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Ancient Water-Raising Devices and the Temple *Muchni*

Rabbinic literature describes a device in the Temple known as the *muchni*. This device, which was made of wood and connected to the laver, was an expensive donation, and was very noisy. Two traditional explanations exist for the *muchni*, but neither corresponds well to these criteria. Instead, a study of ancient technology reveals that the *muchni* was likely a radial water-raising device. This thesis supports the theory that the Temple was not averse to adopting new technology, which in turn has implications for future Temple design.

Although the architectural design of the Temple in Jerusalem is considered to be divinely mandated, its renovators were able to introduce new architectural styles and technology into the edifice. Herod's Temple project, for example, used modern Roman techniques while working within existing biblical and rabbinic restrictions. Likewise, the Temple vessels could be reconfigured to include new technologies. In this essay, I will detail how one vessel, the laver, was given a technological upgrade via a mechanical water-raising device.

THE LAVER AND THE *MUCHNI*

The laver, used for ablutions in the Tabernacle and the Temple, is first mentioned in the Book of Exodus, together with the other Tabernacle vessels:

You shall also make a laver of brass, and its pedestal also of brass, for washing, and you shall put it between the Tent of Meeting and the altar, and you shall put water in it. For Aaron and his sons shall wash their hands and their feet from it, when they go into the Tent of Meeting, they shall wash with water, that they die not, or when they come near to the altar to minister, to burn offering made by fire to the Lord. So they shall wash their hands and

B.D.D. 26, April 2012

their feet, that they not die, and it shall be a statute forever to them, to him and to his seed throughout their generations.¹

In addition, 1 Kings and 2 Chronicles describe the lavers of the First Temple, but contain few logistical details regarding its day-to-day operation.² Only in the Mishna do we find more information, specifically with regard to the *muchni*, a later innovation that was used in conjunction with the laver.

In a mishna listing important donations to the Temple,³ we read that: “Ben Ketin made twelve spigots for the laver, which previously had only two. He also made a *muchni* for the laver, so that its water would not be left out overnight and become unusable.”⁴

The mishna states that the laver originally had two spigots, but that ben Ketin introduced a new design that increased the number of spigots to twelve. In addition, ben Ketin made something called a *muchni* for the laver, so that water would not be left out overnight. Since water placed in one of the Temple’s holy vessels, such as the laver, was considered sanctified, and any sanctified water left out overnight would be rendered unusable, this was an important consideration.⁵ We are not told, however, how the *muchni* circumvented this problem. Instead, the mishna offers only two clues. First, etymologically, the word *muchni* comes from the Greek “μηχανη,” which means a machine or contrivance. This makes it likely that the *muchni* was a type of machine.⁶ Second, the context of the mishna tells us that the *muchni* was a significant donation and related to the supply of water.

1 Exodus 30:18-21. The Hebrew reads: וְעָשִׂיתָ כִּיּוֹר נְחֹשֶׁת וְכִנּוּ נְחֹשֶׁת לְרַחֲצָה וְנָחַת אֹתוֹ בֵּין-אֹהֶל מוֹעֵד וְעָשִׂיתָ מִיַּד בֵּין הַמִּזְבֵּחַ וְנָתַתְּ שָׁמָּה מַיִם. וְרַחֲצוּ אֶהְרֶן וּבְנָיו מִמֶּנּוּ אֶת-יְרֵיָהֶם וְאֶת-רִגְלֵיהֶם. בְּבֹאֵם אֶל-אֹהֶל מוֹעֵד יִרְחֲצוּ-מִיַּד וְלֹא יָמְתוּ אוֹ בְּגִשְׁתֶּם אֶל-הַמִּזְבֵּחַ לְשֵׁרֶת לְהַקְטִיר אֵשׁ לָהּ. וְרַחֲצוּ יְרֵיָהֶם וּרְגְלֵיהֶם וְלֹא יָמְתוּ וְהִיָּתָה לָהֶם חֻק-עוֹלָם לֹא יִלְזָדְעוּ לְדָרְתָם.

See 40:30-32 for a similar description.

2 1 Kings 7, and 2 Chronicles 4:6.

