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Unpublished Bronze Valves and A spout of Tap in the Greco-Roman Museum of Alexandria

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Abstract

Roman engineers designed aqueducts in all cities of the Roman Empire for over 500 years, and construction was funded using public and private money. The aqueducts were created from a series of pipes, tunnels, channels, and bridges. Therefore, the Romans invented lead pipes, tanks, valves, and taps. Despite the abundance of water, Roman water commissioners implemented controls to limit illegal taps and the flow of water to users and imposed penalties on those who violated the regulations. In many Roman archaeological excavations, bronze valves, taps, and lead pipes have been found and now in different Museums. They were used in Rome and Pompeii and even extended to eastern cities during the Roman period. Also the Greco-Roman museum has three bronze valves and a spout of tap. This paper aims to publish these valves and tap. Also, it answers many questions about how these valves and taps were formed and their types which were rarely found in Roman Egypt, with a comparison between them and similar examples from the Roman cities. In addition, it studies the water system in Alexandria and compares it with that of Rome and Pompeii.

Keywords

Taps; Valves; Pipes; Tanks; Aqueducts; A bronze hollow cylinder; A spout; An insert.

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نشر صمامات (محابس مياه) وفوهة حنفية من البرونز محفوظين في المتحف اليوناني والروماني بالإسكندرية

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الملخص

صمم المهندسون الرومان قنوات المياه في كافة أنحاء الإمبراطورية الرومانية، وقد استغرق بناء هذه القنوات حوالي ٥٠٠ عام من ٣١٢ ق.م إلى ٢٢٦ ميلاديا، ودفع تكاليف هذه القنوات من المال العام والخاص. واعتمدت على سلسلة من الأنابيب والأنفاق والقنوات والجسور. لذا اخترع الرومان أنابيب الرصاص والخزانات والصمامات والحنفيات. وعلى الرغم من وفرة المياه، فقد طبق مسؤولو المياه الرومان ضوابط للحد من الصنابير غير القانونية والتحكم في تدفق المياه للمستخدمين، وفرضوا عقوبات على من ينتهك ذلك. هذا وقد تم أكتشاف صمامات وحنفيات من البرونز بالإضافة إلى أنابيب من الرصاص من خلال أعمال الحفائر الأثرية في أنحاء الإمبراطورية الرومانية المختلفة مما يدل على استخدامها في روما وبومبي، وامتداد استخدامها إلى المدن الشرقية خلال العصر الروماني. فبجانب احتواء المتاحف العالمية على بعض من هذه الأكتشافات فقد احتوى المتحف اليوناني الروماني على ثلاثة صمامات برونزية وفوهة حنفية. لذا يهدف هذا المقال إلى نشر هذه الصمامات وفوهة الحنفية، ويجيب على العديد من التساؤلات حول مكونات هذه الصمامات والحنفيات وما هي أنواعها والتي كان من النادر وجودها في مصر الرومانية، مع مقارنة بينها وبين نماذج مشابهة من المدن الرومانية، بالإضافة إلى دراسة نظام المياه في الإسكندرية ومقارنته بروما وبومبيي.

الكلمات الدالة

حنفيات؛ صمامات؛ محابس؛ أنابيب؛ خزانات؛ قنوات المياه؛ أسطوانة مجوفة برونزية؛ فوهة؛ سدادة

Introduction

The Roman aqueducts made water flow into the cities; the water was used for drinking and irrigation and supplied hundreds of public fountains and baths for a fee and private homes[1], especially for the elite. Pliny the Elder praised Rome's aqueducts as an unparalleled wonder[2]. For instance, the Romans built reservoirs, cisterns, and water towers to supply Roman cities[3]. Also, there were various techniques for lifting and controlling the flow of water, which fed public buildings, baths, and homes[4]. Many water-lifting machines were used in Egypt to lift water from the tanks or cisterns; the oldest common machine is the shaduf (well pole), which was probably invented in Mesopotamia in the third millennium[5]. The shaduf consisted of a bucket and a rope attached to one end of a wooden arm with a counterweight at the other end of the arm. Another machine was the sakieh (animal-drawn waterwheel). It was introduced to Egypt in the third century BC. It could lift a substantial quantity of water almost continuously to elevations over 3.5m[6]. Moreover, the Romans used pipes and valves to control the flow and distribution of water. This system was also common across the Roman Empire[7].

Description Study

[Fig. 1A, B, C, D, E]

Graeco-Roman Museum, inv. P.14741

Dimensions: H. 10cm

Material: cast bronze

Provenance: probably Alexandria

Description: The valve consisted of a hollow bronze cylinder (chamber plug) without two pipes and an insert inside (closed tap) side view. The outer cylinder was not soldered by a cap yet to show the insert. The site of the soldered cap was marked by a rough ring at the bottom of the chamber plug. The insert had a big handle with a squire opening on the top. It also fitted firmly inside the chamber plug. The lower part of the insert contained two perforations. When these two perforations faced the two corresponding openings of the two pipes, the tap

[1] Vitruvius, *On Architecture*, book. II, Tran. by Granger, F., (LCL), London, 1985, VIII, VI, 1.

See also: Nicola, C.D., The Roman Aqueducts, p. 5.

https://circularwaterstories.org/wp-content/uploads/2020/10/The-Roman-Aqueducts_Camilla-Di-Nicola-1.pdf, Accessed at: 25/10/2024.

[2] Pliny, *The Natural History of Pliny*, vol. VI, Trans. by Bostock, J., and Riley, H.T., (LCL), London, 1857, 24, 353.

See also: Deming, D., The Aqueducts and Water Supply of Ancient Rome, *Historical Note*, vol. 58, no. 1–Groundwater, 2020, p. 152.

[3] Hodge, A.T., *Roman Aqueducts & Water Supply*, London, 2002, p.58; Spanoudi, S., Colfinopoulos, A., and Kalavrouziotis, A., Water management in ancient Alexandria, Egypt. Comparison with Constantinople Hydraulic System, *Water Supply*, 2021, p. 2430f.

[4] Hairy, I., *Du Nil à Alexandrie - Histoire d'eaux. Editions Harpocrates, Alexandria*, Egypt, 2009, p. 120.

[5] Hairy, *Du Nil à Alexandrie - Histoire d'eaux*, p.120.

[6] For more details see: Butzer, K. W, *Early Hydraulic Civilization in Egypt: A Study in Cultural Ecology*, the University of Chicago Press, Chicago, USA, 1976, p. 46; Hairy, *Du Nil à Alexandrie - Histoire d'eaux*, p.120; El-Ghannam, W.A., Water-lifting Technology in Graeco-Roman Egypt Devices " Rotary Motion " , *Proceeding of the 1st International Conference on Ancient Egyptian Science*, Cairo, 2010, p.247f.

[7] Lorenz, W.F., Ancient Roman Valves. *Valve Magazine*, 2013, p. 1 https://www.valvemagazine.com/articles/ancient-roman-valves, Accessed at: 12/01/2025.

was open, and the water could flow. The two perforations did not face the corresponding openings in this example, so the tap was closed. A bar of wood or iron could be used in this square opening of the insert handle to facilitate its opening. Some scratches appeared on the valve's body.

[Fig.2 A, B, C, D]

Graeco-Roman Museum, inv. P.15156

Dimensions: H. 7.7cm

Material: cast bronze

Provenance: probably Alexandria

Description: A valve with a hollow cylinder (chamber plug) with an insert inside, the insert without a handle. There were two holes at the top at which the hand was soldered. The valve was also closed, as in the previous example. There was no soldered cap at the bottom.

