

NOTES ON A WATER CLOCK IN THE ATHENIAN AGORA

(PLATES 41-44)

IN the southwest corner of the Agora, set up against the façade of the building identified as the Heliaia, there are the remains of a curious hydraulic establishment, first excavated in 1953 (Fig. 1). The unusual design of the installation—so clearly hydraulic, but equally clearly not a canonical fountain or other watering establishment—led the excavator, Eugene Vanderpool, to identify it as a simple out-flow water clock, similar to others known in terracotta, stone, and bronze, but on a much grander scale. Some twenty years later this explanation still seems the most plausible and the following is an attempt to illuminate some aspects of the mechanics and history of the device.¹

Except for the south wall, much of the installation was removed in antiquity, so that it now stands less than a meter high over most of its area. Nonetheless, enough remains to give a clear picture of the main elements (Figs. 2, 3, Pl. 41). There is a square central tank measuring *ca.* 1.68 m. on the outside and *ca.* 0.97 m. within, built of worked blocks of hard yellow limestone. This is preserved only to a depth of 0.70 m., but must originally have been much higher. Two openings for drainage are cut through the north wall near the bottom (Pl. 42:a). Around the tank there is an outer wall built of large, moderately hard, reddish conglomerate blocks, covering an area which measures 3.90 m. north-south by 5.35 m. east-west. Along the north, in front of the tank and level with its bottom, there is a rectangular service area, *ca.* 3.10 m. long by 0.75 m. wide. Steps leading down into it apparently ran along the west side of the tank, with the bottom two steps along the north. The four lowest steps remain *in situ* and show extensive wear. Immediately opposite the outlets of the tank there is a large drain (Pl. 41:b). The channel begins where it was cut through the north wall of the service area; further north it was tunneled through bedrock. It is arched in section, *ca.* 1.05 m. high by 0.60 m. across at the bottom. To prevent collapse, the sides are reinforced with well tiles set edge to edge in such a way as to form a peak.

Water was apparently brought into the structure from the southwest. The con-

¹ We would like to thank the following members of the Agora staff for help in the preparation of this article: T. L. Shear, Jr., H. A. Thompson, W. B. Dinsmoor, Jr., S. Rotroff, and A. Dammin. For published references to the clock, see H. A. Thompson and R. E. Wycherley, *The Athenian Agora*, XIV, *The Agora of Athens*, Princeton 1972, pp. 64-65, and p. 202, with note 55 for earlier bibliography. Also M. Lang, *Waterworks in the Athenian Agora* (Picture Book no. 11), Princeton 1968, ill. 43, 44. For the Heliaia, see *Agora* XIV, pp. 62-65.

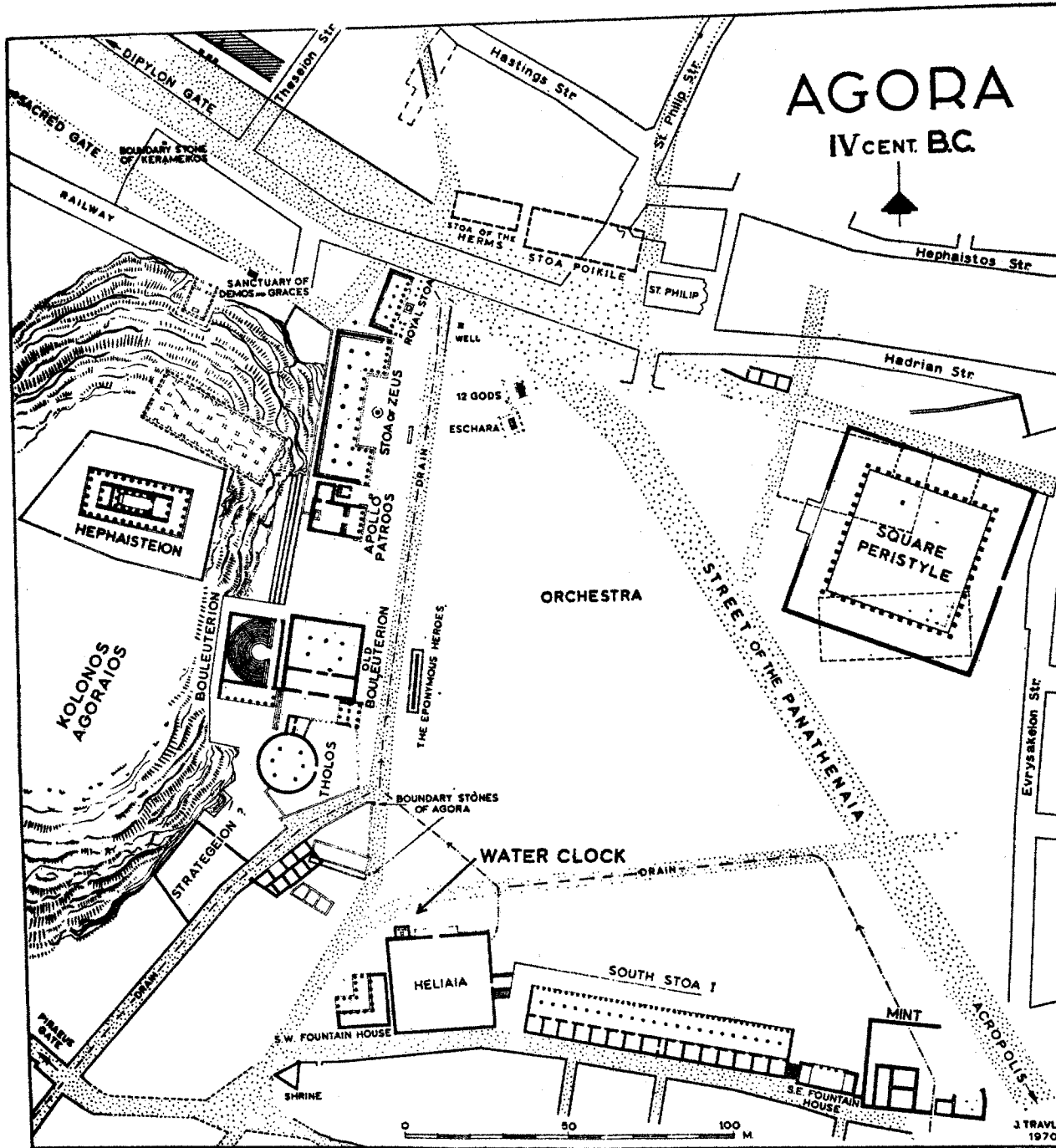


FIG. 1. Plan of the Agora in the late 4th century B.C. showing location of the water clock.