3 The list includes gold vessels for the Yom Kippur service, a mirrored fixture that reflected sunlight, and doors imported from Alexandria. The next mishna censures a number of people for hoarding technology.

4 M. Yoma 3:10. The Hebrew text reads: וְאֵף בֶּן קֶטִין עָשָׂה שְׁנַיִם עֶשְׂרֵי דָרִי לְכִיּוֹר, שֶׁלֹּא הָיוּ לוֹ אֵלָּא שְׁנַיִם. וְאֵף ר. Ovadiya of Bartenura and Rashi each note that ben Ketin was a High Priest.

5 B. Sukkah 49b-50a.

6 H.G. Liddell and R. Scott, *A Greek-English Lexicon*, revised and augmented throughout by Sir Henry Stuart Jones with the assistance of Roderick McKenzie (Oxford: Clarendon Press, 1940), presented online at <http://www.perseus.tufts.edu>. The Aruch (Natan bar Yechiel of Rome) also explains that *muchni* is Greek in origin. Although the English word “machine” is derived from μηχανη as well, “machine” in antiquity had a more specific meaning than

Two other mishnayot also mention the *muchni* and provide additional facts. One appears in a list of Temple activities that were perceivable from Jericho. It states: “From Jericho one could hear the noise of the wood from the *muchni* that ben Ketin made for the laver.”⁷

The other mishna, containing a description of the first job done each morning in the Temple, provides similar information. There, the officiating priest is warned not to touch anything until he washes his hands and feet from the laver: “[The other priests] would not see him nor hear him until after they heard the *noise* of the *wood* from the *muchni* that ben Ketin made for the laver. Then they would say ‘The time has come.’ He would wash his hands and his feet from the laver...”⁸

Even if we do not take the Jericho description literally, it is safe to assume that the *muchni* produced a great deal of noise and that it was made of wood.

To summarize, several clues about the *muchni* can be found in the Mishna:

- It related to the increased need for water in the laver.
- It was a significant donation.
- It was loud.
- It was wooden.
- It prevented water from becoming unusable.
- It was a machine.

THE FUNCTION OF THE *MUCHNI*

Despite the hints in the Mishna, it is not clear what function the *muchni* served. This lack of information is noted by the Talmud, which inquires about the nature of the *muchni*. Abbaye explains that it was a wheel, and uses the somewhat ambiguous word “*mashka 'a*” – which can mean either “lower” or “fill” – to explain that the *muchni*'s function was either to lower or to fill the laver.⁹ These two possible meanings influenced the two traditional descriptions of the *muchni* that are found

today. Vitruvius, the ancient Roman writer, noted that: “A machine is a continuous piece of joinery that has outstanding capacities for moving loads. It is moved systematically by the revolutions of circles.” See Vitruvius, *Ten Books on Architecture*, X.1.1. See also notes 9 and 16 below.

- 7 M. Tamid 3:8. The Hebrew reads: .מכני לכיור בן קטין שעשה בן קטין מוכני לכיור.
- 8 Ibid., 1:4. The Hebrew reads: בן קטין שעשה בן קטין מוכני לכיור וכן אומרים הגיע העת. קדש ידיו ורגליו מן הכיור... “לא היו רואין אותו ולא שומעין את קולו עד ששומעין קול העץ שעשה בן קטין מוכני לכיור והן אומרים הגיע העת. קדש ידיו ורגליו מן הכיור...”
- 9 B. Yoma 37a. The Aramaic reads: “מאי מוכני? אמר אביי גילגלא דהוה משקעא ליה.” It is interesting to note that Abbaye links the term *muchni* to radial movement, just as Vitruvius did. See note 6 above.

in rabbinic literature:

1. **A pulley system used to lower the entire laver into a cistern each evening.**¹⁰
This would solve the problem of leaving water out overnight, as immersing the laver in unsanctified water prevents its water from becoming unusable in the Temple (Fig. 1).
2. **A secondary basin containing unsanctified water, built adjoining the laver.**
Since this basin was not sanctified, the water in it would not become unusable overnight. The basin would feed water into the laver as needed.