[Fig.3 A, B,C]

Graeco-Roman Museum, inv. P. 14914

Dimensions: 7cm

Material: cast bronze

Provenance: probably Alexandria

Description: A hollow bronze cylinder without an insert. This cylinder had two circular holes at the lower end, corresponding to the similar circular openings of the insert. The outer surface appeared to be rough, with many scratches. The lower end had a groove that circled the cylinder.

[Fig. 4 A, B, C, D]

Graeco-Roman Museum, inv. P. 14898

Dimensions: H. 8.5cm

Material: cast bronze

Provenance: probably Alexandria

Description: A spout of a tap had two parts; the rear part was connected to the pipe, it was separated from the frontal part with a rounded elevated ring, and its diameter was less than the frontal part to be fixed on the pipe. The frontal part took the shape of a bull. It had two incised circular eyes with an upper and a lower oblique incision; the nose was merged with the mouth, with a small circular hole through which the water could flow faster. The head of the bull had two horns directed upward, fused together, and decorated with simple incisions.

Analytical Study

Structure of taps and valves

Neither Vitruvius nor Frontinus[1] mentioned anything about taps[2], although Vitruvius discussed the pipes and water system[3]. Taps and valves were less used in Roman water supply engineering than today, as water flowed continuously in the Roman system and never stopped. This led to the neglect of the role of taps[4].

Hodge used the expression tap to both tap and valve[5], reporting that the tap was the so-called discharge tap, which was normally fixed and kept closed. It was only turned on when someone wanted to get water; therefore, it was a device to avoid waste and reduce consumption. Valves served a wider variety of uses, and their operation varied accordingly. They might be purely emergency devices to isolate part of the system for repair or when a customer had not paid their bill. They would be left permanently open and rarely touched. They could be opened and closed in different combinations to direct the water flow in other directions as needed; they could be opened and closed at different times and used to ration water to different establishments, as there is not enough to serve everyone all the time. Taps performed two different functions depending on their location in the water system. First, the tap was located above the sink or bath. It had an insert or handle and a spout from which water flows when the tap is opened. Second, the tap was in the middle of the pipe, or the pipe branches off; when it closed, the water supply cut off, isolating part of the plumbing circuit[6]. In this case, it was called the valve.

So, the Roman valves and taps were similar in shape only, not in function. They formed a hollow bronze cylinder with two pipes connected with it by molten lead at a right angle in the half. Inside the hollow bronze cylinder (chamber plug), an insert or plug was placed on the top. Meanwhile, the lower part of the bronze cylinder was closed with a soldered cap[7]. In the lower part of the insert, just above the cap, a circular groove was used to secure the insert inside the cylinder by a pin or dent hammered by a special tool from outside, even though it couldn't be clear in our examples because the insert located inside the bronze cylinder[8].

This insert or plug had a big handle with a square opening in the top and two oval holes[9] corresponding with the other two openings of pipes to close and open the tap and valve with a quarter turn. It should be tightly locked into a hollow bronze cylinder, making it difficult to open with the fingers. So, an iron or wooden bar was used in its square hole to facilitate the

[1] Frontinus, *Stratagems. Aqueducts of Rome*, I, II, Trans. by Bennett, Ch., (LCL), London, 1925; Vitruvius, VIII, VI, p. 244ff.
[2] Dembskey, F., E.J., *The Aqueducts of Ancient Rome*, Master of Arts, University of South Africa, Pretoria, 2009, p.85.
[3] Vitruvius, VIII, VI, p. 244ff.
[4] Hodge, *Roman Aqueducts*, p. 322.
[5] Hodge, *Roman Aqueducts*, p. 323.
[6] Hodge, *Roman Aqueducts*, p. 322f.
[7] Kretzschmer, F., Römische Wasserhähne , *Jahrbuch der Schweizerischen Gesellschaft für Urgeschichte*, vol. 48,1960-1961, p. 50; Hodge, *Roman Aqueducts*, p. 324f; Schut, P.A.C., et.al., 2008, Neutron resonance capture and neutron diffraction analysis of Roman bronze water taps , *Journal of Radioanalytical and Nuclear Chemistry*, vol. 278, no.1, p. 151; Lorenz, Ancient Roman Valves, p. 1.
[8] Kessener, H.P.M., Roman Taps and two Paradigms, *BABesch Suppl*. vol.4, 2017, p. 371.
[9] Fassitelli, E. *Pipe and Valves of Ancient Rome*, Petrolieri d'Italia, Milan Italy, 1972, p. 2; https://www.scribd.com/document/461561268/Ancient-Roman-Valves. Accessed at: 3/11/2024.

opening of the tap or valve by the time the insert could not be moved[1](Fig.5A,B,C,D). For example, in Pompeii, a tap had a bent large iron nail in the handle of the insert[2] (Fig. 5E). The diameter of the two pipes was tapered into the hollow bronze cylinder, which increased the water flow. These pipes were connected with lead water conduits, soldered called fistulae. Some pipes of Roman taps had the shape of an animal's head with an open mouth from which water flowed.

Material of Taps and valves

The valves and taps were made of cast bronze[3]whose formula was standardized: Copper 73.70%, lead 18.53%, and tin 7.72%. They provided resistance to corrosion and friction and the ductility required for easy manufacture[4]. For example, Roman valves from Pompeii (Fig.6A)[5]had valves connected with pipes to control the water flow inside the Roman house. Another example (Fig.6B) depicted two valves attached to a lead distributing box connected with the conduit on its upper left part[6]. In addition, a bronze valve from Pompeii (Fig.7) was connected with two lead pipes[7]. A bronze valve is in the Museum of the Ancient Roman Civilization, Rome, Italy[8] (Fig.8). Another one, which is a bronze valve without an insert from Antioch on the Orontes and Zeugma in southeastern Turkey (Fig.9), is preserved in the Aqaba Archaeological Museum[9]. Another example from Humayma in the south of Jordon (Fig.10) is a bronze valve without the insert[10].

Shapes of the Taps

The taps in all Roman cities were similar in components but varied in size and design[11]. The Roman taps from Egypt or another country took one of three shapes.

The first shape was common, like a valve with two pipes, one connected with a water conduit and the other through which water flew. For example, some bronze taps (Fig. 11) from Pompeii[12]. Each tap had an insert, pipeline traces on one side, and a spout on the other. A bronze tap (Fig. 12) (H: 14.6 cm; W: 24.3 cm; D: 7.7 cm) from Italy is preserved in the Louvre Museum, Inv. Br3492. It dates to the Roman Period[13]. This tap had a hollow bronze cylinder connected to two pipes and an insert with a square handle. A third example is a bronze Roman tap (Fig.13) (H. 15.24cm) is preserved in London, British Museum, inv.

