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Fine Technology Dialogue Across the Eastern Mediterranean in Giovanni Fontana's *Bellicorum Instrumentorum Liber*

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Abstract The early fifteenth-century Venetian physician Giovanni di Michele, known as 'Fontana', likely earned his name due to a fountain he invented, described in the *Bellicorum instrumentorum liber, cum figuris et fictitijs literis conscriptus*, an illustrated treatise on fine technology written around 1418. This essay explores Fontana's connection with Arab culture, focusing on the relationship between his treatise and Islamic works on hydraulic fine technology, particularly automatic fountains, which were popular in both Islamic and Renaissance courts. The paper also highlights the influence of Fontana's work on Agostino Ramelli's sixteenth-century *Le diverse et artificiose machine*, a notable book on fine technology that includes descriptions of splendid automatic fountains.

Keywords Giovanni Fontana. Fine technology. Hydraulic devices. Automatic fountains. *Ḥiyal*.

1 Introduction

Discussing Arabic fine technology, Donald Hill refers to "those types of machines or instruments that were designed to give pleasure to courtly circles" and explains the advanced scientific and technological principles they incorporated.[1] Fine technology encompasses self-moving artifacts, known as *automata*, created for amusement, timekeeping, and for diverse needs of scientists.[2]

Ancient sources trace the origins of fine technology to the writings of the Roman architect Vitruvius, who credited the Greek engineer Ctesibius, active in Alexandria in the third century B.C., with inventing the organ and the monumental water clock. However, Gian Paolo Ceserani theorises that Archita di Taranto designed the earliest automatic devices, including a bird-shaped device capable of flight by moving its wings and using the energy generated by the mechanism concealed in its stomach.[3] Although the original Greek manuscript is lost, Vitruvius notes that Ctesibius' work included things "quae non sunt ad necessitatem, sed ad deliciarum voluptatem".[4] Later achievements in fine technology have been attributed to Philo of Byzantium and Hero of Alexandria, both of whom, along with Ctesibius, conducted their studies at the Alexandrian School.[5]

1 Hill 1994, 25.

2 Zidan 2021, 141.

3 Ceserani 1983, 5.

4 Vitruvius, *De Architectura,* X 7.5 (Marco Vitruvio Pollione 1990). For a discussion on ancient sources related to self-moving devices see de Miranda 2018.

5 Valavanis, Vachtsevanos, Antsaklis 2007, 265-7. In the Alexandrian School, the most important centre of Greek culture, theoretical studies promoted applied sciences.

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A significant number of Greek texts, including Hero's *Mechanica* and Philo's *Pneumatica*, were translated into Arabic, especially between the mid-eighth and mid-eleventh centuries, driven by the establishment of the Grand Library of Baghdad, *Bayt al-Ḥikma* (House of Wisdom).[6] Thus, Philo and Hero's experiments became reference points for Arab scientists. Notably, Arab scientists such as the Banū Mūsā brothers, al-Kindī, and al-Jazarī, who studied hydraulics, drew upon Greek works. Their interest in Greek authors is evident in manuscripts describing accurate and sophisticated *ḥiyal* (automata),[7] such as water-clocks, siphons, mechanical toys, and automatic fountains, showcasing the development of Hellenistic studies through innovative methods and detailed technical drawings. During the Islamic Golden Age, Muslim engineers manufactured advanced automata artifacts, mechanisms of which are still utilised in modern devices.

Donald Hill highlights that Islamic ideas were transmitted to Europe through interactions between craftsmen, travellers' reports, and inspections of earlier constructions.[8] Additionally, in the early fifteenth century, Giovanni Fontana significantly contributed to the transmission of Islamic ideas to the West. The *Bellicorum instrumentorum liber, cum figuris et fictitijs literis conscriptus*, encompasses a variety of ingenious devices designed for entertainment and pleasure, intended to amaze people with the elaborate mechanisms hidden within the devices. This work has played a fundamental role in promoting technical knowledge of these devices and their mechanical application through a re-evaluation of ancient texts. Fontana's connection with Arab culture is attributed to his frequent travels in Mesopotamia, during which he may have become familiar with studies on hydraulic devices conducted by medieval Arab scientists, incorporating many features of Islamic fine technology into his work.[9]

2 Islamic Influence in Fontana's *Mirabilia*

In the copy of Fontana's *Bellicorum instrumentorum liber*,[10] the Icon 242 – created between 1420 and 1440 and preserved in the Bayerische Staatsbibliothek of München – there is a reference to his name that may be linked to the fountain he invented. On folio 62*v*, we can read **[fig. 1]**:

> De fontibus forsitan non est inventus artifitialior durabiliorque. Est quoque proprie fantaxie, quia ego, Iohannes Fontana, semper in hiis studere placuit.

