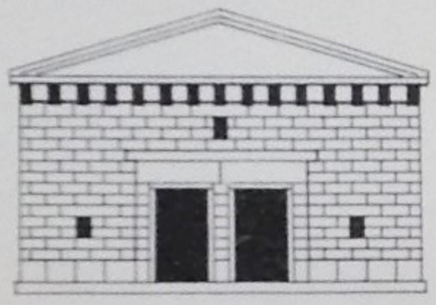
PARADEIGMATA

THREE
MID-FOURTH CENTURY
MAIN WORKS OF HELLENIC ARCHITECTURE
Reconsidered



THESIS TO BE DEFENDED FOR THE DOCTORATE

BY

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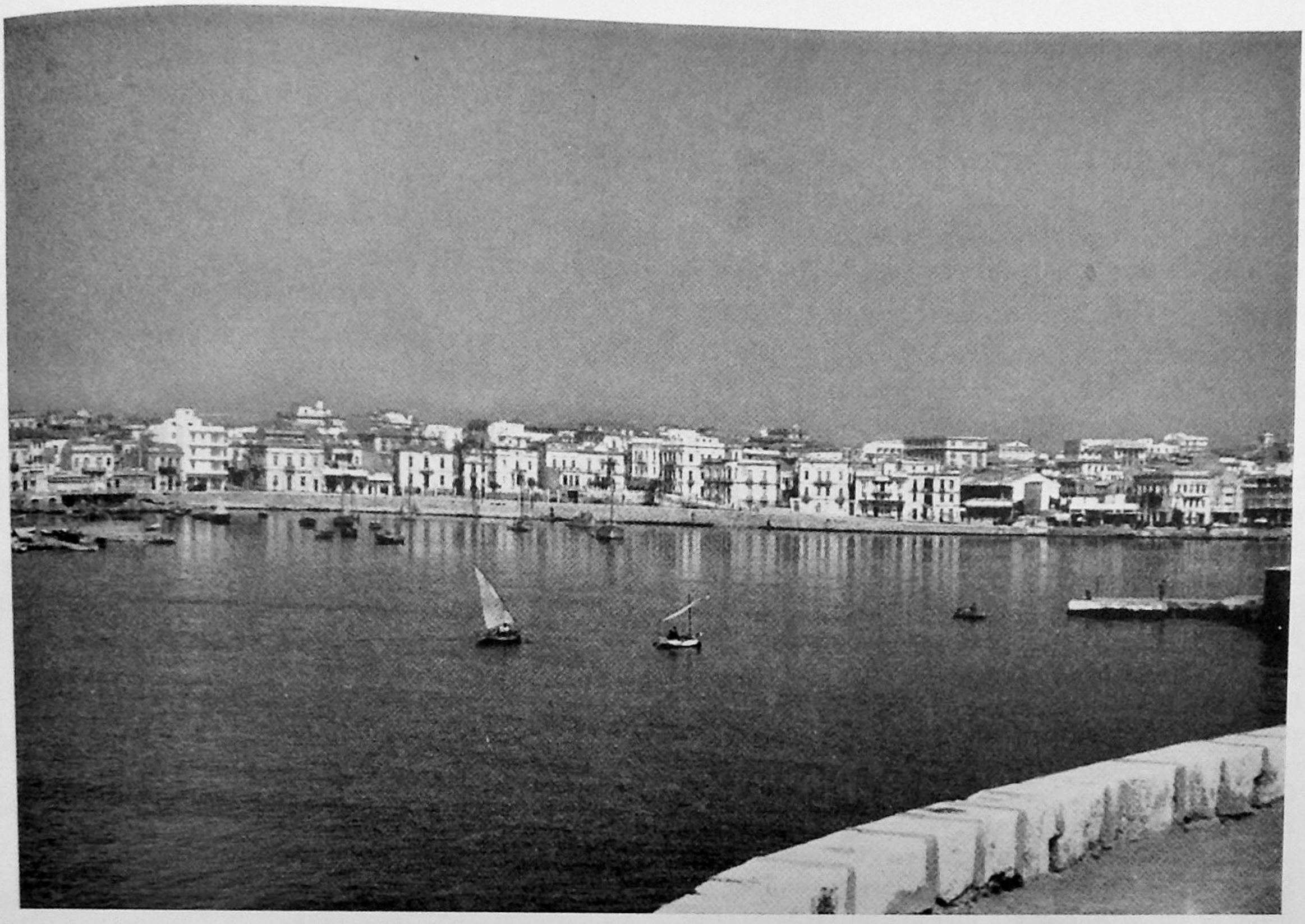

Piraeus – Harbour at Zea (phot. K.J.).

Chapter II

THE ARSENAL OF PHILO AS SPECIFIED IN THE PIRAEUS INSCRIPTION (IG II² 1668)

Shortly after the middle of the fourth century B.C., presumably in the year 347, it was decided by a public assembly in the theatre (at Piraeus) to erect a new arsenal of stone for the Attic navy at Piraeus. The architect Philo of Eleusis submitted his plans at the meeting and in an eloquent and persuasive speech he succeeded in stirring the enthusiasm of the Athenians whose patriotism was challenged at that time by the menace from Macedonia; a storehouse of the impressive dimensions proposed by Philo would in itself be a magnificent symbol of the power of Athens, likely to deter those who might believe that the glorious days of Athens were gone for ever[1]. The project was carried out according to the plans but probably not finished till some time in the twenties[2].

[1] Demosthenes complains that the glory of Athenian architecture is of the past and that the people are now satisfied with upkeep of roads and minor repairs (ΠΕΡΙ ΣΥΝΤΑΞΕΩΣ § 30 (cf. Davis, SOME ELEUSINIAN BUILDING INSCRIPTIONS, 1931, p. 55).

[2] Cf. Pauly-Wissowa, RE, 20¹ (1941) sp. 56 s. v. Philon (E. Fabricius). In a decree in honour of two wealthy denizens from 302/01 B.C. (IG II² 505) it is stated that these had contributed to the funds for the Arsenal and for shipsheds from 347/46 till 323/22. The work was suspended from 339 B.C. when it was decided, on the plea of Demosthenes, to reserve all funds for the war

When Sulla conquered Athens and Piraeus in 86 B.C. the arsenal was burnt down, and no remains of it have been traced in modern times. But the edifice is described in an inscription found in 1882 at Piraeus, giving sufficient evidence for a reconstruction of its main features. In details, however, the text is somewhat deficient or ambiguous, and the scholars who have undertaken to interpret its meaning disagree on a number of points. Thus the commentaries of Foucart, Ludlow, Fabricius, Choisy, Dörpfeld, Keil and Wanscher all contain some specific opinions[3]; and the problems have not been settled by the latest contribution on the subject by Marstrand who characterized the restorations of his predecessors as "inadmissible from a functional point of view" and claimed "to keep much more strictly than has hitherto been done, to the wording of the text"[4].

As a basis for a new discussion I shall reproduce here my own translation of the text (which in some respects follows that of Ludlow, op. cit. 320ff.). I have found it practical, for the purpose of references, to divide the text into 14 points, which will facilitate a survey of its contents:

I	(l. 1–4)	Heading.
II	(l. 4–7)	Location of the arsenal; length and width of ground plan.
III	(l. 7–15)	Foundations; main features of ground plan.
IV	(l. 15–19)	Directing course.
V	(l. 19–26)	Orthostate course; main features of doorways.
VI	(l. 26–30)	Walls.
VII	(l. 30–34)	Specifications for doorways.
VIII	(l. 34–39)	Windows; cornices and pediments.
IX	(l. 39–45)	Stylobate and piers.
X	(l. 45–59)	Architraves; roof construction; tiles.
XI	(l. 59–65)	Stone ceiling above doorways; doors; internal pavement; how to separate the intercolumniations from the middle aisle.
XII	(l. 65–85)	Midway galleries and shelves for tackle.
XIII	(l. 85–94)	Chests for sails, and side curtains; ventilation.
XIV	(l. 94–97)	Stipulations.

Fig. 57 shows all the measurements actually given in the inscription on which is based the complete reconstruction of the building suggested p. 76–84, p. 95–96, figs. 58–59, 66–68.

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against Philip of Macedonia (Philochorus fragm. 135), but resumed still under Lycurgus († 325 B.C.) who was credited with the completion of it and of some other important buildings in Athens (cf. decree in honour of Lycurgus, SYLL.[3] 326, and Plut. VIT. X or. 852a). In the Attic naval accounts for the year 330/329 B.C. (IG II[2] 1627b 279ff.) are listed, among other things, deposits of iron clamps and dowels left over from the Arsenal the walls of which therefore were probably finished at that time.

Philo's rhetorical achievements are mentioned by Cicero (DE ORAT. I, 14, 62), Valerius Maximus (VIII 12. 2) and Philodemus (RHET. IV, 1, 192 ed. Sudhaus), and these as well as other writers (Vitr. preface VII; Strabo IX, c 395; Pliny H.N. VII 125) agree on the name of the architect. See also the list of APXITEKTONEC in the LATERCULI ALEXANDRINI published by Diels, ABH. D. KGL. PREUSS. AKAD. D. WISS. 1904 p. 8:

Kol. 7. [ΜΑΥCCΩΛΕΙΟΝ] · ΦΙΛΩΝ
[····· ΚΗ[·]ΑΘΗ
[·····]Η

I would suggest to fill out in the following way:
17 ΦΙΛΩΝ [ΤΗΝ CΚΕΥΟΘΗ]ΚΗ[Ν] ΑΘΗ[ΝΗCΙΝ

Pliny says: LAUDATUS EST ET CHERSIPHRON GNOSIUS AEDE EPHESI DIANAE ADMIRABILI FABRICATA, PHILON ATHENIS ARMAMENTARIO CD NAVIUM, CTESIBIUS PNEUMATICA RATIONE ET HYDRAULICIS ORGANIS REPERTIS, DINOCRATES METATUS ALEXANDRO CONDENTI IN AEGYPTO ALEXANDRIAM, from which Fabricius infers (Paula-Wissowa RE s.v. Philon) that public honour was bestowed upon Philo. But if so it would apply to Chersiphron, Ctesibius and Dinocrates as well. It does not seem warranted, however, to infer so much from LAUDATUS EST.

Cicero and Valerius Maximus tell us that Philo gave the people an account of his work (RATIONEM REDDIDISSE OPERIS SUI or INSTITUTIONIS SUAE). Fabricius argues (HERMES XVII) that this cannot have happened before the erection of the arsenal but some time before or after it was finished. However, it was hardly the duty of the architect to give accounts of the expenditure. No doubt this was left to a committee in charge of the financial problems. Philo's speech must have concerned architectural matters only. Most likely he explained his plans for the arsenal to the public, and this would not have been necessary if the project had already been accepted or the building was finished.

[3] Cf. the bibliography p. 157.

[4] ARSENALET I PIRÆUS OG OLDTIDENS BYGGEREGLER, København 1922, p. 23.

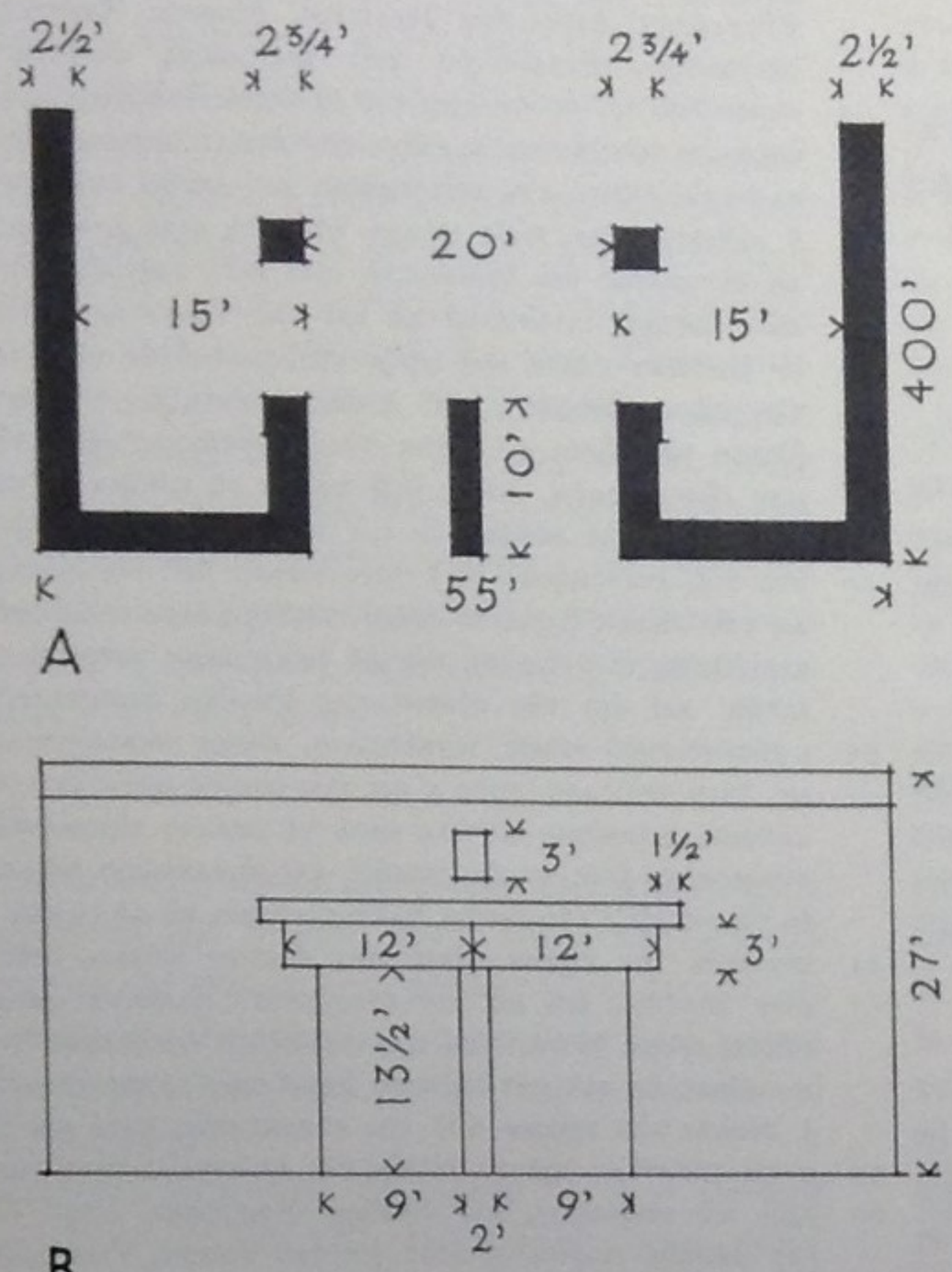

Fig. 57. The measurements given in the Arsenal inscription. A: ground plan. B: front elevation. C: cross section. D–F: dimensions of walls and piers. G–K: timber constructions. G: roof. H: midway galleries. K: shelves above the midway galleries. (K.J.).

TRANSLATION

I. (l. 1–4).
Gods.

Specifications for the Arsenal of stone for naval tackling, by Euthydomus, son of Demetrius of Melite, and Philo, son of Execestides of Eleusis.

II. (l. 4–7).

[They have resolved to propose(?) that:]

An arsenal for tackling shall be built at Zeia, beginning near the propylaion which leads from the agora as one approaches from behind the shipsheds which are roofed-in together, 4 plethra in length, 55 feet in width, inclusive of (the thickness of) the walls.

III. (l. 7–15).

Excavate to a depth of 3 feet from the highest point of the area, remove the rubbish, and lay foundations upon the firm ground, raising them level and straight everywhere, in accordance with the rule. Lay foundations for the piers as well, at a distance from either wall of 15 ft., including the thickness of the piers, the number of piers in either row being 35, thus leaving a passage for the public through the middle of the arsenal 20 ft. in width between the piers; the width of the foundations shall be 4 ft. and the stones shall be placed alternately as stretchers and headers.

IV. (l. 15–19).

Build the walls and the piers of the arsenal of stone from Akte, laying a directing-course (ΕΥΘΥΝΤΗΡΙΑ) for the walls, of blocks 3 ft. wide, $^3/_2$ ft. high, and 4 ft. long, but $4^3/_4$ ft. at the angles.

V. (l. 19–26).

And upon the directing-course lay upright stones (ΟΡΘΟΣΤΑΤΑΣ) over the middle of it, 4 ft. long, $^5/_2$ ft. plus one dactyl in width, 3 ft. high – but at the angles the length depends on the dimensions of the triglyphs – leaving apertures for two doorways at either end of the arsenal, 9 ft. wide; and construct a pillar (ΜΕΤΩΠΟΝ) between the doorways at either end, 2 ft. wide and 10 ft. deep (in inward direction), and let the wall against which each door opens turn off so as to abut on the outermost pier.

VI. (l. 26–30).

Then upon the upright course build the walls of ashlars 4 ft. long, $^5/_2$ ft. wide – but the length at the angles depends on the dimensions of the triglyphs – and $^3/_2$ ft. high. Let the height of the walls above the directing-course be 27 ft., inclusive of the triglyph frieze beneath the cornice.

VII. (l. 30–34).

But let the height of the doorways (that is: above the directing-course) be 15½ ft. (scribal error; see commentary below), and place above them lintels of Pentelic marble 12 ft. long, as thick as the walls and 2 courses high; and erect doorposts of Pentelic or Hymettian marble, laying under them sills of Hymettian marble. And over the lintels place a cornice projecting 1½ ft.