1 Kessener, Roman Taps, p. 371f.
2 Kessener, Roman Taps, p. 377, fig. 15.
3 Kretzschmer, Römische Wasserhähne, p. 50; Hodge, *Roman Aqueducts*, p. 32.
4 Fassitelli, *Pipe and Valves*, p. 17.
5 Kretzschmer, Römische Wasserhähne, p. 60, Abb.8.
6 Kessener, Roman Taps, p. 376, fig. 10
7 https://gigazine.net/gsc_news/en/20200226-ancient-roman-valves/ Accessed at: 12/11/2024.
8 https://ancientwatertechnologies.com/2013/01/13/hydraulic-devices/ accessed at: 12/11/2024.
9 Oleson, J.P., Reeves, M.B, and Foote, R.M., the Nabataean, Roman, Byzantine, and Early Islamic Site of Humayma: A Look Back on three Decades of Research, *Acor News Letter*, vol. 27. no.1, 2015, p. 4.
10 Schram, W.D., Sluice Gates in Roman Aqueducts I, https://static.parks.org.il/wp-content/uploads/2018/01/17-Binder1.pdf, Accessed at: 15/11/2024.
11 Jansen, G.C.M, *Water in de Romeinse stad : Pompeji, Herculaneum, Ostia*, Leuven , 2002, p. 50.
12 Jansen, *Water in de Romeinse stad*, p. 50, II, 64.See also: Menzel, H., *Römische Bronzen*, Hannover, 1964, p. 50, Nr. 98.

13 https://collections.louvre.fr/ark:/53355/cl010291242, Accessed at: 12/10/2024.

1856,1226.864. It dates to the 1st century AD[1]. The tap had an insert and traces of a lead water supply pipe attached and the spout. Also, a bronze tap (Fig.14) from Pompeii, which dates to the 1st century AD. It resembles the later example, but the insert handle had a ring[2]. The insert's handle of the tap could take the shape of a bird, such as a bronze tap from Vindonissa, in Switzerland, which may date to the first century AD[3] (Fig.15). Similarly, four bronze taps were found in the Rhine provinces of the Netherlands due to the common use of taps in bath facilities of villas there[4].

The second shape showed a special shape of tap spouts. Haberey reported that these shapes varied between dolphins, human and animal heads[5], as shown in the example from the Graeco-Roman Museum (Fig. 4A, B, C, and D) and gargoyle[6]. Some examples show the tap with animal spout, such as a bronze tap (Fig. 16A) (H. 8.5 cm, L. 13.1 cm), preserved in the Museum of Fine Arts and Archaeology, Boston, inv. 885.1.1. The tap missed an insert; it had two pipes. The first was connected with the water conduit, while the other pipe ended with a spout in the shape of a dog or wolf head with pricked ears and an open mouth, serving as a spillway[7]. (Fig.16B,C) depict drawing taps with spouts in the shape of a dog[8]. Another example shows a bronze tap (Fig.17) (H. 11.6 cm; W. 3.9 cm; D. 3.15 cm) preserved in the Louvre Museum, inv. Br 3491, which dates back to the 1st century AD. The tap consisted of a hollow cylinder without an insert, connected with two pipes; the first was connected to the main water source, while the other ended with a spout in the shape of a cow head with horns, hollow eyes, and an open mouth[9]. Some taps had animal shapes around the insert, like a bronze tap (Fig.18A,B) (H. 21.80cm), preserved in the British Museum, London, inv. 1865,1214.67[10]. It shows a tap with a long, narrow pipe on one side, a wide pipe on the other, and a hollow cylinder without the insert, attached to which dolphins, their tails touching the narrow end of the pipe.

The Third Shape

A whole tape took the shape of animals like a bronze Roman tap in the shape of a boar's head (Fig.19) (H. 6.5 cm, L.8 cm), preserved in Antikensammlung, Staatliche Museum in Berlin, inv. 30211[11]. The tap took the shape of a boar's head without an insert. It consisted of a hollow cylinder (chamber plug), representing the upper part of the head and neck; the rear part was connected to the water conduit, while the mouth of the boar represented the spillway of the water. Another example of a bronze tap (Fig. 20A,B) dark green patina, L.5cm, from Nemi or Pompeii, is preserved in a private collection in London, inv. 119, dating back to the

[1] https://www.britishmuseum.org/collection/object/G_1873-0820-187, Accessed at: 6/1/2025.
[2] https://ancientwatertechnologies.com/wp-content/uploads/2013/01/day-1-roman-museum-166.jpg , Accessed at: 12/10/2024.
[3] Kretzschmer, Römische Wasserhähne, taf. 6a,2.
[4] Schut, Neutron resonance capture, p. 152, fig. 1a,b,c,d.
[5] Haberey, W., *Die römischen Wasserleitungen nach Köln die Technik d. Wasserversorgung e. antiken Stadt*, Bonn Rheinland-Verlag Bonn Habelt, German, 1972, p. 117.
[6] Haberey, *Die römischen Wasserleitungen*, p. 117; Kessener, Roman Taps, p. 371.
[7] https://memoirevive.besancon.fr/ark:/48565/0314kf9rsljp, Accessed at: 24/10/2024.
[8] Kretzschmer, Römische Wasserhähne, p.55, Abb.4; Jansen, *Water in de Romeinse stad*, p. 50, II, 70.
[9] https://collections.louvre.fr/en/ark:/53355/cl010291241#. Accessed at:10/11/2024.
[10] Walters, H.B, *Catalogue of the bronzes, Greek, Roman, and Etruscan, in the Department of Greek and Roman Antiquities*, British Museum, London, 1899, p. 332, no. 2575.
[11] https://www.deutsche-digitale-bibliothek.de/item/XUOQJZX3GYBX24W2VOFN4I4XT7TGTT7K, Accessed at: 24/10/2024.

1st- 2nd centuries AD[1], in the form of a lion's head, well decorated with a chisel. At the top is a slight recess for opening and closing the valve cover; the insert was missed. A bronze tap (Fig.21) took the shape of a wolf's head from a public fountain or nymphaeum preserved in the British Museum in London. It had a hollow cylinder without an insert and two pipe openings[2]. As for the animal shapes that were decorated with the tap, they were widespread motifs at that time. The large taps in the shape of animals could be connected to public fountains or nymphaeum.

Taps were found in North Africa; some were bronze and had lead pipes like the taps of Pompeii. Several were found in Volubilis[3], and others were from Cirta, Rusicade in Algeria. Two Roman marble taps (Fig.22) from la Cherguia near Cartage and Medjez el-Bab in Tunisia were more unusual. The marble taps were the same as the bronze taps and they were cheaper than bronze[4]. Also, parts of four bronze taps were found in the Netherlands date to the second century AD[5].

Water System in Alexandria

Our valves and tap probably came from Alexandria. Despite its location on the Egyptian coast, where it was flooded with the Mediterranean Sea and Lake Mariout waters[6], Alexandria had always suffered from a shortage of limited, scarce and insufficient natural water resources[7]. Therefore, using facilities and infrastructure to exploit groundwater and manage wastewater was studied and designed[8]. Water systems were implemented from the early days of the city's foundation as water supply from the Nile through the opening of the Shedia canal[9] as identified in Chereoun or Kom el-Guiza, near Kafr-ed-Dawar, carried water from the Canopic branch to the city gates[10] and distributed through a system of branching pipes. Water storage was experienced in many underground tanks or cisterns[11] through channels[12]. The entire city was built mainly on the level of the sewage and water supply infrastructure, which ran underground from south to north and ended at the sea[13]. So, the water sources in Alexandria were based on collecting rainwater; the water came from the Nile through the Shedia channel, in addition to exploiting underground water, then storing this