The *Bellicorum instrumentorum liber* was acquired by the Duke of Bavaria in the sixteenth century, having previously belonged to other South German collectors.[11] The book presents inventions, particularly related to hydraulics and pneumatics, with detailed technical descriptions and accurate drawings, including studies of public and automatic fountains.[12] The great interest that Fontana displays in hydraulic devices demonstrates his deep knowledge of Classical and Medieval sources, including Arabic texts.[13] He particularly references

6 Nadarajan 2007, 3. The early name of the library, *Khizanat al-Ḥikma* (The Treasury of Knowledge), derives from its function as a place for the preservation of rare books and poetry, a primary function of the *Bayt al-Ḥikma* until its destruction in 1258 during the Mongol siege of Baghdad.

7 The Arabic word *ḥiyal*, as applied to mechanics, can denote almost any machine from a small toy to a siege engine (Hassan, Hill 1986, 59).

8 Hill 1979, 22-3.

9 Battisti, Saccaro Battisti 1984.

10 Giovanni Fontana was born in Venice sometime during the 1390s, as evidenced by his licentiate and doctorate of arts at the University of Padua in 1418 (Clagett 1976, 6) and his medical degree in 1421, both of which are recorded in the university registry (Brotto, Zonta 1922, 144). He was also in Brescia in 1432 and appears to have visited Crete and Rome at some unspecified times (Birkenmajer 1932, 48). In the 1430s he was in Udine as a municipal physician. Here Fontana practised medicine for some time (Clagett 1976, 9). He authored treatises on a variety of subjects, including water-clocks, sand-clocks, measurement of depths under water, distances on the earth's surface, heights in the air, terrestrial distances, astronomical measurements, geometry and hydraulics. Fontana died in about 1454, as indicated by the date of the last document wherein the scientist was mentioned.

11 Hartig 1917, 122.

12 The book contains studies of fountains conducted by previous scientists as well as new inventions by Fontana. Fontana illustrates the *fons saracenicus* of the type Hero's fountain (f. 59*r*), the fountains invented by al-Kindī (ff. 28*v*, 46*r*, 46*v*, 47*r*, and 61*v*). New inventions include the *fons venetus* (ff. 22*v* and 23*r*), the *fons virginum* (f. 43*v*), a four-basins fountain (ff. 27*v* and 28*r*), a three-level fountain (f. 31*r*), and the fountain linked to his name (ff. 62*v* and 63*r*).

13 Among Greek authors, he refers to Aristotle, Plato, Archimedes, Philo of Byzantium and Hero of Alexandria. Among the Arabs he often refers to the Egyptian scientist ʿUmar Ibn Muḥammad al-Kindī (897-961), who should not be confused with the ninth-century Iraqi philosopher Abū Yūsuf Yaʿqūb al-Kindī (d. 867) (al-Jazarī 1974, 12; Hill 1979, 20).

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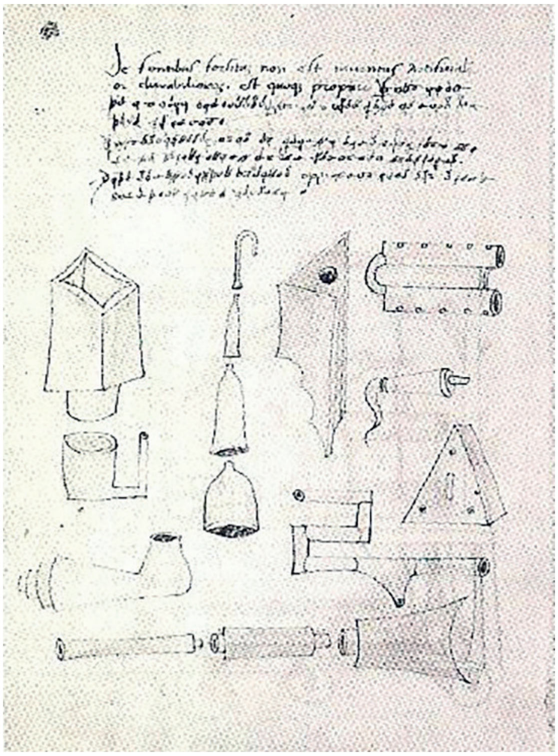

Figure 1 Technical components of the fountain invented by Fontana (f. 62*v*, Icon 242, München, Bayerische Staatsbibliothek)

Hero of Alexandria and Philo of Byzantium, known to him through Arabic copies.[14]

Although the recipient of the *Bellicorum instrumentorum liber* remains unknown, he was likely a curious and erudite man.[15] Fontana's treatise clarifies simple and efficient mechanisms through detailed drawings, demonstrating the application of the physical principles described in ancient texts. In particular, the book includes studies of splendid automatic fountains, showcasing Fontana's interest in combining functionality with aesthetics, and presents a variety of shapes and operational methods.

