people and plants, but also provided sophisticated entertainment. Rainwater was also utilized to demonstrate Scholz's affiliation with an exclusive group of people belonging both to the realms of entertainment and science, appreciating and being fascinated by mechanisms. Specifically, this included a box with lenses, an almost identical device akin to the one described by de Caus in *Problesme XIII, XIIII and XV*.[47]

It appears that a relatively low tower with a container under a conical roof played a fundamental role in supplying water to the recreational, representative, and collector's garden. This structure likely served multiple purposes, including providing drinking water and supplying water to a stone reservoir designed for a flowing display full of fish.[48] The tower was essential because, even with a connection to the city water supply system, it was necessary to accumulate water to direct it under pressure through pipes to the fountain and other devices in the garden. In the discussed drawing, we can see

was erected in the 16th c., and which was the basis for the assumption about the water supply line nearby. On the Wrocław water supply system see, for example, M. Goliński, *XV-wieczny opis wrocławskiej sieci wodociągowej*, [in:] *Studia i materiały z dziejów Śląska i Małopolski*, ed. by R. Żerlik, Wrocław 2001, p. 105–123; J. Piekalski, *Elementy infrastruktury średniowiecznego Wrocławia*, "Wratislavia antiqua. Wrocław na przełomie średniowiecza i czasów nowożytnych" 2004, no. 6, p. 9–24.

45 *D. Fonticūlūs cúm DEA FLORA*; see: G. Hayer, *Horti Scholziani Chalcographica Delineatio* […], chalcography, Vratisl[avia] 1598

46 It seems that as evidence of water in the grotto, we can consider a description by Wolfgang Scharschmidt, the subsequent owner of the garden after Scholz, dating from 1670. Thanks to Schraschmidt, we also know its dimensions (3,5 x 3,5 x 4,5 meters). See W. Scharschmdt, *Breslauischer Wasser-Garten/Darinnen zu befinden Lustige und Zeitvertreibende Wasser-Spiele* […], Breslau 1699; W. Brzezowski, *Der Breslauische Wassergarten von Wolfgang Scharschmidt*, "Zandera" 2009, vol. 24, no. 1, p. 1–10.

47 M. Jagiełło, *Ogrody epoki renesansu i manieryzmu*, p. 127.

48 'Also the spring at which a higher juniper stood, seemed to me to be two stone reservoirs, whose always fresh waters once cooled down and strengthened numb parts in hot summer, once they provided fish with coolness or it was used for drinking'; after: Calagius, *Hortus Doct. Laurentii Scholzii*, sig. C1v (transl. by Sobiesław Nowotny and Zygmunt Łuniewicz).

two coupled wheel and axle machines with different diameters of the cylinder, which made it possible to reduce the effort which was put into drawing water and transporting it up, which took place in buckets, perhaps in two of them, to ensure greater efficiency.

Between the water tower and the pergola, there was a box with lenses – which constitutes the subject of our inquiries – which was provided with good exposure to the sun and quietness. Before recognizing the object's purpose,[49] nobody considered its presence in the garden. This lack of identification in the drawing itself and the absence of an 'engineering' view of the garden meant that this reservoir, unlike many other garden elements, was not described. The observed connection between this device and Renaissance automata, as well as the drawing from de Caus' treatise, proved to be a breakthrough. However, assumptions linking it to the Fountain of Flora appear doubtful in light of the findings presented here,[50] due to the device's low efficiency. Therefore, the purpose of its use remains a puzzle.

As already pointed out, Hayer's drawing does not provide a simple answer to the question about the purpose of this device. Overall, despite its detail, it does not show other elements relevant to the functioning of the garden either. For example, the statue of Janus, which was situated inside the Lusthaus, is not visible in the picture. We know that the statue was placed on a pedestal on which the already mentioned garden rules of conduct (*Leges Convivales* and *Leges Hortense*) were engraved. The description provided by Valens (Valentis) Acidalius,[51] a poet, doctor, philosopher, and graduate of the University of Bologna who lived in Wrocław from 1593 to 1595, indicates that it was a four-faced representation of Janus (*Janus Quadrifrons*). Unlike the most popular Janus in iconography and gardens,[52] having two faces symbolizing opposing dualities (such as creation/destruction, light/darkness, beginning/end, future/past), this one symbolized control over time and all other aspects.[53] Acidalius explained that it guarded the garden as a gatekeeper, positioned centrally with decorative portals on the four sides of the Lusthaus,[54] which was described imprecisely in the drawing as *Pergula ammorissima*, i.e. 'the most beautiful porch,' which rather referred to the whole pergola which divided this section of the layout into four parts.

By analogy, we can speculate that the device powered by a mysterious box was similarly concealed from this perspective, much like the figure of Janus hidden from view in the drawing. The text by Andreas Calagius, a poet, philologist, and professor of two gymnasiums in Wrocław,[55] may be considered – as it appears – to provide a hint about its purpose. It was divided into parts corresponding to subsequent months, symbolizing the relationships of successive Muses (from March to October). In addition to presenting various plants growing in the Scholz Garden and their origins, it includes a poetic description attributed to Urania and October. It reads as follows:

49 M. Jagiełło, *Ogrody epoki renesansu i manieryzmu*, p. 125–127.
50 Ibidem, p. 127.
51 V. Acidalius, *Ianus quadrifrons*, sig. G1r.
52 J. Spence, *Polymetis or, An Enquiry Concerning the Agreement Between the Works of the Roman Poets, and the Remains of the Antient Artists*, London 1747, p. 197–198.
53 At the entrance to the garden of Justus Lipsus in Leiden. Cf. M. Szafrańska, *Ogród jako kolekcja*, p. 72.
54 V. Acidalius, *Ianus quadrifrons*, sig. G1r.
55 A. Calagius, *Hortus Doct. Laurentii Scholzii*.