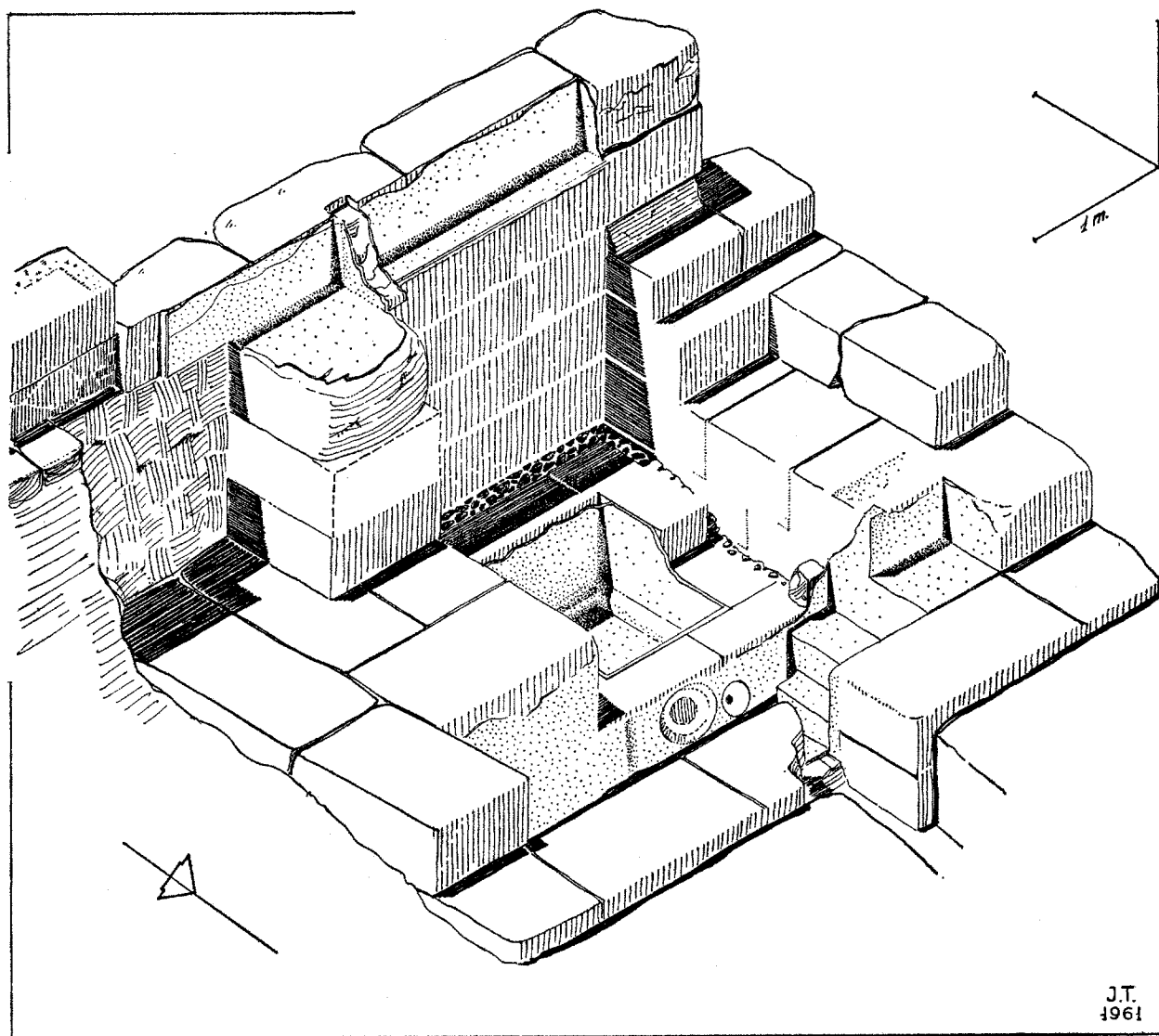


FIG. 2. Actual-state drawing of the Agora water clock, from the northeast.

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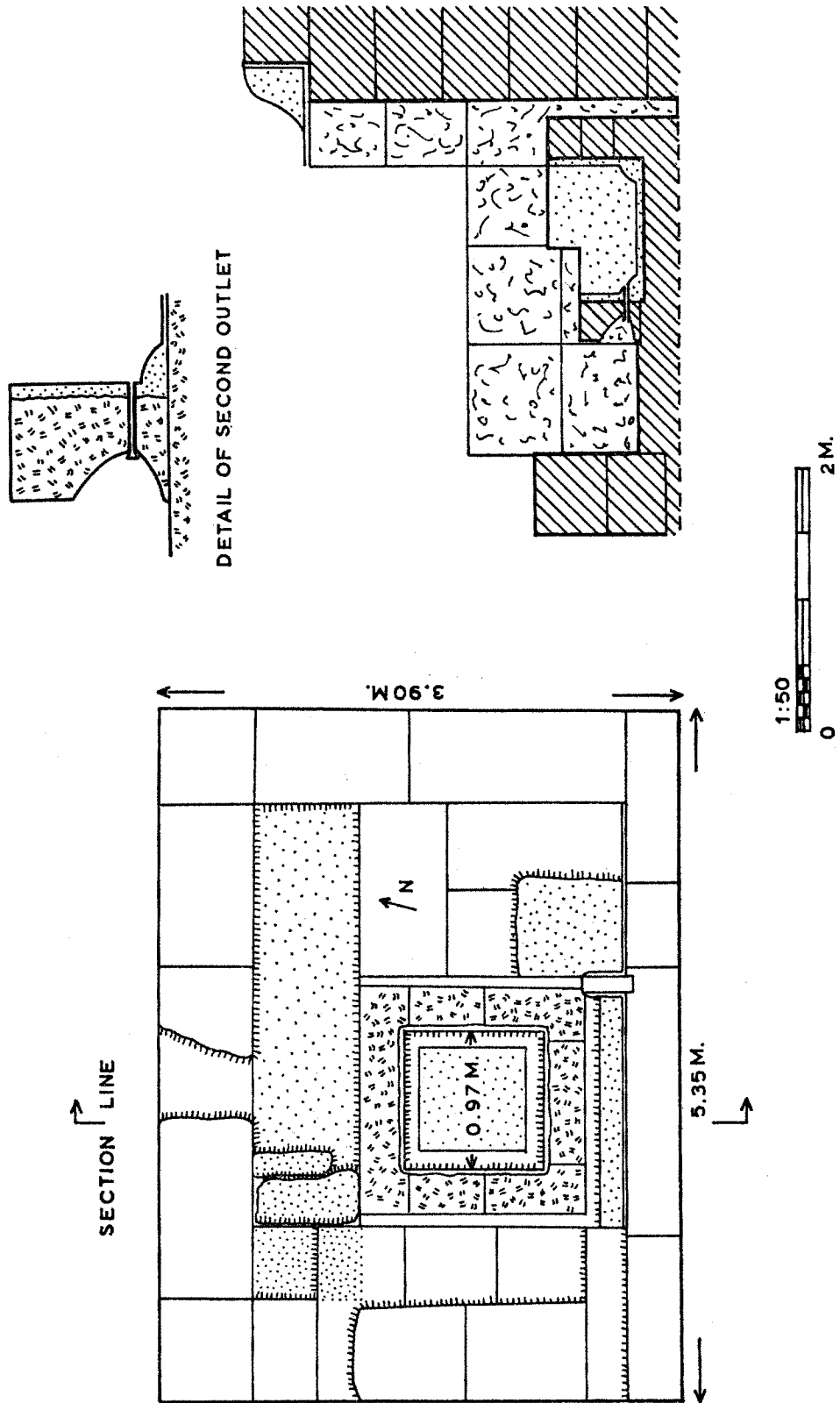