The fountain represented on folio 63*r* **[fig. 2]** exhibits characteristics typical of Islamic automatic fountains, like those described by al-Jazarī and the Banū Mūsā brothers. Like Islamic *ḥiyal*, the device features a light structure and a sophisticated mechanism. It consists of small tanks that, through a system of siphons, create a perpetual flow of water **[fig. 3]**. A curved cistern (1) is filled with water, which is then poured into a parallelepiped basin (2) through a small pipe (p1). From there, water is carried through a vertical pipe (p2) and is poured into the curved cistern. Then a siphon (p3) carries the water to a cylindrical tank (3). Water enters a funnel/pipe (p4) from an opening (4) and discharges into the curved cistern, or, if the opening is closed by a flap valve, water can be discharged through a central vertical pipe (p5) **[fig. 2]**.

This fountain's description and the manuscript's structure reveal connections with Islamic culture.[16] Automatic fountains represent types of *ḥiyal* that were objects of study for Islamic scientists during the Golden Age. Fontana's inventions are described through an illustrated inventory of ingenious devices intended for amusement. Addressing the descriptions to the book's recipient is characteristic of Arab origin,[17] possibly derived from the Greeks.[18]

Although Fontana's drawings are accompanied by descriptions written in Latin and cypher,[19] the technical details of all hydraulic components are meticulously and carefully represented to clarify the machine's functioning. Describing the fountain illustrated on folio 63*r*, Fontana specifies that:

> Partes omnes fontis, et figura eius completa ita clare depingantur, ut cum levitate intelligas.[20]

Thus, writing that "all the parts of the fountain and its complete form are to be depicted so clearly that you will understand it readily", Fontana recalls the Islamic approach that immediate comprehension of the function is essential**,** as shown in the *ḥiyal* invented by al-Jazarī and the Banū Mūsā brothers. This is achieved through a drawing that clearly represents the internal apparatus of the device in detail, making the instrument easy to construct. Additionally, the note that the device "is arranged as a Persian fountain" underscores its Islamic features.[21]

14 Cardini 2006, 10.

15 Fontana was sent by the Doge of Venice to Brescia to visit Count Carmagnola, captain general of the Milanese army (Thorndike 1931, 35). However, an initial hypothesis, that Count Carmagnola was the recipient of the book, is not supported by convincing evidence (Battisti, Saccaro Battisti 1984, 27). Additionally, the notebook was written in about 1418. Fontana was in Brescia in 1432 (see note 10).

16 According to Eugenio Battisti, the drawing may be a copy from an Arabic manuscript (Battisti, Saccaro Battisti 1984, 96).

17 Battisti, Saccaro Battisti 1984, 26.

18 For instance, Philo's *Pneumatica* are addressed to an interlocutor called *Ariston* (Prager 1974, 46-7).

19 According to Bertrand Gille, Fontana wrote in cypher to protect the secrets of his inventions (Gille 1964, 72). The decryption of the Icon 242 has been done by Eugenio Battisti and published in his work in 1984 (Battisti, Saccaro Battisti 1984).

20 The written description of the device is on folio 62*v*.

21 Battisti, Saccaro Battisti 1984, 96.

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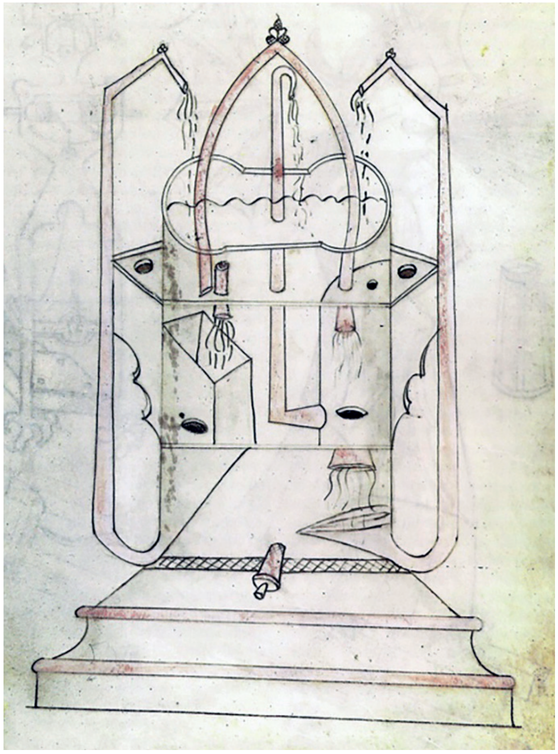

Figure 2 Fountain invented by Fontana (f. 63*r*, Icon 242, München, Bayerische Staatsbibliothek)