[θ]εο[ῖ].
[c]ΥΝΓΡΑΦΑΙ ΤΗC CΚΕΥΟΘΗΚΗC ΤΗC ΛΙΘΙΝΗC ΤΟΙC ΚΡΕΜΑCΤΟΙC CΚΕΥΕCΙΝ ΕΥΘΥΔΟΜΟΥ ΔΗΜΗΤΡΙΟΥ ΜΕΛΙΤΕΩC, ΦΙΛΩΝΟC ΕΞΗΚΕCΤΙΔΟΥ ΕΛΕΥCΙΝΙΟΥ. CΚΕΥΟΘΗΚΗΝ ΟΙΚΟΔΟΜΗCΑΙ ΤΟΙC ΚΡΕΜΑCΤΟΙC CΚΕΥΕCΙΝ ΕΝ ΖΕΙΑΙ ΑΡΞΑ-
5 ΜΕΝΟΝ ΑΠΟ ΤΟΥ ΠΡΟΠΥΛΑΙΟΥ ΤΟΥ ΕΞ ΑΓΟΡΑC ΠΡΟCΙΟΝΤΙ ΕΚ ΤΟΥ ΟΠΙCΘΕΝ ΤΩΝ Ν-ΕΩCΟΙΚΩΝ ΤΩΝ ΟΜΟΤΕΓΩΝ, ΜΗΚΟC ΤΕΤΤΑΡΩΝ ΠΛΕΘΡΩΝ, ΠΛΑΤΟC ΠΕΝΤΗΚΟΝΤΑ Π-ΟΔΩΝ ΚΑΙ ΠΕΝΤΕ CΥΝ ΤΟΙC ΤΟΙΧΟΙC. ΚΑΤΑΤΕΜΩΝ ΤΟΥ ΧΩΡΙΟΥ ΒΑΘΟC ΑΠΟ ΤΟ-Υ ΜΕΤΕΩΡΟΤΑΤΟΥ ΤΡΕΙC ΠΟΔΑC, ΤΟ ΑΛΛΟ ΑΝΑΚΑΘΑΡΑΜΕΝΟC ΕΠΙ ΤΟ ΣΤΕΡΙΦ-ΟΝ CΤΡΩΜΑΤΙΕΙ ΚΑΙ ΑΝΑΛΗΨΕΤΑΙ ΙCΟΝ ΚΑΤΑ ΚΕΦΑΛΗΝ ΑΠΑΝ ΟΡΘΟΝ ΠΡΟC Τ-
10 ΟΝ ΔΙΑΒΗΤΗΝ. CΤΡΩΜΑΤΙΕΙ ΔΕ ΚΑΙ ΤΟΙC ΚΙΟCΙΝ ΑΠΟΛΕΙΠΩΝ ΑΠΟ ΤΟΥ ΤΟΙΧ-ΟΥ ΕΚΑΤΕΡΟΥ ΠΕΝΤΕ Κ[ΑΙ ΔΕΚ]Α ΠΟΔΑC CΥΝ ΤΩΙ ΠΑΧΕΙ ΤΟΥ ΚΙΟΝΟC, ΑΡΙΘΜΟC ΤΩΝ ΚΙΟΝΩΝ ΕΚΑΤΕΡΟΥ ΤΟΥ CΤΟΙΧΟΥ ΠΕΝΤΕ ΚΑΙ ΤΡΙΑΚΟΝΤΑ, ΔΙΑΛΕΙΠΩΝ Δ-[Ι]ΟΔΟΝ ΤΩΙ ΔΗΜΩΙ ΔΙΑ ΜΕCΗC ΤΗC CΚΕΥΟΘΗΚΗC ΠΛΑΤΟC ΤΟ ΜΕΤΑΞΥ ΤΩΝ ΚΙΟ-ΝΩΝ ΕΙΚΟCΙ ΠΟΔΩΝ. ΠΑΧΟC [Δ]Ε ΠΟΗCΕΙ ΤΟ CΤΡΩΜΑ ΤΕΤΡΑΠΟΥΝ, ΤΙΘΕΙC ΤΟΥC
15 ΛΙΘΟΥC ΕΝΑΛΛΑΞ ΦΟΡ[ΜΗ]ΔΟΝ ΚΑΙ ΠΑΡΑ ΜΗΚΟC. ΟΙΚΟΔΟΜΗCΕΙ ΔΕ ΤΟΥC ΤΟΙΧ-ΟΥC ΤΗC CΚΕΥΟΘΗΚΗ[C ΚΑ]Ι ΤΟΥC ΚΙΟΝΑC ΑΚΤΙΤΟΥ ΛΙΘΟΥ, ΘΕΙC ΕΥΘΥΝΤΗΡΙ-ΑΝ ΤΟΙC ΤΟΙΧΟΙC [Π]ΛΑΤΟC ΤΡΙΩΝ ΠΟΔΩΝ, ΠΑΧΟC ΤΡΙΩΝ ΗΜΙΠΟΔΙΩΝ, ΜΗΚΟC Τ-ΕΤΡΑΠΟΔΩΝ ΤΩΝ Λ[ΙΘ]ΩΝ, ΕΠΙ ΔΕ ΤΑΙC ΓΩΝΙΑΙC ΤΕΤΡΑΠΟΔΩΝ ΚΑΙ ΤΡΙΩΝ ΠΑΛ-
20 ΑCΤΩΝ. ΚΑΙ ΕΠΙ ΤΗC ΕΥΘΥΝΤΗΡΙΑC ΕΠΙΘΗCΕΙ ΟΡΘΟCΤΑΤΑC ΠΕΡΙ ΜΕCΗΙ ΤΗ-Ι ΕΥΘΥΝΤΗΡΙΑ[Ι] ΜΗΚΟC ΤΕΤΡΑΠΟΔΑC, ΠΑΧΟC ΠΕΝΘΗΜΙΠΟΔΙΩΝ ΚΑΙ ΔΑΚΤΥΛ-ΟΥ, ΥΨΟC ΤΡΙΠΟΔΑC, ΤΟΥC Δ' ΕΠΙ ΤΑΙC ΓΩΝΙΑΙC ΜΗΚΟC ΕΚ ΤΟΥ ΜΕΤΡΟΥ ΤΩΝ ΤΡ-ΙΓΛΥΦΩΝ, ΔΙΑΛΕΙΠΩΝ ΘΥΡΑΙΑC ΚΑΤΑ ΤΟ ΠΛΑΤΟC ΤΗC CΚΕΥΟΘΗΚΗC, ΔΥΟ ΕΚ[Α]-ΤΕΡΩΘΕΝ, ΠΛΑΤΟC ΕΝΝΕΑ ΠΟΔΩΝ. ΚΑΙ ΟΙΚΟΔΟΜΗCΕΙ ΜΕΤΩΠΟΝ ΕΚΑΤΕΡΩΘΕ[Ν]
25 ΕΝ ΤΩΙ ΜΕΤΑ[Ξ]Υ ΤΩΝ ΘΥΡΩΝ, ΠΛΑΤΟC ΔΙΠΟΥΝ, ΕΙC ΔΕ ΤΟ ΕΙCΩ ΔΕΚΑΠΟΥΝ. ΚΑΙ Π-ΕΡΙΚΑΜΨΕΙ ΤΟΝ ΤΟΙΧΟΝ ΜΕΧΡΙ ΤΩΝ ΠΡΩΤΩΝ ΚΙΟΝΩΝ, ΠΡΟC ΟΝ ΑΝΟΙΞΕΤΑΙ Η ΘΥΡΑ ΕΚΑΤΕΡΑ. ΕΠΙ ΔΕ ΤΟΥ ΟΡΘΟCΤΑΤΟΥ ΠΛΙΝΘΙCΙΝ ΟΙΚΟΔΟΜΗCΕΙ ΤΟΥC Τ-ΟΙΧΟΥC, ΜΗΚΟC ΤΕΤΡΑΠΟCΙΝ, ΠΛΑΤΟC ΠΕΝΤΕ ΗΜΙΠΟΔΙΩΝ, ΕΠΙ ΔΕ ΤΑΙC ΓΩΝΙ-
30 ΑΙC ΜΗΚΟC ΕΚ ΤΟΥ ΜΕΤΡΟΥ ΤΩΝ ΤΡΙΓΛΥΦΩΝ, ΠΑΧΟC ΤΡΙΗΜΙΠΟΔΙΟΙC. ΥΨΟC Δ-Ε ΠΟΙΗCΕΙ ΤΩΝ ΤΟΙΧΩΝ ΑΠΟ ΤΗC ΕΥΘΥΝΤΗΡΙΑC ΕΠΤΑ ΚΑΙ ΕΙΚΟCΙ ΠΟΔΩΝ CΥ-Ν ΤΗΙ ΤΡΙΓΛΥΦΩΙ ΥΠΟ ΤΟ ΓΕΙCΟΝ, ΤΑC ΔΕ ΘΥΡΑΙΑC ΥΨΟC ΠΕΝΤΕ ΚΑΙ ΔΕΚΑ ΠΟ-ΔΩΝ ΚΑΙ ΗΜΙΠΟΔΙΟΥ. ΚΑΙ ΕΠΙΘΗCΕΙ ΥΠΕΡΤΟΝΑΙΑ ΛΙΘΟΥ ΠΕΝΤΕΛΗΪΚΟΥ ΜΗ-
35 ΚΟC ΔΩΔΕΚΑ ΠΟΔΩΝ, ΠΛΑΤΟC ΙCΑ ΤΟΙC ΤΟΙΧΟΙC, ΥΨΟC ΔΙCΤΟΙΧΑ ΠΑΡΑCΤΑΔ-ΑC CΤΗCΑC ΛΙΘΟΥ ΠΕΝΤΕΛΗΪΚΟΥ Α ΥΜΗΤΤΙΟΥ, ΟΔΟΥC ΥΠΟΘΕΙC ΥΜΗΤΤΙΟΥC. ΚΑΙ ΓΕΙCΟΝ ΕΠΙΘΗCΕΙ ΕΠΙ ΤΩΝ ΥΠΕΡΤΟΝΑΙΩΝ ΥΠΕΡΕΧΟΝ ΤΡΙΑ ΗΜΙΠΟΔΙΑ. ΚΑΙ ΠΟΙΗCΕΙ ΘΥΡΙΔΑC ΚΥΚΛΩΙ ΕΝ ΑΠΑCΙΝ ΤΟΙC ΤΟΙΧΟΙC ΚΑΘ' ΕΚΑCΤΟΝ ΤΟ ΜΕΤΑΚΙΟΝΙΟΝ, ΕΝ ΔΕ ΤΩΙ ΠΛΑΤΕΙ ΤΡΕΙC ΕΚΑΤΕΡΩΘΕΝ, ΥΨΟC ΤΡΙΩΝ ΠΟΔΩΝ, Π-ΛΑΤΟC ΔΥΟΙΝ ΠΟΔΟΙΝ, ΚΑΙ ΕΝΑΡΜΟCΑΙ ΕΙC ΕΚΑCΤΗΝ ΤΗΝ ΘΥΡΙΔΑ ΧΑΛΚΑC Θ-ΥΡΙΔΑC ΛΡΜΟΤΤΟΥCΑC. ΚΑΙ ΕΠΙΘΗCΕΙ ΕΠΙ ΤΟΥC ΤΟΙΧΟΥC ΓΕΙCΑ ΚΥΚΛΩΙ Κ-ΑΙ ΤΟΥC ΑΙΕΤΟΥC ΟΙΚΟΔΟΜΗCΕΙ ΚΑΙ ΓΕΙCΑ ΕΠΙΘΗCΕΙ ΚΑΤΑΙΕΤΙΑ. ΚΑΙ CΤ-
40 ΗCΕΙ ΤΟΥC ΚΙΟΝΑC ΥΠΟΘΕΙC CΤΥΛΟΒΑΤΗΝ ΚΑΤΑ ΚΕΦΑΛΗΝ ΙCΟΝ ΤΗΙ ΕΥΘΥΝ-ΤΗΡΙΑΙ, ΠΑΧΟC ΤΡΙΩΝ ΗΜΙΠΟΔΙΩΝ, ΠΛΑΤΟC ΔΕ ΤΡΙΩΝ ΠΟΔΩΝ ΚΑΙ ΠΑΛΑCΤΗC, ΜΗΚΟC ΤΕΤΤΑΡΩΝ ΠΟΔΩΝ· ΠΑΧΟC ΤΩΝ ΚΙΟΝΩΝ ΚΑΤΩΘΕΝ ΔΥΟΙΝ ΠΟΔΟΙΝ ΚΑΙ Τ-ΡΙΩΝ ΠΑΛΑCΤΩΝ, ΜΗΚΟC CΥΝ ΤΩΙ ΕΠΙΚΡΑΝΩΙ ΤΡΙΑΚΟΝΤΑ ΠΟΔΩΝ, CΦΟΝΔΥΛΩ-Ν ΕΚΑCΤΟΝ ΕΠΤΑ ΜΗΚΟC ΤΕΤΡΑΠΟΔΩΝ, ΤΟΥ ΔΕ ΠΡΩΤΟΥ ΠΕΝΤΕΠΟΔΟC· ΤΑ ΔΕ ΕΠ-
45 ΙΚΡΑΝΑ ΕΠΙΘΗCΕΙ ΕΠΙ ΤΟΥC ΚΙΟΝΑC ΛΙΘΟΥ ΠΕΝΤΕΛΗΪΚΟΥ· ΚΑΙ ΕΠΙΘΗCΕΙ ΕΠΙCΤΥΛΙΑ ΞΥΛΙΝΑ ΕΠΙ ΤΟΥC ΚΙΟΝΑC ΚΟΛΛΗCΑC, ΠΛΑΤΟC ΠΕΝΤΕ ΗΜΙΠΟΔΙ-ΩΝ, ΥΨΟC ΕΝΝΕΑ ΠΑΛΑCΤΩΝ ΕΚ ΤΟΥ ΥΨΗΛΟΤΕΡΟΥ, ΑΡΙΘΜΟC ΔΕΚΑΟΚΤΩ ΕΦ' ΕΚΑ-ΤΕΡΟΝ ΤΟΝ ΤΟΝΟΝ. ΚΑΙ ΜΕCΟΜΝΑC ΕΠΙΘΗCΕΙ ΕΠΙ ΤΟΥC ΚΙΟΝΑC ΥΠΕΡ ΤΗC ΔΙ-ΟΔΟΥ, ΠΛΑΤΟC ΚΑΙ ΥΨΟC ΙCΑ ΤΟΙC ΕΠΙCΤΥΛΙΟΙC. ΚΑΙ ΕΠΙΘΗCΕΙ ΚΟΡΥΦΑΙΑ

VIII. (l. 34–39).

Make apertures for windows all around, in all the walls, one opposite each intercolumniation, and 3 at either end, 3 ft. high and 2 ft. wide. And fit into each aperture a grating of bronze fitting closely. Upon the walls all around lay cornices, build pediments and place the pedimental cornices.

IX. (l. 39–45).

Erect the piers and place under (each of) them a base (ΣΤΥΛΟΒΑΤΗΝ) level with the directing-course, $^3/_2$ ft. thick, 3¼ ft. wide, 4 ft. long; the lower thickness of the piers shall be $2^3/_4$ ft., and their height, including the capitals, 30 ft., consisting of 7 drums 4 ft. high except the first which shall be 5 ft. Lay capitals upon the piers of Pentelic marble.

X. (l. 45–59).

Place wooden beams upon the piers and fit them together, $^5/_2$ ft. wide, $^9/_4$ ft. high at the highest point, 18

pieces in either row, and lay cross-beams (ΜΕΣΟΜΝΑΣ) upon the piers across the passage, as wide and as high as the former beams. Thereupon lay rafters (ΚΟΡΥΦΑΙΑ) $^{7}/_{4}$ ft. wide, $^{5}/_{4}$ ft. and two dactyls high, apart from (i.e. measured at right angles to) the slope of the roof, and place under them a prop (ΥΠΟΘΗΜΑ) resting on the cross-beam, 3 ft. high and $^{3}/_{2}$ ft. in width, and put them in position above the cross-beams, kept apart anglewise in accordance with the slope of the roof. Thereupon lay long timbers 10 dactyls thick, $^{3}/_{4}$ ft. and 3 dactyls wide, distant from each other $^{5}/_{4}$ ft., and above these planks, ½ ft. wide and 2 dactyls thick, distant from each other 4 dactyls; thereupon apply boards 1 dactyl thick and 6 dactyls wide and fasten them with iron nails and cover with a coating (of clay), and tile with Corinthian tiles, fitted closely to each other.

XI. (l. 59–65).

Above the doorways, upon the pillars lay a ceiling of Hymettian stone on the inside. Place upon the arsenal doors fitted to the doorways and plated with bronze on the outside. And pave the whole interior floor with stones fitted closely to each other, and work it smooth and level upon its upper surface.

Let each intercolumniation be closed by two upright stone blocks (ΟΡΘΟΣΤΑΤΑΣ) 3 ft. high, and place between them a lattice that can be locked.

XII. (l. 65–85).

Construct the midway galleries, on which the tackle is to be placed, from inside the piers at either side as far as the wall, and fasten them opposite each pier and along the wall at either side by means of a beam (ΔΙΕΡΕΙΣΜΑ) $^{5}/_{4}$ ft. wide and 1 ft. high, extending $^{3}/_{4}$ ft. into the wall, and beside the piers erect posts of stone. Upon the beams lay long timbers, seven in each place filling it out as far as the piers, $^{3}/_{4}$ ft. wide, $^{1}/_{2}$ ft. thick, and cover the whole area with planks fitted and fastened together, 3 ft. wide and 2 dactyls thick. Make also shelves for the undergirding straps and other tackle, along both walls, one above the other, and let them turn off along the end walls and opposite the piers at each interval, 4 ft. above the gallery, but the upper shelf 5 ft. above the lower one: erect posts from the lower ceiling (i.e. the gallery) to the upper ceiling, ½ ft. wide and 6 dactyls thick, and tenon into the posts cross-bars of the same thickness, thereupon lay continuous timbers, one at either side (of the shelves), 6 dactyls square, and above these planks fitted closely together, 4 ft. long, 3 ft. wide and 2 dactyls thick, fitted evenly to the timbers and nailed down. Make wooden ladders to give access to the shelves.

XIII. (l. 85–94).

Make chests for the sails and for the white side curtains, in number 134, in accordance with the model and place one against each pier and one in the space opposite, and make openings in the fronts of the chests along the walls, and in both ends of those against the piers, so that all the tackle is visible to people passing through the arsenal (or: to those inspecting the arsenal). That there may be ventilation in the arsenal, when the courses of the walls are

πλάτος ἑπτὰ παλαστῶν, ὕψος δὲ πέντε παλαστῶν καὶ δυοῖν δακτύλοιν ἄνευ τῆς καταφορᾶς, ὑποθεὶς ὑπόθημα ἐπὶ τῆς μεσόμνης μῆκος τριῶν ποδῶν, πλάτος τριῶν ἡμιποδίων, καὶ διαρμόσει τὰ κορυφαῖα κερκίσιν ἐπὶ τῶν μεσομνῶν. καὶ ἐπιθήσει σφηκίσκους πάχος δέκα δακτύλων, πλάτος τριῶν παλαστῶν καὶ τριῶν δακτύλων, διαλείποντας ἀπ' ἀλλήλων πέντε παλαστάς. καὶ ἐπιθεὶς ἱμάντας πλάτος ἡμιποδίου, πάχος δυοῖν δακτύλοιν, διαλείποντας ἀπ' ἀλλήλων τέτταρας δακτύλους, καὶ ἐπιθεὶς καλύμματα πάχος δακτύλου, πλάτος ἓξ δακτύλων, καθηλώσας ἥλοις σιδηροῖς, δορώσας κεραμώσει Κορινθίωι κεράμωι ἁρμόττοντι πρὸς ἄλληλον. καὶ ἐπιθή[ς]ει ὑπὲρ τῶν θυρῶν ἐπὶ τὰ μέτωπα ἐκ τοῦ ἐντὸς ὀροφὴν λιθίνην λίθου Ὑμηττίου. καὶ θύρας ἐπιθήσει τῆι σκευοθήκηι ἁρμοττούσας εἰς τὰς θυραίας, χαλκᾶς ἔξωθεν ποιήσας. καὶ συστρώσει τὸ ἔδαφος λίθοις τὸ ἐντὸς ἅπαν συναρμόττουσι πρὸς ἀλλήλους καὶ ἐπεργάσεται ὀρθὸν καὶ ὁμαλὲς ἄνωθεν. καὶ διαφράξει τὸ μεταξὺ κιονοστάταις δυοῖν λιθίνοις ὕψος τριῶν ποδῶν, καὶ ἐν τῶι μεταξὺ κινκλίδα ἐπιθήσε[ι] κλειομένην. ποιήσει δὲ καὶ τὰς ὀροφὰς τὰς διὰ μέσου, ἐφ' ὧν τὰ σκεύη κείσεται, τὸ ἐντὸς τῶν κιόνων ἑκατέρωθεν μέχρι τοῦ τοίχου διαρμόσας καθ' ἕκαστον τὸν κίονα καὶ παρὰ τὸν τοῖχον ἑκατέρωθεν διερείσματι πλάτος πέντε παλαστῶν, ὕψος ποδιαίωι, ἐπιβάλλοντι ἐπὶ μὲν τὸν τοῖχον τρεῖς παλαστάς, παρὰ δὲ τὸν κίονα παραστάδια στήσει λίθινα. καὶ ἐπὶ τῶν διερεισμάτων ἐπιθήσει σφηκίσκους ἑπτὰ ἐφ' ἑκάστην τὴν χώραν, συμπληρῶν μέχρι τῶν κιόνων, πλάτος τριῶν παλαστῶν, πάχος ἡμιποδίου, καὶ συστρώσει πίναξιν ἅπαν τὸ χωρίον, συμβαλὼν καὶ κολλήσας, πλάτος τρίποδας, πάχος δυοῖν δακτύλοιν. ποιήσει δ[ὲ κ]αὶ μεσόμνας, ἐφ' ὧν κείσεται τὰ ὑποζώματα καὶ τἆλλα σκεύη, παρ' ἑκάτερον τὸν τοῖχον, διπλᾶς τὸ ὕψος, καὶ ἐπικάμψει παρὰ τοὺς πλ[α]γίους τοίχους, καὶ κατὰ τοὺς κίονας ἐπικάμψει καθ' ἑκάστην τὴν χώραν· ὕψος δὲ ποιήσει ἀπὸ τῆς ὀροφῆς τεττάρων ποδῶν, τὴν δὲ ἐπάνω μεσόμνην ἀπὸ τῆς ἑτέρας ἀπέχουσαν πέντε πόδας· ἱκριωτῆρα στήσας ἀπὸ τῆς κάτω ὀροφῆς μέχρι τῆς ἄνω ὀροφῆς πλάτος ἡμιποδίου, πάχος ἓξ δακτύλων, διερείσας διερείσματα εἰς τοὺς ἱκριωτῆρας τὸ αὐτὸ πάχος θρανους ἐπιθήσει διανεκεῖς, ἕνα ἑκατέρωθεν, πάχος ἓξ δακτύλων πανταχῆι, καὶ ἐπὶ τούτων ἐπιθήσει πίνακας συγκολλήσας, μῆκος τετράποδας, πλάτος τρίποδας, πάχος δυοῖν δακτύλοιν, καὶ [κ]αθηλώσει συναρμόττοντας ἐξ ἴσου τοῖς θρανοις. καὶ καίμακας ποιήσει ξυλίνας ἀναβαίνειν ἐπὶ τὰς μεσόμνας. ποιήσει δὲ καὶ κιβωτοὺς τοῖς ἱστίοις καὶ τοῖς παραρρύμασιν τοῖς λευκοῖς, ἀριθμὸν ἑκατὸν τριάκοντα τέτταρας, πρὸς τὸ παράδειγμα ποιήσας, καὶ θήσει κατὰ τὸν κίονα ἕκαστον καὶ μίαν εἰς τὸ κατάντροκὺ χωρίον, καὶ ποιήσει ἀνοιγνυμένας, τῶν μὲν πρὸς τῶι τοίχωι κειμένων τὸν πρόσθιον τοῖχον, τῶν δὲ κατὰ τοὺς κίονας κειμένων ἀμφοτέρους τοὺς πλαγίους τοίχους, ὅπως ἂν ᾖι ὁρᾶν ἅπαντα τὰ σκεύη διεξιοῦσιν, ὁπόσ' ἂν ᾖι ἐν τῆι σκευοθήκηι. ὅπως δ' ἂν καὶ ψῦχος ᾖι ἐν τῆι σκευοθήκηι, ὅταν οἰκοδομῆι τοὺς τοίχους τῆς σκευοθήκης διαλείψει τῶν πλινθίδων ἐν τοῖς ἁρμοῖς ᾗι ἂν κελεύηι ὁ ἀρχιτέκτων. ταῦτα ἅπαντα ἐξεργάσονται οἱ μισθωσάμενοι κατὰ τὰς συγγραφὰς καὶ πρὸς τὰ μέτρα καὶ πρὸς τὸ παράδειγμα, ὃ ἂν φράζηι ὁ ἀρχιτέκτων, καὶ ἐν τοῖς χρόνοις ἀποδώσουσιν, οἷς ἂν μισθώσωνται ἕκαστα τῶν ἔργων.

vacat

laid, leave the joints between the ashlars open where the architect shall direct.

XIV. (l. 94–97).

All these things shall be carried out by the contractors in accordance with the specifications and with the measurements and the model indicated by the architect. And they must deliver each detail of the work within the time, to which they will agree in the contract.

COMMENTARY

Ad I.

It may be inferred from points XIII–XIV which mention "the architect" that Philo alone was responsible as masterbuilder. The other subscriber, Euthydomus, son of Demetrius of Melite, therefore was probably not an archi-

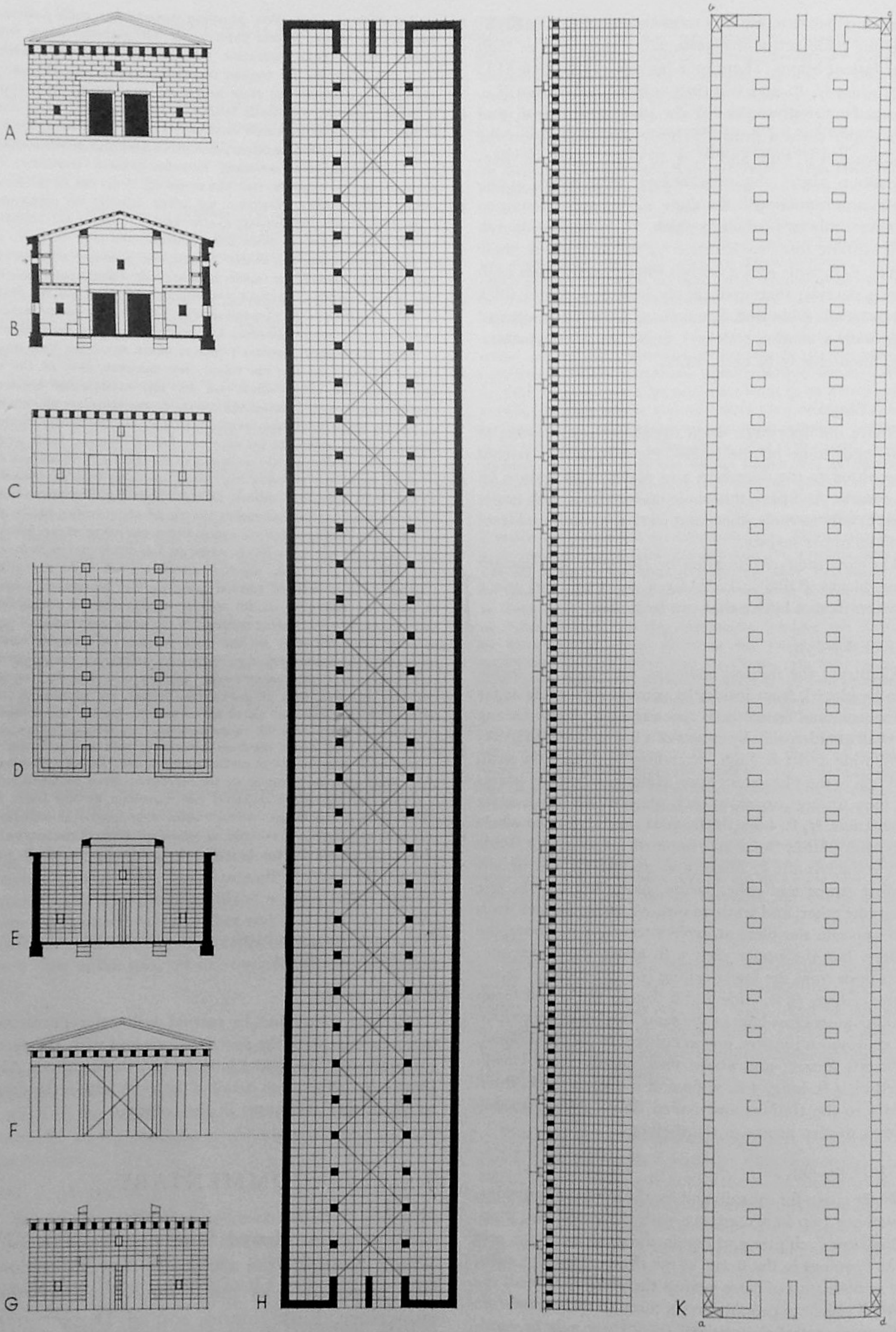

Fig. 58. Reconstruction of the Arsenal and of its theoretical design. A–B: front elevation and cross section of the finished building. C–I: theoretical design. C: front elevation adapted to a network of rectangles 4½ by 3¾ ft. D: ground plan adapted to a network of squares of 3¾ ft. (axial symmetry). E–G–H–I: cross section, front elevation, ground plan and side elevation adapted to a network of 2½ ft. squares. F: octastyle diagram. K: plan of the euthynteria course. (K.J.).