> Nevertheless, the observer is also entertained by the pipe which
> pours stagnant [water] out of the man's mouth and a tree trunk,
> to the pool, gushing waters from a nearby spring
> also extracted from the underground by some hidden art,
> through a thousand holes passing again through the pipe
> for the prepared empty reservoir, but full of cane.[56]

Calagius mentions the closed water circulation. Moreover, he also writes that the water movement is forced by hidden art (*arte latentem*), which allows us to conclude that the poet either did not know how this device operated or intentionally concealed it from the reader in order not to spoil the sense of wonder, which this self-operating device must have inspired. However, taking into consideration the detail of Hayer's drawing, even revealing the operation of many other garden mechanisms, it seems more probable that Calagius – similarly to other guests of Scholz – saw only a part of it. Considering the location of the mysterious box, it is quite possible that this device could have been installed inside the pergola, just behind the gate's portal leading to this part of the garden from the side of today's Piotra Skargi Street. It is not difficult to imagine the impression it would make on the garden's visitors. Let us recall that the creation of hydraulic devices in which the principles of operation were hidden from an observer constituted one of the main objects of interest of Renaissance engineers, despite the technical complexity of such endeavors and their low efficiency.[57]

What might the device described by Calagius have looked like? Comparing the above description with the designs of various automata found in the translations of Hero's treatise, the device most similar in appearance is No. 14.[58] A similar device is also described in the much later work, *Ars magna lucis et vmbrae* (Romae 1645), by a German theologian Athanasius Kircher (1602–1680).[59] In these works, we find a figure's head from which a stream of water is poured into a bowl (Hero), or a half-figure of a satyr (Kircher). However, the principles of their operation differ. In the first device, after the water falls into a bowl, it overflows into a reservoir, pushing air through whistles in bird figurines. Similarly, the sculpture of a satyr could make sounds thanks to pipes where heated air flows through the lenses. However, since Calagius' description does not mention any sounds, it can be assumed that, in the Scholz Garden, there was only the splash of water, which came out of both the 'human mouth' and the 'tree trunk.' After falling into the bowl, this water flowed in the underground pipes into an empty reservoir. In order to prevent backflow, the pipes had gate valves (locks) or ball valves. It can be assumed that the next element of the circulation was a specific reservoir which sucked water from the pipes at night. Then, as a result of sunlight warming the water directly, using lenses, the growing pressure pushed the water to the fountain and the bowl, completing the cycle. Only the mention

56 Ibidem, sig. C1r (transl. by Sobiesław Nowotny and Zygmunt Łuniewicz).

57 Ph. Steadman, *Renaissance Fun*, p. 189. It is also worth paying attention to the prestigious value of gardens, in which the presentation of mechanical devices constituted a demonstration tool of the owner's status. Cf. K. Rinne, *Garden Hydraulics in Pre-Sistine Rome: Theory and Practice*, [in:] *Technology and the Garden*, p. 115.

58 F. Commandino, *Heronis Alexandrini*, No. 14, p. 23; B. Woodcroft, *The Pneumatics of Hero*, No. 14, p. 29.

59 A. Kircher, *Ars magna lucis et vmbrae in decem libros digesta*, Romae 1645, pl. 31.

of 'a reservoir full of phragmites' raises doubts, as it is difficult to interpret the word 'arundine' in any other way.[60] Was it Calagius' mistake, or was the excess water directed to another reservoir with phragmites? The efficiency of the device requires full tightness of valves and pipe flows, which cannot be maintained with organic matter circulating in the device. The poet's puzzle allows us to conclude that the entire fountain's water supply mechanism provided entertainment fueled by curiosity about the source of the water. It also maintained the flow, with the bowl filled with water intensifying the effect of the falling stream even when the volume of outgoing water appeared to decrease due to the reduced pressure in the reservoir at the end of its daily cycle.

Apart from device XIII from Hero's treatise, the one with number XLVII also merits attention.[61] They were similar by the physics of operation – though not due to aesthetics – to automata from de Caus' treatise and the Scholz Garden. It is a 'fountain moved by the beams of the sun,' consisting of a tight metal reservoir connected by pipes in a one-way circuit with a glass sphere and a funnel. According to Hero's description, the liquid movement would be driven by changes in air volume in the sphere. This device could, in fact, have worked only as a result of heating the reservoir because the volume of air in the glass sphere would likely be too low to achieve the intended effect. And this would result in a one-time emptying of the sphere in each cycle due to the presence of the siphon. Visible changes in the volume of heated gas, thanks to the application of glass walls, make it possible to classify the fountain as a type of thermoscope.

The description published by Calagius in 1592 introduced *terminus ante quem* of the existence of the described device in the Scholz Garden. At that exact time, de Caus (who was born in 1576) was only 16 years old. Even though we know little about his youth, it was established that he was in Italy over the period directly preceding 1598. Luke Morgan, author of de Caus' biography, analyzed his treatises and projects published between 1611 and 1624, particularly his major work, *Les Raisons des forces mouvantes*.[62] Morgan established numerous connections between the solutions presented in these works, the equipment described, and formal design elements borrowed from gardens of Pratolino, Boboli, and Villa d'Este.[63] He also provided evidence of de Caus' use of Italian scientific advancements that dominated Europe in hydraulics and military engineering throughout the 16th c. Morgan did not dismiss the possibility of de Caus' apprenticeship under Bernardo Buontalenti (c. 1531–1608), known for designing the Pratolino Garden and works for the Boboli Residence (including the *grotto*). It is quite probable that Morgan recognized the preparation of hand-drawn notes on garden fountains, automata, sculptures by de Caus, etc., as was common practice at that time.[64] Probably for the first time, they were used in de Caus' projects for grottos, fountains, and various water automata, which were installed in the gardens of the Coudenberg Palace in Brussels, where he worked from around 1598. Between 1605 and 1610, de Caus was promoted to the position of a court engineer for fountains (*Ingéniaire à la fontaine artifielle*[65]) of Archduke Albert VII (1559–1621), Governor