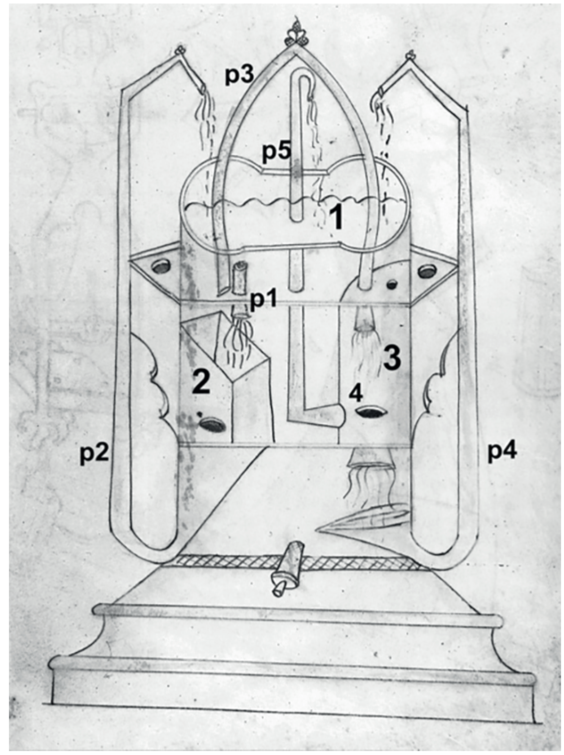

Figure 3 Fountain invented by Fontana with underlined the sequence of the function (reworked drawing by the author of folio 63*r*, Icon 242, München, Bayerische Staatsbibliothek)

Recalling Arabic treatises on fine technology, Fontana's drawings show a chromatic correspondence of the device components. In the *Bellicorum instrumentorum liber*, the moving components are red, while the fixed parts are achromatic.

As mentioned above, the connection with Arab culture is further supported by Fontana's frequent travels in the Mediterranean, which – as E. Battisti remarks – took him to desert areas,[22] perhaps referring to Mesopotamian areas, where the Abbasid Caliphate, which ruled over most of the Arab world between 758 and 1258 AD, had emphasised and encouraged the development of science and technology.[23] Fontana may have learned of Islamic scientists' studies on hydraulic devices possibly through meetings with Arab scientists and visits to their libraries.[24]

In his work, Fontana often refers to the Arabic versions of the *Pneumatica* by Philo of Byzantium and Hero of Alexandria, which form the basis of the physical principles of his hydraulic automata.[25] He also mentions the tenth-century inventor al-Kindī's treatise on hydraulic automata, *De automatis et thaumantiis*, which Fontana studied through the Latin version of the original Arabic work. In the *Bellicorum instrumentorum liber* Fontana represents some of al-Kindī's fountains, which may have inspired some of his own, in terms of style and mechanism. The Latin version of al-Kindī's work mentions Hero's texts on pneumatics by describing automatic fountains. Fontana emphasises that al-Kindī's fountains were inspired by the physical principles of Greek authors.[26] According to Donald Hill, al-Kindī may have also known Arabic translations of Philo's *Pneumatica*.[27] In par-

22 Battisti, Saccaro Battisti 1984, 17.

23 Certainly, Fontana had a deep geographical knowledge of near and far east, as underlined in his *De Omnibus rebus naturalibus* (Thorndike 1934, 159-60).

24 Battisti, Saccaro Battisti 1984, 17.

25 Prager 1971.

26 Prager 1971, 25.

27 Hill 1979, 20.

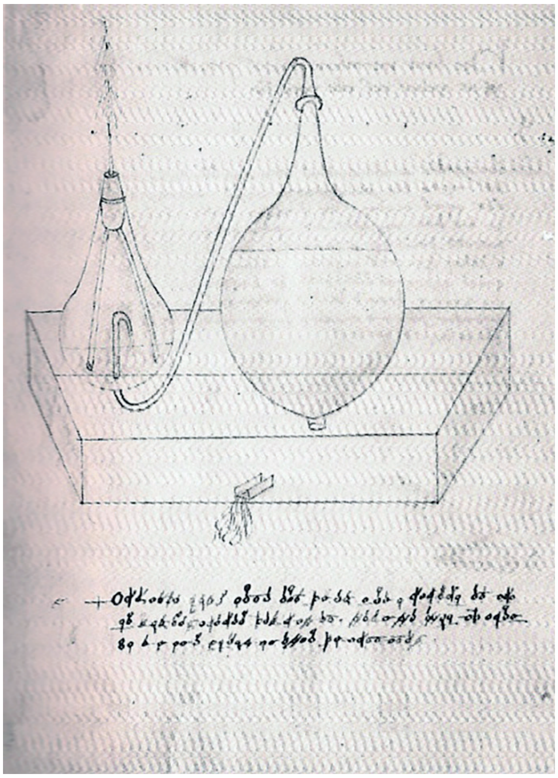

Figure 4 First al-Kindī's fountain redrawn by Giovanni Fontana (f. 28*v*, Icon 242, München, Bayerische Staatsbibliothek)

