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Early Artillery Towers:
Messenia, Boiotia, Attica, Megarid*

JOSIAH OBER

Abstract

The invention of the catapult in 399 B.C. precipitated revolutionary changes in Greek military architecture. Towers were built higher and were provided with upper chambers characterized by the presence of windows often flanked by chases to hold hinged shutters. Comparative study of tower architecture yields more accurate restorations and revised chronologies for fortified sites and helps to define the function of isolated towers. Architectural features of relatively well-preserved and securely dated Theban towers at Messene (369 B.C.) and Siphai (370-362 B.C.) provide models for restoring and dating Athenian-built towers in Attica and the Megarid.

The Athenian and Theban towers reflect a developing architectural tradition; they were designed to house relatively small, anti-personnel catapults, probably of non-torsion design. They predate towers which housed large, torsion, stone-throwing catapults (e.g., at Latmian Herakleia, ca. 297 B.C.). Analysis of shuttering systems of preserved artillery towers suggests that the shutters (thyrides katakakoi) used on windows in the parapet of the Athenian city wall of 307/306 (IG II², 463), like those used at several Athenian and Theban sites, were bottom-hung.

INTRODUCTION

In 1922 F. Krischen's study of the fortifications of Latmian Herakleia laid the foundations for an assessment of the revolution in military architecture spurred by the availability of catapults as offensive and defensive weapons. Major advances came in 1969-1971 with E.W. Marsden's two volumes on Greek and Roman artillery. The tower restorations proposed in these works are still valuable, but they can be considerably augmented and in many cases corrected in light of recent developments in the study of military architecture and by comparative analysis of preserved towers.¹ A better understanding of the architecture of catapult towers allows us to restore elevations more accurately, to date circuits more closely, to gauge the pace of the diffusion of catapult technology, and to form reasonable hypotheses about the function of isolated towers. Here I propose to deal only with "first-generation" catapult towers: those designed to house and to defend against anti-personnel catapults, mostly, if not entirely, of the non-torsion type.

The non-torsion catapult, or gastraphetes ("belly-bow": see fig. 1), invented by engineers in the employ of Dionysios of Syracuse in 399 B.C., was similar in principle to a Mediaeval crossbow. The propulsive power was provided by a laminate bow mounted horizontally on a long wooden stock. The earliest catapults were probably small enough to be hand-held. In advanced non-torsion catapults, the type likely to have been used in the towers considered here, the bow (b) was cocked by attaching the bowstring to a trigger mechanism (c) mounted on a slider bar (a) which was pulled back by means of a winch (d) at the rear end of the stock. The trigger mechanism held the bowstring in cocked position until the operator released it to fire the catapult. The stock was attached to a stand (f) by a universal joint (e) so that an operator standing behind the weapon could aim it by pivoting the stock up and down and back and forth.²

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¹ BHL; GRA 1-II.
² On the invention and development of the non-torsion catapult, see GRA I, 5-16, 48-56; W. Soedel and V. Foley, "Ancient Catapults," Scientific American (March 1979) 150; RPG 212-13.
Non-torsion catapults were made in a variety of sizes; the power of the machine was a function of the length and thickness of the bow. The length of the stock of different models varied in relation to the size of the bow (see Table 2). The towers considered below could have accommodated catapults with bows ranging in length from roughly 1.2–2.8 m.—or 4–9 Greek ft. (I have employed the medium-length foot of 0.3083 m., used by Marsden)—and stocks from about 1.4–3.2 m. in length. Such weapons would be capable of shooting bolts or relatively small stones to an effective range of 200–300 m.³

Torsion catapults, utilizing springs of twisted hair or sinew, were a somewhat later development. Probably invented by Macedonian engineers in the 340s, torsion catapults, like non-torsion machines, were presumably first used against personnel. By the late 330s, catapults capable of hurling stones large enough to destroy city walls had been developed; it is uncertain whether these were huge non-torsion machines or advanced palintone torsion engines. By the end of the fourth century, very powerful torsion stone-throwers had become standard equipment in the siege-trains of the Diadochoi.⁴ Towers built to accommodate and defend against heavy stone-throwing artillery may, therefore, be designated “second-generation” artillery emplacements.

A distinguishing feature of most towers designed to house catapults is the presence of large, usually rectangular, embrasures in the topmost chamber. Archers, who had presumably provided the primary firepower in towers before the catapult age—and who continued to be employed as the secondary armament of catapult towers—were able to shoot arrows through narrow slits which flared on the inside of the tower wall.⁵ An archer could easily achieve the desired range and latitude of fire by moving his bow up and down and from side to side. It was difficult for enemy archers to return fire back through the arrow slits, which are typically only about 0.08 m. wide on the outside. Arrow slits therefore allowed tower defenders to shoot at the enemy in relative security. Arrow slits

³ The stock to bow ratio of ca. 1.15:1, used in the double-bolt catapult designed by Zopyros and described by Biton (W 61–64: GRA II, 74–77 with diagram 5), may have been used in the catapults in many of the towers described below. On non-torsion catapult ranges, see GRA I, 12, 15.


⁵ Unfortunately, although towers are used on the earliest Greek fortifications, no tower of the pre-catapult age is sufficiently well preserved to allow a satisfactory restoration of its superstructure. We may guess that the earliest towers would have been solid bastions with a fighting platform roof, but by the late seventh century it appears that towers were being constructed with chambers for watchmen and archers. See GAP 376–81.
were, however, too narrow to permit a catapult operator to swing the stock of his machine from side to side on its stand. Only the provision of much wider embrasures—windows—would allow stand-mounted catapults inside a tower to achieve an adequate lateral range of fire.  

Unless they were very high off the ground, open windows had the disadvantage of exposing defenders to enemy missiles. Hence, tower windows were often protected by side or bottom-hung shutters attached to the outside of the tower wall. The shutters swung on pairs of hinges attached to bolts which were let into chases, typically about 0.1 m², through the tower wall and located beside or below the window (see below, figs. 8, 11). No examples of shutter hinges are preserved, but the chases which held them can be seen in a number of catapult towers. The presence of chases cut in tower blocks allows restoration of a window, even if the masonry courses in which the window once opened have fallen.  

HISTORICAL BACKGROUND  

It is unlikely that towers especially designed to house artillery pieces were built on the Greek mainland before the second quarter of the fourth century B.C., since at least some time must have elapsed between the invention of the catapult in 399 and the diffusion of catapult technology outside Sicily. Catapults were originally developed as siege equipment; their potential as defensive weapons may not have been immediately appreciated. However, early catapults could not shoot stones large enough to knock down a well-built wall and their use as siege weapons was therefore limited to anti-personnel fire. The heavy machines were difficult to transport and were relatively fragile, which made them inefficient as field artillery. None of these factors limited their usefulness as defensive weapons and the fact that a catapult’s range was increased by placing it in an elevated position naturally led to the employment of catapults in towers.  

The first recorded defensive use of catapults is in 340 B.C., by the citizens of Perinthos, who had borrowed the machines from Byzantium (Diod. 16.74.5), but there is reason to believe that the Athenians and Thebans had been using catapults to defend fortified places well before this date. An inscription from the Athenian Acropolis (IG II² 1422, line 9) indicates that the Athenians possessed stores of catapult bolts, and therefore presumably catapults, by 371/370. Given the Athenian interest in defense during the early and mid-fourth century, it is reasonable to suppose that catapults would have been installed in defensive positions as soon as they were available. In the 360s Thebes was the most powerful polis in Greece and was involved in a major fortification-building program. It seems safe to assume that the Thebans, in the forefront of military developments since the early 370s and allied with Athens from 378 to 371, would have been quick to take advantage of the defensive potential of catapults. It is likely, then, that leading mainland states were using catapults in fortifications by the third quarter of the fourth century, but probably not much before this date.  

A reasonable historical terminus post quem non for first-generation catapult towers is the last quarter of the fourth century B.C., by which time the danger to fortification walls posed by more powerful stone-throwing catapults, dramatically demonstrated by bolts (IG II² 1469B, column i, lines 77–80: 321/320 B.C.; cf. RPG 216 with n. 1; GRA I, 68) stored in the Khalkotheke on the Acropolis. Surely these were military stores, not dedications, and by analogy, it is likely that the two boxes of bolts mentioned in the Acropolis inventory IG II², 1422 were also military stores. On fourth-century Athenian concern with defense, see FA passim.  

On the fortifications of southern Boiotia, see J. Buckler, The Theban Hegemony: 371–302 B.C. (Cambridge, Mass. 1980) 22 with n. 19 (bibliography). A full account of this system is forthcoming from J. M. Fossey; cf. his note in BSA 65 (1970) 261 n. 38. Winter, GF 165, assumes that artillery was used by defenders only “from about 350 onward,” but notes (156 n. 17, 165–67) that in the Hellenistic period artillery was generally more useful for defense than offense. Aineas the Tactician, probably an Arkadian mercenary captain, who wrote a manual “on the defense of fortified positions” in about the middle of the fourth century B.C., mentions catapults only once (32.8), in a list of large machines which might be neutralized if defenders could cause them to fall into pits.
Alexander's siege of Tyre in 332, must have been fully appreciated by leading Greek military architects. Architects of second-generation artillery towers often employed thicker walls, especially for very tall towers; windows were sometimes considerably larger to accommodate the larger torsion machines, and masonry was often much more elaborate. Hence, historical probability suggests a span of not much more than half a century (ca. 375-325 B.C.) for the origination and development of first-generation catapult towers; it remains to be seen whether the existing remains can be reasonably fitted into such a relatively narrow chronological framework.

The existing remains of Theban and Athenian towers—the focus of discussion here—provide a full range of examples illustrative of what appears to be a developing architectural tradition. Theban and Athenian military architects appear to have been at the leading edge of tower design in the earlier fourth century, although towers in Phokis and Aitolia, which display notable similarities to the Theban and Athenian examples, may well be contemporary with those examples.

THE TOWERS

Messene, Tower N (figs. 2–3, 30A)

The great circuit at Messene was built under the direction of Epaminondas of Thebes soon after Spartan military power had been shattered at the battle of Leuktra in 371 B.C. The building of the walls of Messene was one of the major feats of fourth-century military architecture; Epaminondas intended the new city to be an impregnable bastion to preserve Messenian independence, which would ensure Spartan weakness. Work on the circuit began in 369 and, according to Diodorus Siculus (16.66.1, 67.1), was completed within a single season's work. I believe the existing walls and towers were built during the original Epaminondean fortification program and so provide a securely dated example of state-of-the-art mil-
tary architecture of the early second quarter of the fourth century. Windows certainly intended for catapults are preserved in several towers at Messene; I concentrate on two particularly well-preserved towers, “N” and “L” (the letters refer to Blouet’s plan) on the west and north walls of the circuit, respectively.

Tower N is an excellent example of an early catapult tower. Some of the experimental features of the tower were not used in subsequent projects; other features became canonical. Tower N faces west, commanding a very steep and difficult approach (fig. 2). Standing 9 m. high, it consists of a single chamber mounted by a fighting platform, on a solid base (3.6 m. high). The masonry of the tower and of the curtain wall to which it bonds, is isodomic trapezoidal, with occasional use of rabbeting (fig. 3A). Externally the

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14 The date of the circuit at Messene has been often debated. There were certainly Roman repairs to the Arkadian gate. A Hellenistic date for the entire circuit was suggested by, for example, G. Säflund, “The Dating of Ancient Fortifications in Southern Italy and Greece,” *OpusArch* 1 (1935) 99, and E. Kirsten; see especially the summary of his argument in *AA* 1964, 906–10. Kirsten and Säflund’s support of the late date was, however, conditioned by their erroneous notion of the nature of fourth-century fortifications (cf. the refutation of Säflund’s late date for the fortress at Phyle: infra n. 53). An Epaminondean date for the entire circuit was suggested by Winter, *GF* 165 n. 46; and independently by Marsden, *GRA* I, 127–31. Other writers took a *non liquet* stand: *GMI* II, 98 with n. 151; *RPG* 189 n. 6. More recently, E. Meyer (*RE* Suppl. 15 [1978] s.v. Messene) has demonstrated on historical grounds that there is no period in Messenian history other than the Epaminondean foundation of the city to which the main line of the fortifications can possibly be assigned. His conclusion, that “Man muss auch die Datierung des Mauerrings in die Jahre nach 369 v. Chr. als so gut wie dichter aussehen” seems to me irrefutable. Lawrence (*GAF* 384) argues that there is no reason to suppose a Hellenistic rebuilding of any part of the circuit and that the existing walls and towers are Epaminondean. In light of the complete absence of evidence for rebuilding on the north wall east of the Arkadian gate, this is, I believe, the soundest assessment.