FIG. 3. Plan and section of the water clock in the Athenian Agora.

nection itself is missing, but water was readily available near by from the great stone aqueduct which fed the Southwest Fountain House, some twelve meters to the southwest. The aqueduct runs between the Heliaia and the Fountain House and a channel could easily have brought water on around the northwest corner of the Heliaia and into the klepsydra.²

The position of the clock is noteworthy. Set up in the southwest corner of the Agora, facing north on the open square and at the head of the streets which led through the populous deme of Melite to the Pnyx and the Peiraieus Gate, the device is in an ideal location for a large public timepiece: close to major public buildings and readily available to anyone frequenting the Agora square.³

The date of the installation is reasonably secure. The material used in its construction points to a date in the second half of the 4th century B.C., the hard, red conglomerate of the outer wall finding a close parallel in the foundations of the Temple of Apollo Patroos. Pottery found above the overflow channel—in particular two kantharos feet (Pl. 42:b, c)—suggest a date late in the century.⁴ Fill which accumulated over the structure itself and the fact that the foundations of the Middle Stoa cut through the drainage channel indicate that the installation was put out of use during the construction of the great south-square complex in the first half of the 2nd century B.C.⁵

² For the Southwest Fountain House and the large poros aqueduct which supplied it, see *Agora* XIV, pp. 200-201. Cuttings in the steps of the Heliaia at the northwest corner are apparently not related, but do serve to show that water was brought in this direction from the Fountain House.

³ For the topography and roads southwest of the Agora square, see R. S. Young, "An Industrial District of Ancient Athens," *Hesperia* 20, 1951, pp. 138-167. For a water clock set up in the Agora at Samos see *Agora* XIV, p. 202, note 55; and for a possible one at the theater in Priene, A. von Gerkan, *Das Theater von Priene*, Munich 1921, p. 27, pl. XV. Also, somewhat later, the Tower of the Winds in the Roman Market of Athens (*AJA* 47, 1943, pp. 291-299; 72, 1968, pp. 345-355).

⁴ P 23099: fragment from the foot of a black-glazed kantharos. Preserved height 0.039 m., diam. of foot 0.058 m. High molded foot, concave beneath. Reserved: resting surface and band between upper and lower moldings. Reddish brown glaze. Heavy water deposit. Cf. B. Sparkes and L. Talcott, *The Athenian Agora*, XII, *Black and Plain Pottery*, Princeton 1970, no. 704, p. 286, pl. 29, figs. 1, 7. Dated there to 320-310 B.C.

P 23100: fragment from the foot of a black-glazed kantharos. Preserved height 0.021 m., diam. of foot 0.051 m. Molded foot, concave beneath. Reserved: grooved resting surface and band between upper and lower moldings. Good black glaze. Cf. *Agora* XII, no. 661, p. 283, pl. 28, fig. 7. Dated there to 350-325 B.C. Also P 2876, published in Group A (no. 28) by H. A. Thompson, "Two Centuries of Hellenistic Pottery," *Hesperia* 3, 1934, pp. 311-480, esp. p. 319.

At the time of the discovery, the klepsydra was dated to the middle of the 4th century B.C., or perhaps the third quarter. It now seems likely that the date should be put at the end of the century. See V. R. Grace, *AthMitt* 89, 1974, and S. G. Miller, *Hesperia* 43, 1974, for new chronologies based on the excavations at Koroni (*Hesperia* 31, 1962, pp. 26-61). Although our kantharoi are not specifically paralleled at Koroni, the effect of the work there has been to lower the date of most of the material in Group A.

⁵ For the date of the start of construction of the Middle Stoa, *Agora* XIV, p. 67: "late in the first quarter of the second century B.C."

Within this span of about 120 years, the Agora klepsydra would appear to have had two distinct and separate phases. The evidence for this is the fact that there are two successive outlets at the bottom of the tank, both clearly visible on the outside face (Pl. 42:a). The eastern outlet was set in a large round depression which was later filled with a solid mass of lime mortar mixed with sand and stones, clearly a deliberate blocking. Its replacement lies immediately to the west, set in a smaller depression, at a somewhat lower level. The actual aperture is preserved in the form of a small bronze pipe, *ca.* 0.25 m. long with an inner diameter of 0.016 m.; at its northern end the aperture widens out to a diameter of *ca.* 0.03 m.

In establishing the appearance and mechanics of the Agora klepsydra in its original phase it has proved fruitful to examine its counterpart at the Sanctuary of Amphiaraos at Oropos, in northeast Attica.⁶ The klepsydra there lies on the right bank of the ravine, opposite the sanctuary proper, and its similarity to the Agora device is immediately apparent (Pls. 43, 44:b, Fig. 4). The same basic elements of the plan are common to both: square central tank, surrounding walls, stairway, and service area. The Oropos device is remarkably well preserved, with the tank and stairway complete, or very nearly so. Ten steps along the west side lead down into the service area, the walls of which stand *ca.* 1.45 m. high. The central tank itself is preserved to a depth of 1.93 m., the inside covered with a thin layer of waterproof cement. The device at Oropos has been dated by the excavator to the 4th century B.C.⁷ The Agora clock faces north, the one at Oropos northwest, and there are slight differences in dimensions (Figs. 3, 4). Nonetheless, in date, details of construction, and plan, the two installations appear closely related. In view of these similarities, the proximity of Athens to Oropos, and the fact that these two are the only devices of this design yet discovered, it does not seem unreasonable to suppose that they are the work of a single man.

Of particular interest for the present study is the fact that the Oropos clock shows no sign of renovation or remodeling; there is but a single outlet pipe. Given the similarity between the two installations, it therefore seems valid to use the Oropos klepsydra as the basis for a restoration of the Agora clock in its original, unmodified phase.

At Oropos the outlet near the bottom of the tank compares closely with what remains of the blocked-off outlet of the initial construction at Athens (Pl. 44). Both are set in a carved, round depression *ca.* 0.38 m. in diameter by 0.16 m. deep, and both align with a drainage channel cut through the exterior north wall of the service area. As noted above, the actual pipe has been gouged out of the Agora device, and

⁶ For the klepsydra at Oropos see A. Leonardos, *'Αρχ. Έφ.*, 1918, pp. 110-113, and B. X. Petrakou, *Ὁ Ὀρωπὸς καὶ τὸ Ἱερόν τοῦ Ἀμφιαράου*, Athens 1968, pp. 113-116.

