Publications by the Department of Art History at the University of Helsinki, no. XVIII
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Jari Pakkanen

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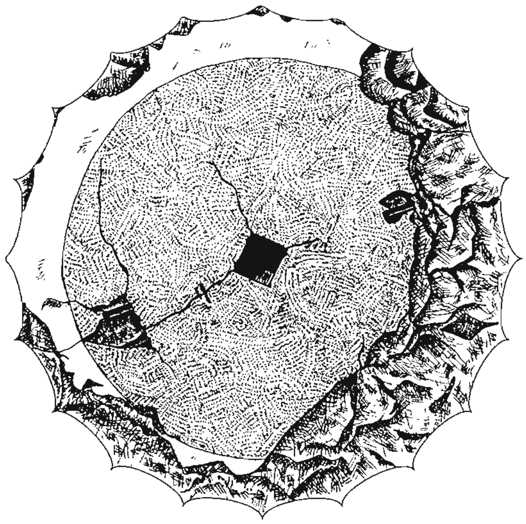
A Reconstruction of the Peristyle Column



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Cover illustration: Tegea, temple of Athena Alea; bottom surface of a peristyle column drum (block 115). Drawing by Petra Pakkanen.

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Preface

My involvement with Tegea began in 1993, the fourth year of the five year Norwegian excavation project at the sanctuary of Athena Alea; this publication has evolved directly from the documentation project of the building blocks at the site. I owe my greatest gratitude to Professor Erik Østby, the director of the excavations and the Norwegian Institute at Athens, for his continuous support and guidance. The Greek collaborators of the excavation project are Dr. Th. G. Spyropoulos, the ephor of antiquities of Arcadia and Laconia, and Dr. A. Delivorrias, the director of the Benaki Museum at Athens.

The slightly unusual appearance of the volume for a book on ancient architecture is due to multiple aims I am trying to attain. Combining methodological questions with the study of preserved blocks is typical of large part of the publication. For example, how can computer programming and statistics be used to obtain more information from architectural and archaeological data? The results are often less accurate than previously published dimensions of the building. In many cases, millimetre exact information of the Greek buildings cannot be achieved, and computerised analysis provides a method for finding the most probable range for the dimension in question. Both the proportional analysis of the buildings and the reconstruction drawings, as well as computer models, are dependent on accurate data; in studies of proportional relationships especially, unwarranted measurement accuracy may lead to incorrect conclusions.

One of the objectives of this study is to make publicly accessible a more thorough account of the computer programs and statistics used in the five papers of my dissertation; for example, no program listings could be published in the papers. In fact, the initiative for the publication came from Seppo Mustonen, Professor of Statistics at the University of Helsinki, who at the time was a referee of my dissertation. I wish to thank him sincerely for his suggestion and all his comments on my work during the past five years; these comments have occasionally resulted in months more work. I am very grateful to the Department of Art History at the University of Helsinki for accepting this book into the publication series and to the Foundation of the Finnish Institute at Athens for its co-operation; from the department I am especially indebted to Professors Riitta Nikula and Jukka Ervamaa for their encouragement. The original basis of this book is my licentiate thesis submitted to the department in 1995.

During the final phase of writing, the comments of Richard Anderson, architect of the Athenian Agora, Dr. Petra Pakkanen, and Dr. Jonathan Tomlinson have been of especial value. The last mentioned has also revised the language of the text. The following persons have also read either my licentiate thesis or various stages of the manuscript of this book, and their comments have been more than welcome: Docent Anja Kervanto-Nevanlinna, Dr. Manolis Korres, Prof. Seppo Mustonen, Prof. Riitta Nikula, Prof. Erik Østby, Prof. Ahti Pakkanen, Docent Leena Pietilä-Castrén, and Dr. Nicholas Rodgers.

To all the friends I have made during the years at Tegea I am very grateful; they are far too numerous to be listed here. The following persons have participated in the documentation of the blocks used in the publication: Anne-Claire Chauveau, Øystein Ekroll, Anne Hooton, Christina M. Joslin, Marianne Knutsen, Tara McClenahan, Petra Pakkanen, Thomas Pfauth, and Tuula Pöyhiä; without their help this study would not have been possible.