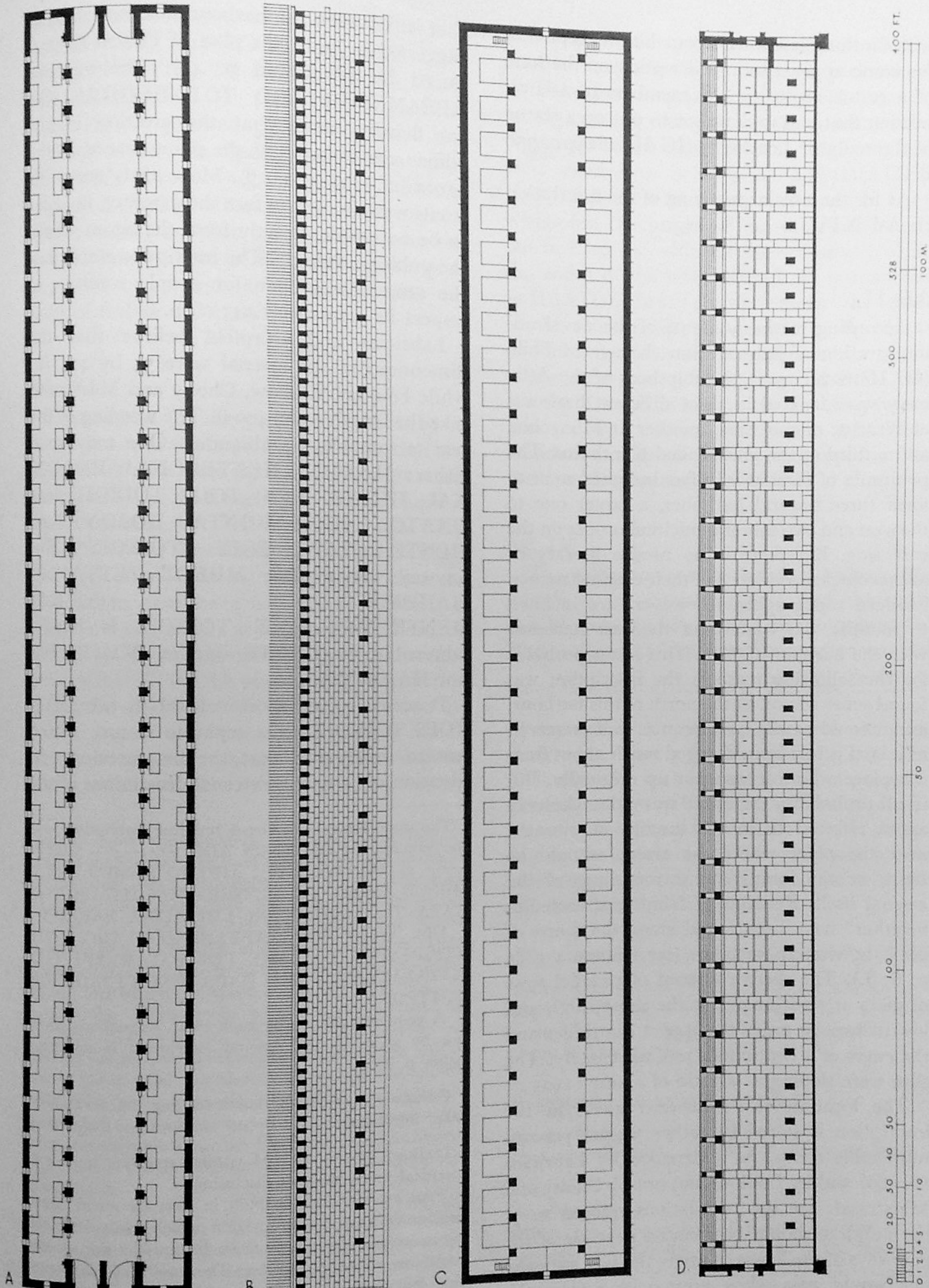

Fig. 59. Reconstruction of the Arsenal. A: ground plan. B: side elevation. C: first floor (midway galleries). D: longitudinal section (K.J.).

tect. Nothing is known about him, except that his name appears in an inscription on the base of a statue recording the members of a commission that had undertaken to put up a statue of the sculptor Leochares (IG II² 2825; c. 350 B.C.).

As for the official meaning of the inscription cf. Ad XIV.

AD II.

According to the accounts of the naval administration of Athens from the age of Philo (IG II²1627 c 400) the shipsheds of the Attic navy were located in three different harbours at Piraeus: one at Zeia, another at Munychia, and a third at the place called Kantharos. The peninsula of Piraeus is in fact indented so as to form three natural harbours, a larger one to the west and two minor semicircular ones on the east side. But there is no precise literary or archaeological evidence of their original names. Modern topographists, however, are inclined to identify the western of the east harbours with the harbour at Zeia. This seems probable for the following reasons: the inscription was found some 100 m. to the north of this harbour, and it could hardly have been as well preserved as it is, if it had been dragged much about from the place where it was put up originally. But in all probability this place was either the very agora referred to in the inscription, situated near the place where the arsenal should be built, or the immediate surroundings of the arsenal itself. Remains of "shipsheds roofed-in together" have been found along the shores of both the western harbours (see PRAKTIKA 1885 p. 63ff.). The sheds consisted of parallel rows of piers at right angles to the shore, high and low in turn in order to support the ridges and the eaves of a continuous roof alternately. The slips were sloping at a ratio of about 1:10.

The location of the arsenal given in the inscription is stated in rather vague, yet unmistakable terms. As understood by Fabricius (p. 560) and by Ludlow (but not by Choisy and Marstrand; see the translations quoted n. 7) the building should be situated near *one* of the gateways of the agora, namely the first gateway one would pass when approaching from the rear of the shipsheds of the harbour at Zeia; that is: between the harbour and the agora, as suggested in Judeich's plan of Piraeus (reproduced by Marstrand p. 43). The sentence ΑΡΞΑΜΕΝΟΝ ΑΠΟ ΤΟΥ ΠΡΟΠΥΛΑΙΟΥ can hardly mean that the erection of the edifice was to begin at the point nearest to the agora (cf. Choisy p. 27). More likely one of its fronts was planned to face the gateway, in order to be accessible directly from the agora where the public gathered[5]. The inscription states that the arsenal was open for people wanting to inspect its contents (1.91; cf. p. 86).

Fabricius and Dörpfeld believe that the dimensions of the arsenal were 55 by 405 ft., while Foucart, Ludlow, Choisy and Marstrand take the length to be 400 ft. The wording of the text is somewhat ambiguous. One may read either: ΠΛΑΤΟΣ ΠΕΝΤΕΚΟΝΤΑ ΠΟΔΩΝ, ΚΑΙ ΠΕΝΤΕ ΣΥΝ ΤΟΙΣ ΤΟΙΧΟΙΣ or: ΠΛΑΤΟΣ ΠΕΝΤΕΚΟΝΤΑ ΠΟΔΩΝ ΚΑΙ ΠΕΝΤΕ, ΣΥΝ ΤΟΙΣ ΤΟΙΧΟΙΣ[6]. But anyway the reading ΜΗΚΟΣ ΤΕΤΤΑΡΩΝ ΠΛΗΘΡΩΝ ..... ΚΑΙ ΠΕΝΤΕ ΣΥΝ ΤΟΙΣ ΤΟΙΧΟΙΣ is hardly admissible, as ΠΕΝΤΕ implies ΠΟΔΩΝ but not ΠΛΗΘΡΩΝ[7].

It seems to me most natural to take ΣΥΝ ΤΟΙΣ ΤΟΙΧΟΙΣ as a separate clause, added just to make sure that the measurements in question refer to the external dimensions of the

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[5] The usual formula in Greek building inscriptions was the precise: ΑΡΞΑΜΕΝΟΝ ΑΠΟ ..... ΜΕΧΡΙ ..... cf. Ditt. SYLL.³ 125: ΑΠΟ ΤΟ ΣΗΜΕΟ ΑΡΞΑΜΕΝΟΝ ΜΕΧΡΙ ΤΟ ΜΕΤΩΠΟ ΤΩΝ ΠΥΛΩΝ ΤΩΝ ΚΑΤΑ ΤΟ ΑΦΡΟΔΙΣΙΟΝ ΕΠΙ ΔΕΞΙΑ ΕΞΙΟΝΤΙ

Ditt. SYLL.³ 973: ΑΡΞΑΜΕΝΟΝ ΑΠΟ ΤΟΥ ΣΤΡΩΜΑΤΟΣ ΤΟΥ ΤΗΣ ΓΕΦΥΡΑΣ ΜΕΧΡΙ ΤΗΣ ΚΑΤΑΒΑΣΕΙΩ[Σ] ΤΗΣ ΠΑΡΑ ΤΟΝ ΓΥΝΑΙΚΕΙΟΝ ΛΟΥΤΡΩΝΑ.

A possible reason why such clear instructions could not be given in the Arsenal inscription is suggested below p. 86.

[6] Curiously enough, the latter reading has never been taken into consideration by any authors up to the present.

[7] Ludlow, Choisy and Marstrand translate in almost identical terms without discussing:

"An arsenal shall be built in Zeia for naval tackle beginning near the propylaion which leads from the agora as one approaches from behind the ship houses which are roofed in together. The length (of this arsenal shall be) four plethra; its breadth shall be fifty feet, or fifty five including the walls." (Ludlow p. 320).

"On commencera (à bâtir) à partir du propylée de

ground plan, on an analogy with ΣΥΝ ΤΩΙ ΠΑΧΕΙ ΤΟΥ ΚΙΩΝΟΣ (l. 11) ΣΥΝ ΤΗΙ ΤΡΙΓΛΥΦΩΙ ΥΠΟ ΤΟ ΓΕΙΣΟΝ (l. 29) ΣΥΝ ΤΩΙ ΕΠΙΚΡΑΝΩΙ (l. 43). That is: in the measurements 400 and 55 ft. is included the thickness of the walls. Quite sure, this dimension was exactly $2 \times 2\frac{1}{2} = 5$ ft., as specified directly in point 6. Both readings are therefore technically possible. But it is not obvious, why the wall-thickness should be mentioned as early as l. 7, and mentioned in connection with the *width* of the ground plan only.

Ad III.

Foundations for the piers are mentioned in l. 10; and as it is stated subsequently that the numbers of piers were 35 in either row, it seems most probable that each pier should have a separate foundation[8] (cf. commentary Ad IX).

After having described the central passage, the inscription adds rather abruptly that the foundations must be 4 ft. thick and consist of stones laid alternately as stretchers and headers. Choisy (p. 6) and Marstrand (p. 67) therefore believe that ΣΤΡΩΜΑ applies to a substructure under the whole area of the passage. But on the rocky ground of Piraeus foundations would hardly be necessary except for walls and piers, and it would be quite unwarranted to support a mere pavement (cf. point XI) by means of a massive foundation 4 ft. deep. As maintained by Fabricius, Foucart and Dörpfeld (op. cit. p. 563, p. 548 and p. 149) the measurement must refer to the foundations for the walls and piers alluded to in l. 9–11: ΣΤΡΩΜΑΤΙΕΙ. ΠΑΧΟΣ l. 14 is an ambiguous term: in l. 17 it signifies the height of the directing-course, but in l. 20 the width of the orthostate, while the width of the wall blocks l. 27 is rendered as ΠΛΑΤΟΣ. In l. 14 it must mean: the width of the foundations; the height of the foundations is not likely to have surpassed the depth of the excavation 3 ft. (that would equal two courses of stones as high as the directing-course and the wall courses) whereas a 4 ft. wide foundation is quite suitable in proportion to the directing-course, 3 ft. wide.

Ad IV.

The orthostate was to be placed above the middle of the directing-course, and the walls should probably be centered on the orthostate. The projection of the directing-course from the outer face of the walls was therefore $\frac{3-2\frac{1}{2}}{2} =$ $\frac{1}{4}$ ft., and its dimensions, measured along its outer edge, were $55\frac{1}{2}$ by $400\frac{1}{2}$ or $405\frac{1}{2}$ ft. if we allow for both interpretations of point II. Consequently, with blocks of the given measurements: 3 ft. wide, 4 ft. long, but $4\frac{3}{4}$ ft. at the angles, the course could be composed of the following units, counting from angle to angle all around the building[9]:

1) ground plan $55\frac{1}{2}$ by $400\frac{1}{2}$ ft. (cf. fig. 58 K).

Angles: A–B: 3 (end) + $4\frac{3}{4}$ + 97 × 4 + $4\frac{3}{4}$ ft.
Angles B–C: 3 (end) + $4\frac{3}{4}$ + 10 × 4 + $4\frac{3}{4}$ + 3 ft. (end)
Angles C–D: $4\frac{3}{4}$ + 97 × 4 + $4\frac{3}{4}$ + 3 ft. (end)
Angles D–A: $4\frac{3}{4}$ + 11 × 4 + 2 + $4\frac{3}{4}$ ft.

2) ground plan $55\frac{1}{2}$ by $405\frac{1}{2}$ ft.

flanks: $4\frac{3}{4}$ + 99 × 4 + $4\frac{3}{4}$ ft.
fronts: 3 (end) + $4\frac{3}{4}$ + 10 × 4 + $4\frac{3}{4}$ + 3 ft. (end).

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l'agora. Pour qui s'avance vers (ce propylée) en partant de l'arrière des cales qui ont un toit commun, la longueur (sera) de quatre plèthres, la largeur de cinquante cinq pieds avec les murs." (Choisy p. 5).

"Der skal begyndes ved søjlegangene paa torvet. Gaaende frem fra forsiden af skibshusene med det fælles tag er længden fire hundrede fod, bredden halvtreds fod og fem med murene" (Marstrand p. 25; cf. p. 63).

Fabricius (HERMES XVII p. 567 n. 1) followed by Dörpfeld (AM VIII p. 148 n. 1), also leaving out philological arguments maintains that the length *must* be 405 ft. "Es ist nämlich schlechterdings nicht möglich, die εὐθυντηρία aus 4 F. langen Blöcken mit $4\frac{3}{4}$ F. langen Eckstücken zusammengesetzt zu denken, ausser wenn man eine Gesammtlänge des Baues von 405 F. annimmt. Etc." But as I shall presently show n. 9 the argument is fallacious.

[8] Cf. Dörpfeld p. 150: "... da nun beim Fugenschnitt des Fundamentes nachweisbar keine Rücksicht auf die Axweite der Säulen genommen ist, so würde es zwecklos gewesen sein, schon hier die Zahl der Säulen anzugeben, wenn letztere keine getrennten Fundamente gehabt hätten."

[9] It cannot be concluded from the wording of the inscription whether the angle blocks in the flanks (or the fronts) should be used as headers or as stretchers, or in both ways. The argument of Fabricius quoted n. 7 therefore seems irrelevant.

In the former arrangement there must be a block of 2 ft. in one of the fronts (that can only be avoided by imagining a block of 3 ft. in both flanks), whereas the latter comes right. But the inscription leaves doubt whether the directing-course was to be continued beneath the doorways.

Marstrand suggests (op. cit. p. 82) that in the flanks every 3 blocks should be used as headers. In this way would be formed a unit of 4+4+3 = 11 ft. equivalent to the inter-axial spacing of the piers in his reconstruction, and the flanks could be composed of blocks of the given dimensions (3+4¾+70×4+35×3 +4¾+3 = 400½ ft.). But it does not appear in the inscription that this was the intention of the architect. If so, he must have given exact specifications in order to avoid waste of stone, for the blocks would be too deep if used as headers.

Ad V.

As for the description of the doorways see Ad VII.

Ad VI.

Apart from the angle blocks, the walls were to be composed of ashlars 4 ft. long. It is implied, no doubt, that each joint should be placed over the middle of a block in the course below, this sort of bond being customary in the Classical architecture of Athens, such as the Parthenon, the Propylaea, the Erechtheum etc. Thus there were two sizes of angle blocks, one two ft. shorter than the other.

The specification that the length of the angle blocks of the orthostate (point V) and of the wall courses shall depend on the dimensions of the triglyphs seems rather mysterious. Obviously these lengths could be specified as multiples of a half foot[10]. But probably the architect did not want to enter into such details and contented himself with stating that the block length 4 ft. would not go perfectly into the dimensions of the ground plan, because the latter depended on the proportions of the triglyph frieze[11]. I have argued already p. 76 (and shall submit further arguments p. 90) that the length of the arsenal must have been 400 ft. Probably, therefore, the architect decided upon an ashlar length of 4 ft. because this was exactly $^1/_{100}$ of the flank length. (while 4 ft. would not go into a length of 405 ft.). But the length of the *fronts* 55 ft. (above the doorways) and of the walls on both sides of the doorways 17½ ft. were *not* divisible by 4 ft. so that the angle blocks must be 3½ and 1½ ft. (or 5½ and 3½ ft.) long respectively[12].

Ad VII.

The description of the main features of the doorways in point V is unmistakably clear. ΜΕΤΩΠΟΝ means a pillar in the middle of the doorways in either front; and the sides of the doorways were to be formed by walls extending as far as the outermost piers. The doors opened against these walls.

The wording of point VII suggests a characteristic difference between the doorposts (ΠΑΡΑΣΤΑΔΕΣ) and the central pillars

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proximate: the exact dimensions were found by adding up triglyphs and metopes, because the measurements of these members if derived by subdivision of the ground plan might happen to be irrational fractions of the foot unit. The argument, in my opinion, is anything but convincing. Fabricius (p. 567), Foucart (p. 546) and Wanscher (p. 134) just touch the subject without discussing its aspects.

[10] As observed also by Marstrand p. 61.

[11] Dörpfeld suggests p. 154 that the dimensions of the ground plan given in the inscription were only approximate: the exact dimensions were found by adding up triglyphs and metopes, because the measurements of these members if derived by subdivision of the ground plan might happen to be irrational fractions of the foot unit. The argument, in my opinion, is anything but convincing. Fabricius (p. 567), Foucart (p. 546) and Wanscher (p. 134) just touch the subject without discussing its aspects.

[12] Thus the length of the angle blocks on the fronts actually depended on the triglyph system, while the flanks could be composed entirely of ashlars of the standard size. Choisy (p. 17) broaches the subject from a somewhat similar point of view: "La prescription relative aux pierres d'angle contient l'énoncé d'une règle d'appareil qui fut observée dans presque tous les monuments des belles époques: au temple de Thésée, aux Propylées de l'Acropole, etc. la pierre d'angle est précisément égale à une pierre d'appareil courant, augmentée de la largeur d'un triglyphe (on peut se rendre compte de cette loi d'appareil par les dessins de Stuart et Revett (Antiquités d'Athènes)). – Telle était la dimension des pierres d'angle à l'arsenal de Philon: et si par contre-épreuve on déduit de la longueur des pierres courantes, qui est donnée, la largeur du triglyphe que l'auteur du marché a omise, on trouve par le calcul le plus élémentaire que la largeur du triglyphe était de 1 p ½. Cela posé il est aisé de reconnaître à l'inspection du plan (pl. I, fig. 2) que les pierres d'angle de la façade principale mesuraient alternativement 5 p ½ et 3 p ½ de longueur." (as for the rule by means of which Choisy calculates the triglyph width, see n. 38).

(ΜΕΤΩΠΑ): the doorposts shall be erected (ΣΤΗΣΑΣ; cf. point IX about the piers l. 39 and point XII about the vertical posts of the shelves ΙΚΡΙΟΤΕΡΑ l. 79) while the pillars shall be constructed (ΟΙΚΟΔΟΜΗΣΕΙ; cf. l. 15 about the walls and l. 39 about the pediments). We must assume therefore that the pillar should be built of ashlars similar to those of the walls, probably of stone from Akte since no other material is specified. The doorposts, however, should be of Pentelic or Hymettian marble and probably monolithic. Evidently they were not supporting members like the central pillars, but doorcasings lining the sides of the apertures and having rebates into which to fit the doors. No doubt horizontal casings, not mentioned in the inscription, were to be placed on top of the vertical posts[13].

The cornice above the lintels implies that the two apertures in either front should be coupled together within a common enframement, probably in the form of anta-like projections as wide as the central pillars and set off from the face of the walls flush with the orthostate and with the lintels[14]. Possibly these "antae" were meant to be crowned by capitals, though such are not mentioned in the text.

It does not appear from the inscription whether the doorposts were to be placed flush with the fronts of the arsenal or on line with the inmost end of the central pillars. Dörpfeld argues (op. cit. p. 155) that the stone ceiling above the doorways mentioned in point XI would be appropriate only if being visible from outside. But the argument is hardly cogent. Greek doors usually opened inwards because in this way they could be bolted most effectively, and in the case of the arsenal there are no obvious reasons for making an exception. The arrangement shown in Fabricius' restoration then seems to be the most correct solution.