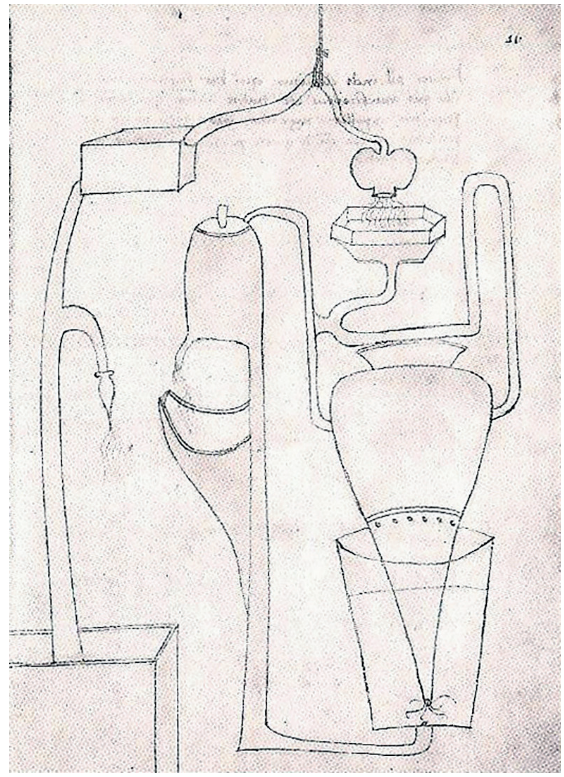

Figure 5 Second al-Kindī's fountain redrawn by Giovanni Fontana (f. 46*r*, Icon 242, München, Bayerische Staatsbibliothek)

ticular, the drawing on folio 28*v* shows the hydraulic apparatus applying the principle of the miniature fountain described by Hero **[fig. 4]**.[28]

The mechanism of the fountain on folio 63*r* is similar to the one represented in the drawing of al-Kindī's fountain depicted on folio 46*r* **[fig. 5]**, characterised by a set of curved pipes through which water – supplied from a source at the top – discharges into a cylindrical basin at the bottom. From the basin, water rises through a pipe and is poured into a funnel from which it is directed to the cylindrical basin to continue its perpetual motion.

The splendid *Kitāb al-Ḥiyal* (Book of Ingenious Devices) written by the Banū Mūsā brothers around 850, was likely a further reference for Fontana's studies on fine technology. The Banū Mūsā brothers lived in Mesopotamia and were important scholars at the *Bayt al-Ḥikma*, Baghdad's renowned institution of scientific learning during the Golden Age of Islam. Their manuscript, which contains several types of fountains driven from below by a number of vertical jets,[29] seems to have inspired Fontana, directly or indirectly,[30] particularly with regard to the accuracy of technical components used in fine technology.

The creation of eloquent drawings showing the internal mechanism of the *ḥiyal* is also notable in the thirteenth-century *Kitāb fī ma 'rifat al-ḥiyal al-handasiyya* (The Book of Knowledge of Ingenious Mechanical Devices) by Ibn al-Razzāz al-Jazarī, who may have influenced Fontana's studies. Al-Jazarī

28 de Miranda 2014, 137-8.

29 There are two manuscripts of the *Kitāb al-Ḥiyal*: one is ms ar. 317 in the Vatican Library, the other is in two parts, i.e. the Codex Gotha 1348 in the Universitäts-Bibliothek at Gotha and the ms von Ahlwardt 5562 at Berlin.

30 Some Banū Mūsā's features were filtered by al-Jazarī, who, talking about fountains, claims to have drawn some of his ideas from the Banū Mūsā, improving some parts and introducing technical innovations. Al-Jazarī's opinion is that the Banū Mūsā's devices could not work properly because of the short-time interval for the changing of the water-jet shapes (al-Jazarī 1974, 157). For instance, with regard to the Banū Mūsā fountain operating by wind or water, al-Jazarī underlines that the time during which water flows through each pipe, in order to be transferred from each tank to the fountain, is not long enough for a complete rotation of the tank. Thus, in his projects al-Jazarī creates the necessary water pressure to determine the height of the gushes, the time necessary to obtain them and the shapes of the jets (de Miranda 2022, 144-5).

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lived in the region of al-Jazīra, situated between the Tigris and the Euphrates, before entering the service of Prince Banū Artuq who governed the region of Diyār Bakr. During his travels in Mesopotamia, Fontana could have seen al-Jazarī's work, which – as Donald Hill has asserted – "is the most important of the Arabic treatises and probably the most important engineering document from any cultural area before the Renaissance".[31] Fontana applies some of al-Jazarī's technical innovations. For instance, in al-Jazarī's fountain with two floats [fig. 6], the use of one or two bowls to receive the quantity of water to drive the device allows for precise timing of the fountain's operation. Al-Jazarī also intends to balance the quantity of water driving the device with that flowing through the pipes and that filling the bowls in a precise timeframe.[32]

Al-Jazarī's *ḥiyal* are playful objects that underscore a magical and intriguing aspect of the devices. Likewise, Fontana took serious interest in both magical and mechanical contrivances.[33] This is evidenced in his automata, which are wonderful toys with intricate appearances that, as noted, reveal their mechanical interiors.[34]

Like al-Jazarī and al-Kindī, Fontana employs impressively detailed drawings accompanying the descriptive text and pays particular attention to the accuracy of the assemblage of the device components. Recalling al-Jazarī's style, Fontana creates partially three-dimensional drawings where the internal hydraulic mechanism is entirely shown, as it also determines the shape of the devices, demonstrating essentiality and efficacy, as can be seen in the fountain represented on folio 63 recto [fig. 2]. As Antony Grafton has asserted, Fontana's devices "are illustrated in real time, as they would look while in operation and in diagrammatic form, to make clear exactly how they functioned".[35]

Figure 6 Fountain with two floats by al-Jazarī (Arabe 2477, 72, Paris, Bibliothèque Nationale)

Compared to Arab drawings, which are accompanied by an extensive explanation of the function of each *ḥila*, the incisive written description of Fontana's automata is counterbalanced by two different visions of the instrument: a drawing of each component and a drawing of the entire instrument [figs 1-2].