[1] https://bertolamifineart.bidinside.com/en/lot/44249/roman-bronze-tap-in-form-of-a-lion-head-1st-/. Accessed at: 2/11/2024.
[2] https://www.pinterest.com/pin/343469909062081902/ Accessed at: 20/3/2025.
[3] It is located near Fès in the Jebel Zerhoun in northern Morocco. See: Fentress, E., Limane, H, and Palumbo, G., The Volubilis project, Morocco: excavation, conservation and management planning, *Archaeology International*, vol. 5, no.1, 2012, pp.36-39.
[4] Wilson, A., Urban Water Storage, Distribution and Usage in Roman North Africa, Boston, 2001, p. 93.
[5] Schut, P.A.C., et.al., Neutron resonance capture, p.151ff.
[6] Hairy, *Du Nil à Alexandrie - Histoire d'eaux*, p.74.
[7] Butzer, *Early Hydraulic Civilization in Egypt*, p.96; Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management in ancient Alexandria, p. 3428.
[8] Hairy, *Du Nil à Alexandrie - Histoire d'eaux*, p.74; Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management in ancient Alexandria, p. 3428.
[9] Empereur, J.-Y., *Alexandria rediscovered*, New York, 1998, p. 130ff; Bergmann, M., and Heinzelmann, M., Schedia Alexandria's customs station and river port on the Canopic Nile, in *La batellerie égyptienne Archéologie, histoire, ethnographie*, edt.by. P., Pomey, Centre d'Études Alexandrines, vol. 34, 2015, p. 87.
[10] Hairy, I., Alexandrie médiévale. La question de l'eau, Alexandrie medieval, 3, edt.by. J.-Y. Empereur , *ÉtAlex*, vol. 16, 2008, p. 263.
[11] Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management in ancient Alexandria, p. 3428.
[12] Ahmed, et.al., Egyptian and Greek Water Cultures and Hydro-Technologies in Ancient Times, *Sustainability*, vol. 12, 2020, p. 15.
[13] Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management in ancient Alexandria, p. 3428.

water in reservoirs. The storage of water motivated the construction of buildings in the form of large, closed, watertight, compact tanks or cisterns that maintained the freshness of the water. Vitruvius argued that three methods were used for conducting water in channels: Masonry conduits, lead pipes, and terracotta pipes to the main reservoirs in the city.

Tanks or Cisterns[1] of Alexandria

According to Vitruvius, when the water reached the Roman city walls, a reservoir (castellum aquae) was built, and next to the reservoir, three-part reservoir compartments were connected to the reservoir to receive the water. Inside the reservoir were three systems of pipes. One for each was connected to tanks so that when the water flew from the tanks at the edges, it could flow into the central tank. The piping system for all public pools and running fountains should be placed in the central tank; the pipes for the baths should be placed in one of the outer tanks to provide tax revenues each year for the people of Rome; in the third tank, the piping system should be directed to private houses, so that there would never be a shortage of public water since the citizens would not be inclined to divert the public supply if they had their supply from the same source[2]. The tanks in Alexandria date back to the Ptolemaic era. They were fed artificially or by collecting rainwater. They were in places where access to water was difficult or in special facilities, such as thermal baths, tombs, or even in areas where craft activities were carried out[3]. The shape of tanks varied according to the period of their formation. During the Ptolemaic period, the tanks were small, put in the rock, and resembled bottles.

The techniques were modified in Roman times. The tanks were formed of bricks and plaster. Moreover, they were covered with ceramic mortar to be watertight. The tanks were small and tree-like; then, they gradually increased to be called welded volumes. Finally, they had covers and were powered by an aqueduct[4]. The dimensions of the tanks extremely varied and depended directly on their destination, from a few cubic meters for a private home to a medium and large capacity of several thousand liters for a public building, such as the baths of Kom el-Dikka. The large tanks were intended for public use. Mediums might be suitable for feeding a neighborhood or a group of dwellings[5]. The public tanks consisted of one, two, three or even four levels. Additionally, the pumping holes were in the ceiling. They were maintained through a drain well, which provided access to the bottom of the tank, which could be up to 13 meters deep. This semicircular well was usually placed around the perimeter of the building and often in one of the corners. The descent was made with stairs located on the walls of the well, which allowed the tank to be cleaned before the annual filling to ensure water quality[6].

The tank had a rectangular shape with dimensions of 2.5m, 2.5m, and 3.5m. The tanks were supported eternally by four columns connected by arches (Fig.22B). Additionally, the

[1] The cistern is a constructed and watertight tank, most often not always underground. For more details see: Leveau, Ph., L'eau dans la maison à l'époque romaine, *DAV6*-1.19, 2024, p.156.
[2] Viruvius, VIII, VI, 1.
See also: Dembskey, *The Aqueducts of Ancient Rome*, p.81
[3] Hairy, *Du Nil à Alexandrie - Histoire d'eaux*, p.113; Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management in ancient Alexandria, p. 2429.
[4] Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management in ancient Alexandria, p. 2430.
[5] Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management in ancient Alexandria, p. 2430.
[6] Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management in ancient Alexandria, p. 3430.

pumping hole was in the upper part of the tank. Alexandria had many tanks of 1 to 4 levels, from 6m to 2.500 m^3 [1] (Fig. 22C). Large tanks were attached to many sites, such as the Serapeum. They also supplied many areas next to the Serapeum in Alexandria and served for the thermal baths in Kom el-Dikka[2], which was provided with an upper canal during the fourth century AD[3].

Small tanks collected rainwater to provide some houses with water[4]. Their pipes were made of terracotta (tubuli)[5] or lead (fistula). Sometimes, bronze was used, but the less expensive lead was used more often[6]. Vitruvius favored using lead pipes for several reasons, including the risk of poisoning from the formation of white lead oxide in lead pipes. Unhealthy symptoms appeared among workers during the melting and casting of lead. Selecting workers who manufacture lead pipes was necessary, as they must have special skills[7]. Pipes were connected to valves to control the flow and distribution of water[8] to public and private places (Fig. 22D), just like Roman cities, e.g., Rome and Pompeii, which had water towers and tanks[9].

In Pompeii, each water tower was connected to three lines: The first to the main water source (supplying the tour with water), the second to customers, and the third to the next water tower[10](Fig.22E). The pipelines among these towers were connected with valves that control water flow. The line of consumers ended with taps through which water flowed out. The water flow from one tower to another reduced water pressure at the tap's spout to withstand the pressure without pushing out of the insert[11]. Kretzschmer argued that the Roman water tap could be damaged due to the high pressure of water[12]. In contrast, Kessener and Fassitelli, among others, disagreed and reported that the Roman tap was well secured by hammering a dent or pine in the lower end of the tap, which corresponded to the groove located in the lower end of the insert and the protruded part due to hammering would prevent any movement of the cylinder but allow only the tap to close and open while the insert could not be removed[13]. A slight circular depression could be observed around the dent, indicating that the hammering tool was adapted to prevent leakage as the greater diameter of the tool could hinder the perforation (Fig.5 E); thus, Roman valves and taps could withstand adequate pressure equal to several bars[14]. Some Roman valves or taps did not have clear dents or pins or any connection from outside to inside the cylinder probably due to hammering a sharp pointed pin, which would lead to leakage of the tap[15]. The presence of valves and taps in the

[1] Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management in ancient Alexandria, p. 3431.
[2] Hairy, I, L'Eau alexandrine : des hyponomes aux citernes, in *Du Nil à Alexandrie. Histoires d'eaux, catalogue d'exposition*, edt.by. I. Hairy, Alexandrie, 2011,p. 213.
[3] Hairy, Alexandrie médiévale. La question de l'eau, p. 264.
[4] Ahmed, et.al., Egyptian and Greek Water Cultures, p. 17.
[5] Dembskey, *the Aqueducts of Ancient Rome*, p. 64.
[6] Jansen , *Water in de Romeinse stad*, p. 49; Hodge, *Roman Aqueducts*, p.110; Dembskey, *The Aqueducts of Ancient Rome*, p. 65, 81
[7] Vitruvius, VIII, X.
[8] Wilson, Urban Water Storage, p.85.
[9] Kessener, Roman Taps, p. 372.
[10] Kessener, Roman Taps, p. 372.
[11] Kessener, Roman Taps, p. 373; Hodge, *Roman Aqueducts*, p.236f .
[12] Kretzschmer, Römische Wasserhähne , p. 51.
[13] Kessener, Roman Taps, p. 375f; Fassitelli, Pipe and Valves.
[14] Kessener, Roman Taps, p.376.
[15] Kessener, Roman Taps, p. 376.