It is not stated whether the sills (ΟΔΟΙ) should replace the directing-course beneath the doorways, or only cover the space behind it as far as the inmost end of the central pillars. But at any rate they must be level with the pavement of the arsenal so that carts loaded with tackle could pass unimpeded through the doorways. It is specified in point V that the doors shall open against the walls that turn off at either side of the doorways i.e. each aperture was probably closed by a single door[15]. To fit into the rebates of the doorposts the doors must be somewhat smaller than the apertures, say about 7 ft. (= c. 230 cm.); but this was a considerable width

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[13] So far my reconstruction of the doorways is identical with that of Fabricius illustrated in his drawing op. cit. p. 594 apart from the horizontal casings which he leaves out. Fabricius discusses the terms in question p. 573ff. Dörpfeld, Choisy and Marstrand, lightly disregarding the philological authority of Fabricius, suggest in their reconstructions (reproduced together with that of Fabricius in Marstrand's book Plan II; see also Wanscher's drawing op. cit. p. 131) that the central pillars (ΜΕΤΩΠΑ) and the doorposts (ΠΑΡΑΣΤΑΔΕΣ) were monolithic members of the same thickness, the latter being incorporated into the walls flanking the doorways. Dörpfeld argues from a purely architectural point of view (see the following note), Choisy takes over Dörpfeld's idea as a matter of course (op. cit. p. 25) while Marstrand tries to support his own somewhat peculiar restoration (op. cit. p. 60 tegning 1) by translating l. 23ff.: "Og man skal bygge en karmmur paa hver side af portaabningerne, af bredde to fod, men indad ti fod ("And erect a jamb-wall on both sides of the doorways (sic!), 2 ft. wide, but 10 ft. in inward direction"). The authors referred to take it that the doors were fitted into the doorways by means of wooden casements. However, if such casements were actually planned (cf. the Dipylon Gate, AM 32, 1907, p. 485, and the South Gate of the Eleusinian Sanctuary, Noack, ELEUSIS p. 205, Abb. 80, Kourouniotis, ELEUSINIAKA 1, 1932 p. 194, Eik. 2) they ought to have been specified on a par with the other wooden equipment in the Arsenal.

[14] The specification that the lintels shall be "flush with the walls" (ΙΣΑ ΤΟΙΣ ΤΟΙΧΟΙΣ) must therefore not be taken strictly literally. If they were to be exactly flush with the face of the front walls the cornice on their top would appear to be a detached and rather motiveless excrescence not clearly connected with the doorways. Dörpfeld argues op. cit. p. 156: "Da jede Thür 9 F und der Zwischenpfeiler 2 F misst, so ragt der Architrav an jeder Seite um 2 F, also gerade um die Breite des μέτωπον, über die Thüröffnungen hinaus. Dieser Umstand setzt es ausser Zweifel, dass die in der Inschrift aufgeführten marmornen Parastaden die Thüre in der Weise einrahmen sollen, wie es die Ansicht auf Tafel VIII zeigt". It is rather obvious as Dörpfeld concludes that the lintels were designed to function as the horizontal members of an enframement 2 ft. wide like the central pillars; but of course this does not prove that the vertical members were identical with the ΠΑΡΑΣΤΑΔΕΣ.

[15] The Athenian Naval accounts of 330/329 B.C. list, among other materials belonging to the arsenal (IG II² 1627 c 418): "a new door, single-leafed (ΜΟΝΟΘΥΡΟΝ) which has been removed from the arsenal" (probably it happened to be under repair just at the time when the accounts were closed).

which necessitated some device to support them adequately. They may have been intended to turn on wheels like e.g. the doors of the Parthenon[16].

The height of the lintels is not given directly as 3 ft.: it shall be equivalent to the height of two wall courses (ΔΙΣΤΟΙΧΑ). This specification surely implies that the lintels shall be placed *level* with two wall courses. However, such arrangement is not compatible with the wording of the inscription 1. 28ff.: "Let the height of the walls above the directing-course be 27 ft., inclusive of the triglyph frieze beneath the cornice, and let the height of (the apertures of) the doorways be 15 ½ ft." which involves that the height of the doorways must correspond to the height of the orthostate 3 ft. + a multiple of wall courses of 1 ½ ft. that is: 15 but not 15 ½ ft. Fabricius, Dörpfeld and Marstrand try to explain away this difference by assuming that the height was measured from a point half a foot lower than the top of the directing-course, either from the bottom of a ledge for the sill cut in the directing-course (Fabr. p. 571 n. 1), from the top of the sill (Dörpfeld p. 156) or from the top of a hypothetical foundation in the middle aisle of the arsenal (Marstrand p. 67), while Choisy measures from the bottom bed of the directing-course, discounting the height of the sill and raising the lintels half a foot above the level of the wall courses to which they should correspond.

But these solutions of the problem are clearly at variance with the specifications of the inscription. Since no separate instruction indicates the point from which the height of the doorways was to be measured it seems unquestionable that the heights of walls and doorways were both taken from the top of the directing-course.

The discrepancy, therefore, is probably due to a scribal error: the correct measurement was not 15 ½ ft., but either 15 ft., or another number of feet plus half a foot. The most lenient amendment of the clause ΎΨΟΣ ΠΕΝΤΕ ΚΑΙ ΔΕΚΑ ΠΟΔΩΝ ΚΑΙ ΗΜΙΠΟΔΙΟΥ (1.30) would be to substitute ΤΡΕΙΣ, ΕΞ or ΕΝΝΕΑ for ΠΕΝΤΕ; and out of these possibilities ΤΡΕΙΣ is the only suitable one. If namely the height was 16 ½ or 19 ½ ft. there would not be adequate space above the doorways for the lintels, the cornice above the lintels, the central window (point VIII) and the triglyph frieze, which together demanded a minimum height of 8 wall courses:

lintel = 2 courses
cornice = 1 course (min.)
window = 2 courses
lintel above window plus triglyph-frieze = 3 courses (see p. 96)
total = 8 courses or 12 ft.

A height of 15 ft. is possible also though questionable from an aesthetical point of view (the sill of the window would touch the top of the cornice). But 13 ½ ft. is suitable from any point of view. Adequate space is left for the architectural members above the doorways, and the proportional principles of the elevation of the arsenal can be explained in very simple terms: the height 13 ½ ft. is half the height of the walls 27 ft. so that the soffit of the stone ceiling above the doorways (point XI) is placed exactly halfway between the directing-course and the cornice of the roof, and the doorways exhibit the same ratio (9:13 ½ or 2:3) as the windows 2 ft. wide and 3 ft. high (point VIII) and the middle aisle 20 ft. wide and 30 ft. high, involving a striking uniformity in the vertical proportions of the design.

Ad VIII.

The apertures for windows were to equal two wall courses in height (3 ft.) and half the length of an ashlar in width (2 ft.). There being 3 apertures in either front, one must be placed above the doorways. But this arrangement did not necessarily mean that the other windows in the fronts and those of the flanks (one opposite each intercolumniation) should be placed at the same level, see Ad XII.

Ad IX.

The wooden architraves shall be 2 ¼ ft. high measured from the highest point, that means no doubt that the top surface was meant to be parallel to the slope of the roof[17]. 18 pieces of timber were required above either row of piers

[16] It is not necessary, therefore, to assume with Dörpfeld (p. 156) that the doors were in fact – despite epigraphical evidence – double doors.

[17] Cf. Fabricius p. 580.

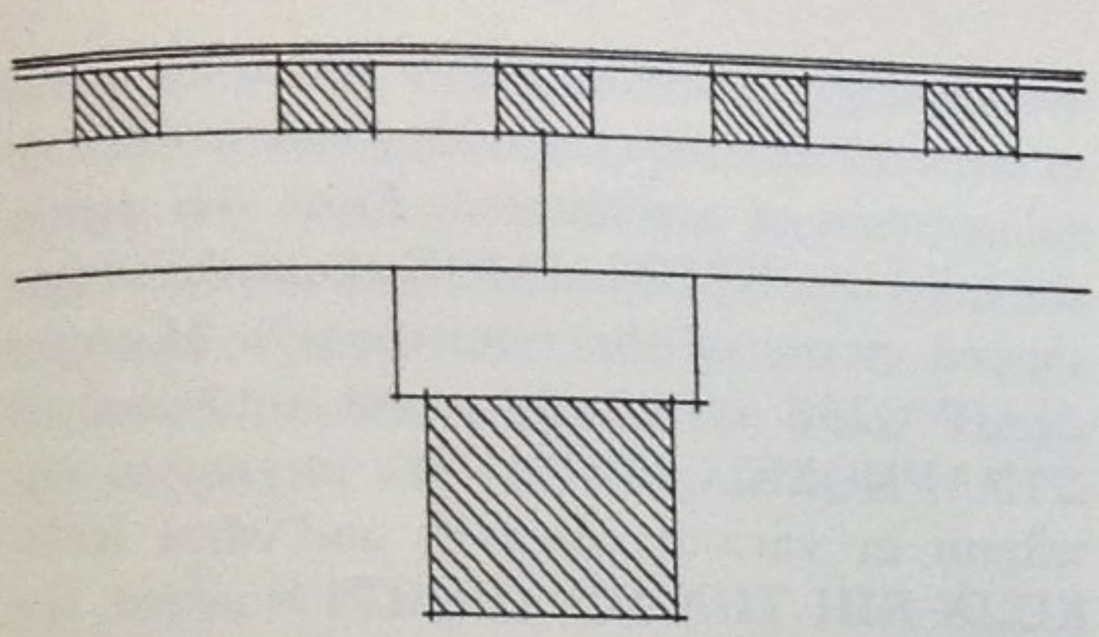

Fig. 60. The roof construction proposed by Fabricius, Dörpfeld and Choisy.

(which comprises 35 piers or 36 intercolumniations each, cf. Ad III), each architrave covering two intercolumniations.

Being made up of one drum of 5 ft. plus 6 drums of 4 ft., the shaft of the piers left 1 foot of the total height 30 ft. for the height of the capitals. In proportion to the upper width of the shaft which probably should correspond to the width of the architrave 2 ½ ft., 1 ft. is too little for the height of an Ionic capital[18], and column bases are not mentioned in the inscription. For the same reason Corinthian capitals must be left out of consideration. Foucart and Fabricius (p. 548 and p. 578) assume that the piers had Doric capitals. But Choisy and Marstrand (p. 18 and p. 74 resp.) argue more convincingly that none of the conventional orders was used, because the piers were quadrangular in section. Choisy's assumption that ΚΙΩΝ would mean a quadrangular pier rather than a round column seems questionable; however, for practical reasons quadrangular piers were certainly more fit for the arsenal than round ones, since the orthostates closing the intercolumniations (point XI) and especially the sidewalls of the doorways would abut more tightly on a plane than on a circular outline (Marstrand). For such square piers Doric anta capitals would be extremely convenient, as they are generally low in proportion to the thickness of the anta; and also because the *exterior* order of the arsenal was Doric[19]. ΣΤΥΛΟΒΑΤΗΣ signifies a separate slab under each pier as suggested by the verb ΥΠΟΘΕΙΣ; and since the wording of the inscription suggests that each column had its separate foundation (cf. Ad III) a continuous stylobate is probably out of the question[20].

[18] The egg-and-dart under the cushion of the Ionic capital reconstructed by Dörpfeld is included in the top-most drum!

[19] See Choisy p. 19. Marstrand invents capitals of a particular design unparalleled in the surviving range of ancient architecture.

Ad X.

According to Fabricius, Dörpfeld and Choisy (p. 580, p. 161 and p. 21) ΚΟΡΥΦΑΙΟΝ means: a ridge beam. Under this supposition the prop (ΥΠΟΘΗΜΑ) supporting the ΚΟΡΥΦΑΙΑ must be placed in a horizontal position, bracket-wise upon the cross-beam (fig. 60; since the raking rafters are intended to rest on the top of the architrave, the prop cannot be placed upright unless the ends of the rafters are lowered beneath the level of the cornice). Marstrand, on the contrary, suggests that ΚΟΡΥΦΑΙΟΝ signifies: a raking rafter. In his opinion ridge-beams were not used at all: the raking rafters rested directly upon the upright props, 3 ft. high, upon the architraves and upon the lateral walls, and this construction was covered with long timbers (ΣΦΗΚΙΣΚΟΙ), transverse planks (ΊΜΑΝΤΕΣ) and longitudinal boards (ΚΑΛΥΜΜΑΤΑ)[21].

Marstrand's argument is, on the whole, quite convincing[22]. But he does not realize that the

[20] Fabricius, however, maintaining (p. 576 n. 1) that the orthostates and lattices of the intercolumniations (point XI) could only be supported adequately by a continuous stylobate, reads l. 42 ΜΗΚΟΣ ΤΕΤΤΑΡΩΝ ΠΟΔΩΝ (ΤΩΝ ΛΙΘΩΝ) (cf. the description of the euthynteria course point IV); but he does not prove that the slabs of the dimensions given could be combined in such a way as to measure exactly the spacing of the piers. His arguments are rightly rejected by Dörpfeld p. 150 and questioned, later, by himself (BERL. PHIL. WOCHENSCHR. 1884, 1115).

[21] Foucart p. 549 was the first to suggest this way of interpretation: "On établit au milieu de cette poutre un poinçon (ΥΠΟΘΗΜΑ) long de 3 p. sur 1 p. ½ de large (l. 51-52), pour soutenir les arbalétriers (ΚΟΡΥΦΑΙΑ) larges de 7 paumes, hauts de 5 paumes et 2 doigts (l. 50–51). Ces arbalétriers sont liés aux poutres transversales par des ΚΕΡΚΙΔΕΣ. Ils posent donc d'abord sur le poinçon où ils se réunissent, puis sur les ΜΕΣΟΜΝΑΙ audessus des colonnes, et enfin sur les murs des longs côtés auxquels ils aboutissent."

[22] 1) the pitch of the roof is clearly defined, being exactly 3:10 (p. 89 tegning 62).
2) the word ΣΦΗΚΙΣΚΟΣ about longitudinal timbers

wording of the sentence ΚΑΙ ΔΙΑΡΜΟΣΕΙ ΤΑ ΚΟΡΥΦΑΙΑ ΚΕΡΚΙΣΙΝ ΕΠΙ ΤΩΝ ΜΕΣΟΜΝΩΝ seems to prove his interpretation. Fabricius, Foucart, Dörpfeld and Choisy agree that ΚΕΡΚΙΣ must mean some device intended to fasten the rafters to the cross-beams: "... wie es scheint, eiserne Stangen, die durch alle drei Theile, ΚΟΡΥΦΑΙΟΝ, ΥΠΟΘΗΜΑ und ΜΕΣΟΜΝΗ hindurchgeführt, dieselben fest zusammenschliessen sollen" (Fabricius p. 580); "Firstpfette, Sattelholz und Träger sind durch eiserne Bolzen (ΚΕΡΚΙΔΕΣ) mit einander verbunden" (Dörpfeld p. 161); "Et on assemblera les faîtages par des broches sur les entraits" (Choisy p. 9). Marstrand supposes that the word refers to wooden wedges connecting cross-beams and rafters where they converge and get into touch with the architraves (p. 90). But obviously the only sensible way of establishing a connection at this point would be to fasten the rafters onto the top of the architraves, and to connect the latter with the cross-beams by means of separate clamps. Wedges therefore are useless in this place, and I cannot see any technical point either in iron bolts such as described by Fabricius and Dörpfeld.

For the correct interpretation of the passage it should be noted that in Greek architectural terminology ΚΕΡΚΙΣ refers primarily to the acute angle between the raking and the horizontal cornices of a pediment. From this derives the adjective ΚΕΡΚΙΔΙΑΙΟΣ about the wedge-shaped stones of the tympanum[23]. Moreover ΔΙΑΡΜΟΣΕΙ is not the exact equivalent of ΣΥΝΑΡΜΟΣΕΙ. ΔΙΑΡΜΟΖΩ means: to distribute in various places[24], and when ΚΕΡΚΙΣΙΝ ΕΠΙ ΤΩΝ ΜΕΣΟΜΝΩΝ is added, the sense must be: to place the rafters and the cross-beams in their proper places – one above the other, but apart from each other – by means of ΚΕΡΚΙΔΕΣ. The ΚΕΡΚΙΔΕΣ therefore must be considered a separating or intervening rather than a connecting link, and we may translate: "Put the rafters into position above the cross-beams, kept apart angle-wise in accordance with the slope of the roof". Consequently, ΚΟΡΥΦΑΙΑ are not horizontal ridge-beams, but raking rafters[25].

To the measurements of the ΚΟΡΥΦΑΙΑ is added the supplementary clause ΑΝΕΥ ΤΗΣ ΚΑΤΑΦΟΡΑΣ "apart from the slope." Fabricius (p. 580) and Dörpfeld (p. 161) quite naturally conclude that the top of the ΚΟΡΥΦΑΙΑ (ridge-beams) had a double slope in conformity with the pitch of the roof. From Marstrand's point of view, however, the specification must refer to the height of the rafters: to avoid mistakes, it is expressly stated that the height shall be measured at right angles to the slope of the roof (Marstrand p. 88).

Ad XI.

The stone roof that was to be placed above the central pillars of the doorways must, of course, have rested on the sidewalls as well[26].

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is used also in l. 71 of the inscription (point XII, construction of the midway galleries).

3) Static calculations (p. 90) show that the roof construction as interpreted by Marstrand is most stable and "harmonious": ΚΟΡΥΦΑΙΑ and ΣΦΗΚΙΣΚΟΙ are equally well-dimensioned for the weight they must carry (max. stress c. 27 kgs/cm²), while if used as ridge-beams and raking rafters they are c. half and twice as heavily loaded respectively (max. stress c. 15 and 50 kgs/cm²).

Furthermore Marstrand discusses Vitruvius' orders for roof constructions (the corrupt passage IV 2) and enters into a somewhat hasty treatment of the roof construction of the Erechtheum, leading to the hypothesis that the ΣΦΗΚΙΣΚΟΙ and 'ΙΜΑΝΤΕΣ mentioned in the surviving accounts concerning this building were placed as longitudinal and transverse timbers, respectively, as in the arsenal. However, after the publication of the circumspective investigations of Stevens, Paton and others in THE ERECHTHEUM (Harvard University Press 1927) this conclusion does not hold good any more. The ΣΦΗΚΙΣΚΟΙ in the roof of the North porch were no doubt raking rafters resting on a ridge-beam and two purlins (see THE ERECHTHEUM p. 314 and p. 95ff.) and the roof of the main building was probably constructed in the same way (op. cit. p. 368ff. and p. 76ff.).

[23] Cf. Erechtheum accounts X col. II 35 (THE ERECHTHEUM p. 332).

[24] Cf. the Erechtheum accounts X col. III 34 T[O]Σ ΣΦΕΚΙΣΚΟΣ ΔΙΑΡ[ΜΟΣΑΝΤΙ (THE ERECHTHEUM p. 334).

[25] ΤΑ ΚΟΡΥΦΑΙΑ (ΞΥΛΑ) therefore would mean "the timbers that form together the ridge of the roof". cf. the Erechtheum accounts X col. II 28, in which ΚΟΡΥΦΑΙΟΣ (ΛΙΘΟΣ) means: the central block of the tympanum i.e. the block indicating with its top the ridge of the roof.

[26] Keil maintains somewhat pedantically (p. 160) that since the sidewalls are not mentioned in connection with the stone ceiling this must have rested exclusively on the central pillars and in a rebate in the lintels! But such

But it is possible that these were continued to the level of the architraves, perhaps in order to sustain the front walls of the arsenal against wind pressure (see Marstrand p. 65). Its thickness, not stated in the inscription, may have been 2 ft. like the width of the pillar, hardly less as the span was considerable (9 ft.).

Ad XII.

The "midway" wooden galleries of the lateral aisles were probably to correspond with the stone ceiling above the doorways. This arrangement would be most satisfactory from an aesthetical point of view, at least; and if we assume that the soffit of the cross-beams (ΔΙΕΡΕΙΣΜΑΤΑ) should be level with the soffit of the stone ceiling, it may be explained why the height of the stone posts supporting the cross-beams is not given in the inscription: it was simply equivalent to the height of the central pillars of the doorways. Thus the expression ΤΑΣ ΟΡΟΦΑΣ ΤΑΣ ΔΙΑ ΜΕΣΟΥ may have had a more definite implication than a purely linguistic interpretation would allow: actually the soffit of the wooden, as well as of the stone ceilings, was placed exactly halfway between the directing-course and the cornice of the roof (cf. p. 80)[27].

The wooden galleries gave access to two shelves (ΘΡΑΝΟΙ) also of wood, on which the tackle was stored, the lower one 4 ft. above the ceiling and the upper one 5 ft. above the lower one. These main features are beyond discussion, and the interpretations attempted by Choisy and Marstrand must therefore be rejected. The former suggests that the galleries were actually the floors of the aisles, constructed above a basement within the foundations of the arsenal (a somewhat peculiar idea). Marstrand places the shelves *beneath* the gallery, basing this arrangement on the hazardous supposition that ΤΗΣ ΚΑΤΩ ΟΡΟΦΗΣ (l. 79) refers to the floor of the arsenal (ΕΔΑΦΟΣ see l. 62) whereas the galleries are alluded to by ΤΗΣ ΑΝΩ ΟΡΟΦΗΣ (l. 79). Moreover he maintains categorically that for practical reasons the shelves must be directly accessible from the central aisle: it would be too laborious to put up and to take down the tackle, if the shelves were placed *above* the galleries (p. 112).

However, one cannot take for granted that Greek architects were as practically minded as modern engineers. The architect of the arsenal obviously wanted, above all, to make the building as beautiful and impressive as possible. It was not merely to be a shed in which tackle could be stored helter-skelter without anybody noticing it, like its wooden predecessors, but a monumental edifice intended to symbolize the power of the Attic navy and to be inspected by the public, foreigners as well as citizens. Sails and white curtains were, therefore, carefully stowed away in large chests arranged on the ground floor (point XIII) while the rest of the tackle, disorderly riggings etc. were placed on the shelves of the first floor where it would not attract the attention of the visitors in the arsenal[28].

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construction would be impracticable and needlessly complicated. Fabricius merely states p. 570 n. 1 "Alle drei Mauern also, die beiden rechts und links von den Thüren und die trennende Mittelmauer, heissen an dieser Stelle ΜΕΤΩΠΑ".

[27] ΔΙΑ ΜΕΣΟΥ means "between" or "more or less exactly in the middle" (Liddell & Scott). Keil argues (p. 151) that 'ΑΙ ΟΡΟΦΑΙ 'ΑΙ ΔΙΑ ΜΕΣΟΥ can only mean: "the galleries somewhere between floor and roof"; if the sense: "galleries exactly in the middle of the aisles" was implied, the pertinent Greek expression would be: ΟΡΟΦΑΙ ΔΙΑ ΜΕΣΟΥ; for ΟΡΟΦΑΙ is introduced here for the first time in the inscription. This may be true. But it is more important to note that even if ΔΙΑ ΜΕΣΟΥ meant "exactly in the middle", the precise position of the gallery could not be concluded directly, since the points between which the middle is to be found are not specified. Probably Philo did not think it necessary to give more accurate information because it was a matter of course to him that the wooden galleries would be level with the stone ceilings. If I am right, this position half–way between floor and cornice was a calculated feature in the design of the arsenal. But the inscription contains on the whole no direct allusions to the proportional principles of the project. – Dörpfeld and Keil (p. 162 and p. 153 resp.) rightly reject Fabricius' idea that the galleries and the upper shelves were placed at equal distance from floor and ceiling (Fabr. p. 589 n. 1). It will be seen, by comparison, that Dörpfeld's arrangement of the galleries resembles my own very much (fig. 58 B). Keil overinterprets the text without attaining any convincing results.