60 In Latin original: 'in vannum fundo vacuam, sed arundine plenam,' after: ibidem, sig. C1r.
61 F. Commandino, *Heronis Alexandrini*, No. 47, p 50; B. Woodcroft, *The Pneumatics of Hero*, No. 47, p. 69.
62 S. de Caus, *Les Raisons des Forces Mouvantes*.
63 L. Morgan, *Nature as Model*, p. 42–49.
64 Ibidem, p. 48.
65 S. Schweizer, *Salomon de Caus*, p. 14.

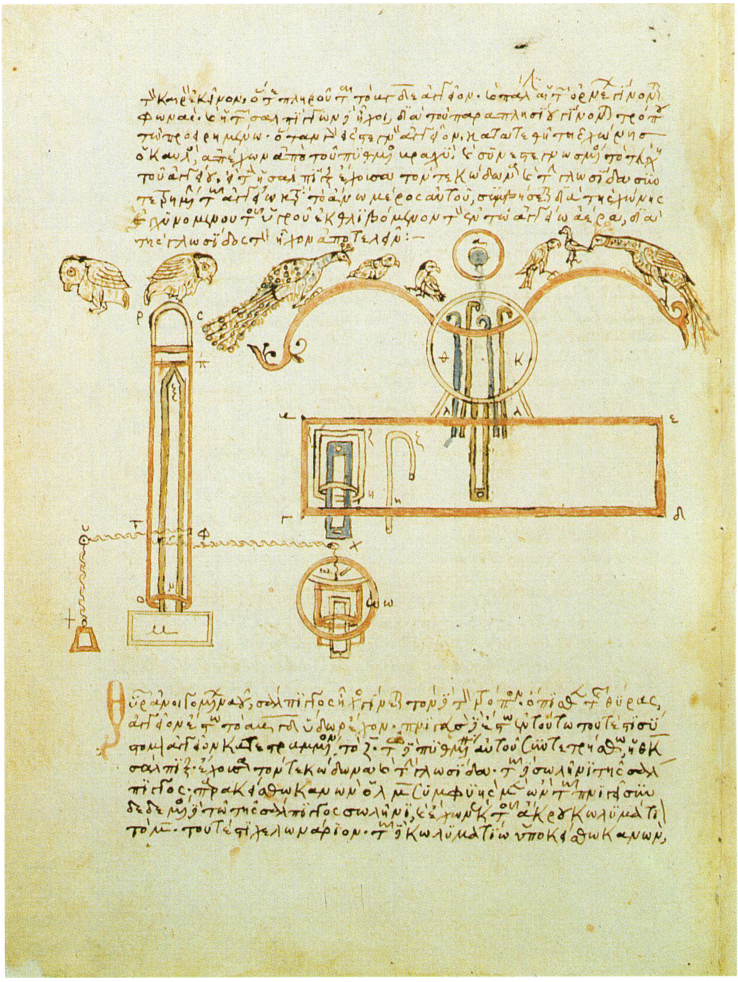

Fig. 6. Hero of Alexandria, hydraulic automaton with singing artificial birds; a Venetian copy of Hero's of Alexandria *Pneumatica* from the beginning of the 14th c. (source: Biblioteca Nazionale Marciana in Venice [BNM], ms. Gr. 516, Hero of Alexandria, *Pneumatica*, 1,16, fol. 172v)

of the Spanish Netherlands. The next stage of de Caus' career was at Richmond Palace under Henry Frederick, Prince of Wales (1594–1612), where he served as *Ingenieur du Serennissime Princes des Galles* from 1610 onwards.[66] It is believed that some illustrations from de Caus' *Raisons des Forces Mouvantes* were intended as projects for decorative elements in the princely garden, while others were designed to 'satisfy a sensitive curiosity' of the prince.[67] Salomon de Caus presented the fullness of his skills by working from around 1614 for Frederick V, the Elector Palatine (1596–1632) in Heidelberg, and creating an extraordinary project for the local

66 The gardens of the Richmond residence were designed by Constantino de Servi, a Florentine architect, and were supervised by Inigo Jones (1573–1652), Prince's surveyor.

67 Similar suggestions refer to other gardens, namely in Hatfield, Greenwich, and Somerset House, where artificial Parnas Mountain, similar to the one from Pratolino gardens, was erected according to de Caus' design. Cf. L. Morgan, *Nature as Model*, p. 53–58.