The Finnish Institute at Athens, and its good co-operation with the neighbouring Scandinavian archaeological institutes and the Nordic Library, has been a of crucial importance for this study. I wish to thank the following the past directors of the Finnish Institute for having especially contributed to this book: General Director Henrik Lilius for bringing me in contact with Erik Østby, and Prof. Jaakko Frösén for his part in the publication process. I am greatly indebted to Prof. Olli Salomies and Maria Martzoukou for the current favourable working environment at the Finnish Institute.

The study has greatly benefited from various discussions on the sanctuary of Athena Alea with my colleagues; in addition to those persons named above, my thanks are particularly due to Michael Djordjevitch, David Johnson, Dr. Gullög Nordquist, Prof. Olga Palagia, Prof. Richard A. Tomlinson, Prof. Mary Voyatzis, and Dr. Ian Whitbread.

On practical matters concerning the publication Eva Kanerva, Stavros Malagardis, and Harri Markkula have been of invaluable help.

The research presented in the publication has been funded mostly by the Academy of Finland and, for the past one-and-a-half years, by my employer, the Foundation of the Finnish Institute at Athens. For my early involvement with the Tegea excavation project I received financial aid from the Centre for International Mobility, the Friends of the Finnish Institute at Athens, and the Kari Kairamo Memorial Fund.

I am very grateful to my parents, Eila and Ahti, my brother and sister, Juha and Laura, and their families, for their continuous support. With love I dedicate this study to my wife Petra.

Athens, December 1998
Jari Pakkanen

All the programs presented in the study whose copyright is owned by the author are freely available on request.

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Abbreviations

AbH	Abacus height
AbW	Abacus width
AnnH	Annulet height
CapH	Capital height
ColH	Column height
$Diam_A$	Diameter of the capital neck at the arrises
$Diam_L$	Lower diameter of a drum or column between the flutes
$Diam_{LA}$	Lower diameter of a drum or column between the arrises
$Diam_U$	Upper diameter of a drum or column between the flutes
$Diam_{UA}$	Upper diameter of a drum or column between the arrises
DrH	Drum height
EchH	Echinus height
Ent_{max}	Maximum entasis
FlW_L	Flute width of a drum or column at the bottom
FlW_U	Flute width of a drum or column at the top
H	Height
L	Length
t.	Temple
TrachH	Trachelion height
W	Width

For the terminology, see the Glossary on p. 83.

List of Illustrations

I. Introduction

Presented here is a restudy of the peristyle columns of the fourth-century BC temple of Athena Alea at Tegea in the Peloponnese.[1] The need for the study is not perhaps immediately apparent as the architecture of the temple was published in 1924 by Ch. Dugas and M. Clemmensen in the excellent monograph *Le sanctuaire d'Aléa Athéna à Tégée au IV^e^ siècle* where it is clearly stated that the reconstruction of the column is absolutely exact.[2] Recent studies have mainly concentrated on the arrangement of the cella and the Corinthian capital,[3] and when the exterior reconstruction has been discussed, almost only the voice of the original publication has been echoed.[4] It is actually this certainty which, in 1994, caused me to start to wonder, how it is possible to give a millimetre exact reconstruction of the column height when there are no column drums *in situ* and there is consid-

1 A brief, preliminary account of this study is published in Pakkanen 1996a, 695–702.

2 "Elles nous font aussi connaître le diamètre inférieur des colonnes et, grâce aux tambours que nous possédons (voir l'appendice II), il est possible de présenter de la colonne une reconstitution absolument exacte." Dugas *et al.* 1924, 18.

3 See pp. 7–8.

4 E.g., most recently, "Enough material remains to reconstruct the exterior of the temple with complete confidence" (Norman 1984, 170) and "more architectural blocks from it [the Classical temple] are coming to light in the excavation, but they will hardly require revision of those reconstructions which were offered in the original publication of 1924, and which have been corrected on minor points in recent studies" (Østby 1994, 53). The only exception I have come across is in a footnote in Norman's article where she cites Clemmensen's own doubts (Clemmensen 1925, 11–12) over the column height reconstruction (Norman 1984, 180 n. 69); see p. 50.