3 From East to West

With the description of the fountain with seven pipes and three levels [fig. 7], Fontana seems to combine the ingenious mechanism of the device derived from al-Kindī's fountain described on folio 47*r* [fig. 8] with its utilitarian use, anticipating the studies of cup-fountains that developed in fifteenth-century Italy. Al-Kindī's device is driven from below, where the cylindrical basin is set. Through a

31 Hill 1994, 27. Al-Jazarī's book includes studies of 50 *ḥiyal* intended to provide wonder and aesthetic pleasure to courtly circles (Hassan, Hill 1986, 59). Of the copies of Jazarī's work, the earliest, i.e. the Ahmet 3472, is preserved in the Topkapı Sarayı Müzesi Kütüphanesi at Istanbul, which also keeps other versions of the manuscript. Among the best preserved copies, in the Bodleian Library at Oxford are the Greaves 27, Marsh 669 and Fraser Or 186. The first translation by D. Hill in 1974 is mainly based on the Greaves 27 (Saliba 1985, 149).

32 de Miranda 2022, 145.

33 The thaumaturgical aspect of his inventions, which recalls the magical and wonder provided by the Islamic *ḥiyal*, is supported by the medicine training activity of the author, as specified above.

34 Grafton 2007, 51-3.

35 Grafton 2007, 46.

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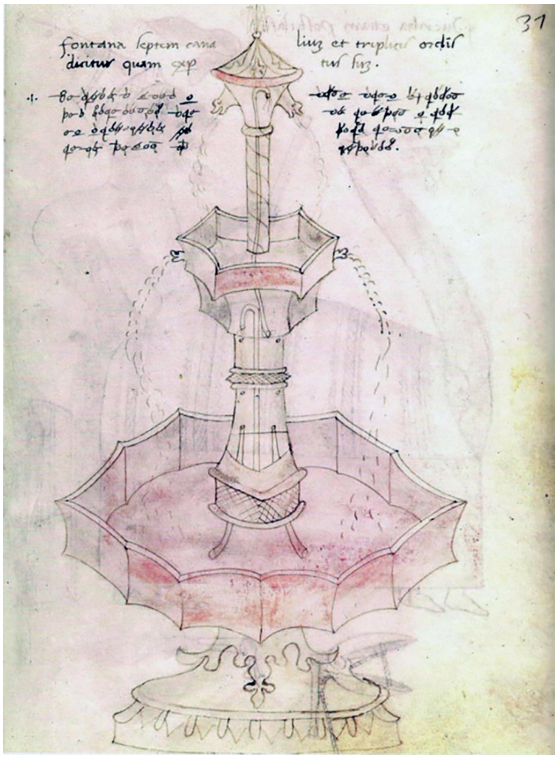

Figure 7 Fountain with seven pipes and three levels (f. 31*r*, Icon 242, München, Bayerische Staatsbibliothek)

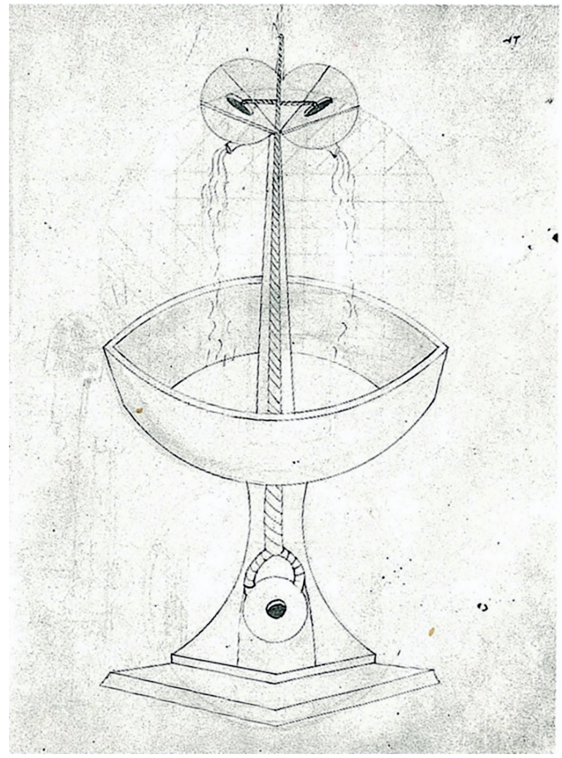

Figure 8 Third al-Kindī's fountain redrawn by Giovanni Fontana (f. 47*r*, Icon 242, München, Bayerische Staatsbibliothek)

vertical twisted pipe, water arrives at the top of the fountain and discharges a vertical jet and two gushes directed downwards. Water is collected in the funnel and directed to the cylindrical basin, continuing the perpetual fluid circulation system.