15 Cf. A. Blouet, *Expedition scientifique de Morée* (Paris 1831) pl. 22 (general plan of the site), pl. 39 (elevation and plan of Tower N), p. 37; *GRA* I, 126–30, 156 diagram 4; *GF* figs. 143, 165–66, 190; *GAF* 382, 403–404; *AMG* pls. 61, 78, 144, fig. 16 (= *RPG* 195 fig. 7); *GMI* pl. 4.9.
The chamber are 0.58 thick. Entry to the chamber was through two side doors from the wall walk (parodos: fig. 3D). The wall walk itself was protected by a crenellated parapet; it was therefore possible for defenders to enter and leave the tower without exposing themselves to enemy fire. Archers and/or javelin throwers standing behind the parapet could help the tower garrison to repel enemy assaults.

The tower windows, two in the front and one in each side wall, are pentagonal and resemble enlarged arrow slits. The windows splay on the inside, measuring an average of 0.74 internally, 0.37 externally. The front windows are splayed on both sides, as is invariably the case with archer slits, but the two side windows are flared only at their rear sides.

The chamber could accommodate three catapults mounted on stands (fig. 3D) or four hand-held catapults. If stand-mounted, two machines would be located at the two front windows and would fire through these windows only. Thus the machines could be placed quite close to the windows, lessening the disadvantage which the fairly narrow openings posed in limiting the lateral range of fire. The bows could not have been longer than 6 ft. (1.8 m.), since longer bows would have fouled one another as the stocks were swung from side to side.

A third stand-mounted catapult may have been placed in the center rear of the chamber, a position which would allow the stock of the machine to be swung from side to side in order to fire through either of the two side windows. Although the center catapult would have had a limited range of fire, this arrangement may explain why the side windows were "half-splayed"—the rear sides of the windows were flared at precisely the proper angle for projectiles from the third catapult to pass through the wall; flaring the front sides of the side wall windows would have served no purpose since stand-mounted catapults could not be positioned to fire at a reverse angle. The third catapult's stock could not have been much over 2 m. in length; a longer stock would not have cleared the back wall as the machine was swung from window to window. Since it is reasonable to suppose that three stand-mounted catapults in the chamber would have been about the same size, the bow-size limitation of the front catapults and the stock-size limitation of the rear catapult suggest that the proportion of stock to bow size used in Zopyros's double-bolt gastraphetes (ca. 1.15:1, see supra n. 3) may have been employed in catapults of the second quarter of the fourth century.

The pentagonal window, which appears to be found only in the towers of the west wall of Messene and at Aitolian Khalkis, was probably directly adapted from the arrow slit. The windows average 0.88 high; the pointed tops were apparently designed to facilitate aiming the machines and/or to allow the catapult stocks to be tilted upwards at a sharper angle, which would increase the range. The bottoms of the windows are 1.0 above the floor. The centers of the windows are only 5 m. above external ground level, but the ground slopes away sharply, improving the range of fire. The windows did not have hinged shutters, but the relatively narrow embrasures would not have exposed the defenders to much danger from enemy fire. Removable wooden panels could have been used to close the windows against the elements when necessary.

The roof of the tower served as a fighting platform (fig. 3C). The platform floor was supported on 11 closely-spaced joists (fig. 3B), each 0.18 wide, which ran back to front. The joists were reinforced at about midpoint by a cross brace. The joists extended through the back wall of the tower (fig. 3C) to allow adequate drainage of the roof, which slanted back at a 10° angle. If the rear wall joist holes had not run through the wall, rainwater would collect in the joist holes and ultimately rot the ends of the joists. The front and sides of the fighting platform were protected by a crenellated parapet, similar to that which protected the wall walk. Access to the roof must have been by ladder from the ground at the back of the tower. A trapdoor from the tower chamber to the roof is unlikely, both because of the close placement of the joists (0.50 center to center) and because a trap would be likely to leak. The bows of the catapults could be damaged by exposure to moisture.17

Messene, Tower L (figs. 4–8, 30B)

The approaches to the north wall of the circuit (northeast of the Arkadian gate) are much easier than

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16 Blouet (supra n. 15) pl. 39, fig. IV, restores a more complicated support structure for the roof, employing a second cross brace running back-to-front below the one I have shown (which runs side-to-side). Blouet's scheme was adopted without comment by Marsden, GAF I, 156 diagram 4d; Lawrence, GAF 231, suggests a similar arrangement. The second cross brace, restored on the basis of a cutting on the inside front wall of the tower, seems to me to be unnecessary and the cutting is not, in my opinion, a joist hole. Several other cuttings, whose function is ambiguous, but which cannot possibly have been joint holes, may be seen inside the tower.

17 GRA I, 168; F.E. Winter, "Ikria and Katastegasma in the Walls of Athens," Phoenix 13 (1959) 188; both refer to torsion catapults, but the sinew in the laminated bows of non-torsion catapults was also sensitive to moisture. Hence, the bows were sometimes stored in leather cases (IG II², 1627B, lines 332–33).
those to the west wall (fig. 4). Tower L, the best-preserved tower on the north wall, presents a number of architectural differences from Tower N, most of which can be explained by the greater threat associated with the relatively level terrain. The tower, originally 12.5 m. high at the top of the gable, consists of two chambers above a solid base (6.6 high). The masonry of the tower and associated wall is strict isodomic ashlar (fig. 5A). The block faces of the tower base are almost square (avg. 0.60 x 0.60); the blocks of the chamber walls are longer, and the courses vary somewhat in thickness. The tower is externally ca. 6.9 m.². The walls of the lower chamber are 0.66 m. thick, and those of the upper chamber 0.48. One could enter the tower by a door in either side wall of the lower chamber (fig. 5B). The doors led to a wall walk protected by a parapet (probably crenellated), now mostly fallen. The relationship of doors to wall walk at L is similar to the arrangement at Tower N and typical of first-generation catapult towers which bond to circuit walls.

The lower chamber has two embrasures in the front and one on each side wall. The embrasures average 0.23 m. externally, splaying to 1.12 internally. They are 0.84 (two courses) high. The bottoms of the embrasures are 0.80 above the floor. The embrasures appear too wide and high, and the splay is too extreme, for arrow slits. These embrasures are very similar in height to those at Tower N (0.88). The embrasures at L, as at N, were presumably designed for catapult fire. Apparently the defense of the tower required more catapults than could be accommodated in the upper chamber, but the architect was unwilling to weaken the structural integrity of the tower or to expose the garrison to enemy fire by using rectangular windows in the walls of the lower chamber. This lower chamber probably housed two catapults.

The main armament of the tower was in the upper chamber (fig. 6). The floor was supported by the 0.08 m. setback of the walls on all sides, and undergirded by four joists, running east to west (0.29 x 0.27 in cross section; see fig. 7). Access to the upper chamber must have been by ladder and trapdoor from the lower chamber. The upper chamber was provided with two windows in the front and two in each side wall. The east front window measures 0.73 x 0.81; the others are similar in size. The window bottoms are 1.08 above the floor shelf, approximately 1.0 above the floor; the centers of the windows are 10.5 above outside ground level.

The rectangular windows would have facilitated aiming and firing the catapults, but it is not necessary to suppose that the machines themselves were larger than those used at Tower N. The embrasures at L and suggested that they were intended for catapults.

Lawrence (GAF 405) underestimated the window size at 0.70 x 0.50 m., which he considered "the maximum size favoured by experts in 368" (GAF 406). I owe my measurements to the rock-climbing skills of one of my students, Mark Langdon.
N are about the same height and the width of the upper chamber windows at L is virtually identical to the internal splay of the windows at N (see Table 1, infra p. 598). The upper chamber of L could have accommodated four stand-mounted catapults. The front windows and side windows are placed quite near the corners. Therefore, the two machines in the front of the chamber could be swung laterally on their stands to fire through either the front or the fore-side windows without moving the stands. The side windows of L afforded excellent enfilading fire along the circuit wall and toward the vulnerable Arkadian gate, but in order to allow a single machine to be aimed through both front and fore-side windows, it must have been necessary to position the stand somewhat back from the windows. This position restricted the lateral range of fire through any given embrasure and therefore it required wide windows; modified archer slits similar to those at N would have rendered the lateral range unacceptably narrow. The stocks of the machines could not have been much longer than 2 m.; longer stocks would have made it impossible to fire out the fore-side windows since the operators would not have had adequate room to stand behind their machines. If the bows were in Zopyros-gastraphetes proportion to the stock, the upper-chamber catapults would have been similar in size to the maximum size which could have been conveniently accommodated at N. Two more machines would have been placed to fire through the rear side windows. The superior elevation of the windows of Tower L, and the greater number of machines which could be accommodated in the two chambers, would help to compensate for the easy approaches to the tower.

The upper-chamber windows were protected by double-leaved, outward-opening, side-swinging shutters which were secured to the tower wall by bolts let into chases measuring 0.07 × 0.06 m. in cross section (fig. 8).21 Side-hung shutters offered advantages over

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21 Cf. GAF 414–15. Marsden (GRA I, 131) assumed that the shutters would open inwards, but this arrangement would have obstructed the interior of the tower and blocked the range of fire of the catapults. For a rare example of a Hellenistic tower with inward-swinging shutters, see Nicoll and Winikoff 318 with n. 19. As the authors point out, at the "Isian tower" the walls are sufficiently thick to allow the use of inward-swinging shutters without blocking the range of fire.
other hanging schemes: one leaf of a shutter could be opened for aiming and limited-range fire (fig. 8B) and the edges of the shutter overlapped all sides of the window, providing security against enemy projectiles, wind, and rain. However, the side-swinging shutters must have been difficult to swing open and shut rapidly, and could be blown closed at inopportune moments if not wedged securely. It is possible that the architect used domestic shutters as his model.

The window masonry at L is peculiar in that the lower parts of the windows are formed by rabbetted blocks (figs. 5A, 7). Lawrence has suggested, I believe rightly, that the architect was unfamiliar with window design and hoped the rabbetted blocks would give the structure greater stability.22 Side-swinging shutters do not occur at other first-generation catapult towers. Like Tower N with its unique pentagonal windows, Tower L was the result of experimentation with a relatively new architectural form.23

The architect of Tower L dispensed with the fighting platform and instead employed a gabled roof, which must have been easier to make watertight. The fighting platform at N allowed the defenders to fire upon enemy soldiers who approached close enough to the wall to be out of range of the catapults, which could not be depressed much below the horizontal.24 Presumably in the case of Tower L, and other fortifications at which gable-roofed towers were used, the designers felt that bolts fired laterally from neighboring towers, in conjunction with arrows or javelins shot by defenders on the wall walk, would provide adequate security against this particular threat.

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22 GAF 404.
23 Side-swinging shutters may have been used at Hellenistic Side, GAF 415–16.
24 GRA 1, 117–18.
is corroborated by a consideration of the architecture of two catapult towers: Tower 3 (the number is from Schwandner’s plan: his fig. 7) and the Sea Gate Tower.