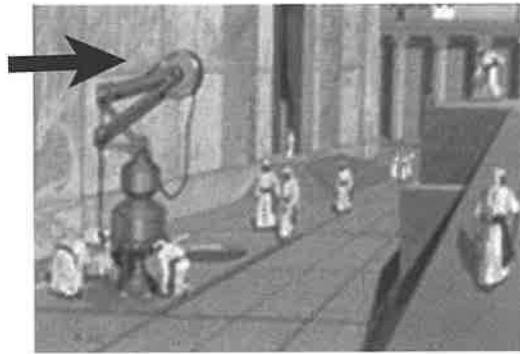


Figure 1: *Muchni* as depicted by Machon HaMikdash, according to the traditional interpretation, as a pulley (www.temple.org.il)

However, the debate on this subject is limited, presumably because identifying the function of the *muchni* is seen more as a curiosity than a question with practical ramification. Rambam even gives both answers in different locations. In *Hilchot Bi'at Hamikdash*, he writes that the laver was lowered into water, and the next morning it was raised or refilled.¹¹ On the other hand, in his *Commentary on the Mishna*, Rambam writes that “[ben Ketin] made a vessel around the laver which always held water. Water would flow from it into the laver as needed.”¹² Although

10 Rashi, B. Yoma 37a, “*muchni*.” See also Bartenura, Ritva and Tosfot Yom Tov on M. Yoma 3:10, who all explain explicitly that the *muchni* was a pulley system for lowering and raising the laver.

11 Rambam, *Hilchot Bi'at Mikdash* 5:14. Although Rambam’s ruling does not explicitly mention the *muchni*, commentators such as the Kesef Mishna (R. Yosef Karo) clearly understand it to relate to the *muchni* and its description in B. Yoma 37a.

12 Rambam, *Commentary on the Mishna*, Yoma 3 and Beit HaBechira 3:18. The Hebrew in the former reads: “וזה עשה כלי סביב לכיור והיו בו המים תמיד והיו שותתין מאותו כלי לכיור כדי הצורך” ראשון ראשון ואותו כלי היה נקרא מוכני.”

Ravad finds the implied contradiction between these two answers puzzling, the Kesef Mishna suggests that Rambam simply recognized that there were two possible explanations and felt no need to isolate the “correct” answer.¹³

These two explanations relate to the wording of the Talmud, but they are problematic when compared with the clues from the content and context of our three mishnayot. The *muchni* is mentioned in M. Yoma 3:10 in the context of expensive and wondrous donations to the Temple: golden lots, golden handles, a sparkling gold fixture, and an inscribed golden tablet. While the pulley is classified as a machine, it was already common in the time of the Mishna and thus does not seem to fit in the mishna’s list.¹⁴ Secondly, lowering the laver nightly and raising it each morning would have been arduous work for the priests, and thus seems far from an ideal solution. Thirdly, by interpreting the word “*mashka’a*” to mean “lower,” a contradiction is created in the Mishna: Yoma only mentions the lowering of the laver, presumably at night, while in Tamid we find that noise only occurs in the morning.¹⁵ A reservoir, on the other hand, cannot be regarded as a machine. Finally, neither explanation accounts for the statements that the *muchni* produced a significant amount of noise. Explanations can be offered for each of these difficulties, but when taken together they seem to indicate a different interpretation of the *muchni*.

Rather than a pulley or a reservoir, I believe that the *muchni* was a water-raising device. A sophisticated, expensive device providing fresh water to the laver and increasing its flow would fit the contexts of our mishnayot perfectly. This solution is similar to the reservoir explanation, but instead of the *muchni* simply being a basin it was a mechanical means of conveying water from a below-ground cistern, thus allowing the water in the laver to be replaced each morning with relative ease. Etymologically, this makes sense: $\mu\eta\chi\alpha\nu\eta$ was frequently used in reference to