In the fountain with seven pipes and three levels, the upper pipe throws water upwards, the lower pipes throw it downwards, and the other four pipes lead the water to the levels due to air pressure.[36] The cup-fountain is a stone structure built on a stepped base. A central column acts as a siphon, to which one or more superimposed basins are connected. Water is gradually poured, through animal-shaped pipes, from one basin to another, from the highest to the lowest. This typology was mainly built in Renaissance Siena, where exceptional knowledge of hydraulic applications is evident in the studies by the Sienese artist-engineers related to fountains and their supply systems. Cup-fountains were developed as they employed a small quantity of water and required smaller areas. They also contributed to beautify the city due to their structures' ornamental details.[37] The cup-fountain's typology was a result of hydraulic studies conducted by the Sienese engineer-inventor Francesco di Giorgio Martini. The shape probably derives from Francesco di Giorgio's studies of 'candelabra-shaped' and 'baluster-shaped' columns, defining the types of candelabra-shaped and baluster-shaped fountains.[38] The mechanism is that of the automatic fountains designed by Francesco, called 'a termine'.[39] An example of cup-fountain following the model of a baluster-shaped fountain is the *fonte dei Pispini* in Siena, built in 1466 and reconstructed in 1534 [fig. 9].

36 The hydraulic mechanism follows the principle by Philo of Byzantium and Hero of Alexandria, that a fountain receives water, under pressure, at a central bottom point and discharges into three different levels.

37 In addition to the type of cup-fountain, the Renaissance also saw the development of the pool-fountain.

38 de Miranda 2020, 20-2, 66-8.

39 Studies of ancient columns and automatic fountains are in the *Trattato di architettura, ingegneria e arte militare* that Francesco wrote between 1475 and 1488. Among the numerous manuscripts, important copies include the Saluzziano 148 (Biblioteca Reale of Turin) and the Ashburnhamiano 361 (Biblioteca Medicea Laurenziana of Florence).

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Fontana's book may have played a role in transmitting Islamic technical innovations to the sixteenth century, influencing Agostino Ramelli's *Le diverse et artificiose machine*, a beautiful book on hydraulic devices that includes the description of four splendid automatic fountains.[40] The 'belle et artificiose fontane' represented in Ramelli's book derive their mechanism from Hero's fountain, using a sequence of internal siphons.[41] We cannot exclude the possibility that Ramelli may have seen Fontana's *Bellicorum instrumentorum liber* during his time in the Veneto region. Fontana employs siphons in his inventions, which – like in Ramelli's inventions – are clearly represented, as the drawings show the internal apparatus in detail. Thus, also in Ramelli's devices, "all the parts of the fountain and its complete form are to be depicted so clearly that you will understand it readily" as Fontana wrote.[42] The Islamic trait of representing the internal apparatus of a *ḥīla* in detail, making the instrument easy to build, is observable in the works of both Fontana and Ramelli, even though Ramelli's fountains are richly decorated **[figs 10-11]**, unlike Fontana's.[43] In addition, Ramelli's text for each illustration presents the engraving as a unit of two parts that complement each other. Ramelli tells the reader to look at the drawing to see the machine's components and form, how it functions with another one, and what it does when it is set in motion, as noted in Fontana's descriptions, and – in turn – in Arabic studies. Furthermore, his descriptions are devoid of personal comment, as they were written for craftsmen who knew how to build the machines,[44] like in Fontana and Arab scientists, particularly al-Jazarī. On the other hand, unlike al-Jazarī, Ramelli does not mention measurements and materials.[45]

Figure 9 Fonte dei Pispini, Siena

4 Conclusion

This study has attempted to demonstrate Giovanni Fontana's fundamental role in transferring technical knowledge of fine technology from the Islamic world to the West. The *Bellicorum instrumentorum liber* contains several connections with Islamic manuscripts that discuss self-moving artifacts designed to entertain courtly circles.

The attention Fontana pays to technical and detailed drawings contributes to demonstrate the passage of his erudition from Arabic-Islamic treatises to Western scholars. Particularly, the studies on automatic fountains illustrate the transmission of fine technological knowledge from the Islamic Golden Age to Renaissance studies.

40 Agostino Ramelli printed the book in Paris ("a Parigi in casa del autore con privilegio del Re, 1588"). Dedicating his book to King Henri III, Ramelli said he had been called away from Italy to France "con honorato stipendio" (Ramelli 1991, 23). Working with draughting instruments, Ramelli brought his illustrations to verisimilitude as drawings on paper; consequently, French engravers rendered them in facsimile.