Tower 3 is located on the north wall of the acropolis fortifications; in front of the tower the ground drops steeply making the approach to the tower very difficult (fig. 9).\(^{26}\) The situation is reminiscent of Tower N at Messene. Like Messene N, Siphai 3 consists of a solid base (5.5 m. high), a single chamber, and a fighting-platform roof. The tower currently stands to a maximum height of 9.6 m. above external ground level; I restore the original height to ca. 10 m. The masonry is isodomic trapezoidal (some courses are wider than others), with some use of rabbetting (figs. 9, 10A). External dimensions are 6.4 (east–west) x 5.4; wall thickness is 0.50 at the front wall, 0.58 on the side walls, and 0.42 on the rear wall. The chamber is entered through doors in each side wall from the wall walk (fig. 10), which was protected by a parapet, now ruinous, but probably crenellated as at Messene.\(^{27}\)

The catapult chamber was provided with two windows in the front wall and one in the west side wall. The windows average 1.12 high x 0.72 m. wide. Thus they are some 0.30 higher, but virtually identical in width to the windows of the upper chamber at Messene L. The bottoms of the windows are 1.1 above the floor of the tower; the middles of the windows are 7.0 above the external ground level.

The chamber could not have held more than two stand-mounted catapults (fig. 10D). The front window spacing, similar to Messene N, limited bow size to 6 ft. (1.8 m.); probably the machines were very close in size to the ones used at Messene. The western catapult may also have been intended to shoot through the side window, but the windows in the northwestern corner are not properly spaced to allow the stock to be swung on its stand from window to window, as was the case at Messene L. The operators of the western catapult would have had to move the stand about a meter to the southwest in order to shoot out of the side window. This may have simply been a design flaw (cf. the problem with the chases of the side window, infra), but a similar situation pertained at Cyphtokastro (infra) and the inconvenience of shifting the stand may have been compensated for by the wider lateral field of fire (ca. 29° at Siphai 3, as opposed to ca. 19° at Messene L) afforded by placing the catapult as close to the window as possible.

The bottom edges of the front windows are each flanked by two chases (average size 0.08 x 0.07 m.). These would have held hinges for single-leaf, bottom-hung shutters. The shutters, probably the sort called “down rushing” in IG IV, 463 (see Appendix), could be raised and lowered by ropes attached to the roof rafters (fig. 11).\(^{28}\) Bottom-hung shutters were used in 18, suggested that the shutters were top-hung and that the chases were to allow an iron bar to be passed through the wall in order to push open the shutters from the bottom. This shutter arrangement has been embraced by Kienast (supra n. 12) 48, 50 with fig. 22; Schwandner (supra n. 26) 527, figs. 20, 23, 25; and, tentatively, by Winter, GF 189. Winter (loc. cit.), however, noted that top-hung shutters could not be opened wide enough for catapults to shoot effectively and suggested that bottom or side-hung shutters would be more efficient; similar objections to top-hung shutters were raised by Marsden, GRA I, 152–53. We might add that propped open top-hung shutters would not provide much protection against missiles shot by enemy soldiers near the wall. Lawrence, GAF 410–18, noting that Philo’s (Pol.
Fig. 10. Siphai, Tower 3. A north face outside elevation, B cross section through north face, C cross section to inside of west face, D plan of the chamber with 6-ft. catapults.

various other first- and second-generation catapult towers. The design offered an important advantage over the side-hung shutters utilized at Messene L: a bottom-hung shutter could be dropped suddenly, so that the catapult could fire, and then quickly be raised again to protect against enemy counter-fire while the machine was being cocked or while the stand was shifted so as to fire out another window. Furthermore, if the catapult stock were tilted up, to achieve greater range, the shutter could be dropped only part way, making it virtually impossible for enemies below to shoot in. The side window in the west wall is provided with only one chase; the rabbeted block which defines the lower left side of the window was ill suited to cutting a second chase (fig. 10C). This was apparently a builder's error (cf. the misplaced chase block at the sea gate, infra) which was never corrected. We may speculate either that a removable shutter was improvised or that the tower was never put to use.

The roof over Tower 3 can be securely restored as a fighting platform (fig. 10C). Cuttings in the front and rear walls of Tower 3 accommodated 15 joists, 0.18 x 0.13 in cross section (fig. 10B). As at Messene N, the joists passed directly through the back wall to allow for drainage of the roof, which sloped back at an angle of 7° (figs. 10C, 12). The close-set joists would not have permitted access from within the tower; as at Messene N, access to the fighting platform must have been from the ground behind the tower. ²⁹

Tower 3 incorporates elements of both Messene N (single chamber with fighting-platform roof) and L (shuttered, rectangular windows), along with some innovations, notably the bottom-hung shutters. The incorporation of elements found at Messene N and L

1.21.2) recommendation that shutters be iron-plated on both sides would not make sense if shutters were top-hung (since missiles could strike only one side of a top-hung shutter), suggested, I think correctly, that chases were used to hold wooden battens or iron bars from which the shutters were hung.

²⁹ The backward slope of the roof is not shown in Schwandner's (supra n. 26, fig. 25) restoration. Schwandner restores a second, unroofed fenestrated chamber above the existing chamber. As in the case of the sea gate tower (infra n. 31), this extra story is unnecessary and excessively grandiose. Schwandner apparently restores the extra stories in order to conform to his hypothetical fenestrated parapet.
in Siphai 3 strengthens the assumption (see supra) that the towers of the north wall east of the Arkadian gate are, in fact, contemporary with the west wall towers, and therefore that the entire Messene circuit, like the circuit of Siphai, is Epaminondan in date.

Siphai, Sea Gate Tower (figs. 13, 14, 30D)
The sea gate at Siphai, located at the extreme western end of the site, was apparently the main entrance to the fortress. The ground in front of the gate to the north is level beach, although directly east of the gate the cliffs rise so precipitously that no wall was necessary. The gate was preserved in the 1970s to a height of only 6.3 m. (where the wall abuts the cliff); several blocks abutting the cliff have since fallen (cf. fig. 14A with fig. 13, taken in 1985). I restore the gabled peak of the gate tower to a height of ca. 10.5 m. The front entrance to the main gate (2.0 wide and 2.5 high) is intact, as is the eastern of two niches flanking the gate (1.2 wide × 2.0 high). On the outside of the eastern niche lintel a gabled roof is carved in high relief (figs. 13, 14A).

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30 Cf. Schwandner (supra n. 26) 528–34, figs. 17–21.
The gate tower, measuring 6.3 x 6.3 m. externally and slightly off square (fig. 14C), was located directly above the gate. At the level of the lintel of the gate the inside of the front wall is set back from a thickness of 0.60 to 0.42, providing a shelf to support the lower catapult chamber floor. In the course above the lintel, two blocks (fig. 14A: a, b) are cut with chases (avg. size 0.08 m.²). A third chase was cut in the opposite end of block b, but was later plugged; this was obviously the result of a builder's error. Above block b two blocks with aligned edges defined one side of a window, 1.10 high. Measuring from the preserved side of the window to a pry hole in block a demonstrates that the window was 0.76 wide; the bottom edge is 1.3 m. above the setback which supported the floor and the center of the window is 4.4 m. above ground level. The window was therefore virtually identical in size and shuttering to the windows in Tower 3.

The sea gate window, centered over the main entrance, was probably the only window in the lower chamber. Since the front wall of the gate tower is flush with the curtain wall (fig. 14C), side windows would not have enfiladed the wall effectively. Furthermore, fire angled toward the front from a west side window would be blocked by the parapet; the east side is very close to the cliff face. Hence there would only have been one catapult in this chamber, which would shoot through the single window. I have restored arrow slits on the side and back walls, however, to allow the tow-

Fig. 13. Siphai sea gate, north face, from outside

Fig. 14. Siphai sea gate. A north wall outside elevation, B cross section through north face, C plan of the lower chamber with 6-ft. catapult. (Masonry of upper left [A] based on E.-L. Schwandner, AA [1977] fig. 17, lower right based on Schwandner, figs. 18, 19)
er garrison to fire upon enemies who succeeded in breaking through the gate. The entrance to the chamber must have been through a door in the western wall of the tower, from the wall walk which we must suppose was protected by a parapet.

No blocks in situ help us to restore the superstructure of the gate tower, but the level ground in front of the tower presented a serious threat and an upper catapult chamber was surely necessary. On the model of the window spacing at Tower 3, I restore two front windows and one window on the west side. Two catapults similar in size to those employed in Tower 3 would fit comfortably. Access to the upper chamber would have been from the lower chamber by ladder and trap, as at Messene L. The roof of the tower must have been gabled, since the relief gable above the niche was presumably modeled on the genuine gable of the gate tower. As I have restored it, the gate tower is quite similar to Messene L, with catapults in two chambers. At Siphai, however, the architect used a window rather than enlarged slits in the lower chamber.

Gyptokastro, Tower 7 (figs. 15–17, 30E)

The relatively securely dated Theban constructions at Messene and Siphai give a good sense of the structural and military problems early catapult-tower architects faced and the solutions they devised. The Theban towers provide comparanda for less securely dated Athenian towers, built by architects working within the same tradition.

The imposing fortress known today as Gyptokastro ("Gypsy castle") is located on the crests of a steep hill on the Athenian side of the Kaza pass; the fort straddles the most important western route between Attica and Boiotia. At the eastern foot of the Gyptokastro hill (near the ruins of the khani of Kaza) is the probable site of the ancient town of Eleutherai. Eleutherai had once been Boiotian, but came under Athenian control by the fifth century B.C. Surface sherds suggest that the fortress hill was occupied by the late fifth/early fourth century B.C. Blocks in situ on Towers 6 and 7 (counting from the northwest corner) of the north wall of Gyptokastro preserve chases and can be demonstrated to have been catapult towers similar in style to Messene L. We concentrate on Tower 7, the better preserved of the two.

Tower 7 faces north, toward a fairly steep slope down to a dry streambed (fig. 15). The approach to the tower is not easy, but not nearly so difficult as the approach to, for example, Siphai 3. The tower consisted of two chambers above a solid base 4.1 m. high. The outside wall of the tower is currently preserved to 7.7 m. above external ground level; I restore the original height of the gable to approximately 10.0. The masonry is isodomic trapezoidal; virtually no rabbets are used in the tower, but rabbetting is used frequently in the circuit wall (figs. 15, 16A, 17). Externally the tower measures 5.8 (east to west) × 6.0; wall thickness of the lower chamber is 0.60; the front wall of the upper chamber is set back to 0.40. Access to the lower chamber was by two side doors which led to the wall walk; part of the crenellated parapet, 2.3 high at the top of the capstones and 0.42 thick, is preserved on the east side of the tower (figs. 15, 16A). I have restored the parapet as crenellated, on the model of the west wall at Messene. The lower parapet blocks of the Gyptokastro wall and of the fighting platform of Messene N are almost identical in height (0.78 and 0.82, respectively). The somewhat lesser height to the top of the Messene capstones (1.90) is probably due to the greater elevation of the fighting platform above external ground level.

The lower chamber was not used for catapults, but for archers; arrow slits (one course, ca. 0.50 m. high, 0.08 wide externally, splaying to 0.55 internally) open in the front and both side walls. The floor of the upper chamber was supported on the setback shelf and undergirded by three joists (0.26 × 0.27 in cross section) which ran from front to back (fig. 16B). The eastmost joist is further off center than the westernmost; perhaps the trapdoor to the upper chamber was between the center and eastern joists.