- 13 It should further be noted that a number of commentators reject the possibility that Rambam gives two contradictory opinions. However, to complicate matters, these commentators do not agree *which* single opinion was held by Rambam. Ravad claims that Rambam only believed the *muchni* to be a pulley. On the other hand, Tosfot Yom Tov writes that Rambam only held that the *muchni* was a secondary basin (M. Tamid 1:4).
- 14 The earliest record of pulleys comes from an Assyrian monument, possibly dating to the eighth century BCE. See K.D. White, *Greek and Roman Technology* (London: Thames and Hudson, 1984), p. 14. Ecclesiastes 12:6 records the use of a pulley for drawing water, as does M. Middot 5:4. M. Eruvin 10:14 allows the use of a pulley for drawing water in the Temple on the Sabbath and on holidays.
- 15 Tosfot Yom Tov points out this problem, and suggests that the laver was actually lowered in the morning, just before daybreak, and then raised shortly thereafter.

several types of water lifting devices.¹⁶ However, to understand the precise nature of the *muchni* and to demonstrate the viability of this explanation, we must familiarize ourselves with the water-raising devices of antiquity.

Ancient Water-Raising Devices

Greek and Roman engineers developed a variety of mechanisms for the purpose of raising water. Surviving literary sources and archeological records demonstrate this fact and provide us with a well-rounded understanding of how these devices were used. Rabbinic literature also records a number of water-raising devices. For example, T. Mikvaot 4:2 mentions the use of two mechanisms, the *antalia* and the *kavolin*, for pumping water into a ritual bath,¹⁷ and two midrashim use a water-wheel in a metaphor about the turning of fate.¹⁸

Ancient Greek and Roman technology included several distinct water-raising devices. To raise water a short height, a water-screw (κοχλίας/*cochlia*)¹⁹ or drum (τυμπανον/*tympanum*) could be used.²⁰ For greater heights, a bucket-wheel (πολυκαδία), bucket-chain (σλυσίς)²¹ or a force-pump (σιφών) would be necessary. While the force-pump is operated by lever, the other four devices are mechanically rotated by hand, foot, or water power, and could – in conjunction with a gear system – be powered by animals.²² Evidence for each mechanism exists

16 J. Landels, *Engineering in the Ancient World* (Berkeley: University of California Press, 2000), p. 59, and John Peter Oleson, *Greek and Roman Mechanical Water-Lifting Devices* (Toronto: University of Toronto Press, 1984), p. 127. Oleson quotes numerous papyri contracts that use the term μηχανή in reference to various water-raising devices. The term is not, however, exclusively used for water-raising devices, and can actually be applied to a variety of mechanical objects. In rabbinic literature as well, the term is used in two other contexts: part of a cabinet (M. Kelim 18:2 and Ohalot 4:3) and as a mechanical device for the slaughtering of animals (*beraita* quoted in B. Hulin 15b).

17 For a discussion of the etymology of *Kavolin*, see D. Sperber, *Material Culture in Eretz-Israel During the Talmudic Period* (Jerusalem, Bar-Ilan University Press, 1993), pp. 38-41, and Shmuel Avitzur, *Adam Ve'Amalo* (Jerusalem: Karta, 1976), pp. 55 and 60. The most thorough treatment of this subject, Oleson's *Greek and Roman Mechanical Water-Lifting Devices*, ignores rabbinic sources, in part due to an unfortunate failure to distinguish between Tosefta and Tosefot and thus a belief that Tosefta was medieval. See Oleson, p. 8.

18 Vayikra Rabba 34 and Ruth Rabba 41, as referenced by Avitzur, p. 60.

19 Several of the devices have problems with naming conventions. I have chosen descriptive terms for each device, and provided Greek and Latin translations where ones exist in ancient sources.

20 Landels, p. 59.

21 Vitruvius does not give a name for this device, but Hero does. See Landels, p. 71.

22 In ancient times, the only mechanism operated by hand was the force-pump. See Landels, pp. 62-63. The operation of these devices by foot using treads was well known. See Oleson,

both in the archeological record and in written sources, including detailed descriptions by Vitruvius.

The water-screw is composed of a long screw set within a cylinder. It is arranged at a low angle with the bottom end submerged in water. An operator walking along treads turns the screw, propelling water up the cylinder.²³ The water-screw has a limited maximum height due to its shallow angle, and was used generally for irrigation. Ancient depictions, such as at Casa di P. Cornelio Teges in Pompeii, show the screw at a low incline, operated by a walking figure gripping a horizontal bar for balance (Fig. 2).