[28] According to the specifications of the Athenian Naval accounts all the tackle (ΣΚΕΥΗ ΚΡΕΜΑΣΤΑ) of one trireme would probably consist of:

1 'ΙΣΤΙΟΝ	(sail)
2 ΠΑΡΑΡΡΥΜΑΤΑ ΛΕΥΚΑ	(canvas curtains)

The purpose of this distribution is so evident that there can be little doubt as to the position of the windows (cf. Ad VIII). Direct light from the windows was needed in the ground floor to illuminate the stately rows of chests along walls and piers, while a grey twilight was sufficient for the shelves of the first floor with their untidy heaps of tackle. I take it for granted, then, that all windows except those above the doorways were placed in the ground floor. In this position they concentrated their light on the stone pavement, and reflection would be sufficient to light up the first floor[29].

Fabricius, Dörpfeld, Choisy and Marstrand agree, without discussion, that the lateral windows were to be placed level with those above the doorways. But this position would be suitable only if the shelves were placed in the ground floor, as in the erroneous reconstructions of Marstrand and Choisy. In those of Dörpfeld and Fabricius, however, the shelves occupy the whole of the first floor so that if the windows were situated between or above them, the tackle would come within their light[30]. Fabricius places the galleries at a level considerably beneath the stone ceilings above the doorways; but even so the upper shelf is almost level with the sill of the windows, though the latter are situated as closely to the triglyph frieze as possible.

The shelves are described in very cursory terms that do not allow us to reconstruct them in details. The inscription tells us only that they were to rest on vertical posts (ΙΚΡΙΟΤΕΡΑ), in which were fixed horizontal timbers (ΔΙΕΡΕΙΣΜΑΤΑ) carrying continuous "benches" (ΘΡΑΝΟΙ ΔΙΑΝΕΚΕΙΣ) covered with planks (ΠΙΝΑΚΕΣ). These planks, like the planks of the ceilings, were 3 ft. wide – an amazing measurement. The words ΣΥΜΒΑΛΩΝ ΚΑΙ ΚΟΛΛΗΣΑΣ (l. 73) and ΣΥΝΚΟΛΛΗΣΑΣ (l. 82) therefore must mean that each plank consisted of several pieces of wood joined together by means of glue.

2 ΠΑΡΑΡΡΥΜΑΤΑ ΤΡΙΧΙΝΑ		(leather curtains)
1 ΚΑΤΑΒΛΗΜΑ ΤΡΙΧΙΝΟΝ		(leather tarpaulin)
1 ΥΠΟΒΛΗΜΑ ΤΡΙΧΙΝΟΝ(?)		(leather(?) tarpaulin)
ΙΜΑΝΤΕΣ ΠΟΔΕΣ ΥΠΕΡΑΙ ΑΓΚΟΙΝΑ ΧΑΛΙΝΟΣ	ΤΟΠΕΙΑ	(mast and rudder riggings)
4(?) ΥΠΟΖΩΜΑΤΑ		(undergirding straps to reinforce the hull of the ships)
4 ΣΧΟΙΝΙΑ ΕΠΙΓΥΑ		(stern-cables?)
4 ΣΧΟΙΝΙΑ ΑΓΚΥΡΑΙ		(anchor-cables)
2 ΑΓΚΥΡΑΙ		(anchors)
4(?) ΚΕΡΑΤΑ ΕΣΚΥΤΩΜΕΝΑ		(anchor hooks?)

The number of some of the categories is conjectural, and there is no evidence that the ΥΠΟΒΛΗΜΑ was of leather. But since only sails and canvas curtains were packed in chests, it is most probable that all other curtains and tarpaulins were of leather. For leather is difficult to fold and liable to perish if stored up in piles.

The list is based on the investigations of Marstrand who discussed the whole evidence p. 121 ff.

Ad XIII.

The total number of chests was to be 134, that is, 67 in either aisle. They should be placed at (the foot of) each pier and in (the middle of) each intercolumniation along the walls; but if this direction was kept strictly there must have been 71 pieces, i.e. 4 pieces more than stated in the inscription. Consequently the ends of the lateral aisles were vacant for other purposes[31].

To keep the arsenal cool space should be left open between the joints of the ashlars where prescribed by the architect. The openings were probably intended to give rise to draught in

[29] As regards the exact position of the windows we may argue that it must have been possible to open the lids of the chests placed along the walls without obstructing the light of the windows. The chests were hardly higher than the orthostates in the intercolumniations i.e. 3 ft. (otherwise it would be difficult to bend over and take up sails and curtains from the bottom of the chests) and for practical reasons also the lids would hardly be more than 3 ft. wide. The sills of the windows could therefore be placed c. 6 ft. above the floor at their lowest i.e. level with the top bed of the second wall course above the orthostate. Aesthetically, I think, this position would be the most favourable though positions up to three wall courses higher are not out of the question.

[30] In the reconstruction of Keil the upper shelf crosses the windows which is, of course, an utterly impossible arrangement. Suggesting however that in order to bring light into the ends of the lateral aisles the lateral windows of the fronts were placed in the ground floor, Keil made some progress towards a better understanding (p. 163).

[31] E.g. to store ladders and other equipment. Cf. Keil p. 163: " . . . oder wo hätte man wohl sonst die Leitern, Schaufeln und all das übrige zur Benutzung und Instandhaltung der Skeuothek nöthige Geräth aufbewahren sollen?"

order to keep the tackle dry. Sails and curtains were, of course, completely dried up before they were packed in the chests, but the riggings on the open shelves (ropes etc.), though apparently dry, might still contain some moisture. Probably therefore the openings were placed beside the shelves, in which position they would allow air as well as some additional light.

Ad XIV.

The stipulations of point XIV do not offer any clue to the official bearing of the inscription. As far as I can see there are 4 possibilities that ought to be taken into consideration: the inscription was meant either as

1) A cursory instruction for the craftsmen
2) A general description published as a basis for tenders

} appended to a decree of the board in charge of the erection of the Arsenal.

3) A general description appended to a decree of the Public Assembly.
4) A record of a project devised at the private initiative of Euthydomus and Philo.

Marstrand argues with great enthusiasm that the inscription supplies *all* the information, any craftsman might want; Philo intended to tell everything, but not more than strictly necessary; for by correct interpretation of the inscription the workmen would be able to conclude whatever instruction they needed (p. 243). But actually we lack information about quite a lot of things. Something may be guessed, it is true, but many things cannot be inferred except by means of calculations:

Length of the sidewalls of the doorways (= length of central pillars 10 ft.?).
Spacing of piers (depends on the length of the sidewalls).
Section of column shafts (quadrangular or round?).
Upper thickness of column shaft (2½ ft.?).
Height and thickness of the stone posts carrying the wooden galleries (height = height of the central pillars of the doorways?).
Design of post and column capitals (bases).
Length and thickness of orthostates between the piers.
Position of doorposts (flush with the face of the fronts?)
Dimensions of doorposts and of sills.
Thickness of stone ceiling above the doorways (= height of a wall course or = thickness of midway galleries?).
Enframement of doorways (projection corresponding with the off-set of the orthostates?).
Height and mouldings of the cornice above the doorways (height = height of a wall course?).
Dimensions of triglyph frieze.
Dimensions and design of geison and sima blocks.
Dimensions of roof tiles and their ornament.
Design of lattices for the windows and the intercolumniations.
Position of windows.
Spacing of wooden posts (ΙΚΡΙΟΤΕΡΑ) carrying the shelves.
Construction of shelves (ΘΡΑΝΟΙ).
Design of chests and wooden ladders.
Temperamental refinements.
Technical specifications (surface dressing, clamps, dowels etc.)

Some elements could, of course, be copied from a model (ΠΑΡΑΔΕΙΓΜΑ). But even if such models (of triglyphs, cornices, chests, lattices, capitals etc.) existed, it is obvious that the inscription can only have served as a brief introduction. In order to carry out the project in details the workmen must have additional specifications, measurements and a model such as promised in point XIV[32]. Provided with such material, however, they would hardly need the specifications of the very cursory inscription, nor take the trouble to read them.

The second possibility to be discussed: public invitation for tenders, is slightly more plausible. In his book about Eleusinian building inscriptions of the Fourth century B.C.[33] Ph. H. Davis comments on some inscriptions which give evidence of the method of contracting used in Attica: specifications for the work were carved and set up; and when the contract was concluded, the name of the contractor, his price, and the name of his guarantor were appended to the document (p. 11 ff.). This procedure was followed e.g. in an inscription concerning repairs to the walls of Athens and Piraeus and the Long Walls, in 307/6 B.C. (IG II² 463) and containing, on the same stone, both the decree, the appropriate specifications and the records of the contracts. In one place where one would expect the name of the contractor and his price, the stone is blank. Davis concludes from this that the specifications were inscribed on the stone

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[32] Marstrand translates 1. 95 ΤΑΣ ΣΥΓΓΡΑΦΑΣ as "these specifications" (i.e. the specifications of the inscription, cf. 1. 2). But the correct Greek equivalent would rather be ΤΑΥΤΑΣ ΤΑΣ ΣΥΓΓΡΑΦΑΣ.

[33] Ph. H. Davis: SOME ELEUSINIAN BUILDING INSCRIPTIONS OF THE FOURTH CENTURY BEFORE CHRIST (Diss. New York 1931).

before the contracts were concluded and that for one reason or another no contract was drawn up for the section in question. Other illustrations are given confirming this construction.

The Eleusinian inscription IG II² 1666 (concerning the Portico of the Telesterion) comprises also a series of detached items: "To quarry so and so many blocks", "to transport so and so many blocks". "to carve and lay so and so many blocks" etc. Each item represents a separate operation, and probably a separate contract. But contractors, prices, and guarantors are not mentioned and no space is left open for them; obviously the specifications were published exclusively as a basis for tenders while the contracts were recorded on other steles. At any rate the preserved stone must have belonged to a series of stones, for the last items of the obverse side are interlocked and not continued on the reverse side[34]. These facts lead Davis to the interesting remark: "The question naturally presents itself, whether something like the Portico inscription existed also for the Piraeus arsenal, and whether we should assume some such set of documents as the following:

1) A general description of the building (the preserved inscription).

2) A list of materials to be supplied, transported, and put in place, along with a statement of the quantity and a description of each item.

3) A series of contracts applying to each part of the building, with appropriate specifications attached to each contract.

The evidence is not yet sufficient for answering the question either way, but the problem must be borne in mind" (p. 17).

Anyway, I should add that *one* thing can be inferred from the wording of the arsenal inscription: when it was carved, contracts had not yet been drawn up or concluded. For the last item says that "each work shall be delivered within the time, to which the contractors may agree (ΕΝ ΤΟΙΣ ΧΡΟΝΟΙΣ ΑΠΟΔΩΣΟΥΣΙΝ 'ΟΙΣ ΑΝ ΜΙΣΘΩΣΩΝΤΑΙ 'ΕΚΑΣΤΑ ΤΩΝ ΕΡΓΩΝ).

Some specifications, on the other hand, suggest that the inscription was addressed to the public rather than to contractors or craftsmen:

1) It is stated that there shall be openings in the chests (point XIII) "so that all the tackle which is in the Arsenal, is visible to those passing through". The word ΔΙΕΞΙΟΥΣΙΝ l. 91 is somewhat ambiguous. It may also mean: "to those inspecting (the arsenal)", that might be guardians (ΦΥΛΑΚΕΣ) or officials in charge of the naval affairs (ΕΠΙΜΕΛΗΤΑΙ). However, since the official status of the persons referred to is not stated at all, it is more probable that people in general was meant, as in point III: "leaving a passage for the public (l. 13 ΤΩΙ ΔΗΜΩΙ) through the middle of the arsenal".

2) According to point VII, the doorposts (ΠΑΡΑΣΤΑΔΕΣ) shall be made of Pentelic *or* Hymettian marble. But a contract could not very well be drawn up on the basis of an ambiguous specification like that[35].

It is suggestive also that the inscription deals mainly with the monumental aspect of the arsenal. The walls and the impressive roof-constructions are described at length, whereas practical equipment such as the shelves above the lateral galleries is passed over with so few words that one may doubt whether exact specifications for these details existed when the inscription was cut. Moreover the location of the building is indicated only in vague terms (cf. n. 5), as if it had not been precisely fixed as yet. Apparently the authors of the inscription *suggest* a place *somewhere* between the shipsheds and the agora.

However, until further evidence can be provided, the problem must be dealt with as by way of hypotheses[36].

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[34] See chapter III, p. 110

[35] A similar expression is found in the Eleusinian inscription published by Kourouniotis, ELEUSINIAKA I, 1932, p. 189ff., l. 13: ΓΟΜ] ΦΟΙΣ ΜΕΛΙΝΟΙΣ Η ΠΤΕΛΕΪ-ΝΟΙΣ i.e. "by means of dowels of ash *or* elm wood". The inscription apparently cites a motion concerning an all-round repair of the gate-ways in the fortification walls of Eleusis, cf. Travlos, The Topography of Eleusis, HESPERIA XVIII, 1949, p. 138ff. But in this case it was probably unessential and therefore left to the contractor to decide which material was to be used.

[36] Few people, apart from Marstrand and Davis, have tried seriously to solve it. Foucart wrote (p. 551): ". . Ces dernières lignes de l'inscription en montrent le véritable caractère. Elle différe un peu de l'inscription des murs d'Athènes. Celle-ci se compose de trois parties: 1° le décret du peuple; 2° le cahier des charges; 3° les adjucations aux divers entrepreneurs.

L'inscription du Pirée correspond à la seconde partie: c'est le cahier des charges dressé par l'architecte Philon

ARCHITECTURAL FEATURES NOT RECORDED IN THE INSCRIPTION

As we have seen: the inscription deals but briefly with details[37], and even the main features of the arsenal cannot be reconstructed completely because information is wanting about:

1) the length of the sidewalls of the doorways
2) the spacing of the piers
3) the height and width of triglyphs and metopes.

Roughly calculated the axial spacing must have been about 11 ft. (400 or 405 ft. divided by 36 spacings). The exact spacing is not directly inferable, as it cannot be concluded e silentio that the sidewalls should be as long as the central pillars of the doorways (10 ft.). As for the triglyph frieze, however, more definite results can be attained by means of a systematic research.

Marstrand, Choisy, Dörpfeld and Fabricius suppose that there were 21, 16, 14 or 11 triglyphs in the fronts (cf. Marstrand pl. II); but they use metopes and triglyphs of different length in fronts and flanks, and the dimensions of the frieze are considered exactly equal to those of the ground plan (400 or 405 ft. by 55 ft.)[38]. In

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et Euthydomos. Une copie, suivant l'usage, devait être gravée sur une stèle et exposée avant l'adjucation, afin que les entrepreneurs pussent en prendre connaissance".

Against this comparison Fabricius argued that while the inscriptions concerning the walls of Athens were headed by a decree the signers of which were probably characterized by ΕΠΙΣΤΑΤΟΥΝΤΩΝ (not preserved), the official status of the signers of the arsenal inscription is not indicated. "Es wird daher schlechterdings nichts Anderes übrig bleiben, als entweder anzunehmen, der Volksbeschluss und was sonst zu einer öffentlichen Urkunde dieser Art gehörte, habe auf einer besonderen Platte gestanden, oder aber die Entstehung der Urkunde zurückzuführen auf ein privates Unternehmen der beiden Männer, die sich um das Zustandekommen des Baues besonders bemüht oder verdient gemacht hatten". (HERMES XVII p. 560). Later Fabricius summarized his views in the following terms: "Sie ist aber kein eigentlicher Vertrag, sondern ein Bauprogramm, eine bei aller Ausführlichkeit doch nur kurze Zusammenfassung der auszuführenden Bauarbeiten. Wenn dabei Euthydomos noch vor Philon als Miturheber der ΣΥΝΓΡΑΦΑΙ genannt ist, so kann er zwar nicht als Künstler, wohl aber etwa als Mitglied der Epistatai mit der Aufstellung des Bauprogramms zu tun gehabt haben. Die Inschrift spricht sonst immer nur von einem ΑΡΧΙΤΕΚΤΩΝ. Die Aufstellung der Inschrift, die keinen Hinweis auf einen Volksbeschluss enthält, überhaupt keinen amtlichen Charakter trägt, geht wohl auf die persönliche Urheberschaft der beiden Männer zurück und soll das öffentliche Interesse an der Entstehung des Bauwerkes wachhalten. Immerhin wird das vorliegende Bauprogramm mit dem von Philon befürworteten Volksbeschluss zusammenhängen" (Pauly-Wissowa RE s.v. Philon).

Dörpfeld remarks (p. 147): "Wie heutzutage die Architekten vor dem Beginne eines Baues Entwurfs-Skizzen und einen Erläuterungsbericht anfertigen und erst nach Genehmigung derselben durch den Bauherrn genaue Pläne mit allen künstlerischen und constructiven Details ausarbeiten, so pflegte man gewiss auch in Athen zunächst nur ein *kurzes* Bauprogramm aufzustellen, welches dem Volksbeschlusse über die Genehmigung des Baues als Grundlage diente".

[37] Little if any information can be derived from Athenian Naval accounts. In the section IG II² 1627,b 279 (330/29 B.C.) are listed the objects that were stored in "the great building near the gateways", and among these we find:
1) iron clamps, dowels, and nails "left over from the arsenal".
2) A model (ΠΑΡΑΔΕΙΓΜΑ) for the tiles of the arsenal.
Immediately after the latter item the inscription mentions:
a) 2 eaves tiles with lion's head spouts belonging to the angles of the pediment (ΠΑΡΑΙΕΤΙΔΕΣ)
b) 2 other eaves tiles with lion's head spouts
c) 1 cover tile with antefix (ΑΝΘΕΜΩΤΟΣ)
d) 2 other eaves tiles with beds for cover tiles
e) 2 cover tiles with antefixes.

These tiles are not listed as models. But it seems possible, a priori though it is not stated that some of them belonged to the arsenal, but had not yet been put in position when the inscription was carved. It should be noted, however, that they must have belonged to two different types of roofs: a roof with lateral simas (b) and a roof without lateral simas (d). The corner blocks (a) are compatible with either type while the cover tiles with antefixes (c e) (unless some of them were ridge cover tiles) go together with the latter type only (Marstrand p. 94 tegning 67 tries to combine all pieces, to the effect that the antefixes are hidden behind the sima). So, from this evidence, it is hardly possible to draw any conclusions at all regarding the roof of the arsenal, except perhaps that the eaves tiles of the corners had lion's heads, in imitation of spouts, carved upon them.

Reference has already been made to another passage in the Naval accounts in which is listed a single-leafed door that had been removed from the arsenal, probably for repair (n. 15).

[38] Fabricius assumes (p. 567) that the axial triglyph spacing was equivalent to the normal length of the wall ashlars 4 ft., except at the angles where the outermost metopes were prolonged. But if so the amount of pro-

Classical architecture, however, the units of the triglyph frieze are standardized members, (except at the corners); and the outer faces of the walls are not strictly vertical but inclined towards the center of the building so that in fact the rectangle of the frieze is smaller than that of the ground plan. Besides one cannot decide upon any particular possibility till all alternatives have been taken into consideration.

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longation would not be the same in the flanks as in the fronts of the building, cf. also Dörpfeld's criticism p. 153.

By employment of a fictitious rule (cf. Fabricius' criticism BERL. PHIL. WOCHENSCHR. 1884, 1116) Choisy concludes that the triglyph width was 1½ ft. (p. 17). Further argument is given p. 28ff. but this is concerned with the front only and based exclusively on the assumption that there was a metope in the middle of the front for which reason the number of triglyphs must be even, say 14, 16 or 18. In Choisy's opinion, 16 triglyphs fit in most harmoniously with the main proportions.

In the reconstruction of Dörpfeld, 3 ft. (= the height of two wall courses) are left for the triglyph frieze above the course forming the lintel of the central window above the doorways. He suggests, therefore (p. 152ff.) that in view of the conventional proportions of triglyph friezes, the triglyph width and the metope width of the arsenal would be c. 2 and c. 3 ft., respectively. And proves that such dimensions would be appropriate if there was the same number of triglyphs in the front as in the front of an hexastyle temple, and if the spacing of the internal piers was equivalent to two triglyphs + two metopes (involving a clear rhythmic relation between the frieze and the lateral windows). In the system fitting in most accurately with the dimensions of the ground plan, the triglyphs and metopes of the flanks are 2 — 3 dactyls wider than those of the fronts:

11 trigl. of 2′2″ + 10 met. of 3′2½″ = 54′15″
73 trigl. of 2′4″ + 72 met. of 3′5½″ = 405 ft.

The fronts, then, are 1 dactyl shorter than stated in the inscription. But Dörpfeld suggests that this difference was settled by placing the walls slightly eccentrically upon the euthynteria course (at variance with the specifications of points II and V).

Marstrand's calculations (p. 62ff.) are based on the assumption (not confirmed by the inscription) that the sidewalls of the doorways were *at least* as long as the central pillars viz. 10 ft. Thus, he concludes, only one rational solution can be found:

21 trigl. of 1′4″ + 20 met. of 1′7″ = 55 ft.
146 trigl. of 1′4″ + 145 met. of 1′8″ = 400 ft.
(note that the lateral metopes are 1 dactyl wider than the front metopes).

According to Wanscher, the fronts of the arsenal must have had the same number of trighlyphs as an hexastyle or octastyle front i.e. 11 or 15. He preferred 15, arguing that if there were only 11 they would be too large (p. 132). This theory is corroborated by my own calculations (p. 90).

The number of front triglyphs proposed by Marstrand and Dörpfeld (21 and 11 respectively) seem to be on the extreme: the size of Dörpfeld's triglyphs looks exaggerated, while Marstrand's triglyphs appear to be too small; but to make sure we will take into account any number between 9 and 22.

The computations below are based on the hypothesis indispensable if we shall deal with the problem in a methodical way that the triglyph frieze consisted of fixed units of an integral number of dactyls. The unit equals the width of metope + triglyph. The fronts and flanks of the arsenal: 400 or 405 ft. by 55 ft. are therefore equivalent to multiples of units + 2 halves of a triglyph width + the projections, on a horizontal plane, of the hypothetical inclination of the wall at either end. Possible modifications of the angle units will be considered later.