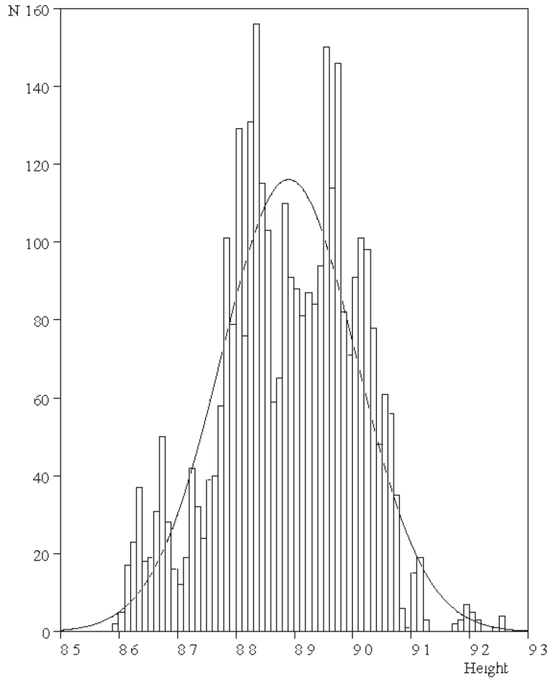

Fig. 1. Histogram of possible column height combinations: N = 3,361, measurement tolerance ± 3 mm. Based on measurements by M. Clemmensen; Dugas . *et al* 1924, 131-133.

erable variation in the height of the drums.[5]

In order to investigate the possible ways of combining the column drums I wrote a computer program:[6] as input data it takes the number of the block, upper and lower diameters of the drum between the flutes, and the height of the drum. The arrises of most of the blocks are largely broken, thus matching the drums on the basis of diameter between the arrises and flute width was not possible—only combining the drums according to the diameters at the bottoms of the flutes was tested. All the published measurements are in millimetres, but usually such precision cannot be attained in measuring the column drums of the temple due to broken surfaces, weathering of the blocks and slight irregularities in the shape of the drums. I chose to consider this problem by giving as a parameter the amount of difference allowed in finding two fitting blocks. For example, tolerance of 3 mm defines a 6 mm range for the drum diameter—in this case I would be expecting a possible error of ±3 mm in Clemmensen's measurements.[7] If the upper diameter

[5] Clemmensen measured the column drums at the site and published the measurements of 47 drums (Dugas *et al.* 1924, app. II 131–133): the greatest variation is found in level *C* (third drum from the bottom) where the shortest drum is 1.321 m and the tallest 1.675 m, giving a difference of ca. 0.35 m. In the appendix Clemmensen is reported as the sole author of the table.

[6] On the program used to produce shaft combinations, see also p. 62 and App. E, p. E2.

[7] It is very hard to find one correct figure for tolerance to be given as the parameter to the program. In the first place, the expected accuracy of Clemmensen's measurements should be considered. It is apparent from his brilliant drawings in the publication (Dugas *et al.* 1924, pls. 1–81) that his work is very accurate. But giving too much respect to the published figures' accuracy leads to loss of information: possible combinations would then be excluded. Therefore, the suggested tolerance of 3 mm is a compromise, and should be regarded only as an initial proposition necessary at this stage of the study.

range of the lower block and the lower diameter range of the upper block overlap, the pair is accepted as possibly matching.

Figure 1 displays the column shaft heights of the possible combinations as a histogram: with the tolerance set at 3 mm there are 3,361 ways to combine the column drums. The minimum height of the column is 8.60 m and the maximum height 9.26 m. The mean, 8.89 m, is close to the shaft height suggested by Dugas and Clemmensen, 8.885 m. But examination of the histogram shows that the centre classes are surprisingly vacant, and there are two clear clusters which do not coincide with the average height: the first at 8.80–8.85 m, and the second at 8.95–8.98 m. Clearly, therefore, the matter needs to be studied further.

In Chapters II–IV I will discuss the documentation and the architectural material, and Chapter V presents the method for reconstructing the height of the column.