31 Schwandner (supra n. 26), figs. 19, 20a, restores a third fenestrated chamber; this appears extremely unlikely in light of the thin (0.42) front wall of the first chamber, which could not safely support two more chambers.
32 On the relationship of the fort to the pass and road and the identification of the site below Gyptokastro as Eleutherai see FA 160, 163, 223. Surface pottery: FA 162; the pottery is published in J. Ober, "Pottery and Miscellaneous Artifacts from Fortified Sites in Northern and Western Attica," Hesperia 56 (1987) 197–227, with plan of the site, showing the road through the circuit.
Currently only two blocks (fig. 16A: a, b) stand in the course above floor level of the front wall of the upper chamber. Two chases (0.10 × 0.08 m.), 0.85 apart, are cut into the upper side of the eastern block, b (cf. fig. 14A). In two photographs taken by W. Wrede ca. 1930 (figs. 15, 17), several blocks, now fallen, are shown in situ. Figure 17 shows two more blocks (fig. 16A: c, d), each with one chase cut in its upper side in the course above the floor level and a single block (e) in the middle of the next course up. The lower side edges of block e are undercut and the bottom edges are flush with the two inner chases (the eastern chase in block b and the chase in block c). Block e obviously stood between two windows which were provided with bottom-hung shutters. The shutters were not, however, flush with the bottom edges of the windows, as at the Siphai towers. The undercut block e and a similarly undercut block above and flush with a chase in the west side wall of the same tower (fig. 17, upper right) must have secured sill blocks. The shutters therefore were hung a half-course below the windows (see fig. 16A, C). Sill blocks beneath shuttered windows are known at Siphai (north gate) and at Aitolian Khalkis, but in these two sites the chases are cut into the bottom edge of the sill block itself, rather than into the upper edge of the course below the sill, as at Gyphtokastro.34

The windows of the front wall would have been about 0.85 m. wide; I have restored their height as 0.90, but, depending on the height of the course above block e, they could have been somewhat taller or shorter.35 The window bottoms were ca. 0.9 above the floorboards and their centers 8.3 above external ground level. Chases visible in Figures 15 and 17, along with a preserved chase on Tower 6, demonstrate that at least one window existed at the fore of each side wall. I have restored a rear window to each side wall, on the parallel of Messene L and to help account for the depth of the chamber, but even in Wrede's day the masonry of the rear side walls was too ruinous to preserve evidence of windows (fig. 15).

The front window spacing is similar to that of Messene N and Siphai 3, and so stand-mounted catapults with bows no larger than 6 ft. (1.8 m.) could be accommodated (fig. 16E). As at Siphai 3, it would have been necessary to shift the stands of the Gyphtokastro windows in FA 161. This width was based on a restoration of the windows without a sill block.

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34 Siphai north gate tower: Schwandner (supra n. 26) fig. 23. Aitolian Khalkis: GAF 415–16, fig. 88b.
35 I suggested a rather narrower width (0.65 m.) for the
catapults in order to shoot through the fore-side windows. Even allowing for the shifting of the stands, stocks over 2.1 m. in length would not have allowed enough maneuvering room for a machine firing out a side window. Hence, the Gyphtokastro catapults appear to have been similar in size to those used at Messene and Siphai. It is just possible that two further stand-mounted catapults were used to fire through the hypothetical rear side windows, but the tower would have been very crowded with four catapults operating simultaneously. I think it more likely that only two catapults were housed in the chamber and were moved about from window to window as the situation demanded.

The roof of Tower 7 must surely have been gabled; the thin walls would not support a fighting platform and there was no need for one, given the possibility of enfilading fire from Tower 6.

Of the 12 Gyphtokastro curtain-wall towers and two gate towers, it is only possible to demonstrate that Towers 6 and 7 on the north wall were fenestrated. In addition to the chase blocks currently in situ, I have found eight fallen blocks, each cut with a single chase, in and immediately outside Towers 6 and 7 (e.g., fig. 16D), and one chase block near the west gate. I have searched in vain for chase blocks near Towers 2–5 in the north wall. Each of these four towers has a ground-floor chamber, without slits or windows, and a second chamber at wall walk level, with arrow slits in the front and side walls. A catapult chamber at any of these towers would therefore have been the third hollow story; given the relatively thin walls and light joists, a third chamber would have been an architectural risk. It seems unlikely, therefore, that Towers 2–5 were designed to house catapults. We may guess that, in addition to Towers 6 and 7 and the west gate tower, the east gate tower, the two towers on the south wall (where thick brush made a search for fallen chase blocks impracticable), and the very ruinous Tower 9 on the east wall were supplied with catapults; the other towers may have employed fighting platforms in lieu of catapult chambers. The probability that non-

Fig. 16. Gyphtokastro, Tower 7. A north face outside elevation, B cross section through north face, C restoration of shutter over window, D fallen block with chase, E plan of the upper chamber with 6-ft. catapults.

36 Marsden, GRA I, 136–37, assumed that Towers 2–5 had a third chamber, and consequently assumed that the towers of Gyphtokastro were contemporary with the three-chambered tower at Aigosthena; see infra.
catapult towers were used along with catapult towers at Gyphtokastro suggests that the Athenian state might not have possessed enough machines to provide every tower with catapults. Perhaps catapults were difficult to obtain or the state was unable to afford great numbers of them. Either possibility would suit a date before the 340s, when Athens was once again doing well financially and catapults were sufficiently widely available so that smaller states, such as Byzantium, could acquire them.\(^{37}\)

The similarity of the Gyphtokastro towers to those at Messene and Siphai suggests that they are contemporaneous, dating to the second quarter of the fourth century. As noted above, the earliest pottery from the site is dated to the late fifth/early fourth century. Assuming that pots may have remained in use for some years, this material can reasonably be associated with the construction of the fortress. It is not possible on architectural grounds to determine whether priority should be assigned to Gyphtokastro 7 or to its closest parallel, Messene L. The windows at Gyphtokastro are somewhat wider, which might be taken as a sign of development, but the front wall of the Gyphtokastro 7 catapult chamber is thinner, the tower masonry less regular, and the flooring system rather less sophisticated. Like the architects of Messene and Siphai, the Gyphtokastro architect was experimenting with window and shutter design. The sill-shutter apparently reflects a concern, shared by the Messene L architect, with overlapping the window on all sides; this concern was manifested by the builders of some second-generation towers (e.g. at Dura), but not by the builders of other late towers, who used bottom-hung shutters on the Siphai 3 model (e.g. Herakleia, Perge).\(^{38}\)

\(^{37}\) On the financial recovery of the 340s, see, for example, G.L. Cawkwell, “Eubulus,” *JHS* 83 (1963) 61–65. It remains puzzling why Towers 6 and 7 were chosen as the north wall towers to house artillery. An answer might be sought in the fields of fire from the east and west gates which, in conjunction with fire from one or more of the south wall towers, 6 and 7 on the north wall, and 9 on the east wall, may have provided adequate artillery cover for the circuit.

\(^{38}\) See *GAF*, fig. 88.
The fortifications at Aigosthena, a small Megarian town located at the eastern end of the Corinthian Gulf, are among the most impressive in mainland Greece. They were even more impressive before the earthquake of 1981; my description is based primarily on the remains as they stood before the earthquake. I have suggested elsewhere, on the basis of historical considerations, that the circuit was built by the Athenians in ca. 343 B.C.39

39 J. Ober, “Two Ancient Watchtowers above Aigosthena in the Northern Megarid,” AJA 87 (1983) 391; Ober, Re-
The main acropolis fortification sits on a relatively low hill above and ca. 500 m. inland from the bay. The best preserved tower ("A" on Benson's plan) is on the southeast corner of the acropolis circuit. The approach is quite difficult from the east, but fairly easy through the door before the earthquake, was provided with an arrow slit one course (0.6 m.) high in each of the east, west, and south walls. Post-Classical rebuilding on the inside of the tower obscured the inside of the second chamber, but the floor of the second chamber was apparently laid directly on the setback formed by decreasing the wall thickness to one block. The middle chamber had two arrow slits on the west wall and one slit each on the east and south walls.

The flooring arrangement of the third (topmost) chamber is also obscured, but presumably joists ran east–west to support the floorboards. The well-preserved south wall of the third chamber had three windows, averaging 0.84 m. wide and 1.10 high. The bottom edges of the windows were ca. 1.0 m. above the floorboards. Block alignments (observed before the earthquake) demonstrated the existence of three win-

41 The evidence for a high parapet consisted (before the earthquake) of four blocks which extend from the south face of the northeast tower and appear to be part of the parapet (GM I II, pl. 5.11). Since three of these blocks are well above the level of the top of the doorway into the tower, the parapet here would have been much too high for defenders standing on the wall walk to see or shoot over it. Hence it is possible that the parapet, rather than being crenellated throughout, was fenestrated in this sector. Winter (GF 142 n. 56, fig. 163) went so far as to suggest the existence of an upper and lower parados, similar to the double parados at Side, and so argued for a late date for Aigiontha. But there is no evidence for an upper parados at Aigiontha. The northeast tower is at a considerably lower elevation than the southeast tower (where the parapet does not appear to have been particularly high) and the high parapet on the north end of the east wall may have been intended to compensate for the drop in elevation. It is worth noting the 3.0-m.-high wall walk parapet which abuts the semi-round tower just north of Tower N at Messene (see AMG, pl. 86 and fig. 29). The extra height here is presumably not due to fenestration of the parapet, but was intended to give extra protection to the doorway into the tower. A similar concern could explain the high parapet at the northeast tower of Aigiontha. In any event, we need not down-date Aigiontha radically on the basis of the hypothetical fenestrated parapet. Fenestrated parapets were certainly in use on the Athenian city wall by 307/306 (see Appendix), and probably by 337/336 (assuming Maier's date for IG II², 244 = GM I 10 is correct). A fenestrated parapet was also used at Aitolian Khalkis, which Lawrence (GAF 368, 403) suggests was roughly contemporary with Messene.
dows in the west wall, at least two in the east wall, and at least one in the north wall. It seems likely that each wall originally had three windows. The presence of windows on all four faces may be explained in terms of the superior height of the southeast tower vis-à-vis the other towers of the fortress (see infra). The greater elevation allowed the catapults of Tower A to command the entire fortress, rather than just the terrain to the tower’s front and fore-sides, as was the case in the other towers we have considered thus far.

The large interior space (ca. 69 m.²) and numerous windows of the third chamber allow a variety of catapult arrangements to be proposed, but it seems most likely that one catapult was placed at each of the corners and one at each of the center windows, for a total of eight catapults in the chamber. If the corner catapults were intended to swing from front to side windows without moving the stand (as at Messene L), the catapults could have had bows no longer than 6 ft. (1.8 m.) and stocks no longer than 2.1 m.—hence about the same size as the catapults at Messene, Siphai, and Gyptokastro (see fig. 20). If the stands were shifted when the corner catapults were aimed out different windows, however, somewhat larger machines with bows of 7 ft. (2.2 m.) and stocks of 2.5 m. could have been squeezed in. An alternative arrangement would have been to place 7-ft. bow catapults in the corners, positioned to swing from window to window, with a single machine in the middle of the chamber which could fire out of any of the four center windows. The “central machine” would, however, have had a rather restricted field of fire out any given window: 9° of arc as opposed to 21° for a machine positioned to swing from front to side windows, 30° for one positioned directly behind a window, and up to 90° for a catapult whose stand was shifted from side to side in front of a window in order to achieve the greatest possible field of fire. In any case, no reasonable arrangement of catapults in the chamber could accommodate machines with bows or stocks significantly larger than 2.2 m. and 2.5 m. respectively.

There are no chases around the windows, and so hinged shutters apparently were not used. Presumably the windows were sufficiently elevated above ground level (16.5 m. at their centers) to minimize the danger posed by the enemy fire. We may guess that in place of hinged shutters, removable shutters were used; these would offer the advantage of not obscuring the field of fire by dangling ropes.

In the course immediately above the windows a line of joists (one joist hole was exposed on the west end of the south wall after the earthquake: fig. 19B, upper right) ran north–south. It would hardly have been necessary to place floorboards on top of these; presumably the joists were intended to increase the structural strength of the tower. The roof timbers were laid on a joist between the gables; the south wall gable joist cutting was clearly visible before the earthquake.

Although likely, it is not possible to demonstrate that any of the other towers on the acropolis or on the walls extending to the bay housed catapults. The traces and have, on the other hand, found (in 1979, in the company of Harold Adams) rock-cut footings for walls on the ridge directly to the west of the southwest tower, about half way between the tower and the bay, on the north side of the streambed. The footings are for two faces (each ca. 1.0 m. thick) of a wall ca. 3.0 thick—about the thickness of

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42 The north wall to the bay is well preserved and had eight towers built into it. Only traces of the footings for the southern wall indicate its line. Benson (supra n. 40) 321-23 suggested that the southern wall was originally located across a dry streambed to the south (citing traces of what he took to be the wall). I have not been able to locate Benson’s
ternal arrangements of the other towers suggest that none was as tall as Tower A.