**Figure 2: Casa di P. Cornelio Teges, Pompeii. Water-screw in use.
Figure supports himself by gripping horizontal bar, while protected by shade.
Water drains to the right**
(Oleson, fig. 101, from A. Maiuri, NSA, 1927, pl. ix)

p. 31. A verse in the Septuagint highlights the use of foot-power in irrigation, stating that Israel “is not like the land of Egypt from which you have come: when they sow the seed [in Egypt] they also water it with their feet, like an herb garden. But the land you are entering, to take possession of it, is a land of mountains and plains, that will drink its water from the rain of heaven” (Deut. 11:10-11). For power by animals, see Oleson, p. 11.

23 Vitruvius (*Ten Books of Architecture* X.6) suggests an angle of 37°, to correspond with a 3:4:5 triangle. See Oleson, p. 122.

Several other water-raising mechanisms use a rotating wheel to pump water. The drum is a wheel whose body is divided into several hollow compartments that scoop up water at their lowest point. As each compartment rotates to the top, its water drains into a sluice via a hole punched near the hub (Fig. 3).

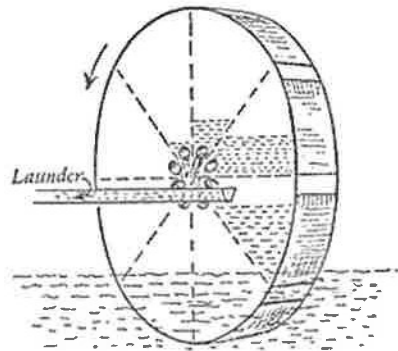


Figure 3: Schematic diagram of Drum. Water is scooped up in the wheel's compartments and spills out onto a sluice as the wheel continues to rotate (Landels, p. 64)

Though its capacity is large, the drum is only able to lift water the height of its radius. For a greater height, a similar device – the bucket-wheel – can be used. Its compartments are located along the wheel's rim – rather than in its body – thus allowing water to rise the full diameter. The compartments can be either an integral part of the wheel or containers fastened onto the rim (Fig. 4). A third radial device, the bucket-chain, acts as a vertical conveyor belt, with cogs rotating a "chain" affixed with containers. The chain dips into the water, allowing each container to fill before it is hoisted up and poured out. The bucket-chain's maximum height

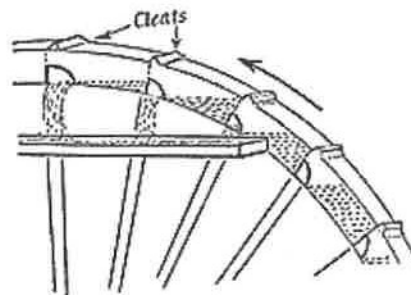


Figure 4: Schematic Diagram of Bucket-Wheel with containers built into the wheel's rim. Cleats along the outside were sometimes used for treading to power the wheel. In other cases, treads were built on the side, or a gear-train could provide power (Landels, p. 68)

depends on the chain's length rather than the diameter of its wheel, so that it can accommodate even greater heights and operate within a narrow confine (Fig. 5).²⁴

A final device, the force-pump, is perhaps the most sophisticated. It consists of a pair of cylindrical chambers and pistons operated by a rocker-arm lever, with

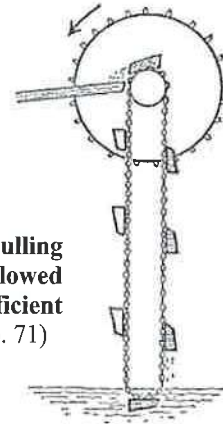


Figure 5: Schematic Diagram of Bucket-Chain. Cog rotates, pulling containers along a “chain” (more often made of rope). This allowed the water to be raised to a great height without requiring sufficient space to accommodate a wheel of similar dimension (Landels, p. 71)

valves regulating the flow of water. Each oscillation empties one chamber and fills the other. The valve in the empty chamber opens, allowing it to fill with water, while the valve in the full chamber shuts as the descending piston forces its water out and up toward the nozzle (Fig. 6). Though relatively expensive, the force-pump allows water to be raised in narrow spaces and was especially useful for fire-fighting.²⁵