⁷ *'Αρχ. Έφ.*, 1918, p. 110; the date is apparently based largely on construction methods and material.

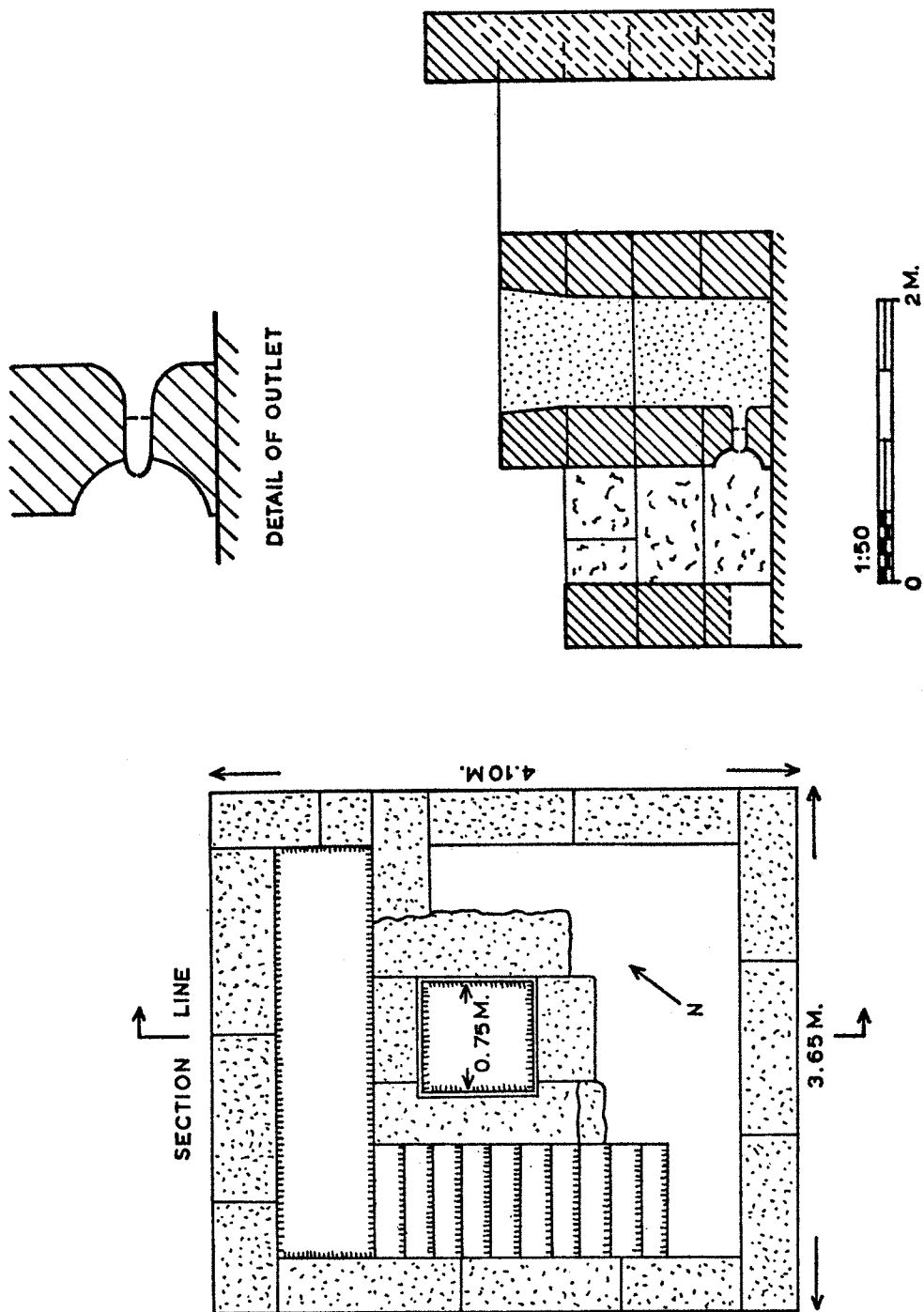


FIG. 4. Plan and section of the water clock of the Amphiareion at Oropos.

the opening has been filled with a patch of stones and mortar. Fortunately its counterpart remains *in situ* at Oropos. This takes the form of a hollow bronze cylinder (Pl. 44:b, Fig. 4), 0.16 m. long by 0.09 m. in diameter, ending in a hemisphere at its outer end. This hemispherical end is pierced by a small hole, *ca.* 0.0026 m. in diameter. Designed to let water out at a slow steady rate, this aperture gives a clear indication of the mechanics of the device. The tank would simply be filled with water at the beginning of the day and as the level of the water fell slowly the passing hours would be recorded by means of some flotation system (Fig. 5).⁸

The construction of the Oropos tank shows a surprising degree of sophistication in the planning of the clock and serves to confirm the interpretation presented above. Left to its own devices, water running out of a straight-walled tank through a fixed aperture will escape at a decreasing rate, due to the lessening pressure. Thus, in the first hour more water will run out than in the last. And if the vertical drop is being measured to show the passing time then the scale used to record that drop will have to be calibrated at uneven intervals to reflect the irregular rate of flow. In order to lessen this disparity in the hour markings of the scale, the designer of the Oropos klepsydra devised the following solution. The upper part of the tank has walls that slope outwards. At the preserved top the tank measures 0.84 m. square, whereas at a point *ca.* 0.75 m. below the top it has decreased to 0.75 m., from which point to bottom the walls are approximately vertical. Thus more water would escape within the first hour under high pressure, but the vertical drop—that which was measured on a scale—would be close to that of the last hour, when less water would be escaping under the decreased pressure.⁹

Thus the nature of the outlet and the construction of the walls of the tank both suggest that the Oropos clock is essentially a large-scale out-flow klepsydra. As noted above, this would seem to serve also as a valid parallel for the Agora device in its initial phase. If so, then it can also be argued that any features of the Agora clock not found at Oropos should in all probability be assigned to the second period. In addition to the added, larger outlet already described above, these differences include a reworking of the interior walls of the tank, a general waterproofing of the service area, two reservoirs set high up above the central tank, and the addition of an overflow pipe along the front (north) face of the tank.

⁸ The lack of firm evidence permits considerable speculation and a variety of systems could be proposed with equal probability. The one shown in Figure 5 is given *exempli gratia*. The thick plaster molding at the bottom of the Agora tank (Pl. 42:a) was perhaps designed to accommodate the float.

⁹ A conical or pyramidal container, truncated so that approximately the upper twenty percent is used, whose sides are at an angle of seventy degrees to the horizontal, will emit water through a small fixed aperture near the bottom at such a rate that the level decreases very nearly uniformly with time. A limestone out-flow klepsydra found at Karnak, Egypt dating to *ca.* 1400 B.C. has sides with this 70° slope. See L. Borchardt, *Die altägyptische Zeitmessung*, B, *Zeitmessung und Uhren*, Leipzig 1926.