Tower A obviously represents a considerable advance over the examples considered thus far. The Aigosthena architect was in full control of the catapult tower form; hence he was able to add an extra chamber and considerably increase the total height. The greater dimensions of the tower allowed 12 windows and as many as eight catapults to be accommodated—twice the number in the upper chamber of Messene L. This eliminated the need to place catapults in the lower chambers, and hence the tower's height was effectively used to maximize the catapults' range of fire.

Aigosthena is clearly somewhat later than Messene, Siphai, and Gyphokastro. On the other hand, the windows at Aigosthena are not much larger, nor are the walls of the upper chambers significantly thicker than those of the earlier towers. There is no reason to suppose that Aigosthena A was intended to defend against artillery capable of throwing large stones. As we have seen, the maximum size of catapults housed in the top chamber of Tower A could not have been much larger than the ones used in other first-generation towers. The architecture of Aigosthena A, despite the tremendous impression it creates, incorporates no revolutionary changes (removable shutters may have been used at Messene N), but rather refinements and enlargements of elements used in earlier towers. The Aigosthena architect was working within the same tradition as the architects of Messene, Siphai, and Gyphokastro, and a date about a generation later than those towers—in the third quarter of the fourth century—seems reasonable. This chronology suits the historical dating of the circuit to the late 340s, noted above.

The Mazi Tower (figs. 21–25, 30G)

About 5 km. to the east of Gyphokastro are the impressive remains of a large freestanding tower. The tower is located on quite level terrain; the approach is

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Fig. 22. Mazi tower. A west face outside elevation, B cross section through west face.
Fig. 25. Mazi tower, plan of the fifth chamber, with 7-ft. catapults

easy in all directions. The best preserved (west) face of the tower stands to 14.1 m.; I restore the original height to ca. 14.5. The tower consists of five chambers and (probably) an open roof. Although only the north-west corner is intact, traces of the foundations demonstrate that the tower was originally 8.8 m.² The masonry is very strict isodomic ashlar (figs. 21, 22A); the stone is a crumbling conglomerate (see especially fig. 23). The north, and presumably the south, walls of the lowest chamber were 1.3 m. thick, the west wall and probably the east wall of the lower chamber, and presumably all four walls of the upper chambers, were 0.7 thick. There is no indication of an entrance in the preserved portion, but a door must have led into the lowest chamber; access to the upper chambers would have been by ladders and trapdoors as was usual in multichambered towers. There are no traces of other buildings or of a walled enclosure near the tower.

The lowest chamber has no embrasures and was probably used primarily as an entranceway. The second chamber floor is supported by a joist and rafter system which can be reconstructed in detail by analyzing cuttings on the inside walls (figs. 22B, 23). A line of heavy joists (0.25 × 0.30 m.) ran from north to south; across these were laid lighter rods. Across the rods was another layer of somewhat smaller joists, supported in part by the setback of the north and
south walls; the floorboards rested on these upper joists. This complicated flooring arrangement, almost a meter thick, is repeated in the floor of the third chamber. The crisscrossed joists and rafters of the two floors of the second and third chambers would have supported a great deal of weight; perhaps heavy material was stored on these floors. The floor of the fourth chamber is similar, although without the second series of joists; the floorboards were laid directly upon the rods. The floorboards of the fifth chamber were supported on a line of joists running north-south mortised into smaller cross joists. The roof was supported by crisscrossing small joists. The various flooring systems used in the tower represent an architectural tour de force; the architect was obviously concerned about the stability of this extraordinarily high unsupported structure and used every means available to him in attempting to bind the walls together.

The west wall of the second chamber preserves two arrow slits, 0.12 m. wide on the outer side, splaying to 0.55 inside; they are 0.5 (one course) high. A single slit is preserved in the west wall of each of the third and fourth chambers, but, on the model of the second-chamber slits, we can restore two slits in each wall of Chambers 2, 3 and 4, a total of 24 slits. In the west wall of the top chamber two aligned blocks and a chase cutting (fig. 24) demonstrate the existence of a window protected by a bottom-hung shutter of the Siphai type. On the assumption that the fenestration system was more or less symmetrical, I restore two windows in each face of the upper chamber. The windows were ca. 1.0 high. The widths of the windows cannot be determined, but we may guess that they would have been in the region of 0.7–0.9. The window bottoms were ca. 0.8 above the floorboards; the centers of the windows were 12.0 above the ground. The chamber was most probably designed to accommodate four catapults. If the catapults were placed to shoot out of the front and side windows without shifting the stands, the stocks could not have been over 2.1 m. in length; if the stands were shifted, considerably larger machines, with bows as long as 9 ft. (2.8 m.) and stocks to 3.2. m. could have been employed. The 9-ft. bow machines would, however, have made for a very crowded chamber and I think it unlikely that bows longer than 7 ft. (see fig. 25) were used here.

The ceiling of the fifth chamber is considerably lower (1.8 m.) than that of Chambers 2–4 (avg. 2.3; Chamber 1 = 2.0); this compression of catapult chamber height is reminiscent of the top chamber at Aigosthena and seems to have been a typical feature of multichambered towers. A sixth chamber is highly unlikely at Mazi; the light crisscrossed joists above the catapult chamber do not appear to have been designed to support a great deal of weight. Yet the corner of the tower is preserved for 1.0 m. (two courses) above the level of the joists which form the ceiling of the catapult chamber. It would have been senseless to add the extra courses if a gabled roof above the fifth chamber were contemplated; hence I restore an open roof that may have served as a fighting platform (in which case we would have to assume that a watertight trapdoor had been devised), and/or as a water catchment area (cf. the roofs of Towers F and C, infra).

It appears unlikely that the Mazi tower was privately owned. The monumental size, the sophistication of the architecture, the number of arrow slits, and especially the provision for catapults in the top chamber, suggest that a state, not a private individual, served as building authority. The Mazi tower must therefore have been designed to be a military tower, rather than a farm building. The total potential firepower of the tower was formidable: 24 archers and four catapults, perhaps with other troops on the roof.

The Mazi tower is strikingly similar to Aigosthena A in external dimensions and masonry. These two first-generation catapult towers are the tallest ancient military buildings on mainland Greece and are only about 15 km. apart; it is probable that they were designed and built at about the same time, conceivably by the same architect. The Mazi tower represents an application of the circuit tower form to an isolated tower. Differences in flooring, roofing, and shuttering at the two sites may be explained in terms of the differences in their situations: an isolated tower hollow to the ground posed somewhat different architectural and security problems than did a tower built on a solid base, buttressed by curtain walls and enfiladed by other towers. The Mazi tower is on the Athenian side of the Kaza pass and was in visual communication with the Athenian fortresses at Gyptokastro, Myoupolis (Oinoe), and Kavasala (Panakton). I would suggest, therefore, that the Mazi tower, like the Aigosthena circuit, was built under Athenian auspices in the third quarter of the fourth century B.C.

_Tower F (Strongylos Pyrgos) in the Vathychoria_ (figs. 26, 27, 30H)

About 6 km. to the southeast of Aigosthena stands a very well-preserved, round, isolated tower, designated...
“Tower F” by N.G.L. Hammond. Tower F stands in quite open terrain just above and to the east of the Megalo Vathychori, an area which was probably within the territory of the Megarian village of Ere­neia. Approaches to the tower are quite easy in all directions (fig. 26). The tower, consisting of four chambers and an open roof, is preserved to a height of 12.3 m.; I restore the original height to about 13.5 m. The outside diameter at the base is 6.2 m.; the walls of the tower (0.56 thick) taper 2° inward; the inward cant was obviously intentional and presumably was meant to increase the tower’s stability. The masonry is trapezoidal-to-ashlar; the width of the blocks decreases in the upper floors (fig. 27A). The door, on ground level, opens to the south.

The high-ceilinged (4.3 m.) lowest chamber has no embrasures; it may have been used for storage. The floor of the second chamber was supported by three joists. The second chamber was provided with three arrow slits, each one course high, facing south, west, and east. The third chamber, also supported by three joists, has a single window, one course (ca. 0.6) high and ca. 0.5 wide, on its south side. The window could have served as an aperture for firing a small catapult.

The inside of the tower wall is badly weathered near the top, but traces of holes to hold joists for the floor of the fourth chamber can be discerned. Aligned blocks demonstrate that six evenly spaced windows opened in the fourth chamber; each window was approximately 1.0 m.² The bottom edges of the windows were about 0.8 above the floorboards; the middles of the windows were 11.6 above the ground. Neither the third nor the fourth chamber windows are flanked by chases; the shutters (which must have existed, if only to keep out wind and rain) must therefore have been removable, as was the case at Aigosthena.

Assuming stand-mounted catapults were used, two possible arrangements may be proposed for the armament of the main chamber. A single larger catapult, with a stock of up to 2.5 m. in length, could have been positioned in the center of the tower and swung to shoot out of any of the windows. The arc of fire through each window would have been only 15°, however, and the total coverage therefore only 90 (6 × 15) of 360°. Thus it would have been possible for enemy troops to approach the tower without being threatened by the catapult. It seems more likely that smaller catapults were placed in front of the windows (see fig. 27D). Three catapults with bows of about 4 ft. (1.2 m.) and stocks of about 1.4 m. could have been accommodated without crowding. If smaller, hand-held machines were used, rather than stand-mounted models, there would have been no difficulty in stationing a catapult operator before each window.

A waterspout, about 0.6 m. long, projects from the east side of the fourth chamber. The bottom of the trough of the spout would have been level with, or slightly above, the level of the floorboards. The spout was mounted too high for effective drainage of the floor of the fourth chamber; if this had been the intention of the architect, the spout presumably would have been placed in the next course down. The fourth chamber must, therefore, have had a roof. The spout does not make sense as part of a gutter system, but can be explained by the assumption that the roof of the tower was an open platform designed specifically to collect rainwater. The water would be let into storage pithoi through a pipe and faucet. When the pithoi were full the water could be drained out through the

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46 This identification, apparently first made by Edmonson (supra n. 33) 154, has been most thoroughly propounded by A. Muller, “Megarika (VIII: Ereneia),” BCH 106 (1982) 379–87.
47 Telephoto pictures of the tower have now convinced me that the window is narrower than the 0.8 m. I estimated in F4 167.
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The inside of the tower wall is badly weathered near the top, but traces of holes to hold joists for the floor of the fourth chamber can be discerned. Aligned blocks demonstrate that six evenly spaced windows opened in the fourth chamber; each window was approximately 1.0 m.² The bottom edges of the windows were about 0.8 above the floorboards; the middles of the windows were 11.6 m. above the ground. Neither the third nor the fourth chamber windows are flanked by chases; the shutters (which must have existed, if only to keep out wind and rain) must therefore have been removable, as was the case at Aigosthena.

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Fig. 26. Vathychoria, Tower F, south side


46 This identification, apparently first made by Edmonson (supra n. 33) 154, has been most thoroughly propounded by A. Muller, “Megarika (VIII: Erénèia),” BCH 106 (1982) 379–87.

47 Telephoto pictures of the tower have now convinced me that the window is narrower than the 0.8 m. I estimated in FA 167.
spout by opening a cock below the faucet and perhaps caught below (fig. 27C). A good deal of water could be collected using this system. Assuming average rainfall at 0.25–0.50 m. per annum, the tower roof could theoretically gather 3,800–7,600 l. of water in a year. If even half this amount was funneled into storage jars, the system would certainly have been worthwhile, given the absence of wells or springs in the vicinity of the tower.48

As in the case of the Mazi tower, Tower F seems unlikely to have been built by a private individual. The similarity of the size and placement of the windows to the other towers we have considered indicates that F was a first-generation catapult tower.49 The height of the tower, use of multiple chambers, and the sophistication of the building technique (inward cant of the walls, even spacing of the windows around the circle, the drainage system) suggest a date fairly late in the series. Tower F resembles the Mazi tower in several respects: the open roof above a fenestrated upper

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48 On the absence of water sources in the area of the tower, see FA 167.
49 J.H. Young, "Studies in South Attica: Country Estates at Sounion," Hesperia 25 (1956) 134–41, 145, included both Vathychoria towers in a list of isolated towers which he argued were agricultural in function, and hence privately owned.
chamber, arrow slits in a lower chamber, as well as in its great height. The Tower F architect did not need to employ the complex flooring systems of the Mazi tower, since the round tower is considerably smaller, the inward cant of the round tower tended to bind the masonry, and the local stone was of better quality. The trapezoidal masonry of Tower F may have been considered suitable to the inwardly canted round shape. We may suggest that Tower F, which was situated in close proximity to Aigosthena and the Mazi tower, was closely contemporary with them, perhaps built as part of the same Athenian fortification program undertaken during the third quarter of the fourth century B.C.