41 The siphons represented in Ramelli's fountains are very similar to those illustrated by Francesco di Giorgio Martini. Ramelli was likely familiar with manuscript-copies of machines in Francesco di Giorgio's *Trattato di architettura* from private libraries in Vicenza, Venezia and Verona (Ramelli 1991).

42 See note 20.

43 Ornaments associated with fountains in Ramelli's engravings are distinctly Italian, including winged putti, acanthus leaves and heads of Pan with his mouth as a water-spout (Ramelli 1991, 27).

44 Ramelli 1991, 28.

45 For instance, in the alternating fountain with two floats, al-Jazarī specifies that the bowl-shaped fountains are made of terracotta.

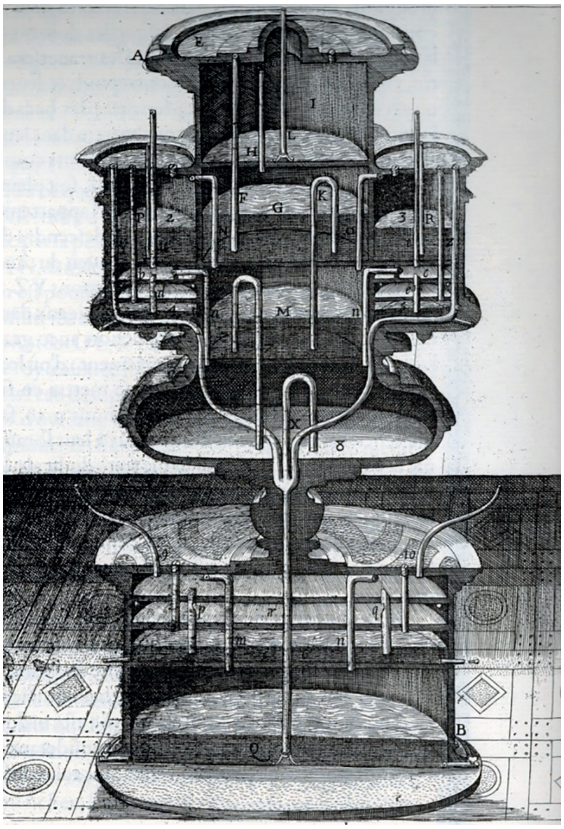

Figure 10 Fountain by Agostino Ramelli (figure 126, *Le diverse et artificiose machine*) showing the internal apparatus

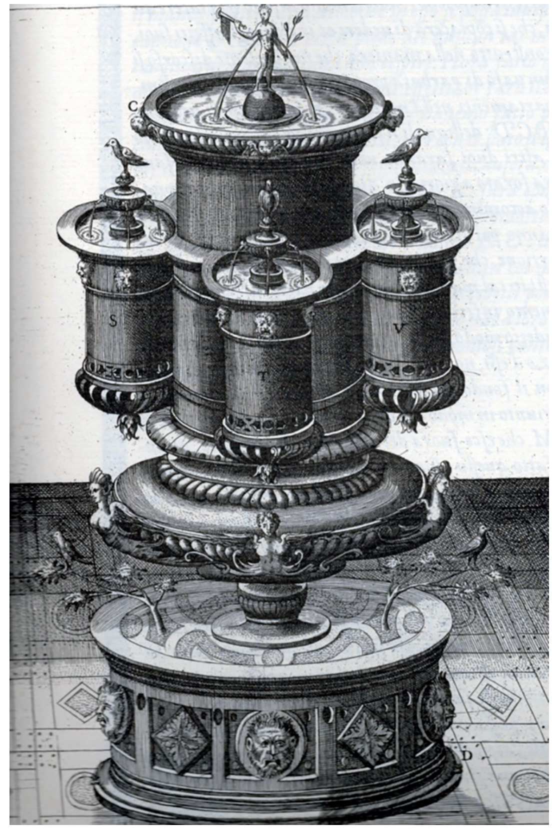

Figure 11 Fountain by Agostino Ramelli (figure 126, *Le diverse et artificiose machine*) showing the external apparatus

Connections with the inventions of Arab scientists, such as al-Jazarī and al-Kindī, are notably evident, particularly in the fountain linked to his name.[46] Many technical features reminiscent of Arabic studies were subsequently transferred to late-Renaissance inventors like the Italian Agostino Ramelli. Ramelli's engravings were studied by early historians of science and technology in the seventeenth and eighteenth centuries, inspiring new interpretations and adaptations of his mechanical components for innovative designs.[47]

Through other inventions, like the fountain with seven pipes and three levels, Fontana combines the ingenious mechanism derived from al-Kindī's studies with utilitarian purposes. This invention anticipates the studies of fifteenth-century cup-fountains by the Sienese engineer-inventor Francesco di Giorgio Martini, who may have defined the main typologies of Renaissance fountains, such as the candelabra-shaped fountain and the baluster-shaped fountain.

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46 It is the device at folio 63*r* discussed above.

47 Ramelli 1991, 30.

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