1. Preliminary Catalogue of Building Blocks

This study on the peristyle columns is closely connected with the project of cataloguing building blocks in the sanctuary. The project has two objects: firstly, it will provide a basis for further research on the temple, and secondly, it is the first step toward a plan to rearrange the blocks at the site and for any future projects of conservation or restoration.

The catalogue was started by E. Østby in 1990, the opening season of the five year Norwegian excavation project led by him.[8] It included forty-nine blocks which had been lifted on top of the temple foundations during the previous excavations and fifty blocks lying north and north-east of the foundations. The catalogue does not include the blocks remaining *in situ*: these are the foundation and stylobate blocks for the columns of the Archaic cella and the foundation and the few euthynteria blocks of the Classical temple. These have been quite well documented during previous research and could therefore be given a lower priority.[9] The entry for each block consisted, at this stage, of a description of the block with its basic dimensions.

In the autumn of 1992 E. Østby requested me to continue the catalogue in 1993. A complete preliminary catalogue of the building blocks was set as the goal for the season: it would include a short description of the block, the basic measurements needed for identifying the block, and its position in the general coordinate system of the sanctuary. The positions of the blocks were plotted using a theodolite with an electronic distance meter.[10] The catalogue currently includes

[8] On the excavations, see pp. 6–7.

[9] A drawing of the Archaic foundations was made by D. I. Sonerud in 1995, and a new drawing of the Classical foundations is being prepared by the author.

[10] I was greatly assisted by T. Pfauth in plotting the blocks' positions. C. M. Joslin and M. Knutsen also participated in taking the measurements. With the measuring and identification of the blocks I

820 blocks, almost all from the Classical temple, but some from other buildings, such as the few Byzantine building fragments (double columns and a capital) and a starting line block from the stadium of Tegea. This is not *in situ*, but it supports the hypothesis that the stadium was in the immediate vicinity of the sanctuary.[11]

The 99 blocks initially studied by E. Østby established the order in which the remaining blocks were documented: the first block lies on the north-west corner of the foundations, and following this, in a clockwise direction, are the blocks on the foundations. Next, starting west of the north ramp and again moving clockwise, the blocks around the foundations were listed. There are two major exceptions to this rule: the large deposit at the south-east angle of the sanctuary and the deposit of smaller blocks at the eastern part of the sanctuary was both initially omitted and catalogued later, after the other blocks. The final task of the 1993 season was the cataloguing of the new blocks found in 1990–93.

A supplement to the catalogue is a plan of the sanctuary; the co-ordinate points with the block identification number are automatically plotted on top of the plan which was redrawn for computer. The greatest advantage of the electronic plan is versatility: plans at different scales can easily be printed, and different prints of certain types of blocks can also be made.[12] The current site plan with all the blocks is at a scale of 1:250.

During the 1994 and 1995 seasons most of the field work was connected with aspects presented in this study: the column drums, cella wall blocks, capitals, architraves, and frieze blocks were subjected to more extensive examination.[13] In 1998 some of the drum data were rechecked and the flute widths of all the drums remeasured. The new measurements and observations have also been included in the preliminary catalogue.

2. Earlier Investigations

The sanctuary was first identified in the village of Piali (now Alea) by E. Dodwell in 1806 from the visible architectural remains of the temple:

> "On the 7th of March, we visited the ruins of Tegea ... Some hundred yards from this church [Palaio Episkopi], is the village of Piali, and a few remains of the great temple of Minerva Alea, built by Skopas of Paros; the original temple, built by Aleus, son of Aphi-

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was helped by Ø. Ekroll whose main task has been to participate in the project of planning a more convenient arrangement of the building blocks at the site.

[11] For a discussion of the stadium location, see Voyatzis 1990, 14–15 and Østby 1994, 53–54.

[12] See Figs. 8, 11, and 17 for plans produced by automatic plotting.