Tower C in the Vathychoria (figs. 28, 29, 301)

Tower F provides a model for restoring another freestanding tower, Hammond's "Tower C," located about 1 km. to the east of Tower F, on a low bluff, next to the line of a major ancient road. The approach to Tower C is quite easy from all directions. Tower C stands to a height of 9.9 m.; I restore its original height to about 11.5, consisting of three chambers and a platform roof. Externally the tower is 5.4 m.2; the walls are a uniform 0.45 thick. The masonry is isodomic ashlar (figs. 28, 29A). One enters the tower through a ground-floor door in the east wall.

The ground-floor chamber is without embrasures and, like the lowest chamber of Tower F, has a relatively high ceiling (3.6 m.). The floor of the second chamber, which was similar to the first chamber in height, was supported by three joists running east-west. The second chamber was provided with a slit, ca. 0.09 wide externally and one course (0.6) high, in the center of each wall. The slits in the east, south, and west walls splay inward, not only at the sides, but also at the bottom (the upper part of the course below the slit has been cut away to provide the splay: fig. 29B). This arrangement, similar to that at some of the slit/windows in towers on the west wall at Messene, might be explained in terms of providing clearance for small, probably hand-held, catapults.51

The third-chamber floor was supported by three joists, identical to those which held the second-chamber floor, but running north–south. In the course above the joists is a water spout, identical to that in the fourth chamber at F. We may suppose, therefore, that the third chamber at C was the topmost chamber and that it was surmounted by a water-catchment roof, similar to the one at F; the greater area of the square roof of C could catch more water than could the roof at F: ca. 5,000–10,000 l. per annum.

The model of Tower F suggests that windows for catapults would have been provided at C as well. The third masonry course of the top chamber is somewhat wider than the average (0.76 vs. ca. 0.60 m.); a photograph in Tillyard's 1905 article (his fig. 1; cf. fig. 29C), shows three blocks in situ in this course on the north wall. The blocks are evenly spaced and leave two gaps between them. While it is not impossible that intervening blocks have fallen away, this would be a very unusual pattern of collapse. I would suggest that

50 Cf. Tillyard (supra n. 45) 101–104; Hammond (supra n. 45) 108–11; Edmonson (supra n. 33) 74; FA 165–66.
51 The Messene slit: GF 174 fig. 166. Lawrence, GAF
the gaps were windows and that there were two windows in each wall of the third chamber. If only one block in height, the windows would be about 0.76 m$^2$, their bottoms 1.0 m. from the floorboards, and their centers 9.5 m. above ground level.

The tower chamber could have held four stand-mounted catapults. If positioned to swing from window to window, these could not have been much larger than the catapults I have suggested were used at Tower F: 4-ft. (1.2 m.) bows and 1.4-m. stocks (fig. 29D). If the stands were shifted as necessary, somewhat larger machines, with bows to 6 ft. (1.8 m.) and stocks to 2.1 m., could just be fitted into the chamber.

The identical spouts and similar joisting systems at C and F, in light of their physical proximity, lead inevitably to the presumption that the two towers were contemporary, and probably designed by the same architect. Why the hypothetical architect designed both round and square towers remains mysterious, but it might be explained in terms of the experimentation in design typical of other first-generation catapult towers. As I have restored Tower C, it is very much like a smaller-scale replica of the Mazi tower, with which it is probably closely contemporary. The flooring system is much simpler at C than at Mazi; no doubt at least in part due to the lesser size and somewhat better stone of C. Like the Mazi tower and Tower F, then, Tower C is interpreted as a state-built, military tower of the third quarter of the fourth century B.C.
Fortress at Phyle, Tower 3 (fig. 30J)

The preserved superstructures of the towers considered above provide models for restoring other, less well-preserved towers, such as those of the Athenian fortress at Phyle.\(^{52}\) The small, well-built fortress, located near the probable site of the Athenian deme of Phyle, sits on a commanding eminence about 20 km. north-northwest of Athens. The approach is easy only from the north; in other directions steep cliffs make the position almost inaccessible. The fort was excavated in the 1920s by Wrede, who assigned it a date in the early third century, but a reexamination of pottery from the excavation renders Säflund’s date impossible.\(^{53}\) On the basis of the sites discussed above, it is possible to restore the towers at Phyle with typical first-generation catapult chambers.

Tower 3 (the numbering is from Wrede’s plan), on the northeast corner of the Phyle fort, currently stands to 10.5 m. above external ground level; 8.5 m. of that height is solid base. I restore the height of the tower to approximately 16.5 m., consisting of two chambers and a fighting-platform roof.\(^{54}\) Externally the tower measures 5.5 m.\(^2\); the masonry is isodomic ashlar. The lower chamber is entered from a door at ground level inside the fort. Just outside this door a stairway leads up to the wall walk which was protected by a crenellated parapet, 1.6 m. high and 0.48 thick, sections of which are still preserved. On the basis of Gyphtokastro 7, I restore arrow slits in the north and east (front) walls of the lower chamber.

The walls of the lower chamber, laid in headers and stretchers, are 1.0 m. thick. It is not impossible that the walls continued up through the upper chamber at that thickness, but the much thinner walls of the parapet certainly do not suggest that the builders anticipated barrage by torsion catapults. Thus, on the basis of Gyphtokastro 7 and Messene L, I restore a setback to 0.48 m. (the thickness of the parapet) to support the floor of the upper chamber. The upper chamber floor is restored as level with the wall walk; doorways lead from the wall walk through the north and south walls into the chamber. The upper chamber would have

52 Cf. W. Wrede, “Phyle,” *AM* 49 (1924) 153–224. This is by far the fullest description and all other treatments are dependent upon it: Winter (supra n. 17) 189; *GF* 139–40, 162 fig. 141, 193 n. 110, 198 n. 122; *GAF* 175–76, 202, 357, 360, 362; *FA* 145–47.

53 Säflund (supra n. 14) 107–10. Säflund’s date was based on pottery from a terrace built against the inside wall of the tower, which he assumed was contemporary with the existing walls. The mold-made bowls from the fill, however, date to ca. 225–175 B.C., a date much too late for the architecture of the fort: see Ober (supra n. 32).

54 Wrede (supra n. 52) 194–97.

55 Cf. Wrede’s discussion (supra n. 52) 193–94.
firms the assumption that the towers housed relatively small catapults and were built neither to withstand siege equipment capable of destroying stone walls nor to house artillery capable of destroying heavy siege engines.

Some architectural features remain fairly constant throughout the series. Wall thickness in the upper (catapult) chambers does not change drastically; the extremes are 0.40 m. at Gyphtokastro, and 0.70 at Mazi (see Table 1). The greater wall thickness noted at Mazi and at Aigosthena (0.60) can easily be explained in structural rather than defensive terms. Very tall towers with walls of only 0.60-0.70 m. thick would have been vulnerable to catapults hurling large stones against them. Hence, the architects do not seem to have been concerned with the significant new artillery threat of the late fourth century. Alexander had stone-throwing machines capable of destroying city walls by 332 B.C. (Diod. 17.42.7, 45.2). As noted above, it is not certain whether these were torsion or non-torsion machines. The first non-torsion heavy stone-thrower for which a description survives was designed in Thessalonike by Isidoros of Abydos some time after 315 B.C. (the foundation date of the city). Isidoros's machine could hurl a shot of ca. 18.2 kg., from a huge bow of ca. 15 ft. (4.6 m.). Meanwhile, torsion technology was advancing rapidly. Demetrios Poliorcetes used catapults, certainly of torsion design, capable of hurling stones weighing up to three talents (78.5 kg.) during his sieges of Cyprian Salamis in 307 and Rhodes in 305/304 (Diod. 20.48.3, 20.87.1). Torsion technology was not limited to the armies of the Diadochoi; the Athenians were building large torsion stone-throwers by 306/305 (IG II², 1487B, lines 84-91). By the mid-third century the one-talent (26.2 kg.) catapult was the standard siege engine some as potentially unreliable. Cf. Table 2.

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56 GRA I, 15, 63; II, 82-84, diagram 2, for size estimates of the machine and the suggestion that it was designed after torsion technology was fairly advanced, but still regarded by
Table 1. Comparative Dimensions of Catapult Towers

<table>
<thead>
<tr>
<th>Site</th>
<th>Ext. Measure (front by side)</th>
<th>Height (restored)</th>
<th>No. of Chambers</th>
<th>Avg. Window Size (width x height)</th>
<th>Window Distance (above floor)</th>
<th>Window Distance (above ground)</th>
<th>Wall Thickness (top chamber)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Messene N</td>
<td>6.5 x 6.6</td>
<td>9.0</td>
<td>1</td>
<td>(0.37) 0.74 x 0.88</td>
<td>1.0</td>
<td>5.0</td>
<td>0.58</td>
</tr>
<tr>
<td>Messene L</td>
<td>6.9 x 6.9</td>
<td>12.5</td>
<td>2</td>
<td>0.73 x 0.81</td>
<td>1.0</td>
<td>10.5</td>
<td>0.48</td>
</tr>
<tr>
<td>Siphai 3</td>
<td>6.4 x 5.4</td>
<td>10.0</td>
<td>1</td>
<td>0.72 x 1.12</td>
<td>1.1</td>
<td>7.0</td>
<td>0.50</td>
</tr>
<tr>
<td>Siphai sea gate</td>
<td>6.3 x 6.3</td>
<td>10.5</td>
<td>2</td>
<td>0.76 x 1.10</td>
<td>1.1</td>
<td>7.5</td>
<td>0.42</td>
</tr>
<tr>
<td>Gyphtokastro</td>
<td>5.8 x 6.0</td>
<td>10.0</td>
<td>2</td>
<td>0.85 x 0.90</td>
<td>0.9</td>
<td>8.3</td>
<td>0.40</td>
</tr>
<tr>
<td>Phyle</td>
<td>5.5 x 5.5</td>
<td>16.5</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>14.0</td>
<td>0.48</td>
</tr>
<tr>
<td>Aigosthena</td>
<td>8.9 x 8.9</td>
<td>18.4</td>
<td>3</td>
<td>0.84 x 1.10</td>
<td>1.0</td>
<td>16.5</td>
<td>0.60</td>
</tr>
<tr>
<td>Mazi</td>
<td>8.8 x 8.8</td>
<td>14.5</td>
<td>5</td>
<td>0.80 x 1.00</td>
<td>0.8</td>
<td>12.0</td>
<td>0.70</td>
</tr>
<tr>
<td>Tower F</td>
<td>diam. 6.2</td>
<td>13.5</td>
<td>4</td>
<td>1.00 x 1.00</td>
<td>0.8</td>
<td>11.6</td>
<td>0.56</td>
</tr>
<tr>
<td>Tower C</td>
<td>5.4 x 5.4</td>
<td>11.5</td>
<td>3</td>
<td>0.76 x 0.76</td>
<td>1.0</td>
<td>9.5</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Note: All dimensions are given in meters

* Hypothetical restoration
  a (External) and internal splay
  b Upper chamber. Lower chamber embrasures = (0.23) 1.12 x 0.84

(Philo, Poliorketika 1.29, 70-73). Such weapons do not seem to have been conceived of by the designers of any of the towers considered above.58