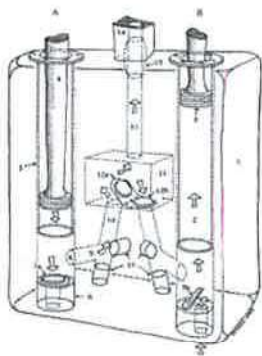


Figure 6: Schematic Diagram of Wooden Pump (Richard Stein, “Roman Wooden Force Pumps: A Case-Study in Innovation.” *Journal of Roman Archaeology* 17 [2004]: 227. Draughtsman Bob Spain. Image courtesy of the author)

²⁴ See Vitruvius, X.4.1-4.

²⁵ *Ibid.*, X.7. Most devices in Vitruvius and Hero are not coupled with practical applications. The force-pump, however, was designed in part to fight fires.

The *Muchni* in the Context of the Mishna

When we compare what is known about ancient water-raising devices with the descriptions of the *muchni* in the Mishna, it is clear that this solution fits our context. It would not be surprising to find one of these devices employed in the Temple. Though we lack additional Jewish sources, Hero describes a water wheel traditionally used at the entrance to Egyptian temples.²⁶ This mechanism was used for purification and was turned by hand as a way of cleansing the body before entering the temple,²⁷ a concept similar to the ablutions performed with the laver. A site in Hermoupolis reveals the use of a bucket-chain and a gear system in a temple precinct.²⁸ One papyrus refers to a mechanism supplying water to a synagogue.²⁹ In addition, we know that technological innovations were often used in temples. Regarding ancient inventions, H. Hodges writes that: “Much of the output of these inventors, however, went into creating interesting gimmicks often used in temples as, for example, doors that opened and closed when a fire was lit on the altar.”³⁰ Therefore a man-operated water-raising mechanism would not have been out of place in the Temple.³¹

The construction of a water-raising device was regarded as a considerable donation, worthy of inclusion in our mishna’s list. *Inscriptiones Latinae Salectae* (8903) records a declaration that people “constructed the water-screw installation at their common [expense].”³² A Negev inscription states that “the Illustrious Father Hilarion caused this hydraulic device to be constructed.”³³ Such recognition is similar to the lauding of ben Ketin in the Mishna.

26 Pneumatica 1.32.

27 Oleson, pp. 44-45.

28 Ibid., pp. 363-64.

29 See Oleson, p. 153, summarizing P. Lond 1177. This same device also served a bath, fountains, and a brewery.

30 Henry Hodges, *Technology in the Ancient World* (Harmondsworth: Penguin Books, 1971), p. 183.

31 J. Patrich arrives at a similar interpretation of the *muchni*, which he explains briefly in a footnote to an article about the location of the Temple on the Temple Mount. He comments that the Temple’s water-raising mechanism was the most sophisticated temple watering system in antiquity. Inexplicably, he references the temple in Hermoupolis and several other examples as proof of this, when they seem to prove the opposite – that other temples with similar mechanisms existed in antiquity. See Joseph Patrich, “The Second Temple and its Courts: A New Proposal about their Location on the Temple Mount,” in *Eretz Israel* 28 (2007): 174 and 181-82 note 25.

32 Oleson, pp. 55-56.

33 *Revue Biblique* 70 (1963): 255-57, as quoted by Oleson, p. 95.

The need for the *muchni* may also be related to the addition of extra spigots installed by ben Ketin, which would have increased the required supply of water. Our first mishna directly connects the additional ten spigots to the donation of the *muchni*, so it seems that the two events were related. The extra spigots must either have required a larger tank of water – which would have had to be refilled each morning – or else a steady supply of new water. In either case, a water-raising device would have resolved the problem.