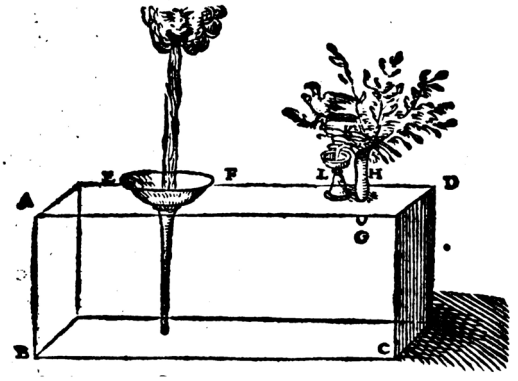

Fig. 7. Hero of Alexandria, hydraulic automaton with singing artificial birds (source: F. Commandino, *Heronis Alexandrini Spiritalium liber. A Federico Commandino Vrbinate, ex Graeco, nuper in Latinum conuersus*, Urbino 1575, No. 14, p. 23)

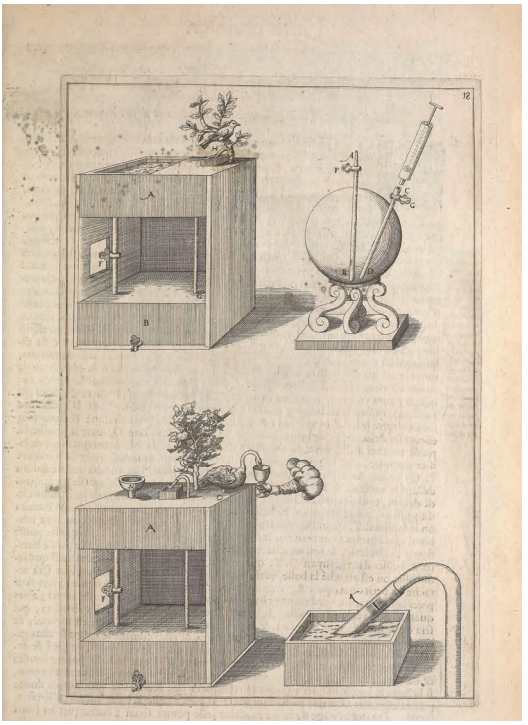

Fig. 8. Salomon de Caus, two hydraulic automata with singing artificial birds, a fountain for piston compressed air (source: S. de Caus, *Les Raisons des Forces Mouvantes avec diverses machines tant utiles que plaisantes*, Francfort 1615, pl. 18)

garden, showcasing his engineering (hydraulic and mechanical) as well as gardening and artistic skills. It was published in 1622.[68]

Pneumatic automata of the late Renaissance

Morgan's juxtaposition of events and dates, supported by the analyses of the creative activity of de Caus, allows us to suppose that both Scholz and de Caus copied the device defined as a solar steam machine, which was probably located in one of the Italian gardens at that time and referred to as the so-called automaton – the first one in his Wrocław garden, and the second, at least twenty-three years after Scholz, on the pages of his treatise. The resurgence of interest in ancient scientific heritage in Italy during the second half of the 16th c. likely contributed to the creation of automata. However, it must be noted that various other automata had been known in Europe much earlier. Early modern Europe was replete with mechanical devices such as clocks and pipe organs, and the publication of ancient texts, including the first edition of Vitruvius' treatise *De Architectura*[69] with a description of the aqueous pipe organs by engineer Ctesibius (fl. 3rd c. BC), along with other automata, further spurred their construction. Initially, automata appeared in secular contexts since the mid-14th c. on the town halls and city clock towers, but growing popularity led to rapid mini-

68 S. de Caus, *Hortus Palatinus*.

69 J. Ryskin, *Machines in the Garden*, [in:] *Renaissance Futurities: Science, Art, Invention*, ed. by Ch. Villaseñor Black, M.-T. Álvarez, Oakland 2019, p. 16–43.

aturization, with devices appearing in the homes of aristocrats and wealthy city burghers by the mid-16th c.[70] The use of automata in gardens developed almost concurrently; playful devices were seen in the gardens of the Hesdin Castle (in present-day Pas-de-Calais) in the late 13th c., known in modern Europe as water games or *giochi d'acqua*.[71]

However, while water arts at the end of the 13th c. constituted an exclusive exception in Europe,[72] it was already in 1580 and 1581, when Michael de Montaigne traveled around Europe, that hydraulic automata were very popular, also in the gardens of patricians. Near Augsburg, in the summer estate of the Fuggers (a wealthy family of bankers), Montaigne saw, for example, water gushing on careless guests from 'small brass nozzles which could not be seen' and which were launched by 'hidden sources.'[73] *Giochi d'acqua* and automata in Italian gardens – Pratolino and Villa d'Este – made even greater impression on Montaigne. He described, among other things, the grotto in Pratolino and various figures of animals leaning at the water, singing birds, and many other water arts inside the grotto. Because of its importance, the topic of gardens in Pratolino, where, based on the description by the philosopher Francesco de' Vieri (1524–1591),[74] one can find devices significantly similar to the discussed fountain, as well as works by de Caus, will be further elaborated. In another residence belonging to Prince Francesco I de Medici (1541–1587), he came across hydraulically powered windmills, and figures of people and animals during hunting. From his stay in Villa d'Este, he remembered the water pipe organs which he described in detail.[75] In fact, these were the first water pipe organs implemented in Italy[76].

Along with the Scholz Garden, i.e. probably from 1591, the garden of Zygmunt Gonzaga Myszkowski (c. 1562–1615) in Pińczów was established almost simultaneously. There, based on extensive relations from the epoch, it was possible to indicate various mobile, sound-producing devices in the shape of human figures, animals, and plants, which poured alternately warm and cold water on guests.[77] It is worth emphasizing, however, that although the entertainment aspect of water devices remained important since the Middle Ages, the metaphysical aspect of garden fountains was also considered significant in the early modern period. Existing in the complexes of grottos as an element which shaped rocks, formed minerals, as well as drove machines, it was perceived as a life-giving force connected with the heart of the Earth, and by the possibility of giving the automata the appearance of life, it gave man the position of a demiurge.[78]