Roman water system allowed the passage of water without any waste[1]. Taps in Pompeii served as controls installed in pipelines at the entrance to buildings to regulate water distribution[2]. In the Pompeii house, the lead pipes of unequal diameter were joined with lead sleeves[3].

Dating

Roman taps and valves were first used in the first century BC when the lead pipes were using and over the next several centuries. The use of valves to control the flow of water in these pipe systems also spread throughout the empire[4]. It is difficult to identify a certain date of the examples under investigation, as they are not decorated by specific decorations which enable us to determine their exact date, but we consider them dating back from the first century BC to the third century AD, where this period shows the valves used in Pompeii and other Roman cities.

Conclusion

-Roman engineers excelled in inventing an integrated water network that ancient historians praised. These aqueducts were created from a series of pipes, tunnels, channels, and bridges.

-The word “tap” was sometimes used for both tap and valve as they were similar in structure but not function. The tap was always closed and could be opened whenever the person wanted, while valves were used to control water flow and distribution. They were always open at the branches of pipelines, and if water was cut off for users who did not pay the fees or for other purposes, they were closed. They were similar to the stopcock of today.

-The taps and valve consisted of a hollow cylinder of cast bronze with an insert inside it and connected to pipes that varied between lead pipes (fistula) and terracotta pipes (tubuli). Despite that, there were some examples of valves that were made of marble in Tunisia which were cheaper than bronze.

-Taps took one of three shapes: the first was like a valve with two pipes, one connected with a water conduit and the other through which water flew; the second had a spout from which water flowed in the shape of an animal's head, e.g., a bull, a dog, and a cow; the third took the shape of an animal, such as a pig, a lion, or a wolf. The connection between these animal shapes and the taps was a common natural motif that did not serve specific symbolism.

-Alexandria, from which the examples came, was a coastal city and depended on three sources of freshwater: The Nile water through the Shedia Canal, the collection of rainwater, or groundwater, which led to the construction of reservoirs (castellum aquae) to supply the city.

-These tanks differed in shape. In the Ptolemaic period, tanks were small, set on a rock, and resembled bottles in shape. In the Roman period, they took a rectangular shape and were built

[1] Rossi, A., How Water Distribution Modeled the Architecture of a City. The Emblematic Case of Ancient Pompeii, *Journal of Architecture and Construction*, vol. 1, 3, 2018, P. 1.
[2]Schut, et.al., Neutron resonance capture, p. 151.
[3] Jansen, *Water in de Romeinse stad*, p. 51.
[4] Lorenz, W.F, Ancient Roman Valves. Valve Magazine, 2013.
https://www.valvemagazine.com/articles/ancient-roman-valves, Accessed at: 12/2/2025.

of bricks and plaster and covered with ceramic mortar to be watertight. The public tanks consisted of one, two, three or even four levels. Many tanks were found in Alexandria in different places, such as the tank of Kom el-Dikka, the other one next to the Serapeum, and many other places.

-The water in the tanks was distributed to the entire city through pipes connected to valves to control water distribution to public places, fountains, and baths for a fee, as well as some private homes.

-The private homes also contained pipelines connected with valves and taps. The large taps, which took animal shapes, were connected with fountains. Taps and valves were widespread throughout the Roman Empire, as shown in the examples from Rome, Pompeii, North Africa, and the Near East.

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FIG. 1

A **B**

C **D**

A,B,C,D) An unpublished cast bronze valve, H. 10cm, probably from Alexandria, preserved in Greco-Roman Museum, inv. P.14741.

E

E) Bottom view of bronze cylinder with the insert inside it. The lower part of the cylinder (chamber plug) is opened to show the insert.

FIG. 2

A **B**

C **D**

A,B,C,D) An unpublished cast bronze valve, H. 7.7cm, probably from Alexandria, preserved in the Greco-Roman Museum, inv. P.15156.

FIG.3

A **B**

C

A,B,C) An unpublished bronze cast hollow cylinder, H. 7cm, probably from Alexandria, preserved in Graeco-Roman Alexandria, inv. P.14914.