[13] The persons who have also participated in the documentation are as follows: column drums: A.-C. Chauveau, Ø. Ekroll, and T. Pfauth in 1994, P. Pakkanen in 1995; cella wall blocks: Ø. Ekroll in 1994; architraves and frieze blocks: P. Pakkanen in 1995 and 1996; study and new drawings of various blocks: T. Pöyhiä in 1996; column drum rechecks: A. Hooton and T. McClanahan in 1998. Without their help the building block study would not have been possible.

das, having been burnt in the ninety-sixth Olympiad. It was composed of the three orders of Grecian architecture. Above the Doric was the Corinthian, surmounted by the Ionic. I found fragments of the different orders. There are several large masses of Doric columns of white marble, but the greatest part is buried. I was not able to take exact dimensions; but those of the Doric order did not appear to be much inferior in size to those of the Parthenon.

Their size may probably have contributed to their preservation, as they were too heavy to be removed. The two other orders were no doubt much smaller, and have been carried to Tripolitza, as very few fragments of them remain.

We are informed by Pausanias that this temple was one of the largest and most ornamented in the Peloponnesos. The Calydonian hunt was represented on its front tympanon, while the posticum exhibited the battle of Telephos and Achilles in the plain of Kaikos."[14]

Dodwell is quite liberal in reading Pausanias' description of the temple,[15] but the passage has been a difficult one for modern scholars as well: for more than a century it has been debated whether to keep Pausanias' original ἐκτός in connection with the Ionic columns,[16] or to emend it to ἐντός.[17] I have recently argued that the original reading should be kept and that instead of reconstructing the temple interior with Ionic half-columns on top of the Corinthian ones,[18] a podium could be placed below the Corinthian order and the Ionic order omitted.[19] Dodwell's observation on the size of the Doric columns is also slightly erroneous: the difference in size between the exterior orders of the Parthenon and the temple of Athena Alea is substantial, but even today the drums at Tegea are an impressive sight.[20]

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[14] Dodwell 1819, 418–419.

[15] Paus. 8.45.4–7. Pausanias explicitly states that the temple was the largest in the Peloponnese (8.45.5), even though there are several larger ones (see Østby *et al.* 1994, 89 n. 2).

[16] ὁ μὲν δὴ πρῶτός ἐστιν αὐτῷ κόσμος τῶν κιόνων Δώριος, ὁ δὲ ἐπὶ τούτῳ Κορίνθιος· ἑστήκασι δὲ καὶ ἐκτὸς τοῦ ναοῦ κίονες ἐργασίας τῆς Ἰώνων. Paus. 8,45,5.

[17] The latest Teubner edition of 1977 accepts the emendation. For a recent general discussion of the problem, see Norman 1984, 179.

[18] As suggested by N. J. Norman (1984, 179–180).

[19] Pakkanen 1996b, 153–164. On the cella wall height, see n. 31 on p. 62. The single piece of material evidence that Norman was able to connect with the Ionic order at Tegea, the small fragment of a column drum (Norman 1984, 180, pl. 31, fig. 10; see also p. A27, block 319, and p. A42 for a drawing), was studied by O. Palagia in December 1997: it has actually sharp arrises and therefore a part of a small *Doric* column, not Ionic. However, new field work carried out in June 1997 showed that the reconstruction presented in Pakkanen 1996b (fig. 8) cannot be regarded as final: The centre podium block (8) is slightly irregular, suggesting that it could be from a statue podium. The front surface of the top podium block is previously undocumented and its top front corner seems to be deliberately hacked away, but the cut part is most probably a smooth rim and not a projecting moulding (on this "sub-toichobate" block, see Pakkanen 1996b, 157, 161). This indicates that there was originally another block in front of it, necessitating a wider reconstruction of the podium, as in the tholos at Delphi (see e.g. Pakkanen 1996b, fig. 5).

[20] The lower diameter of the drums of the Parthenon is 1.905 m (Dinsmoor 1950, 338); at Tegea the lower diameter is c. 1.55 m (see pp. 22–23).