70 Ibidem, p. 25.
71 From a census conducted in 1467 by Philippe le Bone, the Duke of Burgundy. See J. Ryskin, *Machines in the Garden*, p. 32.
72 Simultaneously, such devices were continuously constructed since antiquity in Byzantium and the Islamic world. See G. Brett, *The Automata in the Byzantine 'Throne of Solomon*,' "Speculum" 1954, vol. 29, p. 477–487.
73 M. de. Montaigne, *The Journal of Montaigne's Travels in Italy by Way of Switzerland and Germany in 1580 and 1581*, vol. 1, ed. by W.G. Waters, London 1903, p. 140–142.
74 F. de' Vieri, *Discorsi delle Meravigliose Opere di Pratolino, et d'Amore*, Firenze 1587.
75 M. de. Montaigne, *The Journal of Montaigne's Travels*, p.168–170.
76 S. Kaiser, M. Valleriani, *The Organ of the Villa d'Este in Tivoli and the Standards of Pneumatic Engineering in the Renaissance*, [in:] *Gardens, Knowledge and the Sciences in the Early Modern Period*, ed. by H. Fischer, V. Remmert, J. Wolschke-Bulmahn, Basel 2016, p. 82.
77 A. Stankiewicz, *Łaźnia i ogród w rezydencji Zygmunta Gonzagi margrabiego Myszkowskiego w Pińczowie*, "Modus. Prace z historii sztuki" 2015, vol. 15, p. 172–175.
78 Ibidem, p. 171–172.

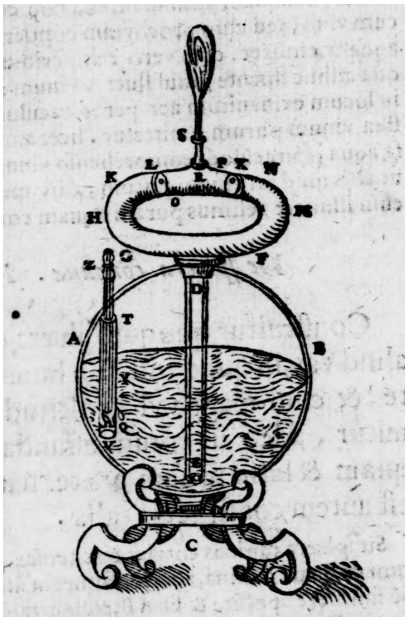

Fig. 9. Hero of Alexandria, fountain for piston compressed air (source: after F. Commandino, *Heronis Alexandrini Spiritalium liber. A Federico Commandino Vrbinate, ex Graeco, nuper in Latinum conuersus*, Urbino 1575, No. 9, p. 19–20)

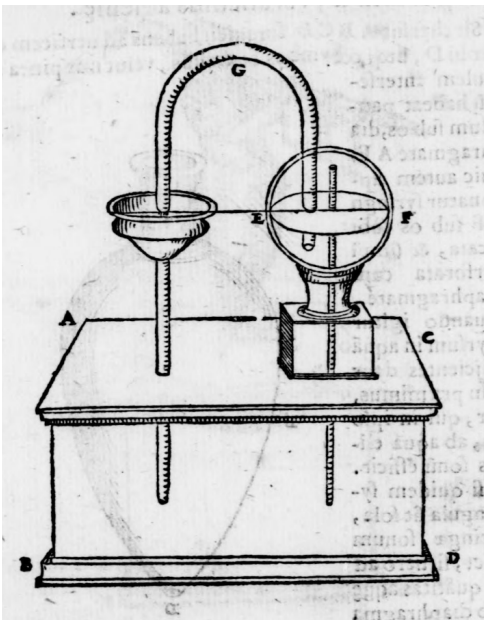

Fig. 10. Heron of Alexandria, a fountain with a thermoscope (source: F. Commandino, *Heronis Alexandrini Spiritalium liber. A Federico Commandino Vrbinate, ex Graeco, nuper in Latinum conuersus*, Urbino 1575, No. 47, p. 50)

The above outline allows us to conclude that most constructed automata constitute the reception of ancient heritage,[79] and despite the apparent complexity, the operation principles of these devices are very simple. Within this domain, Salomon de Caus' achievements largely consist of compiling previous works in mechanics, pneumatics, hydraulics, and optics, incorporating ideas, observations, and findings from ancient authors.[80] They were collected by the Greek mathematician Hero of Alexandria (10–72 AD) and then presented in the descriptions and illustrations by Villard de Honnecourt, Conrad Kyeser, Francesco Gogio Martini, and at the beginning of the early modern period also by Leonardo da Vinci.[81] *Pneumatics and Mechanics* by Hero survived in many illustrated Greek copies,[82] which were then published in Latin[83] and Italian,[84] becoming the knowledge basis for

79 J.M. Bradburne, *Local Heroes – Memory in Action in the Late Renaissance Garden*, "Nordisk Museologi" 2008, vol. 1–2, p. 74–96; M. Valleriani, *Galileo Engineer*, Dordrecht 2010; Idem, *Ancient Pneumatics*, p. 127–131; Ph. Steadman, *Renaissance Fun*, p. 279–327.

80 A.G. Drachmann, *The Mechanical Technology of Greek and Roman Antiquity: A Study of the Literary Sources*, London 1963.

81 M. Valleriani, *From Condensation to Compression. How Renaissance Italian Engineers Approached Hero's Pneumatics*, [in:] *Transformationen der Antike*, ed. by H. Böhme et al., vol. 1, Berlin, New York 2007, p. 333–353.

82 M. Valleriani, *Ancient Pneumatics*, p. 131.

83 F. Commandino, *Heronis Alexandrini*. It was the first printed edition translated from Greek into Latin, with numerous illustrations, developed by Federico Commandino.