FIG.4

A

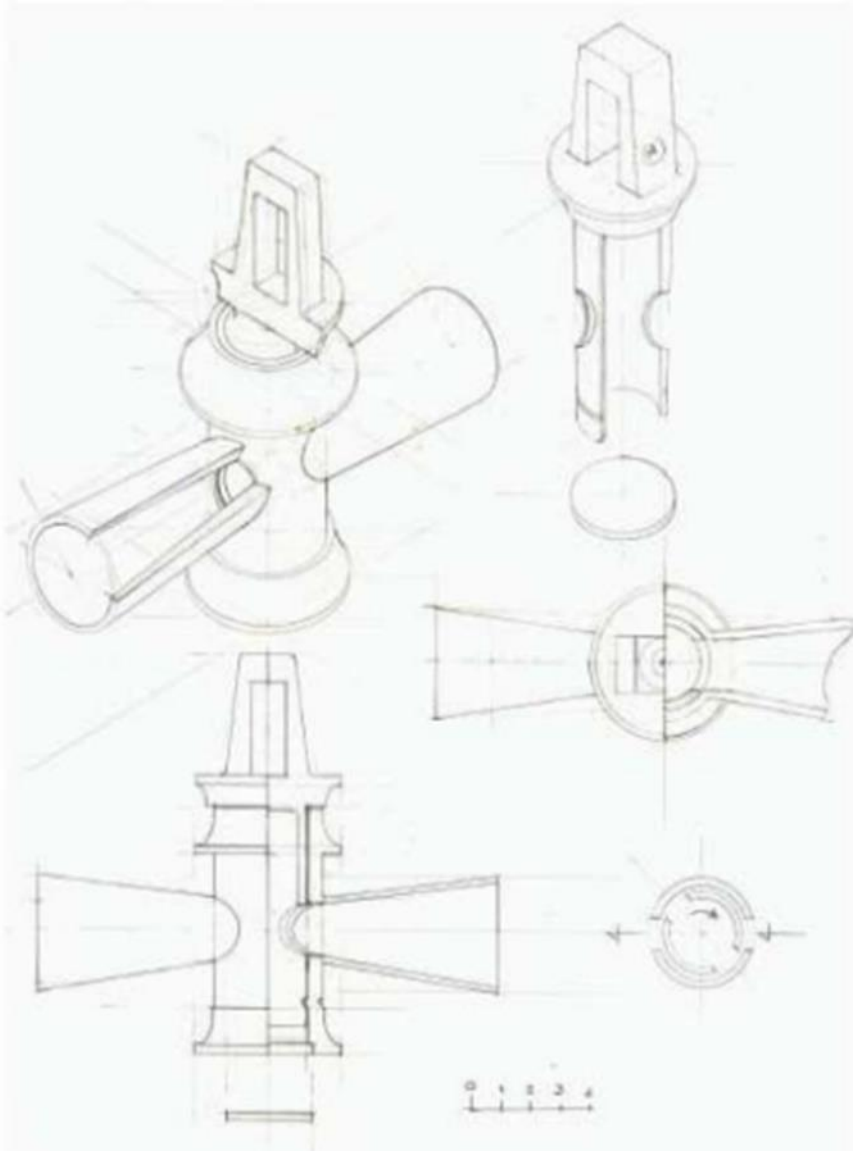
B

C

D

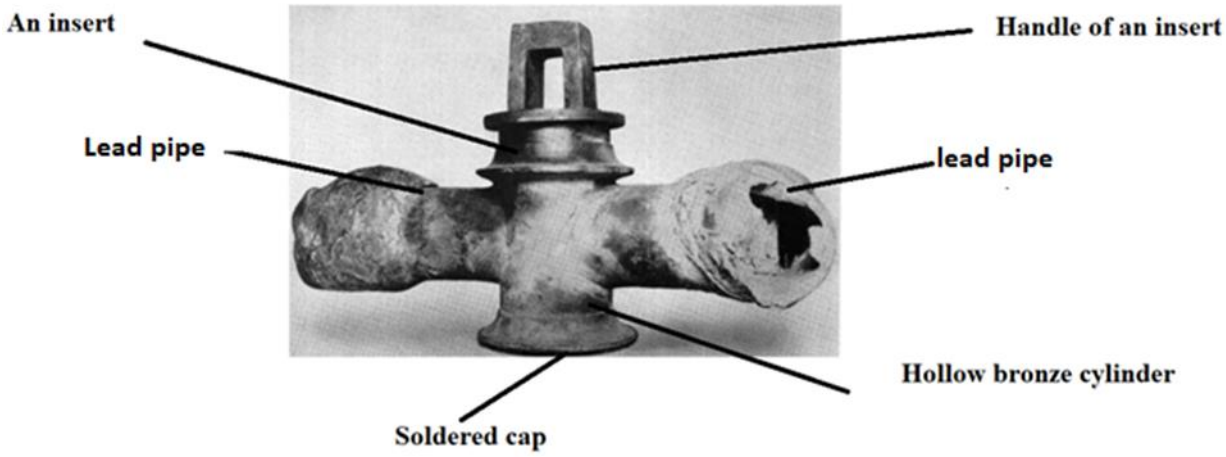
A,B,C,D) An unpublished bronze spout of tap, H. 8.5cm, probably from Alexandria, preserved in Greco-Roman Museum, inv. P.14898. It takes the shape of a bull.

FIG. 5

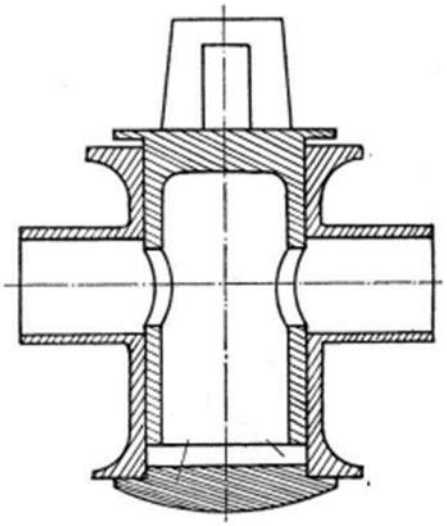


A) Drawing show the contents of the tap and the valve.

Rossi, How Water Distribution, p. 10, fig. 15.

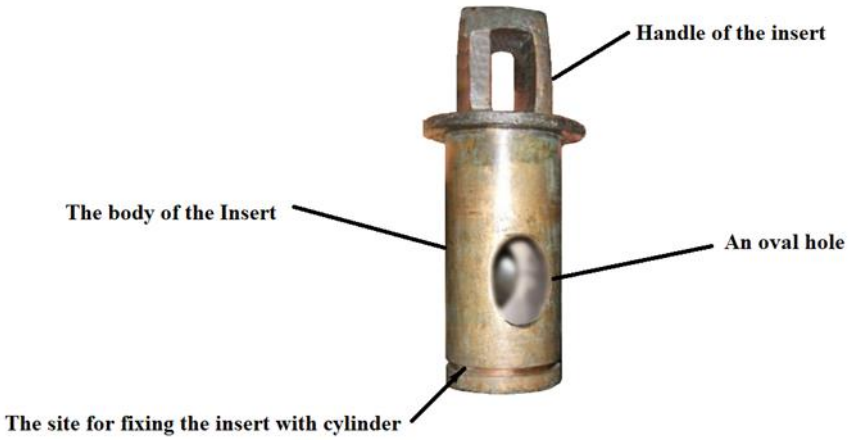


B) The structure of a Roman valve or tap.



C) The drawing shows a Roman valve or tap.

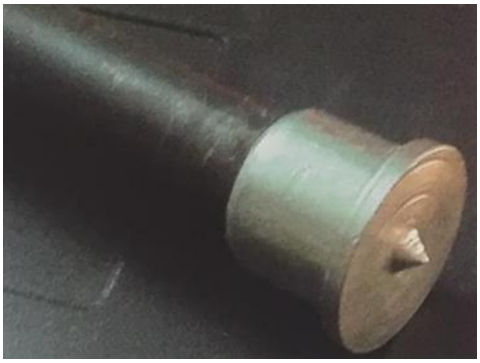
Kretzschmer, Römische Wasserhähne, p. 51, Abb.1.2.



D) Components of the insert.

E) A valve from Pompeii had a bent large iron nail in the handle of the insert.

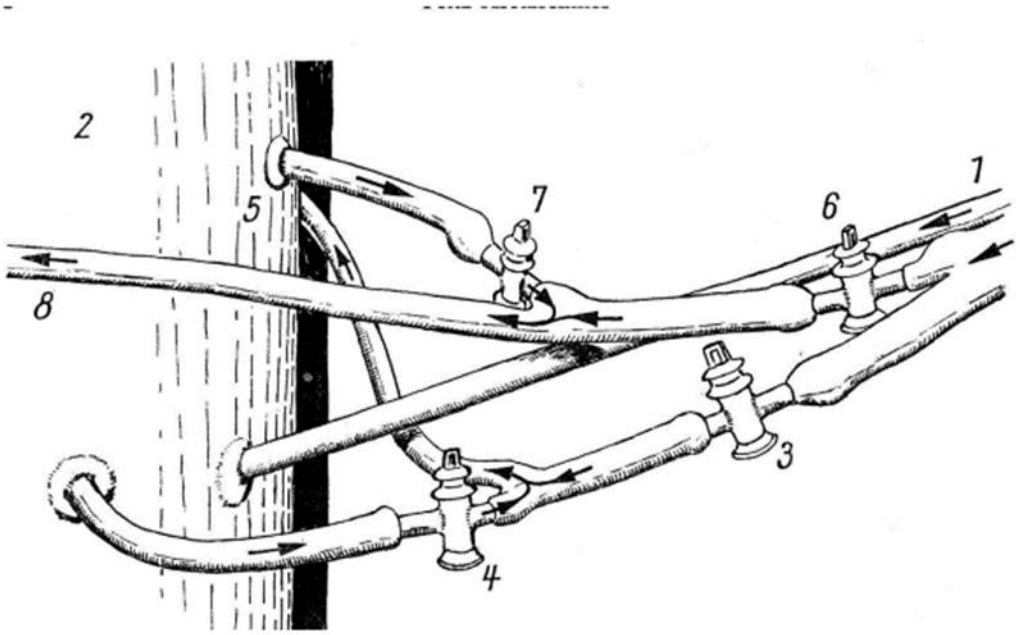
Kessener, Roman Taps, p. 377, fig. 15.