None of the windows in the towers I have designated as “first-generation” appear to have been designed for particularly large catapults. The windows are quite uniform in size and the differences in window size between Group I and Group II towers are marginal (see Table 1). Thus, window size suggests that the catapults used in the later towers were not significantly larger than those used in the earlier ones. Window spacing and constraints of floor space support this hypothesis, suggesting that the catapults used at Messene N, Messene L, Siphai 3, and Gyphtokastro 7 were similar in size: machines with ca. 6-ft. (1.8 m.) bows and ca. 2.1-m. stands seem to have been the rule. Aigosthena A could have accommodated slightly larger machines (7-ft. bows, 2.5-m. stands) only if the stands were shifted. Similarly, the Mazi tower chamber could crowd in catapults with bows of up to 9 ft. (2.8 m.) with stocks of up to 3.2 m. only by shifting the stands. If we assume that the stands were not shifted, the “standard” 6-ft. bows and 2.1-m. stocks would have been the largest employed at both Aigosthena and Mazi.59

The 6-ft. bow, which may have been more or less standard for catapults in the Group I towers (and may have been used at Aigosthena and Mazi as well), was apparently an advanced non-torsion design, since it probably required a slider-bar and winch for cocking and since a stock of this size must have been mounted on a stand.60 The catapults used in most of these first-generation towers were somewhat smaller than the 9-ft. (2.8 m.) bow, 3.2-m. stock, “double-bolt” gastraphetes which Biton (W 61–64: GRA II, 74–77 with diagram 5; cf. Table 2) claims was designed by Zopyros of Tarentum. Even Zopyros’s single-bolt “mountain” gastraphetes, which used a 7-ft. bow and 2.9-m. stock (Biton W 65–67: GRA II, 77 with diagram 6; cf. Table 2), and was apparently designed as...
field artillery for rugged terrain, was somewhat larger than the largest catapult that would have fit into the Group I towers. Zopyros may have been the Pythagorean mentioned by Iamblichus. Marsden notes, “Zopyrus the Pythagorean must have lived not later than the middle of the fourth century; this is also a suitable date for the artilleryman.”\textsuperscript{61} Thus, it appears that by the mid-fourth century, at the latest, advanced non-torsion machines with 7–9 ft. bows had been developed. It therefore seems safe to assume that non-torsion catapults with 6-ft. bows would have been available in the second quarter of the fourth century, the date I have suggested for the Group I towers.

Size limitations do not exclude the possibility that the towers considered above could have housed small to moderate-sized torsion bolt shooters (see Table 3 for a range of torsion bolt-shooter sizes). The date of the introduction of torsion artillery to Thebes and Athens is unknown, but a date before ca. 340 for Athens—there is no evidence for Thebes—is unlikely. Athenian inventories from 330/329 (\textit{IG} \textsuperscript{11} \textit{2}, 1627B, lines 328–41) include various sorts of catapult equipment, including (lines 328–29) 11 frames from what may have been torsion catapults and (lines 333–34) 6 stocks for “scorpions,” a name later used for small torsion bolt-shooters. Marsden suggests that the 11 frames may have been captured from Macedon, but that by the Lykourgan period (338–326 B.C.) the Athenians were able to build hair-spring torsion machines capable of shooting bolts of 2 and 3 cubits (0.9, 1.4 m.; see Table 3).\textsuperscript{62} Torsion bolt shooters would presumably have been employed in towers (both new constructions specifically designed for them and in older towers, originally designed to house non-torsion machines) as soon as they were available, since their theoretical range was greater (400 m. vs. 200–300 m.). Torsion machines of the size which could be accommodated in the towers considered here, shooting bolts under a meter in length, would in any case remain primarily anti-personnel weapons.\textsuperscript{63}

In order to destroy enemy siege engines, heavy stone-throwing artillery was required, but the above towers could not have housed large stone-throwing machines of either torsion or non-torsion design. Stone-throwing artillery, capable of inflicting fatal wounds on infantry, existed by 352/351, the date that Onomarchos devastated Philip II’s army with \textit{petrobolous mechana} (Polyaenus, \textit{Strat.} \textsuperscript{2}.\textsuperscript{38}.\textsuperscript{2}), but these need not have been particularly powerful machines and their size is unknown. It is possible, though far from certain, that

\begin{table}[h]
\centering
\caption{Sizes of Non-torsion Catapults}
\begin{tabular}{|l|l|l|l|l|}
\hline
Name & Reference & Bow & Stock & Missile & Date \\
 & & (ft.) & m. & (m.) & B.C. \\
\hline
Simple, winchless \textit{Gastraphetes} & \textit{GRA} I, fig. 1 & \textit{infra} pp. 599–600 & (4) 1.2 & 1.6 & 0.8 m.\textsuperscript{*} & 399 \\
“Group I Standard” & & & (6) 1.8 & 2.1 & 1.1 m.\textsuperscript{*} & 375–325 \\
Zopyros’s mountain & \textit{GRA} II, diag. 6 & & (7) 2.2 & 2.9 & 1.2 m. & 350? \\
Zopyros’s double-bolt & \textit{GRA} I, fig. 5 & & (9) 2.8 & 3.2 & 1.8 m. & 350? \\
Charon’s stone-thrower & \textit{GRA} I, fig. 6 & & (9) 2.8 & 2.0 & 2.27 kg. & ? \\
Isidoros’s stone-thrower & \textit{GRA} II, diag. 2 & & (15) 4.6 & 5.5 & 18.2 kg. & after 315 \\
\hline
\end{tabular}
\end{table}

\begin{itemize}
\item \textsuperscript{61}Iamb. \textit{Vita Pyth.} 267; \textit{GRA} II, 98 n. 52.
\item \textsuperscript{62}See \textit{GRA} I, 56–58, 68–69. The evidence for a Lykourgan catapult-building program rests on \textit{IG} \textsuperscript{II} \textit{1}, 1467B, lines 48–56 (338–326 B.C., on letter forms), mentioning the two- and three-cubit bolt-shooters with hair springs. Cf. \textit{IG} \textsuperscript{II} \textit{1}, 1469B column i, lines 72–73, 77–80 (321/320 B.C.), 1475B, lines 30–35 (318/317). For Athenian catapults in the last decade of the fourth century, see \textit{GRA} I, 69–71. On the diffusion of torsion technology through the Greek world, see \textit{GRA} I, 56–83.
\item \textsuperscript{63}On the range of torsion catapults, see \textit{GRA} I, 86–91. Note, however, that the maximum range and power may not have been easy to achieve before the development of the calibrating formulas in ca. 270 B.C. For bolt-shooters the key formula was $D = L/9$ where $D$ is the spring diameter in dactyls, and $L$ is the length of the bolt to be shot, also in dactyls. See \textit{GRA} I, 25–26. As in the case of stone-shooters, the total length of a bolt-shooter would be about 30 spring diameters; see \textit{infra} n. 65.
\end{itemize}
Table 3. Sizes of Torsion Bolt-shooters

<table>
<thead>
<tr>
<th>Missile Length (= 9D) [cubit] (dactyl) m.</th>
<th>Stock Length (= 30D) m.</th>
<th>Arms: Total Width (= 14D) m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1] (24) 0.5</td>
<td>1.5</td>
<td>0.7</td>
</tr>
<tr>
<td>(36) 0.7</td>
<td>2.3</td>
<td>1.1</td>
</tr>
<tr>
<td>[2] (48) 0.9</td>
<td>3.1</td>
<td>1.4</td>
</tr>
<tr>
<td>(64) 1.2</td>
<td>4.1</td>
<td>1.9</td>
</tr>
<tr>
<td>[3] (72) 1.4</td>
<td>4.6</td>
<td>2.1</td>
</tr>
<tr>
<td>(80) 1.5</td>
<td>5.1</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Based on the calibration formulas developed by ca. 270 B.C. See GRA I, 24–4:7; stock length formula is derived from comparison with the formula for the length of the stone-shooter on p. 34 and fig. 34, the arm width formula from figures on p. 45. D = spring diameter.

these early stone-throwers were about the size of the non-torsion machine Biton (W 45–48: GRA II, 66–69) says was developed in Rhodes by Charon of Magnesia (date unknown). This catapult threw a stone of perhaps 2.27 kg., using a 9-ft. (2.8 m.) bow and a short 2.0-m. stock. Shot from this machine would not have threatened stone walls. It might have been of some use against enemy siege engines, although it had only about half the throw-weight recommended for this purpose by Philo (see infra). In any event, the 9-ft. bow would have been too large for most first-generation catapult chambers. The sizes and throw-weights of known non-torsion catapults are listed in Table 2.

Torsion stone-throwers had to be built with very long stocks, since the power of the weapon was directly related to the length of the stock. Using the calibration formulas devised about 270 B.C., which allowed advanced torsion machines to be built as compactly as possible (earlier machines would have been less powerful for their size), it is possible to determine the "throw-weights" of machines which could be accommodated at various first-generation towers. A torsion catapult 2.1 m. long (the longest that could be accommodated at most Group I sites) would be capable of hurling a stone weighing only about 0.16 kg. (0.36 minas); a 2.5-m. machine (which could be accommodated at Aigosthena A) had a throw weight of 0.26 kg. (0.6 minas). The 3.2-m.-long catapult, which could be fitted into the Mazi tower, could shoot a stone of 0.55 kg. (1.26 minas). These weights are a far cry from the throw weights of 10 minas (4.37 kg.) and 30 minas (13.09 kg.) recommended by the third-century poliorcetics expert Philo (Pol. 3.5–6, 3.67–71) for defense of fortified positions against enemy stone-throwing catapults and siege towers, respectively. A 10-mina stone-thrower would have had a stock of about 6.4 m.; a 30-mina machine, a stock of 8.4 m. Table 4 lists a range of stock-lengths and arm-widths for torsion stone-throwers.

The catapults, whether torsion or non-torsion, whether bolt-shooters or stone-throwers, that could have been fitted into the towers considered above were apparently anti-personnel weapons. Since our towers were not designed to accommodate machines capable of destroying siege engines of the sort faced by late-fourth and third-century defenders, we need not suppose that the tower builders anticipated defending against such equipment. Thus, a late-fourth to third-century date for the towers seems unlikely both on the grounds that the towers were not designed to withstand bombardment by heavy artillery and because they could not have housed defensive artillery powerful enough to neutralize large siege engines.

64 Cf. GRA I, 15, 59, for the suggestion that Onomarchos's machines were about the size of Charon's; GRA II, 78–82, diagram 1, for Charon's machine. Cf. Table 2.

65 For the calibrating formulas in general, see GRA I, 24–41. The significant formulas for our purposes are $D = 1.1 V (100 \text{ M})$ and $30D = L$, where $D$ = spring diameter in dactyls, $M$ = weight of missile in minas, and $L$ = the total length of the catapult plus small allowances for clearances at front and rear.

66 Garlan, RPG 376, commenting on Philo, Pol. 3.6, notes that the defensive artillery recommended by Philo is "de calibre relativement faible" when compared with the catapults used by besiegers.
### Table 4. Sizes of Torsion Stone-throwers

<table>
<thead>
<tr>
<th>Missile Mass (D = 1.1 × [100 M]) (minas) kg.</th>
<th>Stock Length (= 30D) m.</th>
<th>Arms: Total Width (= 12D) m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 0.44</td>
<td>2.7</td>
<td>1.1</td>
</tr>
<tr>
<td>(5) 2.20</td>
<td>5.1</td>
<td>2.0</td>
</tr>
<tr>
<td>(10) 4.37</td>
<td>6.4</td>
<td>2.5</td>
</tr>
<tr>
<td>(20) 8.70</td>
<td>7.3</td>
<td>2.9</td>
</tr>
<tr>
<td>(30) 13.10</td>
<td>8.4</td>
<td>3.3</td>
</tr>
<tr>
<td>(60) 26.20</td>
<td>11.6</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Based on the calibration formulas developed by ca. 270 B.C. See GRA I, 24-47: stock length formula is on p. 34; the arm width formula is derived from figures on p. 47. D = spring diameter.

Given the possibility that 6-ft. bow catapults were used at Aigosthena and Mazi, the only other size of catapult demanded by the architecture of the towers considered above is a small (4-ft. bow, 1.4-m. stock) machine for Vathychoria F, and perhaps for Vathychoria C as well. This machine may have been a simple *gastraphetes* similar to the earliest form of non-torsion artillery described by Heron. A simple *gastraphetes* did not require a winch for cocking, or, necessarily, a stand. The windows in the upper chambers of C and F are, however, close enough in size and in height above the floor to those of other towers in the series (see Table 1) to justify the assumption that the small catapults used at C and F were mounted on stands. In any event, there is no reason to assume that the smaller machines of the Vathychoria towers were later than machines used in other towers in the series.