84 In 1582, it was translated into Italian, commissioned by Bernardo Buantalenti, a chief engineer at the Medici mansion house in Florence, who worked at the construction of the residence since 1569, and from 1580 supervised arranging of the gardens of the Villa Pratolino, which indicates the purpose of the text. K. Rinne, *Garden Hydraulics*, p. 111–128; M. Valleriani, *Ancient Pneumatics*, p. 138. In 1589, a corrected Italian translation was published in: G.B. Aleotti, *Gli artifitiosi*.

mechanical, pneumatic, and hydraulic devices until the end of the 17th c.[85]

The thermoscope,[86] which was earlier described in *Pneumatics* by Hero,[87] due to numerous imperfections, was certainly a theoretical device; however, its variants appeared in the works of the 16th-c. inventors.[88] Let us add that Leonardo da Vinci included his own version of thermoscopes in the *Codex Atlanticus*, sketching various systems of containers connected by means of siphons.[89] In 1592, Galileo created his thermoscope;[90] sometime later, Della Porta's *Aparatus* appeared. It was published in 1606[91] and constituted – just like de Caus' *Theoresme V* – a combination of *aeolipile* and a fountain for compressed air according to the concept of Hero of Alexandria.[92]

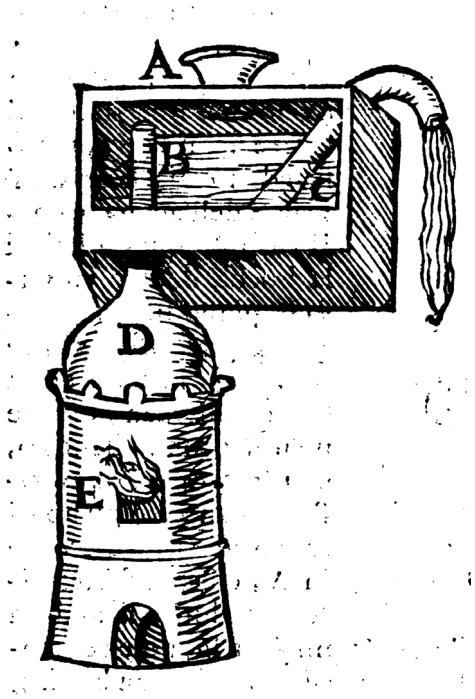

Fig. 11. A device throwing water with compressed water vapor power, the so-called *Aparatus* (source: G. della Porta, *De distillatione lib. IX* […], Romae 1608, p. 75)

It is also noteworthy that the idea of using sunbeams which were focused by lenses or mirrors, known since ancient times, appeared prior to the publication of de Caus' work. The description of the 'burning glasses' is included in Book XVII of *Natural Magic* by Della Porta, published in 1559.[93] In turn, the description of the distillation of the liquid heated with the rays of the sun appeared even earlier, as in 1560, in the medical and botanical treatise by Adam Lonitzer (1528–1586), we can find the principle of operation and a drawing depicting vessels heated with the focused sunbeams in the concave mirror.[94] Della Porta contained almost the same illustration in his later work, *De distillatione* (Romae 1608).[95] Moreover, the development of device No. 14 (present in all editions of Hero's work) can also be found in de Caus' treatise from 1615, on the page following the description of *Problesme XI*, as well as in the aforementioned work by Kircher,[96] which proves the unabated interest in

85 W.R. Laird, *Hero of Alexandria and Renaissance Mechanics*, [in:] *Mathematical Practitioners and the Transformation of Natural Knowledge in Early Modern Europe*, ed. L. Cormack, S. A. Walton, J. Schuster, Cham 2017, p. 149–165.
86 A thermoscope is a device that shows changes in temperature, mostly by rises and falls of level of liquid.
87 F. Commandino, *Heronis Alexandrini*, No 47, p. 50; B. Woodcroft, *The Pneumatics of Hero*, No. 47, p. 69.
88 M. Valleriani, *Galileo Engineer*, p. 173–175.
89 Biblioteca Ambrosiana in Milan [BA], ms. CA, L. da Vinci, Codex Atlanticus, sig. 1113r–1113v.
90 M. Valleriani, *The Garden of Pratolino*, p. 160 et passim.
91 G. della Porta, *De distillatione lib. IX* […], Romae 1608, p. 75.
92 B. Woodcroft, *The Pneumatics of Hero*, No. 9, p. 23–24; No. 50, p. 72; F. Commandino, *Heronis Alexandrini*, No. 9, p. 19–20, No. 50, p. 52–53.
93 G. della Porta, *Magiae naturalis libri XX*, Book XVII, Chapter XIV, p. 271. An English translation was used in the article: idem, *Natural Magick in XX bookes*, London 1658, p. 371.
94 A. Lonitzer, *Kreuterbuch*, Franckfort am Meyn 1560, p. VIr.
95 G. della Porta, *De distillatione lib. IX*, p. 30.
96 A. Kircher, *Ars magna lucis et vmbrae*, pl. 31.