The basic equation is $\frac{b \cdot x}{b \cdot y} = \frac{880 - a}{6400 \text{ (or } 6480) - a}$ in which

y = number of units in the flanks
x = number of units in the fronts
a = triglyph width + two projections (in dactyls)
b = unit (triglyph + metope) (in dactyls)

880, 6400 and 6480 are the equivalents, in dactyls, of 55, 400 and 405 ft. respectively.

Rating the triglyph width at $^2/_5$ of the unit, we find that $^2/_5\ b < a$, and as $b = \frac{880 - a}{x}$ we get $\frac{1760}{5x + 2} < a$[39]. Consequently, for any integral x between 8 and 21 we can calculate a min. and the corresponding value y min., as shown in the following table[40]:

I. for flank length = 6400 dact.			II. for flank length = 6480 dact.		
x	y min.	y min. − x	x	y min.	y min. − x
8	60	52	8	61	53
9	67	58	9	67	58
10	75	65	10	76	66

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[39] $\frac{2\,(880 - a)}{5x} < a$; $352 - \frac{2}{5}\,a < ax$

$\frac{352}{x + \frac{2}{5}} < a$; $\frac{1760}{5x + 2} < a$

[40] I am indebted to Dr. Thöger Busk for mathematical assistance.

11	82	71
12	89	77
13	97	84
14	104	90
15	112	97
16	119	103
17	126	109
18	133	115
19	140	121
20	148	128
21	155	134

11	83	72
12	91	79
13	98	85
14	105	91
15	113	98
16	120	104
17	127	110
18	135	117
19	142	123
20	149	129
21	157	136

Next, from the subtractions:

by = 6400 — a	by = 6480 — a
bx = 880 — a	bx = 880 — a
by — bx = 5520	by — bx = 5600

we get:

$$y - x = \frac{2^4 \cdot 3 \cdot 5 \cdot 23}{b} \qquad y - x = \frac{2^5 \cdot 5^2 \cdot 7}{b}$$

from which can be derived the integral values of b. For both b and y — x must be integers and therefore must be combinations of the prime factors 2, 3, 5, 23 or 2, 5, 7. And of these factors those which are not contained in b must be contained in y — x.

In the first case (flank length = 6400 dactyls), it is obvious that only the values of b and of y —x embodying 23 as a prime factor are integers. The values of y — x to be considered, then, are the multiples of 23 containing the factors 1, 2, 2^2, 2^3, 2^4, 3 or 5, that is, 23, 46, 69, 92, 115, 138, 184, 230 etc.

But since 52 < y min. — x < 134 (cf. the table), the only values of real interest are only 69, 92, 115 and 138, and the values corresponding to values of b including the factor 23. Equivalents of x are easily found by means of the table. So we get:

y–x	x	y	a	b	triglyph width ($^2/_5$ b)	projection
(48				115)		
60	9	69	52	92	c. 37	c. $^{15}/_2$ = 7.5
69	10	79	80	80	32	$^{48}/_2$ = 24
80	12	92	52	69	c. 28	c. $^{24}/_2$ = 12
92	14	106	40	60	24	$^{16}/_2$ = 8
115	17	132	64	48	c. 19	c. $^{45}/_2$ = 22.5
120	18	138	52	46	c. 18	c. $^{34}/_2$ = 17
138	21	159	40	40	16	$^{24}/_2$ = 12
(240				23)		

In the second case (flank length = 6480 dactyls), $2^5 \cdot 5^2 \cdot 7$ can be subdivided into the following factors: 2, 4, 5, 7, 8, 10, 14, 16, 20, 25, 28, 32, 35, 40, 50, 56, 70, 80, 100, 112, 140, 160, 175, 200, 224, 280, 350, 400, 560, 700, 800, 1120, 1400, 2800.

As 53 < y min. — x < 136, we get:

y–x	x	y	a	b	triglyph width	projection
(50				112)		
56	8	64	80	100	40	$^{40}/_2$ = 20
70	10	80	80	80	32	$^{48}/_2$ = 24
80	12	92	40	70	28	$^{12}/_2$ = 6
100	15	115	40	56	c. 23	c. $^{17}/_2$ = 8.5
112	17	129	30	50	20	$^{10}/_2$ = 5
140	21	161	40	40	16	$^{24}/_2$ = 12
(160				35)		

The most obvious outcome of these calculations is the fact that no standardized triglyph system without modifications at the angles can be adapted directly to the ground plan (whether this was 405 or 400 ft. long) unless the triglyph width is rated at more than half the unit (throughout the tables $a > \frac{b}{2}$). Whatever system we choose, there will remain a surplus that must be filled up by the projections and, if necessary, also by using angle triglyphs somewhat wider than $^2/_5$ of the unit, or protracted angle metopes. This seems to prove that the outer faces of the arsenal were actually tilted inwards.

In order to detect the dimensions of the triglyph frieze as they were fixed by the architect, then, the only chance is to make our choice among the 13 possibilities, which we have just arrived at. A priori this seems to be very difficult. But it becomes sensible to attempt a selection if we maintain that any wellfitting triglyph system should be clearly related to the divisions of the ground plan, that is, to the axes of piers and walls. We must claim above all that the lateral windows shall be placed in rhythmic accord with the triglyphs i.e. that the spacing of the piers be equivalent to a multiple of frieze units.

As for the position of the axes it is evident that the plan can be fitted into a network of 2 ½ ft. squares, the total length being 160 (or 162), the total width 22[41], the width of the central and lateral aisles 8 and 5 squares respectively, and the lower thickness of the walls and the upper thickness of the piers both 1 square (fig. 58 H). This I consider the theoretical plan of the arse-

[41] Marstrand demonstrated that the cross section of the plan can be formulated in terms of 5′ (or 2½′) squares (p. 181 tegning 152).

nal, while in practice the upper thickness of the walls was less, and the lower thickness of the piers more, than 2 ½ ft., owing to the inclination of the outer face and to the tapering of the piers. As the piers were higher than the walls, it was but logical to make them wider also. The theoretical axial spacings of the central and lateral aisles would therefore be 22 ½ and 15 ft. respectively, and the axes of the walls would be situated at a distance of 1 ¼ ft. from the outer face.

As pointed out above, the spacing of the piers depended on the length of the sidewalls abutting on the outermost piers. No doubt the stone ceiling that rested on the sidewalls and the central pillars of the doorways reached as far as the end of the pillars, that is: to a line 10 ft. from the front of the arsenal. The sidewalls, therefore, were hardly longer than 10 ft.; but if the theoretical width of the outermost piers was included they may have been 2 ½ ft. shorter. Thus the distance from the fronts to the axes of these piers would be either 11 ¼ or 8 ¾ ft., and the spacing of the piers would be:

I. for flank length = 6400 dactyls

$$\frac{400 - 22\frac{1}{2}}{34} \text{ ft.} = 177{,}64 \text{ dactyls, or}$$

$$\frac{400 - 17\frac{1}{2}}{34} \text{ ft.} = 180 \text{ dactyls}$$

II. for flank length = 6480 dactyls

$$\frac{405 - 22\frac{1}{2}}{34} \text{ ft.} = 180 \text{ dactyls, or}$$

$$\frac{405 - 17\frac{1}{2}}{34} \text{ ft.} = 182.35 \text{ dactyls.}$$

Consequently the spacing was 177,64–182,35 long, depending whether the thickness of the outermost piers was wholly, partially or not at all included.

Among the frieze units found above there is but one that goes into a figure within this interval: three times 60 dactyls make 180 dactyls (x = 14, flank length = 6400 dact.).

4 times 46 dactyls (x = 18, flank length = 6400 dact.) and two times 92 dact. (x = 9, flank length = 6400 dact.) make 184 dact. The joint length of sidewall + outermost pier therefore is only 5 ¾ ft. i.e. 4 ¼ feet less than the length of the central pillars. 3 times 56 dactyls (x = 15, flank length = 6480 dact.) make 168 dactyls, 4 times 40 dactyls (x = 21, flank length = 6400 or 6480 dact.) and two times 80 dactyls (x = 10, flank length = 6400 or 6480) make 160 dact. But these spacings mean that the sidewalls would be as much as 22 ¾, 31 ¼ and 28 ¾ ft. long, respectively[42].

Obviously, then, the unit of 60 dactyls is the only employable one. And we can note to our satisfaction that the triglyph system based on this unit fits in perfectly with the axial features of the plan: triglyphs are centered both on the axis of the walls and on the transverse and longitudinal axes of the piers (the axial spacing of the central aisle being 22 ½ ft.; see fig. 58 G, I). Almost the same degree of correspondance could be attained by using a unit of 40 dactyls (x = 21, flank length = 6400 or 6480 dact.); in this case, however, there would be a triglyph over every second pier only, the lateral windows being clearly displaced in proportion to the rhythm of the triglyphs; and if units of 70 or 56 dactyls were employed (x = 12 or 15, flank length = 6480 dact.) there would be triglyphs above the axes of the walls only.

It is indeed no more than a postulate that a well-adapted triglyph system ought to be related to the axes of the ground plan. But if we accept this postulate we must conclude that a frieze consisting of 14 by 106 units (flank length = 6400 dact.) was by far the most suitable one to be found. We shall see that reasons other than those hitherto advanced may speak in favour of this system:

First, it is noteworthy that there were 15 triglyphs in the fronts. For this is the same number as in the fronts of an octastyle temple[43]. Hence it is very tempting to infer that the design of the arsenal was based on principles of proportioning derived from the theory of the peripteral buildings[44].

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[42] 6480 — (168 × 34) − 40 = 728 dact. = 45 ½ ft.
6480 — (160 × 34) − 40 = 1000 dact. = 62 ½ ft.
6400 — (160 × 34) − 40 = 920 dact. = 57 ½ ft.

[43] So, by calculating instead of guessing, we have reached to the same conclusion as Wanscher, cf. n. 38.

[44] According to Vitruvius (preface VII), Philo was the author of two architectural treatises: one on the Arsenal and another DE AEDIUM SACRARUM SYMMETRIIS. The latter must, of course, have dealt mainly with peripteral buildings. In this connection it should be noted also that Philo

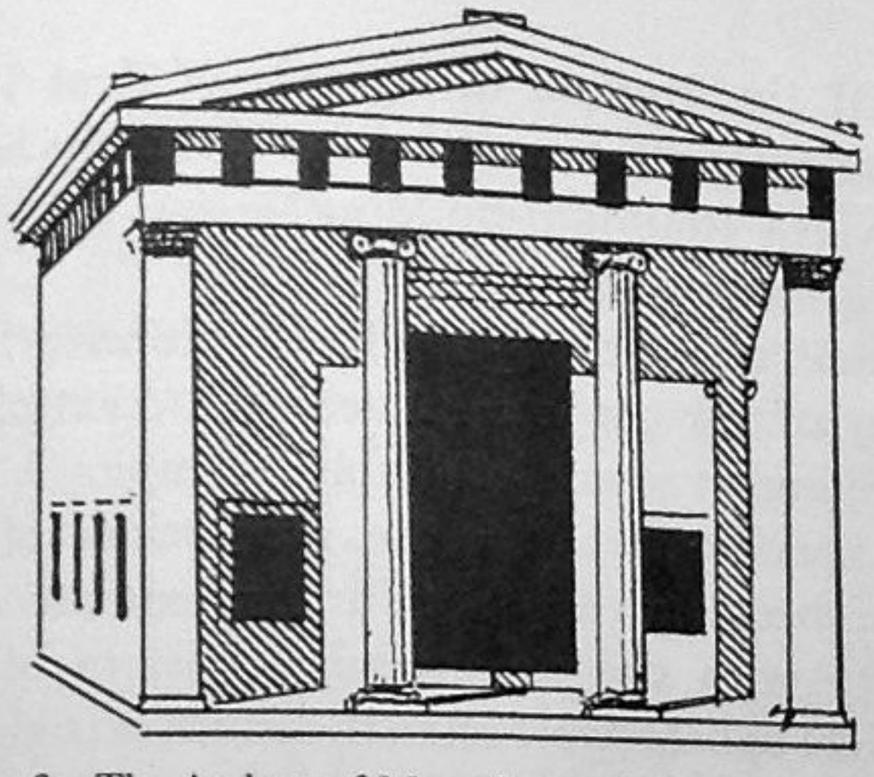

Fig. 61. The Andron of Mausolus at Labranda restored (sketch by K. J.).

Next, if we adopt Vitruvius' instructions for the dimensions of the Doric frieze (IV, 3; perhaps based to some extent on the treatises of Philo) the height of the frieze was $^3/_5$ of the unit = 2 ¼ ft., and the triglyph width $^2/_5$ of the unit = 1 ½ ft. In accordance with late Hellenistic taste, the architrave of Vitruvius is very low in proportion to the frieze, while in Philo's age architraves were still made approximately as high as the frieze. The joint height of frieze and architrave in a peripteral version of the arsenal must therefore be rated at about 2 × 2 ¼ = 4 ½ ft., which equal 3 wall courses. So there was left for the height of the columns 27 — 4 ½ = 22 ½ ft. = the axial spacing of the central aisle; and the column diameter would hardly surpass 3 ft. (equivalent to two triglyph widths, as in Vitruvius' Doric order, or to the thickness which he prescribes for columns of the Ionic pycnostyle order (III,2; intercolumniation = 1 ½ diam.)).

Actually, Doric columns as slender as that ($\frac{3}{22\,1/2} = \frac{1}{7{\cdot}5}$) were not in use in the 4th century B.C. – as far as we know for the present – and even the height of Vitruvius' Doric column was no more than 7 diameters. Higher ratios were valid only for Ionic columns. Besides, the ratio column height: axial column spacing is $\frac{22\,1/2}{7\,1/2}$ = 3, which is more than usual in Doric peripteral buildings of the 4th century, but nearly the same as in Ionic architecture [45]. Consequently, if Philo's design was based on a peripteral diagram this would have combined Ionic columns with a Doric entablature [46].

Just a few years ago this idea would have seemed incredible [47]. Vitruvius strongly criticized the composite orders as if they were degenerate inventions of a post-classical age. He says (I 2, 6): "Likewise, if dentils are carved at the top of Doric entablatures, or if triglyphs are imitated in Ionic entablatures above columns with cushion capitals, the particular features of one order being transferred to the other, it hurts the eye, for one of them was instituted before the other" [48] (Viz. the Doric order; cf. Vitr. IV, I, 3. E COLUMNARUM ENIM FORMATIONIBUS TRIUM GENERUM FACTAE SUNT NOMINATIONES, DORICA, IONICA, CORINTHIA, E QUIBUS PRIMA ET ANTIQUITUS DORICA EST NATA).

But in the course of the Swedish excavations at the Carian Labranda 1948–1953 were unearthed the ruins of two banquet-halls (ΑΝΔΡΩΝΕΣ), one dedicated by Mausolus († 353 B.C.) (fig. 61) the other probably by his brother Idrieus († 344 B.C.) in which the di-style fronts in antis were composed of Ionic columns and Doric entablatures [49]. Evidently architects were experimenting on composite orders just at the time when Philo was working

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was the architect of the Doric prostyle portico of the Telesterion of Eleusis (chapter III).

[45] Cf. the "Chronological list of Greek temples giving their approximate dates and principal dimensions and proportions" appended in Dinsmoor's THE ARCHITECTURE OF ANCIENT GREECE (1950) p. 340.

[46] Presumably the theoretical column diameter was somewhat less than 3 ft., say 2 ½ ft. like the thickness of the walls (diam.: intercol. as 1:2, as in the systyle order of Vitruvius) that is, $^1/_9$ of the column height which is the approximate ratio of Ionic 4th century columns. (see fig. 58f).

[47] The earliest examples then known belonged to the epoch of the Attalids (i.e. the upper storey in the stoas of Eumenes II and of Attalus II at Pergamum and Athens).

[48] This is clearly the meaning of the passage, though a few words appear to be corrupt (see the edition of F. Krohn 1912).

[49] See the plan of Labranda after the excavations appended in LABRAUNDA vol. I part 1 (ACTA INSTITUTI ATHENIENSIS SUECIAE SERIES IN 4°, V, 1:1). All buildings erected by the Hecatomnidae at Labranda had dedications inscribed on their front architraves. The surviving parts of these inscriptions testify that one of the banquet-halls was built by Mausolus, while Idrieus rebuilt the archaic temple of Zeus Lambraundeus and erected the OIKOI (in front of the temple) and the South propylaea. The beginning of the dedication of the other banquet-hall inclusive of the builder's name is lost, but we may infer

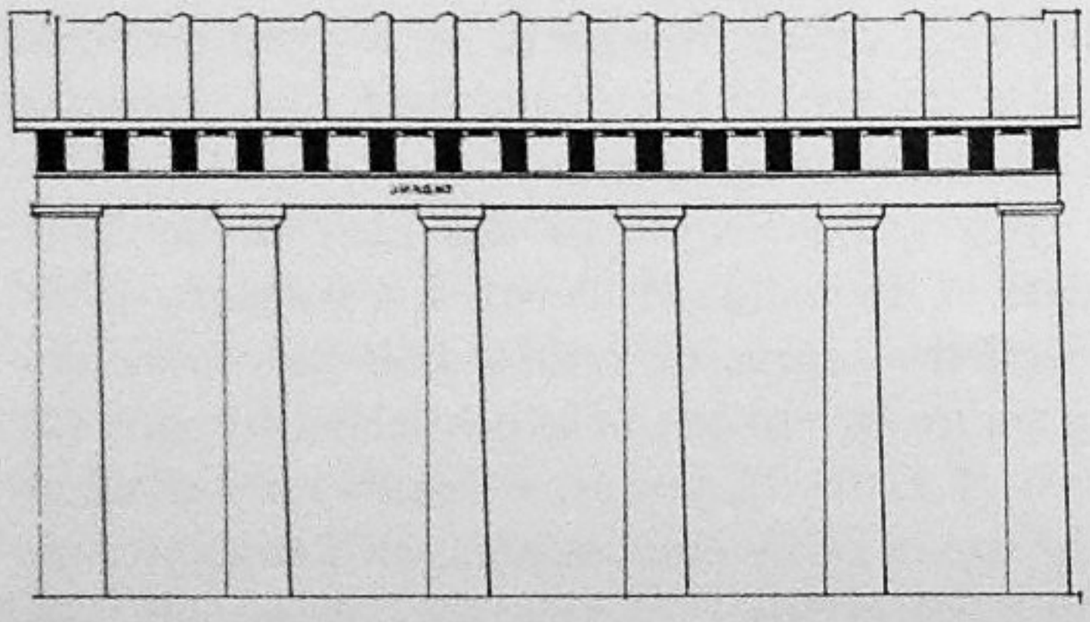

Fig. 62. The »Doric House« near the South Propylaea at Labranda restored (K.J.).

out his project for the arsenal about 350 B.C., and he may well have found it interesting to take part in these fashionable attempts at a renewal of the conventional orders[50].

Apropos of the axial relation between the piers and the triglyph frieze of the flanks of the arsenal we can note that in this period it also became customary to use 3, instead of 2 triglyphs, per intercolumniation. Two examples of this practice are found among the buildings of the Hecatomnidae at Labranda: The socalled OIKOI (in front of the temple of Zeus Lambraundeus), and a small edifice beside the South propylaea (fountain-building?) (fig. 62), both with 4 columns in antis[51].

These arguments, I believe, are clearly in favour of our conjectural reconstruction of the frieze; and it seems justifiable to employ Vitruvius' specifications for the proportions of the frieze, because they are in approximate conformity with the architectural custom of the Classical epoch. Most often the width of triglyphs was not exactly $^2/_3$ of the metope width, and metopes were not strictly quadratic[52]. But the extreme simplicity in the plan of the arsenal suggests that the proportions of the entablature and of the columns of the peripteral diagram should be very simple as well, in terms like those of Vitruvius.

By analogy with other buildings of the period in question we may conclude that the inclination of the arsenal could hardly exceed 4 dactyls. However, in the triglyph system which we

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both from epigraphical and architectural criteria that he was one of the Hecatomnidae, probably Idrieus (this edifice was formerly identified with the temple of Zeus and classified as Hellenistic; see Dinsmoor, THE ARCHITECTURE OF ANCIENT GREECE, 1950, p. 278 n. 1 and cf. the preliminary reports by A.W. Persson "Swedish Excavations at Labranda 1948" Lund 1949 (K. HUMAN. VETENSKAPSSAMF. I LUND, ÅRSBERÄTT. 1948/49 p. 24–32) and "Clues to an unknown Aegaean Alphabet. Important Swedish Discoveries in Asia Minor" (ILL. LONDON NEWS 214 (1949) p. 85–87).

[50] As far as I know, the history of the mixed order in monumental stone architecture cannot be traced any further back for the moment. Occasionally it occurs in vase paintings, not only of the fourth cent. B.C. (e.g. fragm. of calyx crater publ. by Bulle, 94 WINCKELMANNSPROGRAMM, Berlin 1934; situla, CVA Villa Giulia fasc. 1, IV D r tvl. I, 1–4; lekanis, CVA Siracusa fasc. I, IV E tvl. 12, 1–4), but even earlier, note e.g. the fountain buildings represented on the black-fig. hydriae CVA BM fasc. 6 III He, pl. 88; Langlotz, GR. VASEN IN WÜRZBURG Tf. 96, 317. It is also found in some early fifth cent. terracotta plaques from Locri, see RA XXV, 1946, p. 217ff, fig. 1. However, it is difficult to estimate the importance of this secondary kind of evidence and the range within the field of architecture to which it applied. We may surmise, perhaps, that the mixed order was put into practice a long time (and possibly in unpretentious fabrics only) before it was adopted as an independent style intended to replace the pure orders.

[51] A fragment of the dedication of the latter building reads ·· ΕΚΑΤ]ΟΜΝΩ ΜΥ[ΛΑΣΕΥΣ···, which shows that it was built by one of the Hecatomnidae, probably Idrieus. The columns were left unfluted. In the provisional reconstruction shown fig. 62 the height of the columns is estimated at about 310 cm. (calculated from a number of loose drums) while the axial spacing is c. 160 cm.

[52] A few examples will suffice:

	height of architrave	height of frieze	triglyph width	metope width
Parthenon	135	134.7	84.4	130.35 (average)
Sunion*)	83.6	82.9	51.0	75.0
Rhamnous*)	58.5	57.5	37.0	57.5
Hephaesteum*)	82.4	82.8	51.9	77.2
Asclepius at Epidauros**)	61.0	68.5	44.0	69.3
Athena Alea at Tegea	56.8	108.8	71.0	108.1
Telesterion of Eleusis (IG II² 1666)		5′	3′	4½′ ft.

*) See W.H. Plommer, Three Attic Temples, BSA XLV 1950, p. 67ff.
**) See Defrasse & Lechat, ÉPIDAURE, restauration et description des principaux monuments du sanctuaire d'Asclépios, Paris 1895, elevation opp. p. 54.