A. Archaeology

A. Milchhöfer of the German Archaeological Institute at Athens was the first to conduct archaeological research at the site by excavating exploratory trenches to determine the position of the temple in 1879.[21] G. Treu suggested that the sculptures in the museum of Piali must come from the pediments and were, therefore, original works by Skopas.[22] The architectural fragments were further studied by F. Adler, R. Borrmann, W. Dörpfeld, P. Graef, and F. Graeber, and they agreed that the fragments were from the temple of Athena Alea.[23] In 1882 Dörpfeld carried out a systematic study of the foundations and the architectural remains uncovered by Milchhöfer, and he was able to present fairly accurately the peristyle plan.[24] In 1900 the French School at Athens purchased most of the private houses on top of the temple and full-scale excavations were started; between the years 1900–1902 G. Mendel uncovered all of the foundations except for the south-west part of the temple.[25] The last house on the foundations was bought by the Archaeological Society of Athens and excavated by K. A. Rhomaios in 1909.[26]

From 1910 to 1913 the French archaeologist Ch. Dugas worked at the temple site in order to publish the excavated material and to carry out additional archaeological work: the latter task was limited to the surroundings of the altar and some very small trenches around the temple area. Dugas' chief collaborators were architect M. Clemmensen and sculptor J. Berchmans.[27] The result of their work was the lavishly illustrated publication of the Classical temple in 1924. Dugas had previously published an article—mainly a catalogue of small objects—on the earlier sanctuary in 1921.[28]

In 1964 and 1965 Ch. Christou and A. Demakopoulou of the Greek Archaeological Service cleared the temple site and did limited excavation work 200 m south of the temple, uncovering some new sculptural and architectural fragments of the temple.[29] G. Steinhauer, also of the Greek Archaeological Service, opened seven trenches to the north of the temple in 1976 and 1977.[30]

From 1990 to 1994 the Norwegian Institute at Athens, under the direction of E. Østby and as an international co-operation, excavated two sectors: between the two rows of Archaic foundations within the cella of the Classical temple, and

[21] Milchhöfer 1880, 52–69.
[22] Treu 1881, 393–423.
[23] Dörpfeld 1883, 274.
[24] Dörpfeld 1883, 275–277.
[25] Mendel 1901, 241–256; Dugas *et al.* 1924, X.
[26] Rhomaios 1909, 303–316.
[27] Dugas 1911, 257–258. Dugas *et al.* 1924, X–XII.
[28] Dugas 1921, 335–435.
[29] Christou—Demakopoulou 1965, 169–170, and Demakopoulou 1966, 152–154.
[30] Østby *et al.* 1994, 96. The work is still unpublished, but M. E. Voyatzis has studied some of the objects and Steinhauer's section drawings; see Voyatzis 1990, 21, 24–25, 52 n. 85 and 53 n. 110.

north of the temple in approximately the same area as G. Steinhauer. In the cella area it was confirmed that the foundations belong to the Archaic temple, and beneath these Archaic foundations two apsidal Geometric buildings were identified.[31] In the northern sector the stratigraphy of the area from the early Archaic to the late Byzantine period has been established. Remains of large, collapsed mudbrick structures have been discovered in the northernmost part of the excavations.[32]

B. Other Previous Studies on the Temple

After Dugas and Clemmensen, the first to undertake an investigation of the temple at Tegea was B. H. Hill: from 1946 to 1954 he studied the building in order to obtain comparative material for his work on the temple of Zeus at Nemea. He mainly used the French publication, but he also made several visits to the site. Hill presented a new reconstruction of the Corinthian capital inside the cella,[33] but otherwise his results were left unpublished until N. J. Norman was able to use Hill's work-notes for her study.[34] The Corinthian capital is discussed by H. Bauer as well: he suggests a slightly taller capital than Hill's reconstruction, but it is otherwise similar.[35]

Norman's article on the Classical temple proposes a new reconstruction of the cella interior: there are Corinthian half-columns on three sides of the cella, and Ionic half-columns above them. Hill's evidence for his reconstruction of the Corinthian capital is included in the paper.[36]

H. Knell has made an attempt to demonstrate that the ratio 6:14—number of columns on the short and long sides—can also be found at the euthynteria level of the temple, and that the normal axial spacings of the short side colonnades is 3.607 m, but neither of these observations should be accepted.[37] H. Bankel has

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[31] Østby *et al.* 1994, 96–107; Nordquist 1995, 27–30.