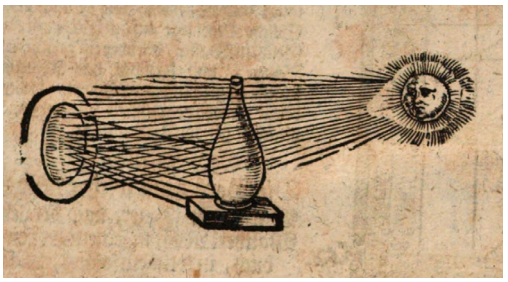

Fig. 12. Heating the vessel with a concave mirror (source: A. Lonitzer, *Kreuterbuch*, Franckfort am Meyn 1560, sig. VIr)

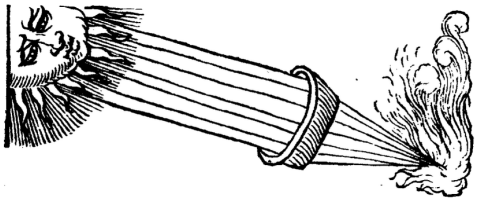

Fig. 13. Use of lenses to focus sunrays (source: G. della Porta, *Magiae naturalis libri XX in quibus scientiarum naturalium divitiae et deliciae demonstrantur*, Neapoli 1589, p. 271, *Liber XVII, Cap. XIIII*)

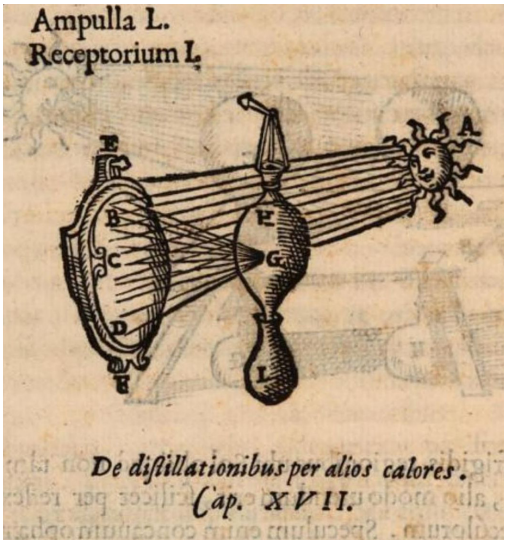

Fig. 14. Distillation in a vessel warmed up using a concave mirror (source: G. della Porta, *De distillatione lib. IX* […], Romae 1608, p. 30)

this mechanism in the 17th c. and even in its later improvements and more sophisticated shapes.

It is worth noting that the idea of heating objects using focused sunlight was utilized in the garden installations at Pratolino. In his description of the garden, Francesco de' Vieri likened it to the wonders of antiquity, juxtaposing them with contemporary achievements. He invoked the mythical figure of Daedalus, attributing to him the invention of concave lenses that could be used to ignite the enemy's ships.[97] In the later part of the text, as a counterpart to Daedalus' invention, he included a somewhat enigmatic description of automata powered by the heat of concentrated sunlight:

> With their concave lenses, great mathematicians positioned them to the sun and reverberated the rays to burn the ships so soon and with much stupor. It's not a great thing that water in many, many statues in many places and in many ways bathe us with pleasing tricks that imitate the waters of the universe. Of these, some take the material principle of the Earth below, as much as in itself being humid, by virtue of the Sun vapors rise from it, and they are conveyed to the middle realm of air; and the cold of itself, abandoned by dry breath, condenses in clouds, and the clouds come down as drops of water.[98]

Unfortunately, the general nature of the description does not allow for the reconstruction of the operating principle of these automata. Simultaneously, it unequivocally highlights the signifi-

97 Ibidem, p. 59.

98 F. de' Vieri, *Discorsi delle Meravigliose Opere di Pratolino, et d'Amore*, Firenze 1587, p. 61–62 (transl. by the authors).

cance of lenses in the creation of Pratolino's automata. The conjecture about Scholz and de Caus imitating a common object can therefore be linked to a more closely unknown device from Pratolino. There are, however, more indications. One of the devices described by de' Vieri can be found in the treatise by de Caus, namely the moving statue of Galatea and her entourage, alternately appearing and disappearing in a rocky grotto.[99] This description aligns well with the depiction of the device shown in the engraving as a 'Machine with a figure of Galatea being pulled through the water by two dolphins.'[100] With some caution, one can consider the statue of Galatea as evidence that de Caus might have copied the Pratolino automata. This perspective can also be applied to solar pumps. Multiple reproductions of devices were, in fact, typical for most of the inventors mentioned in the article, and we should not perceive the discussed device as an exception.

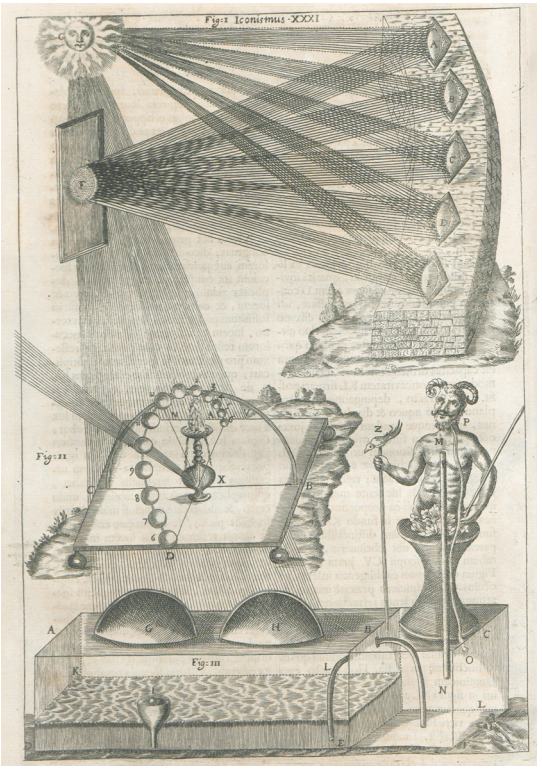

Fig. 15. Device for focusing rays of the sun by means of concave mirrors; fountain in which the movement of water is forced by a pneumatic reservoir heated with lenses with an adjustable position, sound-producing automaton in which the air movement is forced by a pneumatic reservoir with lenses (source: A. Kircher, *Ars magna lucis et vmbrae in decem libros digesta*, Romae 1645, pl. 31)