In our calculations above p. 88ff. we have rated the triglyph width at $^2/_5$ of the unit (or $^2/_3$ of the metope width). As appears from the table, it was often a trifle less (Parthenon, Rhamnous, Asclepius Epid., Athena Alea). The tables p. 89, however, are based on the unit alone (metope + triglyph) no matter what was the exact width of the triglyphs.

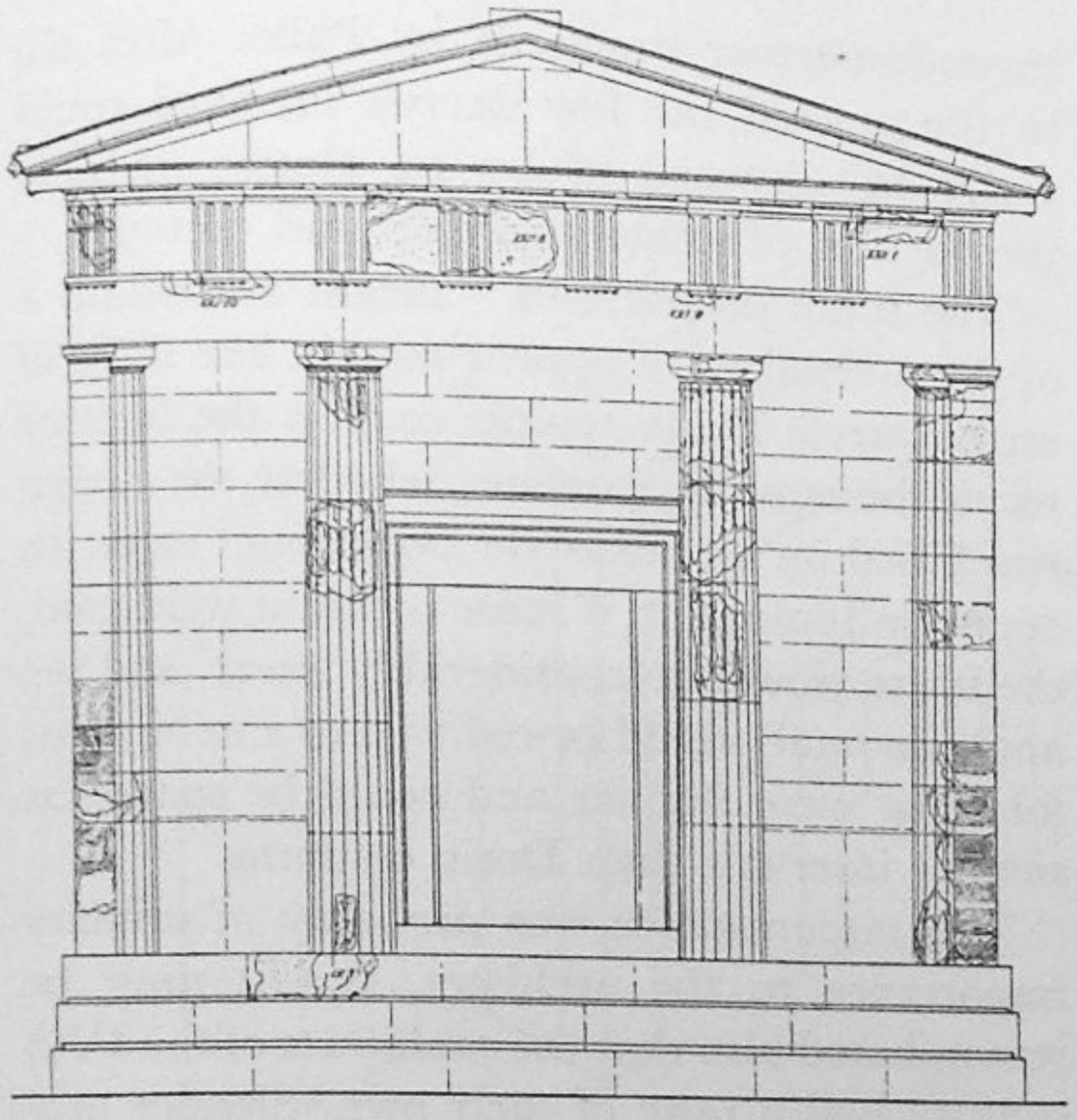

Fig. 63. The Cyrenaic Treasury at Delphi restored by Bousquet (reprod. from Le Trésor de Cyrène 1952, pl. XXXI)

have selected, there would be left between the angle of the ground plan and the angle triglyph a horizontal distance of about eight dactyls. It would be necessary to dispose, somehow, of the surplus in the octastyle diagram as well, for the tapering of the columns would be equivalent to the inclination of the walls. To solve this problem, the architect might choose among three different ways 1) contraction of the outermost intercolumniations 2) prolongation of the metopes and (or) the triglyphs next to the angles 3) addition of a "semimetope" of c. 4 dactyls at the angles. If he had chosen the first possibility, the front width of the arsenal must have been 54½, but not 55 ft. Presumably, therefore, he preferred one of the latter methods which allowed him to retain the normal column spacing in the outermost intercolumniations.

Considering the prevailing theoretical ideas of his age it was but natural that he should do so. Symmetry was the motto of that time (as is obvious also in the design of the arsenal, see below) and perfect symmetry could not be reached if the outermost intercolumniations were contracted. In the traditional Doric style angle contraction was inevitable: it could be softened by moderate prolongation of the angle metopes or triglyphs, but not completely eliminated unless the rhythm of the frieze was visibly disturbed. This was the reason why Pytheus, the great contemporary of Philo, preferred the Ionic style (Mausoleum, Temple of Athena at Priene) and why he was among those ancient architects who according to Vitruvius argued that Doric temples should not be erected[53]. But Philo, on the other hand, was not an extremist like Pytheus: at least he employed the Doric style, both in the arsenal and in the porch of the Telesterion at Eleusis, and it is possible, therefore, that he was the originator of the special solution of the Doric angle treatment recommended by Vitruvius i.e. the use of a "semimetope". By this method contraction could be avoided completely. Vitruvius says that he is quoting what he learnt from his teachers and quite often he refers to these teachers (PRAECEPTORES) but always without mentioning their names. Possibly however they included the authors of the architectural treatises listed in the preface of book VII, among others both Philo and Pytheus.

Other unusual arrangements were in actual fact attempted in order to maintain the axial congruity of angle columns and angle triglyphs – note e.g. the peculiar narrow antae reinforced by lateral half-columns of the Cyrenaic Treasury at Delphi (fig. 63; according to Bousquet, FOUILLES DE DELPHES II, Le Trésor de

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[53] Vitr. IV 3: "Several ancient architects argued that Doric temples should not be erected (any more), because their proportions are faulty and distorted. This was the opinion of Arcesius (?), and of Pytheus, and especially of Hermogenes. For the latter, when he had designed a temple of marble in the Doric style, he changed his mind and made instead of this an Ionic temple for Dionysos. Not because the Doric order is not beautiful and dignified, but for the reason that the distribution of triglyphs and lacunars is difficult. For the triglyphs must be placed exactly above the axes of the columns, and the metopes between the triglyphs must be as long as they are high. The triglyphs above the angle columns, however, shall be placed close to the angle but not above the center of the angle columns. The metopes, therefore, which are nearest to the angle are not quadratic but half a triglyph width longer. But those who want to make uniform metopes must contract the outermost intercolumniations by half a triglyph width. Yet, these solutions whether attained by contracting the intercolumniations or by widening the metopes are faulty. For that reason the ancient architects rejected the Doric style in temples".

Vitruvius' criticism of the mixed orders quoted above p. 91 may originate in an issue by Pytheus, who was no doubt sharply opposed to such compromises.

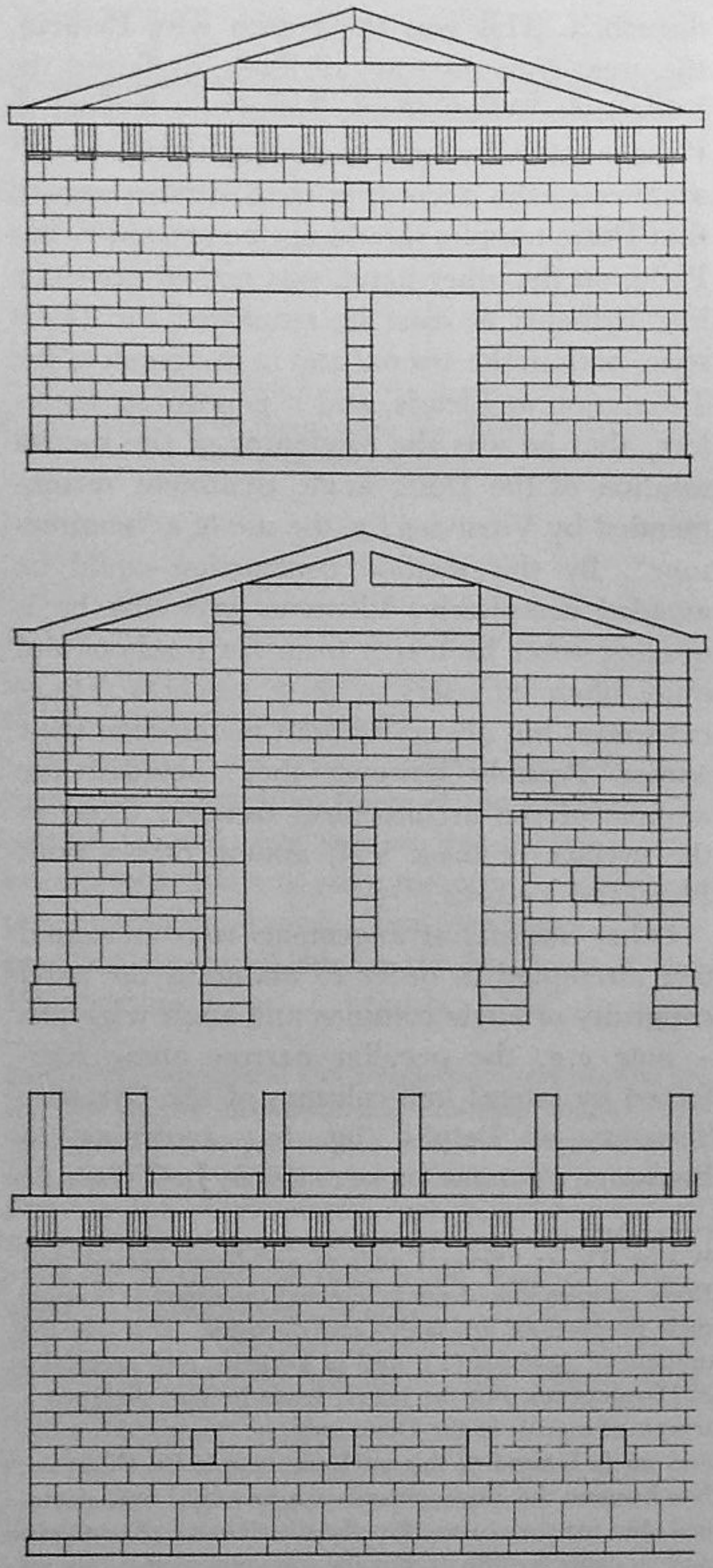

Fig. 64. Theoretical design of the Arsenal, front, section and side elevation (K.J.).

Cyrène, 1952, p. 69ff., it was erected from c. 360 to c. 330 B.C.). But as far as archaeological experience goes, Vitruvius' angle treatment was never used before his own time. The Arsenal may, of course, have served as an isolated trial example. However, since the Doric porch of the Telesterion was designed with conventional angle contraction, it is equally possible that the "semimetope" method was a purely theoretical invention never practiced by Philo. After all, in the arsenal the few dactyls involved could easily be disposed of by an almost invisible protraction of angle triglyphs and metopes.

The main proportions – height and width – of the arsenal were approximately like those of an hexastyle Doric temple so that the interior would be equally spacious, whether the design was based on an hexastyle Doric front or on an octastyle Ionic. Yet, if Ionic columns were used, the frieze would be considerably lower, and the angle anomaly could be reduced to a minimum; for these were thinner and could be spaced at smaller intervals than Doric columns.

This circumstance was probably of primary importance to the architect. But it must be remembered also that the architects of the IVth century had a taste of their own. Slender proportions and delicate details were preferred. The Doric column, for instance, was often made much higher in proportion to its diameter than was usual in the Vth century, in order to achieve a closer resemblance of the elegant Ionic column. Consequently the intercolumniations became narrower in proportion to their height; and this striving for vertical accentuation involved the use of triglyphs comparatively smaller than the monumental ones of the archaic and the first classical phases of Doric architecture. Sometimes, also, the very liking for such neat, diminutive triglyphs would induce architects to use 3 instead of 2 triglyphs per intercolumniation, as in the case of the small Doric building from Labranda already mentioned (fig. 62) the proportions of which were otherwise purely conventional (or we may assume, that the architect endeavoured in this case to make the Doric entablature as light and airy as the friezeless Ionic entablature of the adjacent South propylaea).

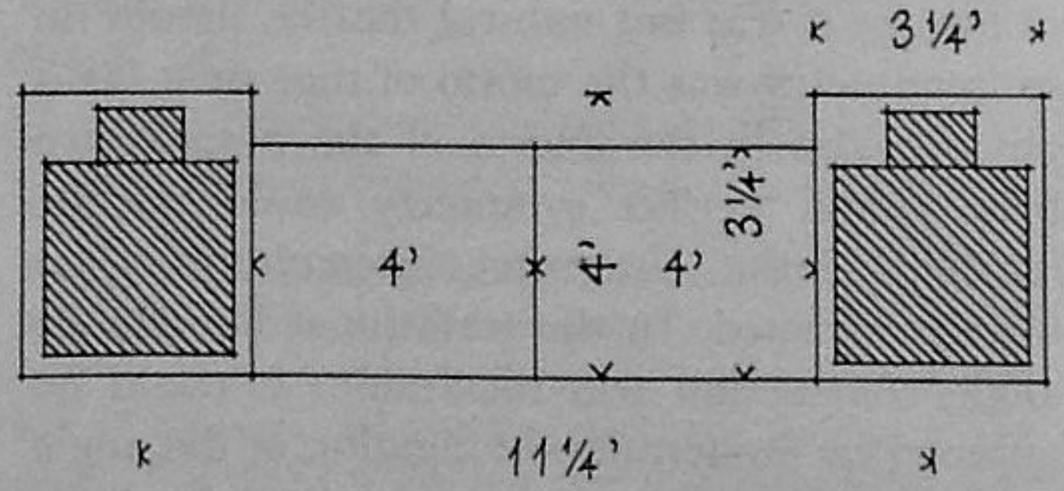

Fig. 65. Hypothetical arrangement of the stylobate stones under the piers (K.J.).

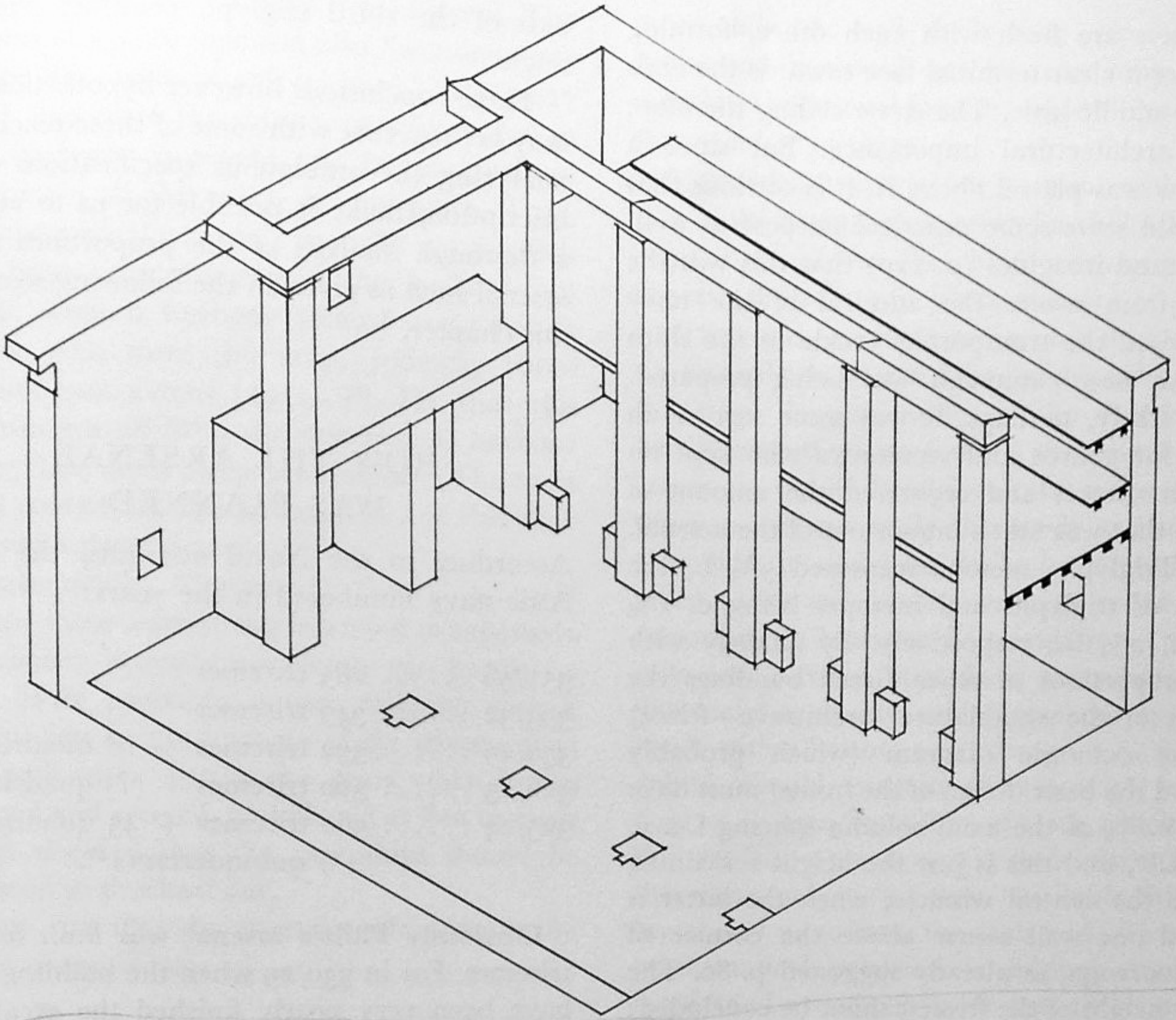

Fig. 66. The interior of the Arsenal as restored by the author (K.J.).

Considering, thus, the manifest approach between the two traditional orders that took place in this period, the front of the arsenal may be regarded as a formulation of the octastyle Doric front as typical of the IVth century, as was the Parthenon of the Vth century B.C.

Finally, let us sum up the total issue of our calculations concerning the triglyph frieze of the arsenal (see figs. 58 A–B, 59 A–D):

1° The total length of the building was 400, but not 405 ft., (as already concluded from the wording of point II of the inscription; see p. 77).

2° No standardized triglyph system can be devised exactly congruent with the outline of the ground plan. It is to be assumed, therefore, that optical refinements such as the inclination of the outer faces of the walls were actually planned by the architect though they are not referred to in the inscription, apart from the tapering of the piers. The specifications of the inscription were presumably based mainly on a right-angled "theoretical" design (fig. 64). And the clause, that the length of the angle blocks of the orthostate and of the walls shall depend on the measurements of the triglyph frieze (points V–VI) therefore can only refer to a purely axial congruence between frieze and ground plan.

3° The axial spacing of the piers was 11 ¼ ft.[54]. It should be noted at all events that stylobate blocks of the dimensions given in point IX could be combined so as to measure exactly this spacing (fig. 65). However, for reasons already stated above p. 77, the stylobate was probably not continuous. Fig. 66 gives an idea of the interior of the arsenal. It will be observed that the outermost piers, the central pillars and the stone ceiling of the

[54] Dörpfeld, Wanscher and Marstrand calculated 11′3″, c. 11 1/3, and 11′, respectively.

doorways are flush with each other, forming together a clear terminal face towards the ends of the middle aisle. The stone ceiling therefore is of architectural importance. But since a window was placed above it, it is obvious that it should serve some practical purpose as well. Marstrand imagines (p. 120) that this was the place from where the admiral of the navy supervised the transport of tackle to the ships when a new campaign was being prepared. More likely, perhaps, it was some sort of an office for guards and secretaries who kept an eye on visitors and registered the amount of tackle that was taken into or out of the arsenal.

4° Triglyph+metope measured 3¾ ft, the width of triglyphs and metopes being c. 1½ and c. 2¼ ft., respectively. By analogy with the proportions of other Greek buildings the height of the entablature (architrave+frieze) of the octastyle diagram (which probably formed the basic design of the fronts) must have been c. $^3/_5$ of the axial column spacing i.e. c. 4½ ft.[55], and this is just the height remaining above the central window, when the latter is placed one wall course above the cornice of the doorways, as already suggested p. 80. The exact height of the frieze cannot be concluded; it may have been slightly higher than the architrave.

5° There was a triglyph over the central window of the fronts while each window of the flanks was placed under a metope[56]. The lateral windows of the fronts were most probably centered on the axis of the lateral aisles, i.e. the axis of the third triglyph counting from the angle.

These conclusions however hypothetical they may be, together with some of those reached by analyzing the ambiguous specifications of the inscription, make it possible for us to attempt a thorough analysis of the proportions of the arsenal such as given in the following section of this chapter.

HOW THE ARSENAL WAS PLANNED

According to the Naval accounts, the entire Attic navy numbered in the years:

357/56 ..... 283 triremes
353/52 ..... 349 triremes
330/29 ..... 392 triremes + 18 quadriremes
326/25 ..... 360 triremes + (?) quadriremes
325/24 ..... 360 triremes + 43 quadriremes + 7 quinqueremes[57].

Obviously Philo's arsenal was built for the triremes. For in 330/29 when the building must have been very nearly finished the great majority of the ships were still triremes.

From the accounts of this year it appears also that the ships were stationed in three different harbours: Munychia, Zea and Kantharos. In total 372 shipsheds are listed, namely:

82 in Munychia
196 in Zea
94 in Kantharos (IG II² 1627 c 401)

Actually there were 392 + 18 = 410 ships, i.e. 38 ships more than sheds, but it is stated in the accounts that this total included the ships still in the wharves which would not need sheds till they were finished (among these were 8 of the 18 quadriremes).

These specifications agree with Strabo's statement (IX, c 395) that the Athenians (at the top of their power) commanded a fleet of no less than 400 ships. But there is no evidence that all the tackle of this enormous fleet was

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[55] In the following buildings this ratio was:

Parthenon: $\frac{3 \cdot 13}{5}$ (axial spacing: 429.6)

Hephaesteum: $\frac{3 \cdot 2}{5}$ (axial spacing: 258.3)

Sunion: $\frac{3 \cdot 3}{5}$ (axial spacing: 252.2)

Rhamnous: $\frac{3.06}{5}$ (axial spacing: 190.4)

Asclepius Epid.: $\frac{2.66}{5}$ (axial spacing: 227)

Athena Alea at Tegea: $\frac{2 \cdot 851}{5}$ (axial spacing: 361.3)

cf. note 52.