F) A circular groove and reconstructed hammering tool.

Kessener, Roman Taps, fig. 13.

FIG.6



A) Valves connected with pipes to control the water flow from Boscoreale, preserved in National Museum of Naples.

Kretzschmer, Römische Wasserhähne, p. 60, Abb.8.

B) Depicts two valves attached with lead distributing box, which connected with the conduit on its upper left part.

Kessener, Roman Taps, p. 376, fig. 10.

FIG.7

A bronze valve from Pompeii with pipes.

https://gigazine.net/gsc_news/en/20200226-ancient-roman-valves/ Accessed at: 12/11/2024.

FIG. 8

A bronze valve preserved in the Museum of the Ancient Roman Civilization, Rome, Italy.

https://ancientwatertechnologies.com/2013/01/13/hydraulic-devices/ Accessed at: 12/11/2024.

FIG. 9

A bronze valve from Jordon.

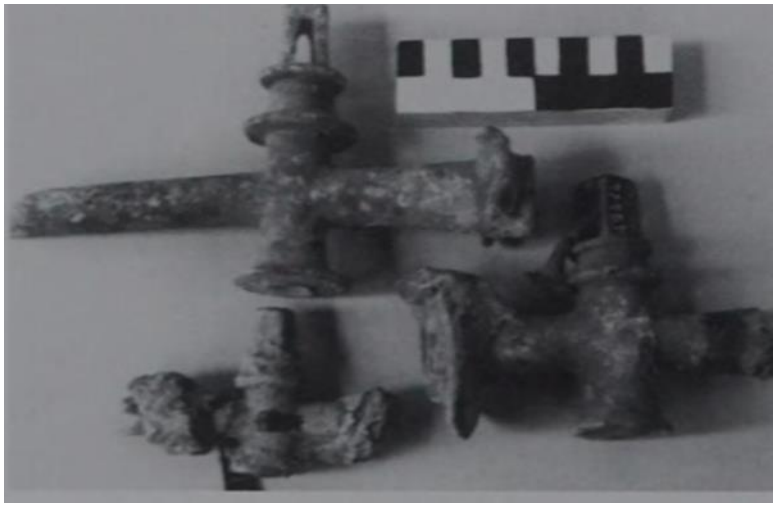
Schram, W.D., Sluice Gates in Roman Aqueducts I, https://static.parks.org.il/wp-content/uploads/2018/01/17-Binder1.pdf, Accessed at: 15/11/2024.

FIG.10

A bronze Roman tap without an insert from Antioch, preserved in the Aqaba Archaeological Museum.

Oleson, the Nabataean, Roman, Byzantine, and Early Islamic Site of Humayma, p. 4.

FIG.11



Some bronze taps from Pompeii.

Jansen, *Water in de Romeinse stad*, p. 50, II, 64.

FIG.12

A bronze tap, H: 14.6 cm; W: 24.3 cm; D: 7.7 cm, from Italy, preserved in Louvre Museum, inv. Br 3492, it dates back to the Roman Period.

https://collections.louvre.fr/ark:/53355/cl010291242, Accessed at: 12/10/2024.

FIG.13

A bronze Roman tap, H. 15.24cm, preserved in London, British Museum, inv. 1856,1226.864, it dates back to 1st century AD. The tap has an insert, traces of a lead water-supply pipe attached and the spout.

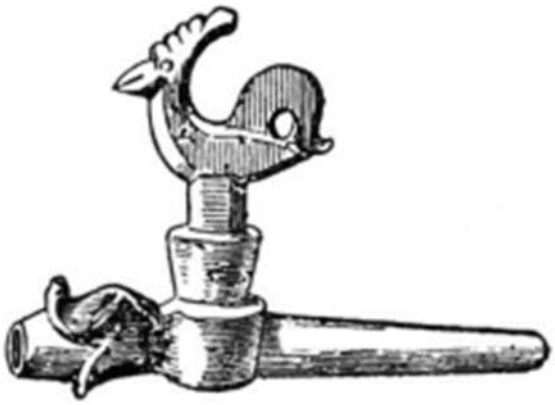
https://www.britishmuseum.org/collection/object/G_1873-0820-187, Accessed at: 6/1/2025.

FIG.14

A Bronze tap from Pompeii, it dates back to the 1st century AD.

https://ancientwatertechnologies.com/wp-content/uploads/2013/01/day-1-roman-museum-166.jpg , Accessed at:12/10/2024.

FIG. 15



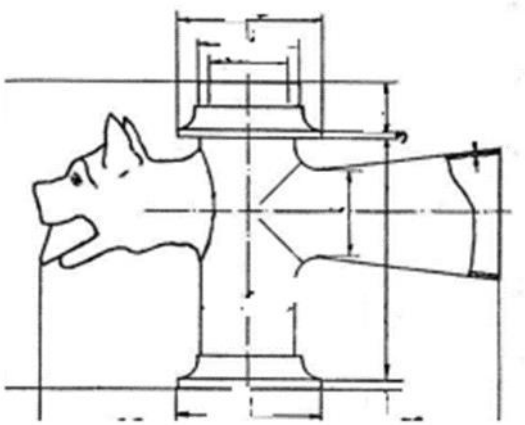
A bronze tap from Vindonissa in Switzerland, it dating back to the first century AD.

Kretzschmer, Römische Wasserhähne, tafel. 6a, 2.

FIG.16

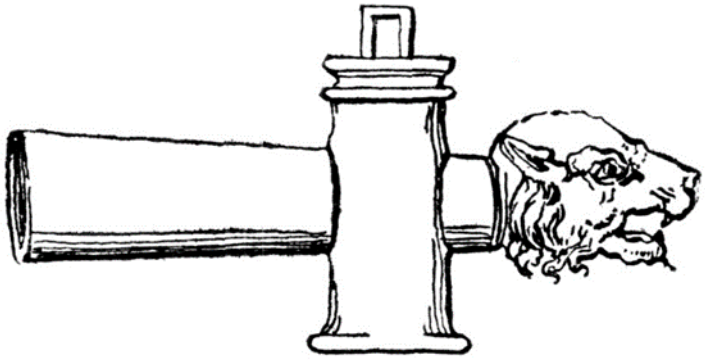
A) A bronze tap, H. 8.5 cm, L. 13.1 cm, preserved in Museum of Fine Arts and Archaeology, Boston, inv. 885.1.1, missing an insert .The spout takes the shape of a dog or wolf's head.

https://memoirevive.besancon.fr/ark:/48565/0314kf9rsljp, Accessed at 24/10/2024.



B) Drawing of a tap with spout in the shape of a dog's head.

Kretzschmer, Römische Wasserhähne, p.55, Abb.4.



C) Drawing of a bronze tap from Pompeii with spout as a dog's head.