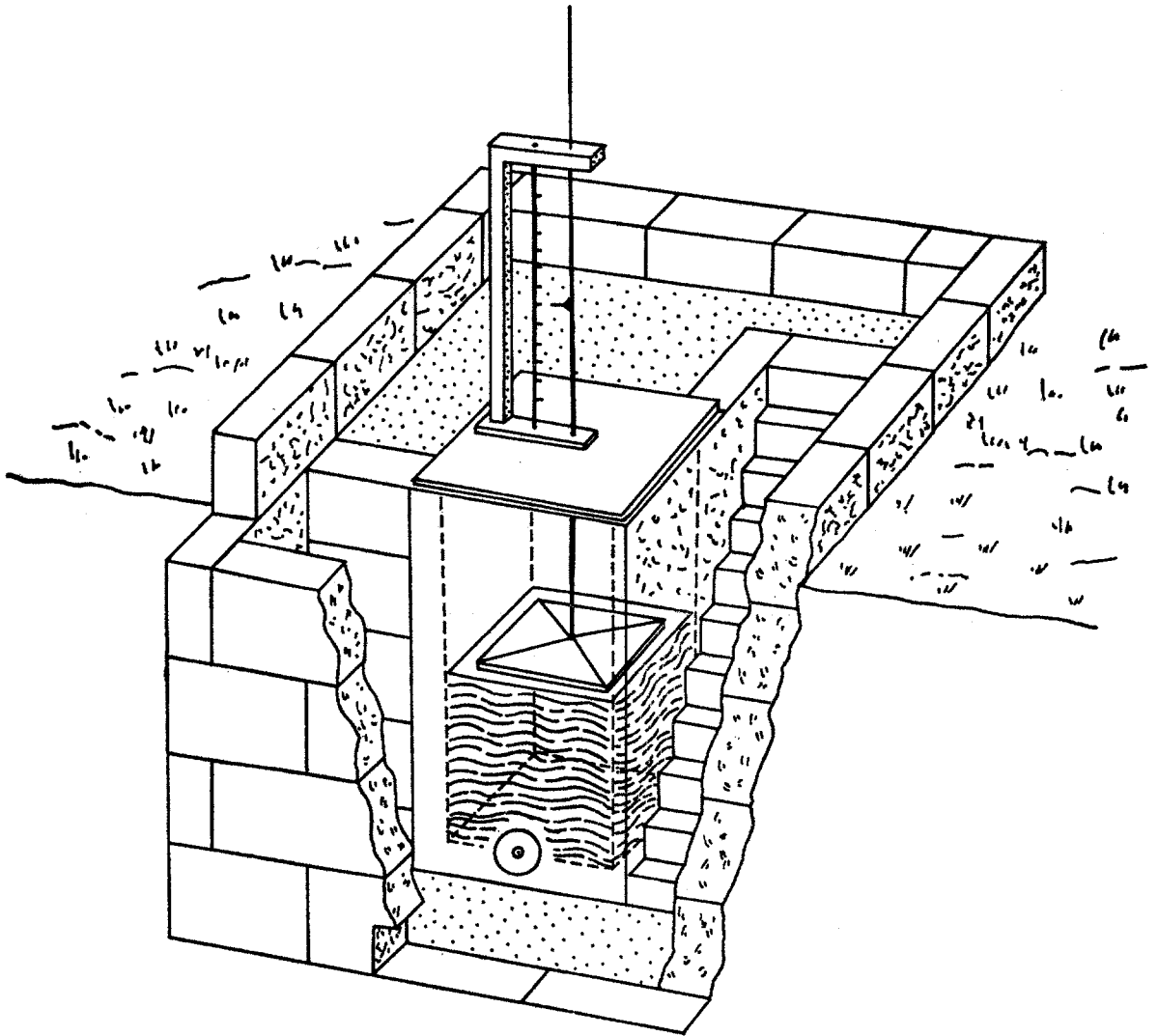


FIG. 5. Restored drawing of an out-flow klepsydra, based on the remains in the Agora and at Oropos. Adapted from a drawing by Marilyn Bagley.