The differences between the Theban and Athenian towers are relatively minor. There may have been a tendency toward slightly wider windows at Athenian fortifications, judging by the ca. 0.85 m. at Gyphtokastro and the ca. 0.75 average at the Theban sites, but this is hardly a significant difference and slightly wider windows at other Athenian forts may be a function of their later date. On the other hand, similarities, especially between Gyphtokastro and the Group I Theban sites, abound. In addition to the similarities in tower architecture noted above, it is worth mentioning the general similarities between the profiles of gate-post capitals at Siphai's sea gate and the two main gates at Gyphtokastro, the decorative surface treatment at the tower doorway lintels at Gyphtokastro and Messene N, and the masonry at Gyphtokastro, Messene, and Siphai.

The similarities between Athenian and Theban towers go beyond what one might reasonably expect from architects working in isolation, but faced with similar problems. Although it is not possible to determine the chronological seriation of either of the two tower groups on present evidence, it seems clear that the architects and masons involved were experimenting within the bounds of the same general set of assumptions. Is it possible, therefore, that a single building authority was responsible for the towers I have variously described as Theban and Athenian? This

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67 Belopoeica 75–81, edition of Marsden: GRA II, 20–23, with notes ad loc. and GRA I, 5–12, with fig. 1. Cf. Table 2.
68 McNicoll and Winikoff (322) support a third-century date for the *Isian tower* by postulating that the one-course slits there were designed for small "scorpion" torsion catapults similar to those used in the defense of Syracuse in 213. Judging by the photographs and the authors' description (317, figs. 2, 5, 6, 7), however, the slits appear similar to conventional archer slits (the rather wide external gap of one slit, 0.30, might be explained by the rough masonry). The comparanda cited by McNicoll and Winikoff (322 n. 45) include the embrasures at Gyphtokastro and Aigosthena, which I consider to be archer slits (see supra). It is unclear why the authors assume (322) that "ordinary archer slots" were two courses high. Lawrence (GAF 399–402) suggests the opposite: that slits for archers were typically one course high, while slits for catapults were two courses high. The concern with use of catapults as anti-personnel weapons, which McNicoll and Winikoff (322 n. 44) consider a late third-century innovation, was anticipated in the non-torsion catapult period, when artillery was of necessity anti-personnel.
possibility has been advanced in a recent paper which argued that Gyptokastro and the Aigosthena fortifications were built by the Thebans in the period 371–362. A consistent architectural tradition need not imply a single building authority, but the suggestion that Gyptokastro and the fortifications of Aigosthena were Theban deserves careful examination.

Assuming that the identification of ancient Eleutherai with the settlement below the hill is correct, the hypothesis that Epaminondas built Gyptokastro renders it unnecessary to suppose that the Thebans controlled Eleutherai at the time Gyptokastro was built and that the Theban takeover left no trace in the historical record. Pausanias (1.38.8) states that "formerly the border of Attica was Eleutherai, but since they [the Eleutheraians] have come over to the Athenians, Kithairon is the border of Boiotia." Pausanias goes on to describe Eleutheraian motives for the transfer, which apparently occurred in the second half of the sixth century B.C. There is no reason to suppose that Eleutherai reverted to Theban control at any time between the sixth century B.C. and the second century A.C., much less during the fourth century B.C. In 379/378 the Athenian general Chabrias occupied Eleutherai with Athenian peltasts and denied access to the Kaza pass to a Spartan army (Xen. Hell. 5.4.14). In Book III of the Memorabilia, written no earlier than the 360s and during a time when he anticipated conflict with Thebes, Xenophon (Mem. 3.5.25) has Socrates state that "our [Athenian] land is protected by great mountains extending to Boiotia . . . ." Neither this description of the border nor Xenophon's subsequent suggestion (Mem. 3.5.27) that Athenian troops posted in the mountains would be able to raid enemy territory below and protect Athenian land would make sense if Thebes controlled a major post southeast of Kithairon, where Gyptokastro is located.

The Theban Gyptokastro argument furthermore ignores strategic considerations. When building a fortress to control a pass (certainly the intention of the Gyptokastro architect, who built the fort across the main road through the pass), it is always preferable to build the fortress on one's own side of the pass. This position forces an enemy army approaching the fort through the pass to remain deployed in column within the pass until the fort has been taken. If Gyptokastro were Theban, enemy forces approaching from the southeast could easily mass in front of the fort without endangering their lines of communication. In the event that light-armed enemy troops seized the heights to the northwest of the fort it would become extremely difficult for relief forces from Boiotia to reinforce the garrison. On the other hand, Gyptokastro is ideally placed to defend Athenian territory. A general leading an army against Gyptokastro from the northwest would have a very difficult time concentrating his forces against the fort. His baggage train and the bulk of his combat forces would be strung out along the narrow road through the pass and vulnerable to ambush from the heights until Gyptokastro had been captured. Since the fort straddles the road, attempting to take heavy-armed men and baggage around the fort under the fire of the catapults would be an unacceptable risk. Athenian relief forces could approach the fort easily from the southeast, and would be able to regroup, if necessary, under the protection of the catapults of the Mazi tower. The historical and strategic arguments, therefore, weigh heavily against a Theban Gyptokastro.

In order to claim that the Aigosthena fortress was built by the Thebans it is necessary to suppose either that it was built in the same decade as Messene and Siphai or that it was built after the collapse of Theban power in 362. Neither alternative is attractive. As noted above, the architecture of Aigosthena represents a significant advance over the Group I sites; it requires excessive compression of development to put Aigosthena A in the same decade as the towers of Messene and Siphai. On the other hand, it is hard to imagine Eleutherai was Athenian by 447, when an Eleutheraian appears on an Athenian casualty list (IG I1, 943); on the date, see W.K. Pritchett, The Greek State at War 4 (Berkeley 1985) 183–84. Chabrias faced down Cleomenes several months before the Spartan general Sphodrias's raid on Attica in spring of 378 precipitated an alliance between Thebes and Athens. Hence Chabrias's peltasts were defending Athenian territory, not acting at the behest of the Thebans. See FA 211–12.

70 Πρότερον μὲν γὰρ Ἥλεθεληνικόν ἤρει πρὸς τὴν Ἀττικὴν πύλαν προσηματάτων δὲ Ἀθηναίων τούτων, οὗ τὸς Ἡβειαντιανὸν ἐκατερῶν ὀρείων. On the date, see Edmonson (supra n. 33) 148–52 (whose excellent discussion of the literary evidence for the chronology of Eleutherai is not significantly marred by his faulty assumption that the site of Eleutherai was modern Myoupolis, 7 km to the east of Gyptokastro); F.J. Frost, “Toward a History of Pelisstratid Athens,” in J.W. Eadie and J. Ober eds., The Craft of the Ancient Historian: Essays in Honor of Chester C. Starr (Lanham, Md. 1985) 69–70, with literature cited. Certainly
what military advantage the Thebans hoped to gain from a fortress at Aigosthena in the 350s or 340s, a time when their main military threat was the Phokians to the west. From about 341–335 B.C. the Thebans were worried about the Macedonians, who would approach Theban territory from the northwest; after 335 Thebes did not exist. Furthermore, the acropolis of Aigosthena was linked to the sea by walls extending to the bay. Walls to the sea would only be built by a state confident of its naval strength and Thebes was not a sea power after the 360s. Athens, on the other hand, was a major naval power during the 340s, when I would date the fortress at Aigosthena. The Athenians concluded a treaty with Megara in 343, under which Athenians rebuilt the long walls to Nisaia (Plut. Phok. 15); an Athenian stronghold at Aigosthena would serve to bind the Megarians to the Athenian side, give the Athenians a desirable naval base on the Corinthian Gulf, and secure the western land approaches, from south and north, through the Vilia valley into Attica.

The architectural similarity of Theban and Athenian fortifications can be explained without making Aigosthena and Gyphtokastro Theban. Athens and Thebes were allies for much of the first quarter of the fourth century and we may guess that the allies exchanged information on military architecture. At least one Boiotian contractor worked on the rebuilding of the Athenian long walls in the 390s (IG II², 1657 = GMI 2); there were probably other similar contacts of which we are ignorant. If we assume Gyphtokastro is a few years earlier than Messene, it is possible that Theban state architects observed or even participated in the construction of the fortress. Even after the breakdown of friendly relations between the two states after 371, there is no reason to assume that all intercourse was cut off. Indeed, early and mid-fourth-century military architects need not necessarily have been “state architects” at all; perhaps, like some temple designers, they went where there was work. The similarity of towers at Lilaia and Tithorea in Phokis and the towers at Aitolian Khalkis to the Athenian and Theban towers may be seen as further evidence for architectural forms, and therefore perhaps architects, crossing state frontiers. The development of a consistent architectural tradition in the first-genera-

tion catapult towers may, therefore, be viewed as an example of art—if one is willing to grant this title to functional military constructions—transcending political boundaries.

APPENDIX

THE THYRIDES KATERAKTOI OF IG II², 463

The restorations of windows and shutters at Siphai, Gyphtokastro, and Mazi, advanced above on the basis of Lawrence’s analysis of the function of window chases (supra n. 28), suggest a new restoration of the “downrushing shutters” (thyrides kateraktos) which were to be placed over the windows in the epalaxis (frenestrated parapet) of the mostly-brick city wall of Athens in 307/306 B.C. (IG II², 463 = GMI no. 11). The shutters were to be constructed of wood, five planks wide, and reinforced by two cross-boards (fig. 31d) attached with five iron nails each (lines 75–80). The windows were about 0.9 m² (GAF 412). The shutters typically have been restored as top-hung, attached to the wooden lintels (a) of the windows. Some of these earlier restorations were apparently influenced by Krischen’s restorations of the shutters at Herakleia, and the restorers probably assumed that most shutters were top-hung.

In light of the inefficiency of top-hung shutters (supra n. 28) it is a priori unlikely that they would have been

Fig. 31. Restoration of window with bottom-hung shutter in Athenian city wall. a lintel, b kyboi, c rings/hinges, d cross-board.
used in the Athenian city wall. There appears to be no preserved stone parallel for top-hung shutters. Furthermore, it is hard to explain why top-hung shutters, which would have to be propped open from the bottom, would be described as “down-rushing.” The term is surely more descriptive of the action of a bottom-hung shutter, which would in fact rush downwards when it was dropped open. Even Lawrence (GAF 411-12), however, decided that the shutters on the Athenian wall must have been top-hung, because there did not seem to be anywhere but the lintels to hang them, given the scarcity of wooden elements to which shutters could be attached. Iron bolts through chases in the brickwork would place too much strain on the mud bricks when the shutters were raised and lowered.

I suggest that the shutters in question were attached to the “blocks of wood” which were to be placed “beneath the lintels” of the windows (νοθήσει δὲ καὶ κίβους τοῖς ἐπὶ τῶν ναίων, lines 54-58). Most restorations, if they make use of the κίβους at all, place them directly under and in contact with the lintels, but there is no structural or philological necessity for this restoration. I restore the blocks (b) as running lengthwise through the wall on either side of the bottom edge of the window (thus the height of the window “beneath the lintel”), in precisely the position at which the chases are located in relation to the windows at the Siphai and Mazi towers. The wooden blocks would be held in place by the brickwork and would hold iron hinges (c)—the “six rings (δύο διάδοι) each two dactyls thick” (lines 77-78)—on which each shutter was hung. My restoration of the Messene L shutters (fig. 8A) suggests how these “rings” might have functioned.

The objection may be raised that the wooden blocks, as I have restored them, would not have been structurally strong enough to hold the shutter, but since we do not know the dimensions of the blocks, or the exact size or weight of the shutter, it is not possible to make a meaningful calculation of the stresses involved.

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77 Cf. Holland (supra n. 76) fig. 5.1, 3; Winter (supra n. 17) fig. 3.5-6.
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