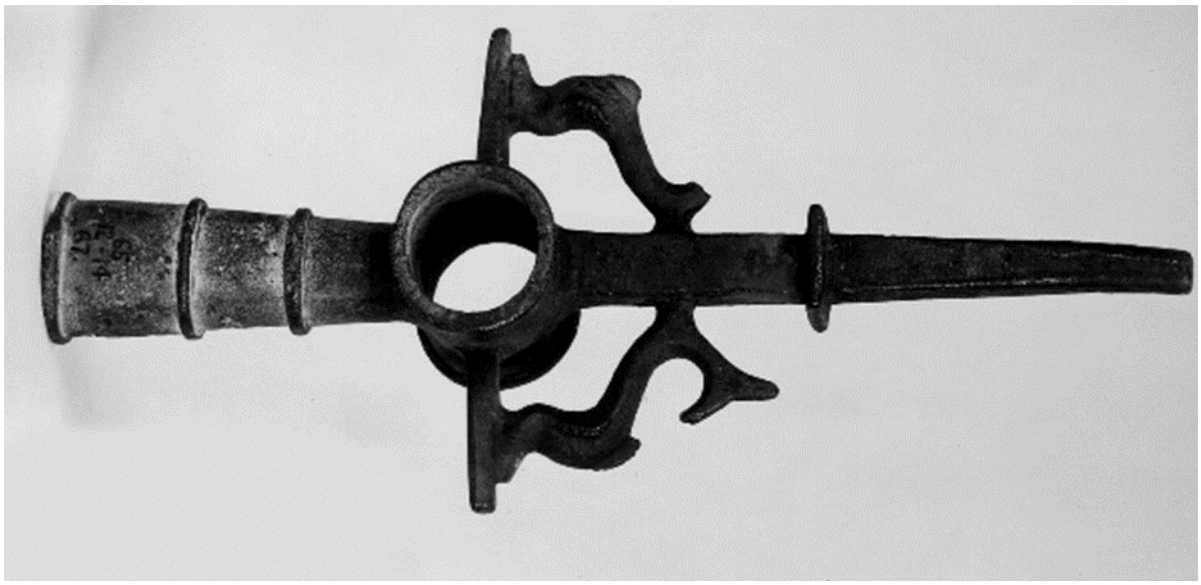
Jansen, *Water in de Romeinse stad*, p. 50, II, 70.

FIG.17

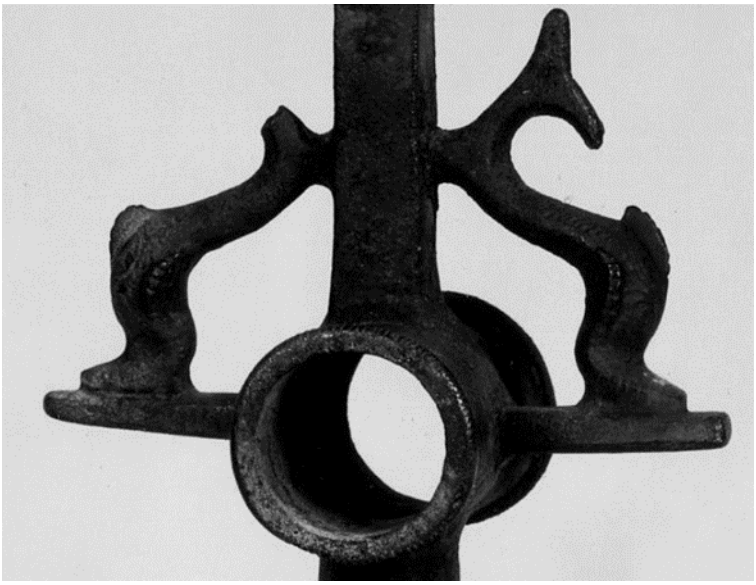
A bronze tap, H. 11.6 cm; W. 3.9 cm; D. 3.15 cm, preserved in Louvre Museum, inv. Br 3491, it dates back to the first century AD.

https://collections.louvre.fr/en/ark:/53355/cl010291241#. Accessed at: 10/11/2024.

FIG.18



A) A bronze tap, H. 21.80cm, preserved in London, British Museum, inv. 1865, 1214.67



B) Details in the tap.

Walters, *Catalogue of the bronzes*, p. 332, no. 2575.

FIG.19

A bronze tap in the shape of a boar's head, H. 6.5 cm, L.8 cm, Antikensammlung, Staatliche Museen zu Berlin, inv. 30211. https://www.deutsche-digitale bibliothek.de/item/XUOQJZX3GYBX24W2VOFN4I4XT7TGTT7K, Accessed at: 24/10/2024.

FIG. 20

A B

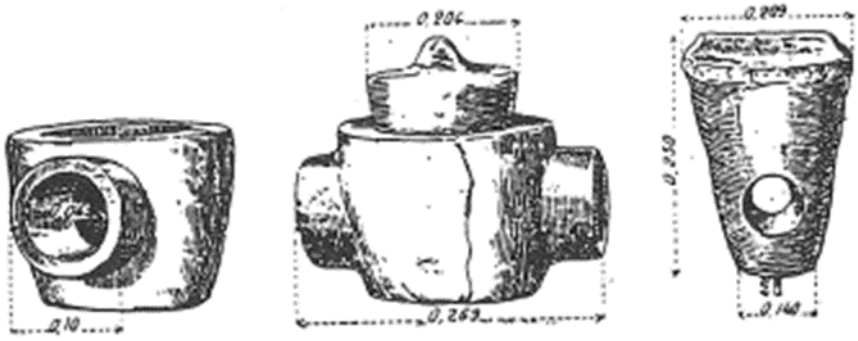
A, B) A bronze tap, dark green patina, L.5cm, from Nemi or Pompeii, London private collection , no. 119, dating back to 1st- 2nd century AD, In the form of a lion's head.

https://bertolamifineart.bidinside.com/en/lot/44249/roman-bronze-tap-in-form-of-a-lion-head-1st-/. Accessed at: 2/11/2024.

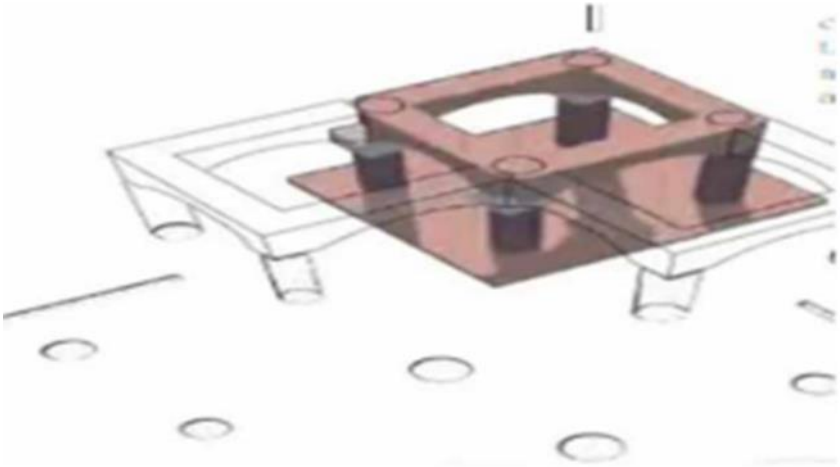
FIG.21

A bronze tap in shape of a wolf's head, it preserved in London, British Museum.
https://www.pinterest.com/pin/343469909062081902/ Access at: 20/3/2025.

FIG. 22



A) Roman marble taps from la Cherguia, Tunisia.
Wilson, A., Urban Water Storage, p. 94, fig. 7.10.



B) Structure the tanks.

Spanoudi, Colfinopoulos, and Kalavrouziotis, Water management, fig. 3.

C) Shows one of tanks in Alexandria.

Ahmed, et.al, Egyptian and Greek Water Cultures, p. 16, fig. 15.

D) Pipes connected with valve without the insert.

E) The water tower in Pompeii with three lines.

Kessener, Roman Taps, p. 372, fig. 3.