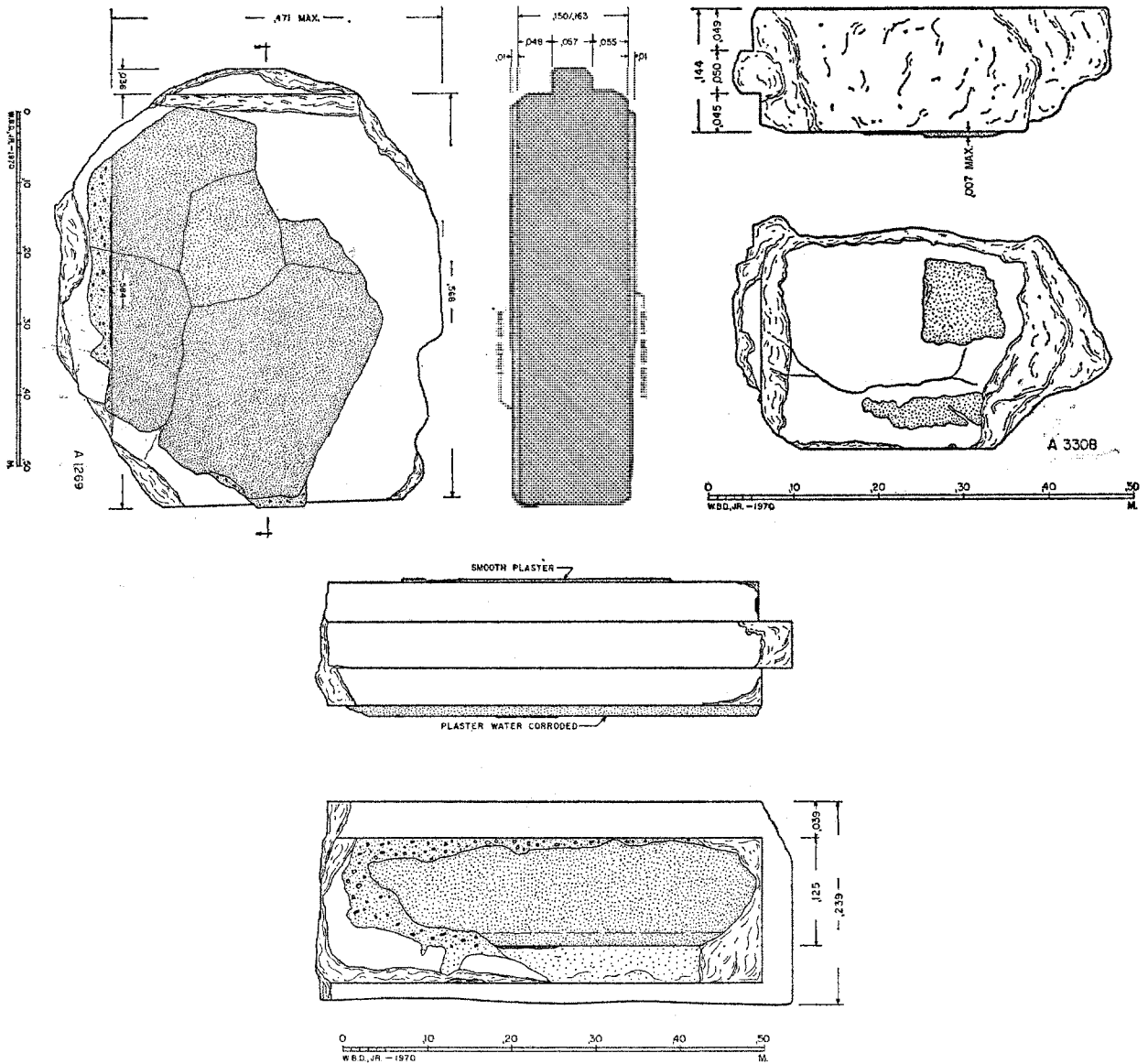


FIG. 6. Blocks from the upper reservoirs of the Agora water clock (see footnote 10).

The layer of waterproofing in the interior of the tank is far thicker (0.03-0.06 m.) than the fine coat within the tank at Oropos. Of particular interest is the fact that the original face was cut back by means of heavy scoring, which reaches a depth of 0.06 m. in places. This is exceedingly crudely done, and the resultant surface is far rougher than on any other part of the structure, even those surfaces left rough picked and not intended to be seen (Pl. 42:a).

The service area immediately to the north of the main tank has been covered with a thin layer of hydraulic cement throughout, at least to a height of 0.45 m. The southeast corner shows a high concentration of water deposit on the walls.

Above the main tank there are traces of two reservoirs. Both are poorly preserved, with only the lower parts of the southern ends *in situ*, coated inside with hydraulic cement (Pl. 41:a, Figs. 3, 6). Immediately to the south of the main tank is a reservoir measuring 1.80 m. east-west, preserved to a height of *ca.* 0.45 m., with some 0.30 m. left of its north-south dimension. To the east, immediately adjacent, is a second reservoir, measuring 1.30 m. east-west, preserved for 0.30 m. north-south, and 0.45 m. deep. The floors of these two reservoirs are at the same level, and they are divided by a party wall *ca.* 0.15 m. thick. The material used is a fossiliferous poros, clearly different from the hard, yellow limestone of the central tank.¹⁰

Evidence for the vertical overflow pipe survives in the imprint of its curve preserved in the hydraulic cement on the outer face of the central tank, passing just to the east of the earlier outlet (Pl. 42:a).

All these elements, and particularly the rebuilt outlet and the added reservoirs, represent substantial additions to the Agora device and presumably indicate an extensive modification of the original structure. A clue to the nature of its new design is provided by the outlet pipe, still *in situ*, and this in turn may help to explain the other new features. As noted, this outlet is appreciably larger (0.016 m.) than the one at Oropos (0.0026 m.) and, by analogy, than the presumed outlet of the first phase of the Agora device. It would appear as though there were no attempt to control the flow through this second outlet and that, in fact, it served only as a means of emptying the tank swiftly.¹¹ If this hypothesis is correct, then there was no provision at the bottom of the tank for controlling the out-flow. This in turn implies a radical shift

¹⁰ Three additional blocks apparently from the reservoirs were found in the area (Fig. 6). A 1269 (P.L. 0.60 m.; P.H. 0.53 m.; Th. 0.15 m.), A 2438 (P.L. 0.57 m.; H. 0.24 m.; Th. 0.145 m.), A 3308 (P.L. 0.43 m.; P.H. 0.28 m.; Th. 0.145 m.). All three are of fossiliferous poros, tan to light brown in color. They preserve tenons for tongue-and-groove jointing, and the faces are covered with a thin layer of hydraulic cement, often overlaid with water deposit. The fact that they are of a clearly different stone from that used in the central tank might perhaps be regarded as an indication that they are of a different date, presumably later.

¹¹ Computations based on working models suggest that the full Agora tank would drain completely within 40 minutes through the large aperture of the second period. By contrast, the slightly smaller tank at Oropos with its small aperture would require over 17 hours to empty.

in the mechanics of the device. In the first period water was let out at a steady rate, with the water level dropping slowly. This arrangement now seems precluded for the second period and we are led to believe that some new system was in force. As the tank clearly remained in use, the most probable explanation is that time was measured by filling the tank rather than by emptying it. The same flotation system could be used, only now operating on the principle of a rising water level rather than a falling one. The evidence that this is the correct explanation for the various changes is, first, the fact that the outlet pipe has become nothing more than a well-built drain, apparently designed only to empty the filled tank quickly and not equipped to control the out-flow. Secondly, it is at this time that the upper reservoirs come into play. They would serve no function in the original phase, nor do they appear at Oropos; at that time the tank could be filled at the beginning of each day simply by diverting water from a nearby aqueduct.¹² In the second period, however, at least one reservoir would be required to supply water at the top of the tank. The actual flow of water could then be regulated as the water passed from the reservoir into the central tank. The reservoir immediately to the south of the main tank would be kept overflowing in order to insure a steady flow and thereby prevent fluctuations caused by varying water pressure. This, then, will explain also the addition of the overflow pipe on the outside of the central tank, as well as the cutting back of the inner walls of the tank. With this proposed change, the flaring walls at Oropos—postulated also for the initial phase of the Agora device—designed to compensate for the decreasing pressure as water escaped, would be obsolete. With the newly installed supply reservoirs, the water level in the central tank would rise at a constant rate, and in order to register properly on an evenly calibrated scale the walls of that tank should accordingly be vertical. The lower walls of the tank were apparently cut far back, in order to conform to the larger dimension of the upper part of the tank.

The function of the second reservoir, to the east, is less clear. It was presumably instrumental either in ensuring a steady supply of water, or in collecting and carrying off the overflow. One of its functions might well have been to serve as a settling basin, to ensure that small particles did not reach the supply reservoir and clog the aperture between reservoir and collecting tank.¹³ In addition, the heavy water deposit at the east end of the service area indicates a fair volume of water flowing over the vertical faces at this point, perhaps suggesting that overflow from the eastern reservoir served as a small fountain of some sort.

¹² Such an aqueduct was reported by the excavator at Oropos ('Αρχ. Έφ., 1916, p. 119), and mention has already been made of the aqueduct near the Agora clock (footnote 2 above).