[32] Østby *et al.* 1994, 107–117; Østby 1994, 46–53. During the last year of excavation, levels approaching the Geometric period were reached.

[33] Hill 1966, pl. 29 B.

[34] Norman 1984, 169 and n. 1. I am indebted to W. Coulson, previous Director of the American School of Classical Studies at Athens, for permission to study B. H. Hill's papers on the Tegea temple, and to C. Zerner in practical matters connected with the papers. I was not able find any important points in the notes left unnoticed by Norman.

[35] Bauer 1973, 65–71, 142.

[36] Norman 1984, 169–194.

[37] Knell 1983, 225. The ratio 6:14 at euthynteria level is based on a false figure for euthynteria width: 21.184 m is actually the foundation width (21.200 m in Dugas *et al.* 1924, pls. 9–11). Euthynteria edge at Tegea was slightly recessed from the edge of the foundations (Dugas *et al.* 1924, pls. 21–26 and 29), so the correct figures for the calculation of the euthynteria ratio are 21.04 m (width) and 49.40 m (length, Dugas *et al.* 1924, pls. 3–4 and 9–11). If the ratio 6:14 is used to calculate the width from the length (6×49.40 m / 14 = 21.17 m), the discrepancy (0.13 m) between the calculated width and the measurement is not acceptable. In trying to redefine the axial

compared the elevations of the Tegea temple and the temple of Zeus at Stratos: it is a sound metrological study and demonstrates well the general difficulty of determining the foot units possibly used in Greek architecture.[38]

The most complete discussion on the sculpture from the temple is A. F. Stewart's monograph on Skopas.[39] Very recently O. Palagia has proposed that Skopas was only the architect of the temple and that the pedimental sculptures are by a local Peloponnesian workshop. Her argument is based on literary and stylistic evidence, and as a whole, I find it quite convincing.[40]

The foundations within the Classical temple's cella were independently suggested by N. J. Norman and E. Østby to be Archaic rather than belonging to a Byzantine basilica, as Dugas had proposed.[41] The former briefly discusses the foundations in her paper which concentrates mainly on the cella of the Classical temple, while the latter has published an extensive article on the subject and also gives a hypothetical reconstruction of the plan.[42]

New observations on the column height and entasis as well as the cella interior have been preliminarily reported by the author in several recent papers.[43]

3. The Classical Temple

According to Pausanias the old temple of Athena Alea was destroyed by fire in 395/394 BC and the architect of the new temple was Skopas of Paros.[44] The foundations of the temple are mainly of conglomerate with some reused marble blocks from the Archaic temple, and the superstructure is completely of Dolianà marble.[45]

The foundations of an entrance ramp to the temple on the east front are pre-

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spacings of the short side colonnades Knell presents two figures for "uncontracted euthynteria length and width" which are used in the calculations. How these figures have been produced is not clear from the text and they do not fit measurements that can be otherwise calculated (Dugas *et al.* 1924, pl. 9–11: uncontracted euthynteria length would be $49.400 + 2 \times (3.582 - 3.238) = 50.088$ m, cf. Knell 50.15 m; uncontracted euthynteria width $21.040 + 2 \times [(2 \times 3.613 + 3.582) / 3 - 3.355] = 21.535$ m, cf. Knell 21.642 m), so Knell's figure for normal axial spacing on the front is also questionable.

[38] Bankel 1984, 413–430. On the foot units, see also pp. 67–68.

[39] Stewart 1977, 5–84.

[40] Palagia 1995, 4. Her monograph on Skopas is under preparation.

[41] Dugas *et al.* 1924, 11–13.

[42] Norman 1984, 171; Østby 1986, 75–102.

[43] See Pakkanen 1996a, Pakkanen 1996b, 153–164, and Pakkanen 1997, 330–332.

[44] Paus. 8.45.4–5.

[45] The marble has not been studied scientifically and therefore in some modern studies the building material is not identified as certainly from Dolianà; see e.g. Waelkens *et al.* 1988, 90–91. However, as the Dolianà quarries are only ca. 10 km to the south-east of Tegea, and as they show extensive traces of ancient quarrying, they are very likely to be the source of the temple marble.