[56] Wanscher assumed that there were 108 instead of 107 triglyphs in the flanks, each pier corresponding with a metope and each window with a triglyph (op. cit. p. 132).

[57] IG II² 1611 a 3; 1613 f 302; 1627 b 266, 275; 1628 d 481, 495; 1629 d 783, 808, 811.

stored exclusively in the new stone arsenal. The accounts of 330/29 mention also "wooden arsenals for the tackle of 278 triremes" (IG² 1627 c 396), and since the ships were distributed in three harbours it would not be practical to concentrate all the tackle in one place. True, the stone arsenal was built near the agora which must have been situated in the lowland just off the western harbour (Kantharos); but it will be seen from the map, Judeich, TOPOGRAPHIE VON ATHEN (1931) Pl. III that this area was cut off from the easternmost harbour (Munychia) by a steep promontory. The most direct route from this harbour to Zea therefore involved a great detour.

Consequently, Marstrand's theory (p. 34)[58] that the stone arsenal was intended to supersede the wooden arsenals completely can hardly be true. More probably it was designed with a special view to the increase of the trireme fleet that took place during the years when it was planned and erected, and placed at Zea because it was decided that the new ships should be stationed in this harbour.

Pliny says that the arsenal could contain the tackle of 400 ships:

LAUDATUS EST ..... PHILON ATHENIS ARMAMENTARIO CD NAVIUM (VII 125).

But as a matter of fact there were only 196 shipsheds in Zea in 330/29. And simple calculations will prove that this harbour could never provide space enough to hold 400 sheds. Remains of shipsheds found at Zea show that they were c. 6.5 m. wide each, while the coast line of the harbour was only c. 1100 m. in circumference and could be utilized only where the slope of the coast permitted. So, even if all the sheds were double (containing two ships, one behind the other) and every bit of coast was exploited, there would not be space for more than $\frac{1100}{6{\cdot}5} \times 2$ = c. 340 sheds. The top capacity of this place therefore was hardly much more than the 196 sheds that were actually built, and it would not be reasonable to dimension the arsenal for the tackle of more than this number of ships.

Marstrand assumes that each intercolumniation of the arsenal gave room for the tackle of 6 ships: each of the 134 chests was designed to contain the sails and white curtains of 3 ships (one sail and two curtains for each ship) so that the arsenal was intended for 402 ships altogether. But since the dimensions of the chests could hardly exceed $3 \times 3 \times 6$ ft. (if they were much larger, it would be difficult to move among them, to get out easily the tackle and to open their lids) it would no doubt be impossible to place 3 sails and 6 white curtains in one chest. According to Marstrand's calculations (p. 147) sails and curtains must have measured about 320 and 124 square cubits, respectively. Each chest, with a bottom area of c. 3×6 ft. = 8 sq. cubits, should contain therefore $3 \times 320 + 6 \times 124 = 1704$ sq. cubits of cloth which must be bent into 1704:8 = 213 folds. In this way there was only c. 4.7 mm. available for each layer, and c. 10 mm. for each fold. An almost mathematical precision in folding would be required. Layer upon layer had to be pressed down carefully and finally tramped together into a massive block of cloth to make sure that the lids would close!

It is not unlikely that each chest was designed to hold the tackle of 2 ships (268 ships in total). But the distribution would be clearer and more practical if each ship had a chest of its own and the rest of its tackle was placed on the shelves immediately above the chest. In this way the transverse shelves (extending from pier to wall) would belong to the chests at the base of the piers, while the longitudinal shelves would correspond with the chests placed along the outer walls.

I am inclined to believe therefore that the arsenal was built for no more than 134 ships. It was probably intended mainly for a planned augmentation of the fleet; but it is obvious that a building of this size and artistic perfection was not meant merely as a simple store-house. As the arsenal par excellence it was ranked among the most prominent public buildings of Athens, on a par with the temples on the Acropolis, the Bouleuterium, the Prytaneum,

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[58] In the account referred to in n. 37 are listed also: ΚΛΕΙΘΡΑ ΑΠΟ ΤΩΝ ΣΚΕΥΟΘΗΚΩΝ ΤΩΝ ΞΥΛΙΝΩΝ. It may be true as Marstrand maintains that these locks were left over from demolished wooden arsenals. But one cannot conclude, therefore, that all wooden arsenals had been demolished at the time when the inscription was cut.

the Stadium, the Theatre of Dionysos, the Stoa Basileios, the Stoa Poecile. And it was probably as amply dimensioned as these so that it would not only meet any imaginable wants for the moment and for the nearest future, but would be for ever what people would call *The* Arsenal of Athens. We may imagine that this building should contain the tackle of ships to be used for current services, the rest of the fleet being held in readiness for cases of more extensive warfare.

Actually, between 353/52 and 330/29 the total increase of triremes was only 392 − 349 = 43 ships. But it was probably anticipated to be considerably larger than that, and it may have been taken into account from the beginning that it would be convenient to dispose of so much space in the new arsenal that some tackle could be transferred from the oldest and most worn-out of the wooden arsenals.

As a consequence of this interpretation it follows that the plan of the arsenal was laid out in the generous way characteristic of architects who have undertaken to create a truly magnificent building and need not bother about money. Philo was not a cool-headed engineer who would plan according to strict calculations: so and so many ships, so and so much space for the tackle etc. First he decided boldly that the length of the building should be 400 ft., that the central aisle should be 20 ft. wide, and that the axial spacing of the piers should be exactly half the axial spacing of the central aisle. In this simple way he fixed the main features of the plan and found that an arsenal of these dimensions would be spacious enough to contain the tackle of 134 ships. The idea of building so many new ships was, of course, startling! Doubtlessly, it would satisfy the most daring ambitions of the Attic politicians of that time. But if this optimistic program could not be realized to full extent, it would be easy to fill the empty chests and shelves with tackle from the wooden arsenals which could be pulled down or used for other purposes when they were not needed for the tackle any longer.

Next he planned the triglyph system. This was dimensioned in order to correspond with the main axes of the plan, and it was decided that there should be the same number of triglyphs in the fronts as in an octastyle peripteral front. The whole width of the arsenal accordingly became 55 ft., and the width of the lateral aisles 12 ½ ft. As the thickness of piers and walls was fixed, theoretically, at 2 ½ ft., all the proportions of the plan were divisible by this unit, or module.

Further, in the elevations, the central aisle was made 30 ft. high, and the height of the walls inclusive of the triglyph frieze 27 ft. The latter measurement was not clearly related to the width of the arsenal 55 ft. but resulted from a peripteral diagram of the following dimension:

column height = 22 ½ ft. = 3 axial spacings of 7 ½ ft. = 9 lower diameters of 2 ½ ft.

height of entablature: 4 ½ ft. = $\frac{3}{5}$ of the axial column spacing.

column + entablature: 27 ft.

(it should be noted, on the other hand, that if the triglyph width was 1 ½ ft., as seems likely, the total length of the frieze in the fronts was theoretically 54 ft. = 2×27 ft.).

The remaining principal features he worked out in the following simple terms:

The doorways occupied the whole width of the central aisle, and their height 13 ½ ft. was half the height of the walls inclusive of the triglyph frieze 27 ft. Consequently the soffit of the stone ceilings above the doorways was placed exactly halfway between the floor and the principal cornice. Central pillars, 2 ft. wide, were erected in the middle of the door openings which were divided in this way into two doorways. Each doorway thereby became 9 ft. wide i. e. $\frac{9}{13\frac{1}{2}}$ or $\frac{2}{3}$ of the height. The height of the doorways incl. of the lintels and cornices was 18 ft. i. e. $\frac{18}{27}$ or $\frac{2}{3}$ of the height of the walls. The width of the doors, incl. of their enframement was 24 ft. i. e. $\frac{24}{18}$ or $\frac{4}{3}$ of the height. The soffit of the main beams of the lateral galleries was placed level with the soffit of the stone ceilings, and the roof was constructed with a slope of exactly 3:10 (cf. Marstrand p. 89).

If one tries to analyze an architectural design, it may often be very difficult to find out which

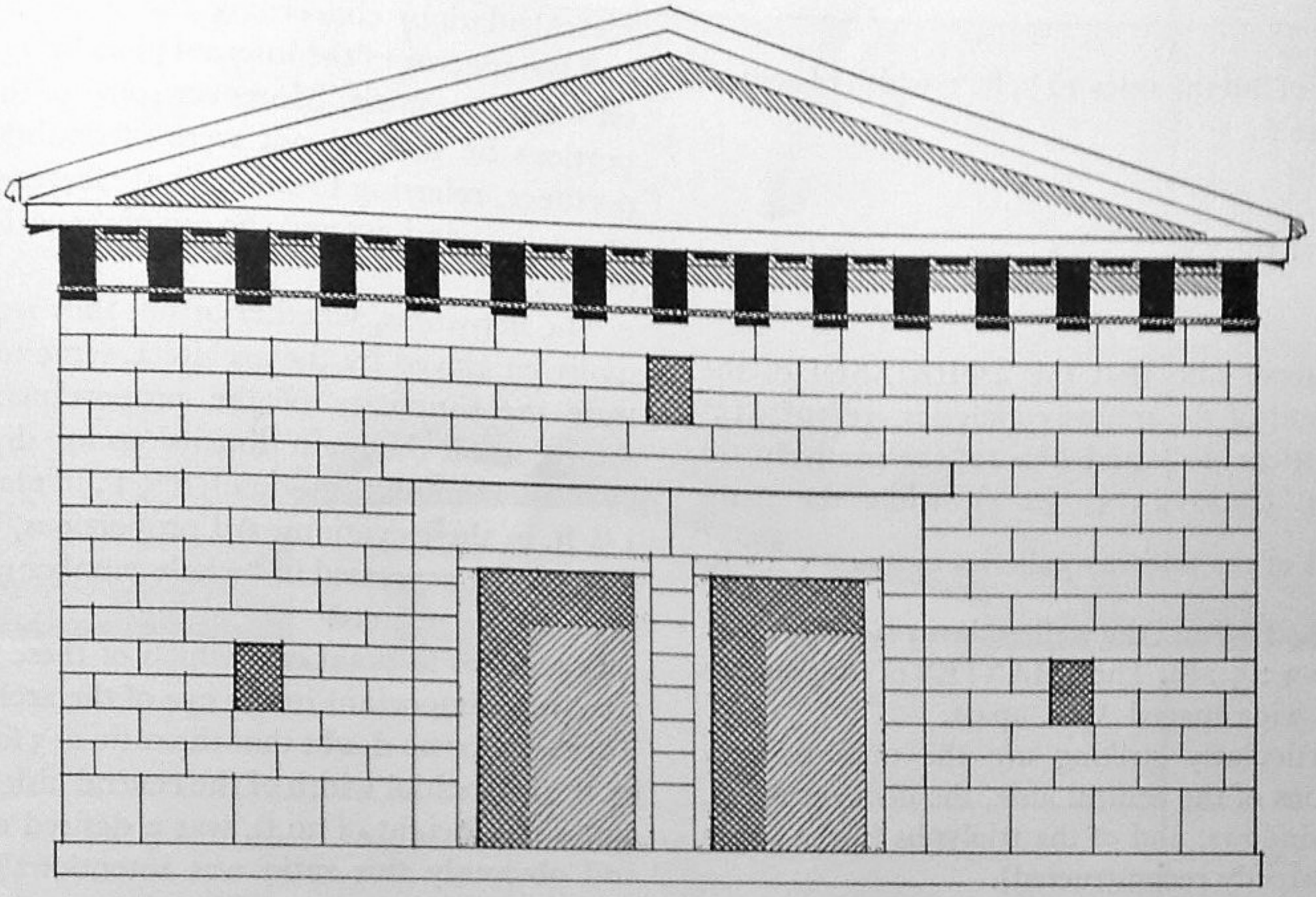

Fig. 67. The front of the Arsenal restored (K.J.).

were the deepest motives of the architect. But in the present case there can be no doubt. What Philo aimed at, above all, was symmetry. Therefore, by examining the proportions of his design as we have already done to some extent, we can explain quite directly and satisfactorily how the arsenal was planned. In the list below are pointed out systematically the most conspicuous examples of simple ratios to be found in the arsenal which, I believe, will not leave the slightest doubt as to the intentions of the architect:

1:1
height of the door openings 13 ½ ft.: height of the walls above the doorways 27 — 13 ½ = 13 ½ ft.
length of geison above the doorways 24 + 2 × 1 ½ = 27 ft.: height of walls 27 ft.

1:2
axial spacing of the piers 11 ¼ ft.: axial spacing of the central aisle 22 ½ ft.
height of doorways incl. of cornice 18 ft.: height of the walls above cornice 27 — 18 = 9 ft.
height of walls 27 ft. : length of triglyph frieze in the fronts 54 ft.(?).

2:3
width of central aisle 20 ft. : height of central aisle 30 ft.
width of door openings 9 ft. : height of door openings 13 ½ ft.
width of windows 2 ft. : height of windows 3 ft.
triglyph width 1 ½ ft.(?) : triglyph height 2 ¼ ft. (?)
axial spacing of the lateral aisles 15 ft. : axial spacing of central aisle 22 ½ ft.
height of doorways incl. of cornice 18 ft. : length of cornice 27 ft.

1:3
axial column spacing 7 ½ ft. : column height 22 ½ ft. (peripteral diagram)

3:5
height of piers 30 ft. : internal width 50 ft.

3:4
height of doorways incl. of cornice 18 ft. : width of doorways incl. of enframement 24 ft.
axial pier spacing 11 ¼ : axial spacing of lateral aisle 15 ft.

3:8
axial pier spacing 11 ¼ ft. : height of piers 30 ft.

5:8
width of lateral aisles 12 ½ ft. : width of central aisle 20 ft.

3:10
slope of the roof.

Observe also that the ΣΦΗΚΙΣΚΟΙ of the roof and of the midway galleries are 10″ × 15″ (interstice: 20″) and 8″ × 12″, respectively, in section (ratio 2 : 3; 3 : 4), while the main beams of the midway galleries measure $1 \times \frac{5}{4}$ ft. (ratio 4 : 5) and the wall ashlars 1 ½ × 2 ½ × 4ft. (ratio 3 : 5 : 8). The ʻIMANTEΣ of the roof are ½ ft. wide spaced ¼ ft. apart.

Particularly striking are the uniform proportions of the central aisle, the door openings, the windows, and of the triglyphs (if the latter be correctly reconstructed).

The amazing simplicity of both plan and elevations appears immediately from the diagrams shown in fig. 58 G–I. As already noted, the main features of the plan can be fitted into a network of 2 ½ ft. squares, and it will be seen also that the axial system of walls, piers and triglyphs may be illustrated exhaustively in a network of 3¾ ft. squares (fig. 58 C–D).

Choisy was the first who tried seriously to analyze the proportions of the arsenal (p. 31 ff.). But his results were poor. He noted just a few simple ratios (e.g. 2:3 of the windows and of the central aisle) and believed that the other proportions were only approximately simple. He pointed out, for instance, that the height of the walls 27 ft. was nearly half, and the width of the door openings 9 ft. nearly $^1/_6$ of the front width 55 ft. etc. The composition of the fronts was explained, further, by dubious geometrical constructions (p. 37).

Marstrand rightly criticized this vague interpretation and showed that the simplicity of the design was far more pronounced than assumed by Choisy (p. 179 ff.). The issue of his researches, as a matter of principle, agrees with mine. But Marstrand took account also of architectural features that cannot be reconstructed because they are not described in the inscription (such as cornice, sima and acroteria) and failed to understand the composition of the ground plan, his calculations concerning the triglyph frieze and the spacing of the internal piers being based on wrong premises. Moreover some of the proportions he pointed out were of doubtful importance, referring to subordinate features such as e.g. the windows and the top of the orthostate course.

The net-works, whether or not they were actually employed by the architect, serve to illustrate the simplicity of the proportions: they show that all the main dimensions are divisible by a common unit (module), 2 ½ ft. in plan and 1 ½ ft. in the elevations. All proportions, therefore, can be expressed in "whole number ratios" such as 2:3, 3:5 etc.

It remains to point out, which of these ratios were most important in the eye of the architect. There can be no doubt that the ratio 2:3 formed by the interstitial width of the central aisle 20 ft. and a pier height of 30 ft. was a desired effect; and obviously this ratio was intentionally repeated in the openings of windows and doorways. It can hardly be due, then, to mere chance that the interstitial widths of central and lateral aisles are as 8 to 5. But it should be noted at the same time that the interaxial proportions of the plan are equally simple: width of central aisle: width of lateral aisle as 3 to 2; width of central aisle: axial pier spacing as 2 to 1; and width of lateral aisles: axial pier spacing as 4 to 3. We may conclude therefore that Philo's design was a result of both interaxial and interstitial planning.

The proportions of the elevation, as already demonstrated, can be explained conclusively in the terms of an octastyle diagram, apart from the doorways, which were designed with a view to the height of the walls 27 ft.

Evidently, then, the most conspicuous divisions of the arsenal were fixed by application of the simplest ratios imaginable: 1:1, 1:2, 1:3 (axial column spacing: column height in the octastyle diagram), 2:3, and 3:5 (height of entablature: axial column spacing in the octastyle diagram).

The aesthetic effect of the building, as restored in conformity with the foregoing analysis of the inscription, may be judged from figs. 67–68 (as regards the height of the door-ways, fig. 68 differs from the drawing previously reproduced in "KUML" 1954, p. 78, fig. 1). The most con-

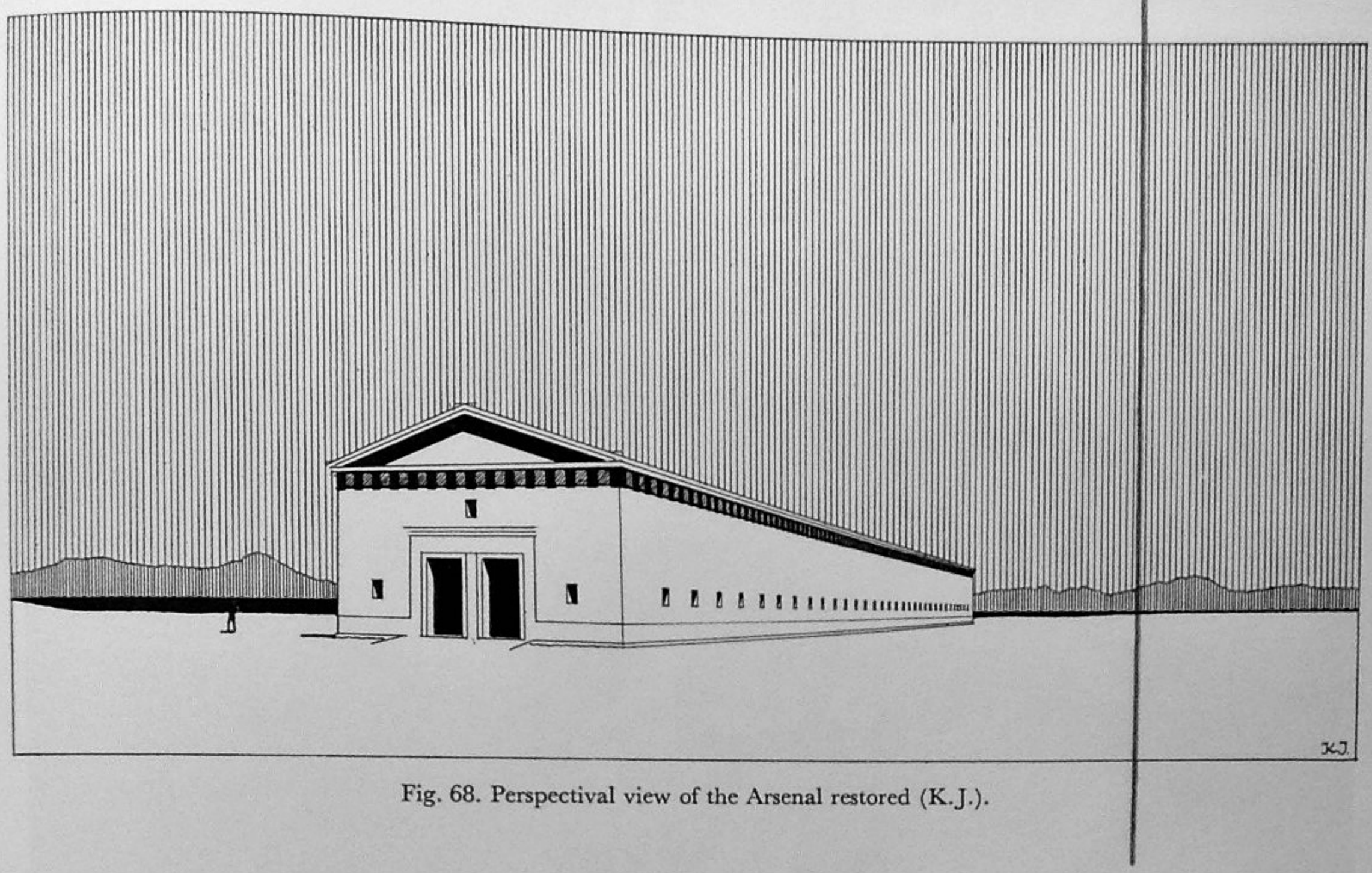

Fig. 68. Perspectival view of the Arsenal restored (K.J.).

spicuous feature is the enormous length. But in contrast to this seascape-like dimension there is a marked vertical tendency in the proportions of the fronts. Above the heavy double doors rises a high "fore-head" (ΜΕΤΩΠΟΝ as the Greek would say) perfectly clear and unbroken, apart from the little window in the middle of it, and crowned by a triglyph frieze of very moderate dimensions. Poised on a superstructure of such lightness the roof almost appears to be "hanging in the open air" (cf. Martial's epigram p. 10). However, this effect is counterbalanced by the weight of the gable, the raking cornice of which is much steeper than was usual in the architecture of the 4th century B.C.; and not merely the doorways, but also the low-sitting "loop-holes" of the ground floor seem to add to the bodily gravity of the building.

Though the appearance of the arsenal was distinctly military, some of its features will be recognized in the Andron of Mausolus at Labranda (fig. 61) erected a few years before the Arsenal project was conceived. But as regards the interior, the Arsenal was probably unique at its time. The fascinating perspectival view through the middle aisle (see the drawing Marstrand pl. IV), as serene and dignified as the long nave of a Gothic cathedral, may well have been the basic architectural idea of Philo's project, and, in actual fact, what people in Antiquity found so impressive and awe-inspiring to merit perennial fame.