¹³ The danger of grime clogging the outlet in the initial phase is apparently the explanation for the setting of the outlet holes some 0.20 m. above the floor at both Athens and Oropos. The tank could be filled and the silt allowed to settle to the bottom before the device was started each morning. See also Vitruvius, *De Arch.* IX. 8. 4 on the problem of keeping the aperture clear.

Despite this uncertainty, the basic outline seems clear. Water was kept flowing into the reservoirs at the upper levels and would have been let through a controlled outlet into the collecting tank, with the rising water level in this lower tank recorded in some way to show the passing time. At the end of the day the water collected in the tank would be let out through the large outlet pipe still *in situ* at the bottom of the tank.¹⁴

It might be well at this juncture to digress briefly and consider the nature of time-keeping in antiquity, as this has some bearing on our interpretation of the remodeling of the Agora clock. Time was kept in temporal hours, which is to say that there were twelve equal units of time during the period of sunlight of each day; this in effect means shorter hours in winter and longer ones in summer.¹⁵ Frequent adjustment was therefore necessary in the time-keeping devices. In a simple out-flow klepsydra one must change the scales frequently to account for the changing lengths of the temporal hours. With the change to an in-flow clock, however, there is an alternate solution. Rather than changing scales, one can have a fixed scale and adjust the flow-rate, so that less water flows in summer and more in winter. Done properly, this method is more efficient and provides greater accuracy than that of the out-flow klepsydra. In addition, the fixed scale would permit a ready means of attaching mechanisms designed to sound the hours. This attractive innovation—not feasible with the changing scales of the out-flow device—may well have been a primary motivation for such extensive modifications.¹⁶

¹⁴ The lack of any trace of a channel joining the outlet of the tank with the overflow channel across the service area is a bit puzzling. As it now stands, it would seem as though the large flow when the plug was pulled would flood the lower part of the service area, at least until the water drained away. This, in fact, may be the explanation for the waterproofing of the area, though it seems to be a great deal of unnecessary work and the waterproofing might better be explained by the heavy flow of water (fountain?) noted in the east end of the service area.

In the first phase, no channel across the service area would be needed. As noted, the apertures at both Oropos and Athens align with the drain and the water pressure through the tiny aperture would throw the water across the service area directly into the drain in a powerful jet that would not touch the floor until the final minutes of the day.

¹⁵ Ancient sources referring to the varying lengths of hours: Aineias Taktikos, XXII. 24-25; Pliny *Nat. Hist.* VII. 215 (DXCV), and Vitruvius, *De Arch.* IX. 8. 7.

In Athens during the winter solstice of 1974 the sun rose at 7:38 a. m. and set at 5:09 p. m. a total of 9 equinoctial hours and 31 minutes of sunlight; that is, a temporal hour of 47 minutes, 35 seconds. On the summer solstice the sun rose at 5:02 a. m. and set at 7:51 p. m., a total of 14 equinoctial hours and 49 minutes of sunlight; that is, a temporal hour of 74 minutes, 5 seconds. In this connection it is interesting to note that the Oropos clock had a capacity of close to 1,000 liters, far more than would escape during twelve (equinoctial) hours. This additional capacity was presumably intended in part to lessen the disparity in the flow-rate caused by decreasing water pressure (above, p. 154), but it would also serve to provide enough water to measure the longest day of the year.

¹⁶ We can only speculate as to the appearance and workings of such mechanisms, but see Vitruvius, *De Arch.* IX. 8. 5, for a description of various sounding devices which could be hooked up to an in-flow clock.

The state of preservation does not permit us to speak with any assurance of the type of scale used to indicate passing time in the Agora or Oropos devices. But the evidence presented above can be used to show that an attempt was made to control the rate of flow in the second period of the Agora clock. No such control would be possible in the first period; the tiny outlet would not permit adjustment of the fine nature required here, and decreasing water pressure within the tank would call for constant regulation. By making the tank a collecting basin rather than by emptying it, however, the flow-rate could be adjusted according to the season. A control mechanism would be installed where water was let from the reservoir into the main tank, and by keeping the reservoir overflowing there would be no fluctuation due to changing water pressure. In short, this restoration explains both the large outlet at the bottom—with no provision for controlling the flow—as well as the addition of at least one of the added reservoirs, essential for a controlled in-flow clock. Other lesser changes can also be explained in terms of this new scheme.

A further bit of evidence for this restoration should be noted. In his *De Architectura*, Vitruvius credits one Ktesibios of Alexandria with the invention of the water clock.¹⁷ Ktesibios, the son of a barber, lived in all probability in the 3rd century B.C., with a *floruit* of ca. 280-230 B.C.¹⁸ Clearly Vitruvius is not crediting him with the invention of the simple out-flow klepsydra; such devices were known on a small scale as early as the 14th century B.C. in Egypt and by the late 5th century in Athens.¹⁹ In addition, both the Agora and Oropos devices predate Ktesibios. Rather, specific improvements are claimed for him, in particular the invention of the in-flow concept, devices to control the rate of flow, and more sophisticated scales with which to register the hours. Vitruvius' remarks on control mechanisms are of some interest:

Praeclusiones aquarum ad temperandum ita sunt constitutae. Metae fiunt duae, una solida, una cava, ex torno ita perfectae, ut alia in aliam inire convenireque

¹⁷ *De Arch.* IX. 8. 2: Item sunt ex aqua conquisitae ab eisdem scriptoribus horologiorum rationes, primumque a Ctesibio Alexandrino. . . .

De Arch. IX. 8. 4: Item aquarum expressiones automatopoetasque machinas multaque delicia- rum genera, in his etiam horologiorum ex aqua comparationes explicuit.

¹⁸ For an introduction to Ktesibios and his contributions: A. G. Drachmann, *Ktesibios, Philon, and Hieron*, Copenhagen 1948, pp. 1-3, 16-21. For the date of Ktesibios: A. G. Drachmann, "On the Alleged Second Ktesibios," *Centaurus* 2, 1950, pp. 1-9. For a more extensive treatment of Ktesibios' contribution to the development of the water clock: Joe E. Armstrong, *The Water Clocks of Ktesibios: Their Origins and Reconstructions*, Master's Thesis, California State University at San Jose, 1974. For Egyptian influence on Greek time-keeping at about this period, see also S. West, "Cultural Interchange over a Water-clock," *ClassQuart* 23, 1973, pp. 61-64.

¹⁹ S. Young, "An Athenian Clepsydra," *Hesperia* 8, 1939, pp. 275-284. The earliest reference to the use of a klepsydra in the lawcourts is in the *Acharnians* of Aristophanes (425/4 B.C.), line 693. See also Athenaeus, *Deipnosophistae* IV. 174. C, for a clock devised by Plato for use at night which was essentially a large-scale klepsydra. For the Karnak device, see above, footnote 9.

possit et eadem regula laxatio earum aut coartatio efficiat aut vehementem aut lenem in ea vasa aquae influentem cursum. Ita his rationibus et machinatione ex aqua componunter horologiorum ad hibernum usum conlocationes. (IX. 8. 6)

“ To regulate the supply of water, stopcocks are thus formed. Two cones are made, one solid, one hollow, and so finished by the lathe that one can enter and fit the other; the same rod, by loosening or tightening them, produces a strong or gentle current of water flowing into the vessels. Hence by this methodical contrivance, water-clocks are set up for use in the winter.” (Granger trans.)