While a water-raising device fits the context of the first mishna, it must also reconcile with the clues in the second pair of mishnayot – that it was wood and caused a loud noise. These clues may also allow us to identify the specific mechanism of the *muchni*. In ancient Arabic sources, the drum and the bucket-wheel are called *hannana* (“the sigher”) due to their distinct noise. However, this name comes from the pleasant, gurgling noise of the water, not a loud noise.³⁴ Rather, I believe the wooden noise was generated by a gear-train that powered the water-raising device, allowing a wheel rotating vertically to be turned by horizontal rotation, thus enabling circling animals or humans to provide power (Fig. 7). This was a common arrangement, one mentioned by Vitruvius alongside his list of water-pumps.³⁵ The gears themselves were wooden and created a great deal of noise, so this could very well be the noise of the *muchni*.³⁶ Finds in Cosa and Alexandria demonstrate that this type of gear was in use well before the destruction of the Temple in 70 CE and was sometimes man-powered. Literary sources often call this type of gear “μηχανή.”³⁷ The gear-train greatly boosted water flow but was expensive, facts that fit with the context of our mishnayot.³⁸

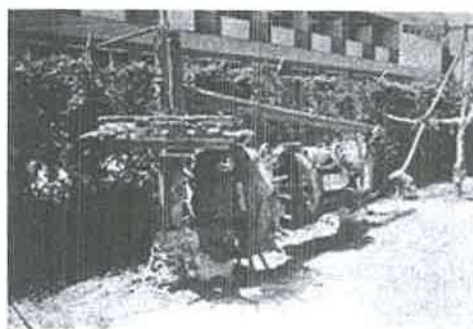


Figure 7: Gear Wheel built in modern era, from exhibit “Adam Ve’Amato” (Amitzur, p. 61)

34 Oleson, pp. 10, 71.

35 Vitruvius X.5.

36 Oleson, p. 375.

37 Ibid., pp. 377-80. He also notes that Cosa was man-powered.

38 Ibid., p. 385.

Accepting that the noise was caused by a gear-train, we still would like to determine which of the five ancient water-raising devices it powered. Any one of the devices has the capacity to refill the laver daily, but neither the force-pump nor the water-screw could be operated by a gear-train. Furthermore, the mishna implies that the *muchni* was wooden, and the earliest known wooden pumps are from the second century, postdating the Temple's destruction.³⁹ Therefore, it seems that the gear-train powered either a drum, a bucket-wheel, or a bucket-chain.⁴⁰ The shape of the water cistern located on the Temple Mount beneath the site of the laver – with long, thin channels – appears to be able to accommodate any of these three⁴¹ (Fig. 8). Narrowing it down further borders on speculation, but based on its minimal space requirements and parallels at Cosa and Hermoupolis, the bucket-chain seems the most likely option.

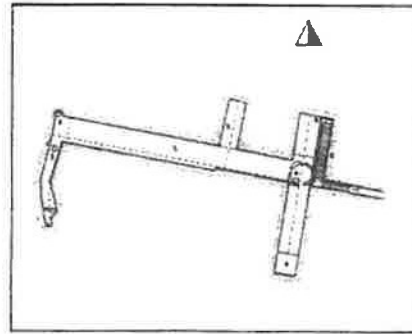


Figure 8: Cistern #5 on the Temple Mount, According to Wilson's numbering system (S. Gibson and D.M. Jacobson, *Below the Temple Mount in Jerusalem: A Sourcebook on the Cisterns, Subterranean Chambers and Conduits of the Haram al-Sharif*. Oxford: BAR International Series, 1996, p. 137)

- 39 Richard Stein, "Roman Wooden Force Pumps: A Case-Study in Innovation," *Journal of Roman Archaeology* 17 (2004): 225. Tosfot Yom Tov (M. Yoma 3.10) quotes the Kaf Nachat (Avraham ben Leib Hailbut) as saying that the *muchni* was a "hollow tube" that raised water by a pumping action, i.e. a force-pump. This is one of the only opinions in *chazal* that explicitly declares the *muchni* to be a water-raising device. However, the Tosfot Yom Tov correctly points out that the pump does not fit with the context of the Talmud, which mentions a wheel and noise. See also R. Yakov Emden's commentary, which understands the Kaf Nachat differently.
- 40 Patrich claims that the level of the cistern was deep enough to eliminate the drum as a viable option. See Patrich, p. 180 note 14.
- 41 It would be enlightening to conduct a study of plans for the various water-raising devices, in order to determine the most common shape of cistern used for each. Lacking such a study, the archeological evidence on the Temple Mount does not seem to be sufficient to prove definitively which device was used. Charles Wilson, who documented the cistern in the 19th century, noted that it "has a curious cruciform shape" and surmised that it must have had a specific, unknown purpose. See S. Gibson and D.M. Jacobson, *Below the Temple Mount in Jerusalem: A Sourcebook on the Cisterns, Subterranean Chambers and Conduits of the Haram al-Sharif* (Oxford: BAR International Series, 1996), pp. 136-37.