Conclusions

In the light of the above observations, it can be seen that – although separately – individual elements of the machine, i.e. the solar pump, which consisted of a metal box equipped with lenses and the other, smaller, equipped with outlets of water gushing 'from the mouth of man' and 'trees,' existed in available works in which they were described and illustrated. And although it was not possible to find the text which described it in full or any description of the implementation of this type of device, it can be assumed that a similar device, which was previously described, could have existed in one of the often visited gardens, probably in Italy, where both Laurentius Scholz and Salomon de Caus might have come across them during their studies and travels. Scholz stayed in Italy during his studies in Padua and Bologna in the years 1576–79 and then in the most distin-

99 Ibidem, p. 61.
100 S. de Caus, *Les Raisons des Forces Mouvantes*, *Problesme XXIIII*.

guished places of Italy and southern France while traveling between 1579 and 1580. Salomon de Caus visited Italy probably only before 1598.[101] It is most probable that they visited the gardens of Pratolino (completed around 1581), which were famous for numerous pneumatic automata taken from Hero's[102] work and even referred to as 'Heronic villa par excellence.'[103] Both are considered a kind of training ground for pneumatic experiments, and it was within these contexts that Scholz and de Caus likely became familiar with a functional solar fountain. The description by Francesco de' Vieri, containing references to lenses in Pratolino, suggests that analogous devices were functioning at that time, and the principles of their operation were known. It is quite possible that such a device – in whole or in parts – was ordered by Scholz in Italy, as it is not certain whether there were workshops producing appropriate lenses and valves in Silesia at the end of the 16th c.

Transferring the idea or material solar pump from Italy to the Scholz Garden in the years preceding the end of the 16th c., rules out de Caus' authorship of the described device, which was earlier attributed to him. Fortunately, this most famous Wrocław (or even Silesian) garden gives us additional knowledge about its owner and his vast horizons. The garden he established, previously perceived as a multifaceted phenomenon ('space of knowledge,' 'school of medical art,' 'Museum of Nature,' 'theatrical world of plants,' and a metaphor for the human and natural world order),[104] now enriches us with a new exhibit in its diverse collection, connecting it within this context to the person and achievements of one of antiquity's most outstanding scholars – Hero of Alexandria.

Certainly, we do not feel entirely satisfied regarding, for instance, the creator (originator) of this device – not only in the Wrocław Garden. Nevertheless, we still hope to continue considerations of this extraordinary place and its increasingly intriguing owner, who in his Garden Laws included the following sentence:

> Educated people should practice their minds by agreeable conversations: preferably in discussions about science and gardening as well as by asking questions; one who can teach, let them teach; and whoever wants to learn, let them learn.[105]

Previous studies on the Scholz Garden indicate that we can view it as a metaphorical *summa* of humanistic perceptions of nature and a phenomenon of collecting. According to Szafrańska,

> Collectors' gardens, which were established as part of the emerging and developing humanistic culture […] [had] their shape significantly influenced by printed scientific dissertations. They created an increasingly denser information flow network, connecting scholars, amateurs, collectors, and tourists.[106]

However, while scientific dissertations of the epoch were characterized by transparency and conventionalism in their research methods, the portrayal of gardens often conveyed

101 L. Morgan, *Nature as Model*, p. 42.
102 M. Valleriani, *Ancient Pneumatics*, p. 147 et passim.
103 J.M. Bradburne, *Local Heroes*, p. 83.
104 Ch. Lauterbach, *Der erzählte Garten*, p. 81–88.
105 L. Scholz, *Leges hortenses*, sig. G4v–H1r, after: P. Oszczanowski, *Wrocławski ogród*, p. 126 (transl. by Jan Przytulski).
106 M. Szafrańska, *Ogród jako kolekcja*, p. 92 (transl. by Bogusław Setkowicz).

similar concepts in a veiled and metaphorical manner. For example, in describing the solar pump from the Scholz Garden, the poet mentioned 'hidden art,' i.e. *arte latentem*, which set water in motion and prompted observers, including ourselves, to engage in inquiry and reflection.

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Śląski refleks traktatu Herona. Salomon de Caus i wrocławski ogród Laurentiusa Scholza

W dotychczasowej literaturze Salomon de Caus uchodził za pomysłodawcę urządzenia, w którym obieg wody wymuszany był pneumatycznymi zbiornikami zaopatrzonymi w soczewki. Identyfikacja takiego urządzenia w blisko dwie dekady wcześniejszym ogrodzie Laurentiusa Scholza we Wrocławiu, unaoczniła konieczność weryfikacji tego przekonania. Autorzy podjęli próbę wyjaśnienia sposobu działania urządzenia w oparciu o dostępne teksty, analogie i ikonografię i przedstawili kontekst urządzeń wodnych w ogrodach, ich

źródła, funkcje i kulturowe znaczenie. Przeanalizowane zostały sposoby dostarczania wody do ogrodów, prawdopodobny sposób połączenia ogrodu z wrocławskimi wodociągami, jak również szerokie tło obejmujące preferencje i ocenę jakości wody ze względu na pochodzenie. Wyjaśniono symbolikę oraz złożony obraz manifestacji żywiołu w ogrodach. W oparciu o zachowane traktaty i relacje, Autorzy ustalili, że poszczególne elementy urządzenia można znaleźć w pracach poświęconych hydraulice, pneumatyce, destylacji czy medycynie. Wysunęli przypuszczenie, że zarówno Scholz, jak i de Caus zaznajomili się z pompą solarną w którymś z ogrodów północnych Włoszech: w Tivoli, lub najprawdopodobniej w Pratolino, w których zrealizowano liczne automaty, wywiedzione przede wszystkim z dzieł Herona z Aleksandrii.