In short, Vitruvius is describing a valve designed to control the rate of flow so that more water could be let out to indicate the shorter temporal hours of winter, as opposed to the longer ones of summer which would require a slower flow (see footnote 15). As noted, we are not in a position to discuss in any great detail the scales of the Agora clock, but we have seen reason to believe that the device was modified in such a way as to permit an adjustable rate of flow. Nesting cones, of the sort described above, could well have been installed at the bottom of the supply reservoir, where the water ran into the central tank. Substantial structural changes were carried out on the Agora clock, and it is perhaps not coincidental that these modifications can best be understood as reflecting technical advances made in time-keeping devices at about this time.

The history of the Agora clock can be summarized as follows: the device was built at the end of the 4th century B.C., a simple monumental out-flow klepsydra which can best be understood by comparison with the better-preserved example at Oropos. Technical advances made in Alexandria in the 3rd century rendered the clock old-fashioned, if not obsolete, and the structure underwent a major renovation, designed to keep pace with new methods of controlling the rate of flow. This modification cannot be dated precisely, but some time in the 3rd century seems plausible.²⁰ The device was finally put out of use in the early 2nd century B.C. by the construction of the great Hellenistic Middle Stoa, a project which radically altered the appearance and very nature of the Agora square, thereby ruining the splendid location occupied for over a century by the Agora water clock.

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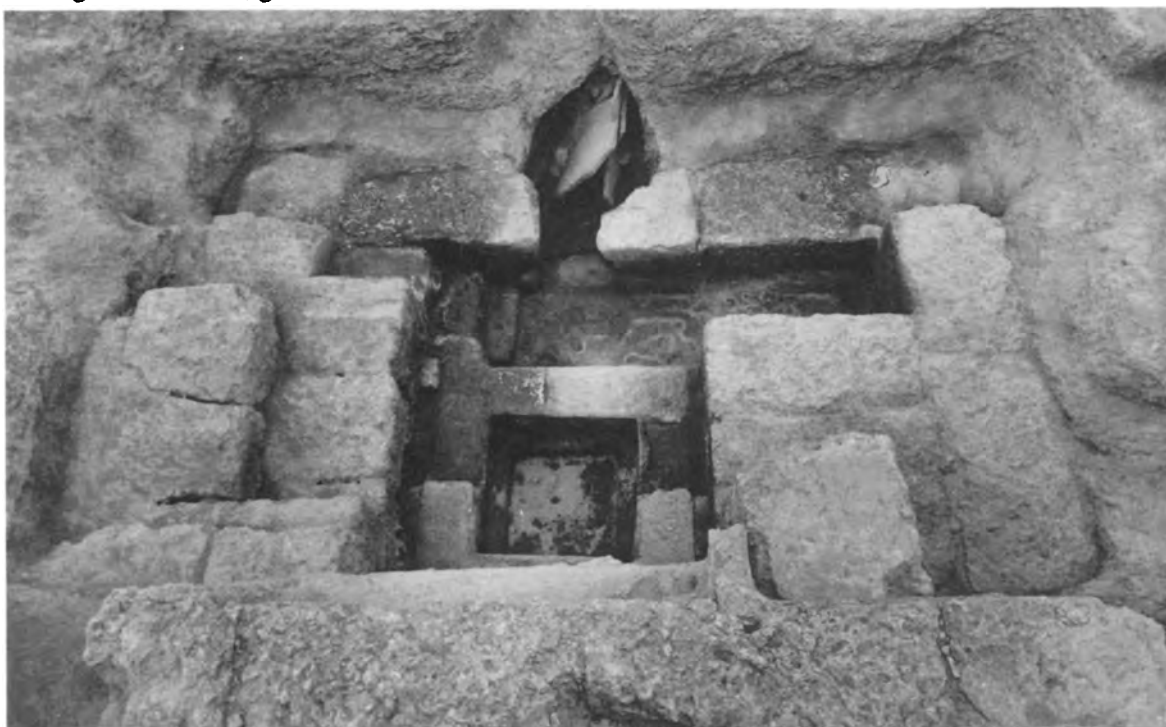
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ATHENIAN AGORA EXCAVATIONS

²⁰ Adjustments or repairs to the drain channel at the north were reported in subsequent excavations by D. B. Thompson. Though a more precise date is not possible, these were dated to some time within the 3rd century B.C.



a. Agora water clock, general view from north



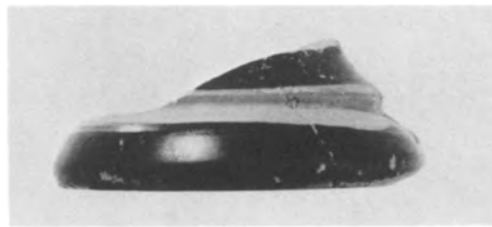
b. Agora water clock, general view from south



a. Agora water clock, detail of tank, from north



b. P 23099



c. P 23100



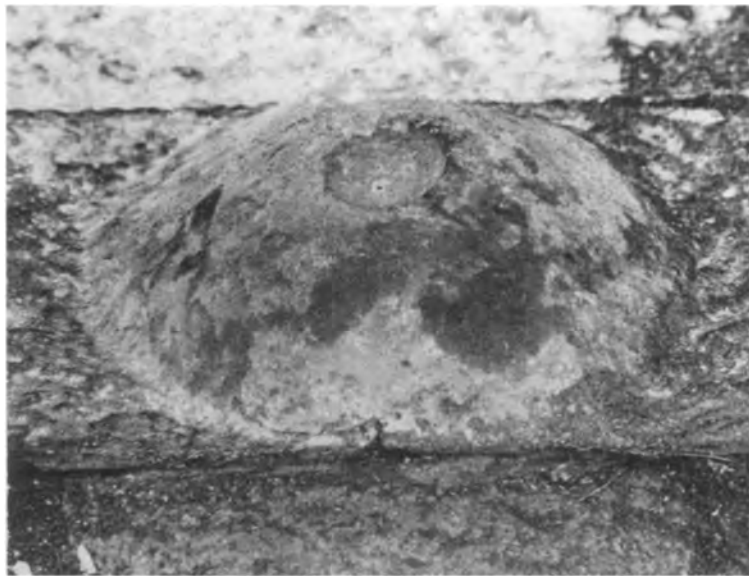
a. Oropos water clock, general view from west



b. Oropos water clock, general view from south



a. Agora water clock, detail of outlets



b. Oropos water clock, detail of outlet