Concluding this explanation of the *muchni*, we can speculate as to how the laver developed. We are told that the laver originally had two spigots. This laver was likely smaller in size, and perhaps using a pulley to lower it into a cistern nightly was a viable solution. At some point, ben Ketin renovated the laver so that it had twelve spigots. The enlarged laver could no longer be practically raised and lowered or easily refilled, so the *muchni* was installed. This allowed simple and practical refilling of the laver on a daily basis. The *muchni* thus provided a solution to a pressing need in the Temple using the advanced technology of the day – a radial water-raising device connected to a wooden gear-train.

Future Implications

As a technological solution used in the Temple, the *muchni* offers proof that the Temple was not averse to adopting new solutions to existing problems. When confronted with a technical problem – keeping an ample supply of water on hand without leaving it overnight – ben Ketin utilized a machine that solved the problem elegantly.⁴² A number of other examples can be found in rabbinic literature, with both high- and low-tech solutions presented for various technical difficulties in the Temple. For example, the greater height of the Second Temple led to a problem with the stability of the wall between the Holy and the Holy of Holies. To solve this problem, the wall was replaced with two curtains a cubit apart.⁴³ The Mishna tells of decorative spikes on the roof of the Temple to prevent birds from soiling it.⁴⁴ Various midrashim tell of the *shamir*'s use in shaping stones when metal implements were forbidden.⁴⁵ A passage in the Talmud relates how artisans unsuccessfully tinkered with musical instruments in the Temple to correct deficiencies.⁴⁶ Complications existed with the drainage from the altar, not all of which were adequately resolved.⁴⁷ The Mishna even discusses how to indicate that

42 The focus of the Mishna suggests that the *muchni* was not introduced simply because it was fancy technology, but rather because it was part of a clever solution for the laver's water supply. This distinguishes the Jerusalem Temple from other temples in antiquity, which tended to employ technology as gimmicks to amaze the worshippers (see note 30).

43 The Teraksin Cubit. See B. Bava Batra 3a. The thickness of the wall was limited by the biblically mandated dimensions of the Temple to one cubit, which was not thick enough to support a wall 100 cubits high.

44 M. Midot 4:6. See also Josephus, *The Jewish War*, V. 224. The Hebrew term is בלה עורב.

45 B. Sotah 48b and M. Middot 4:3.

46 B. Erchin 10b.

47 M. Midot 3:2-3, M. Yoma 5:6.

a bathroom was occupied.⁴⁸ Each of these problems was addressed with the existing technology of the day, and innovative solutions clearly were permitted.

This use of technology has interesting implications. Just as ben Ketin introduced the *muchni*, we can expect that new technological solutions will be included in any future Temple design.⁴⁹ Problems listed in the Mishna can be reexamined: perhaps a stronger material could now be used to construct a wall between the Holy and the Holy of Holies, and non-metallic methods of cutting stone could replace the *shamir*. In addition to old problems, the construction and day-to-day activities of a future Temple will inevitably introduce a variety of new complications. What we learn from the development of the *muchni* is that modern technology will certainly be used to resolve these issues. Ironically, the *muchni* itself – a technologically advanced product of antiquity – will presumably be absent in a new Temple, replaced by modern pumps and plumbing.

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48 M. Tamid 1:1.

49 The topic of technology in a Third Temple has not been widely addressed, but the Temple Institute did hold a conference in 2010 on the subject. At the conference, a number of possible applications for modern technology were raised, such as broadcasting the Temple service, making use of modern heating and cooling, and using ovens to roast the Pascal Lamb.