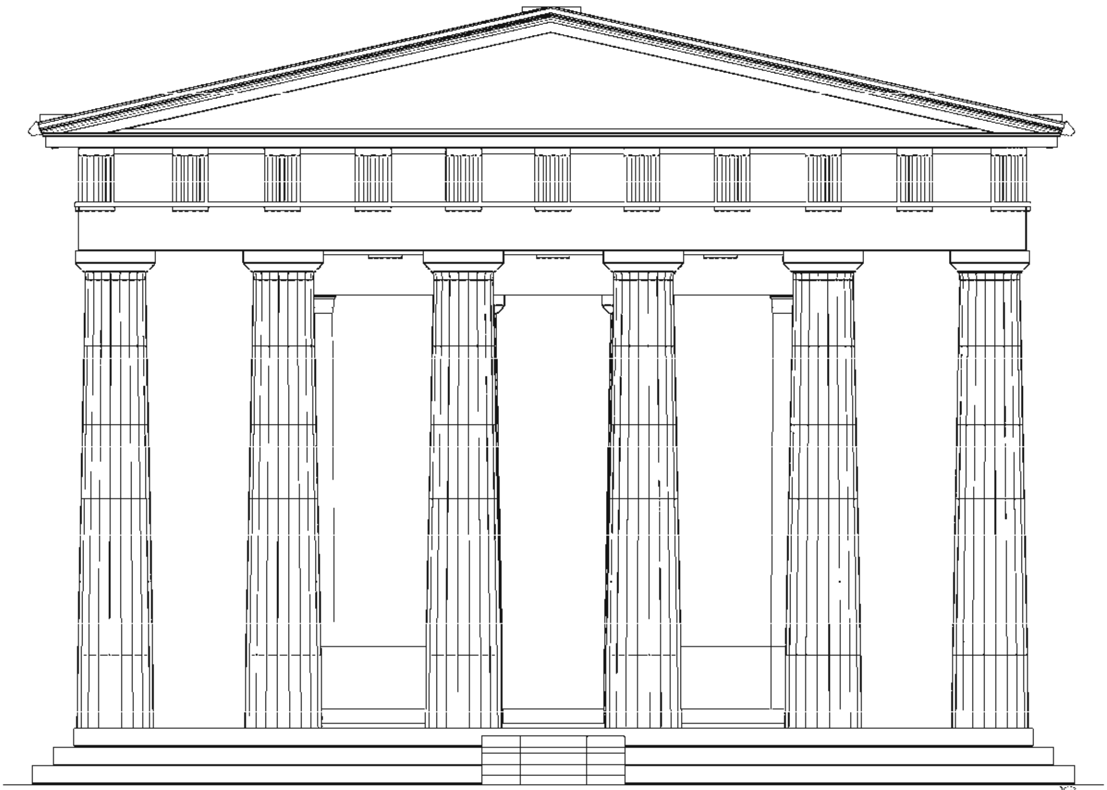

Fig. 2. The east façade of the temple of Athena Alea. Scale 1:150.

served, and the north side also has a similar structure.[46] Figures 2 and 3 present the elevation of the east façade and the plan of the temple. The plan, six by fourteen columns, is rather long for a fourth-century building; the elongated proportions of the plan of the temple are most probably borrowed from the Archaic temple.[47] The columns have slender proportions[48] and, likewise, the entablature is low compared to column height. The porches were distyle-in-antis, and as described above, in the cella the Corinthian half-columns columns were probably standing on a podium—no Ionic order can be attributed to the cella interior.[49] The most complete discussion of the date of the temple is by N. J. Norman: she dates it to 345–335 BC.[50] According to E. Østby, the pottery discovered in the Norwegian excavations supports the dating of the temple to the second half of the fourth century.

[46] On whether the foundations on the north flank are for a ramp or a platform, see Østby *et al.* 1994, 114–115.

[47] See e.g. Norman 1984, 172 and esp. n. 18; Østby 1986, 93–95.

[48] See pp. 72–73.

[49] See p. 5, esp. n. 19.

[50] Norman 1984, 191–193.

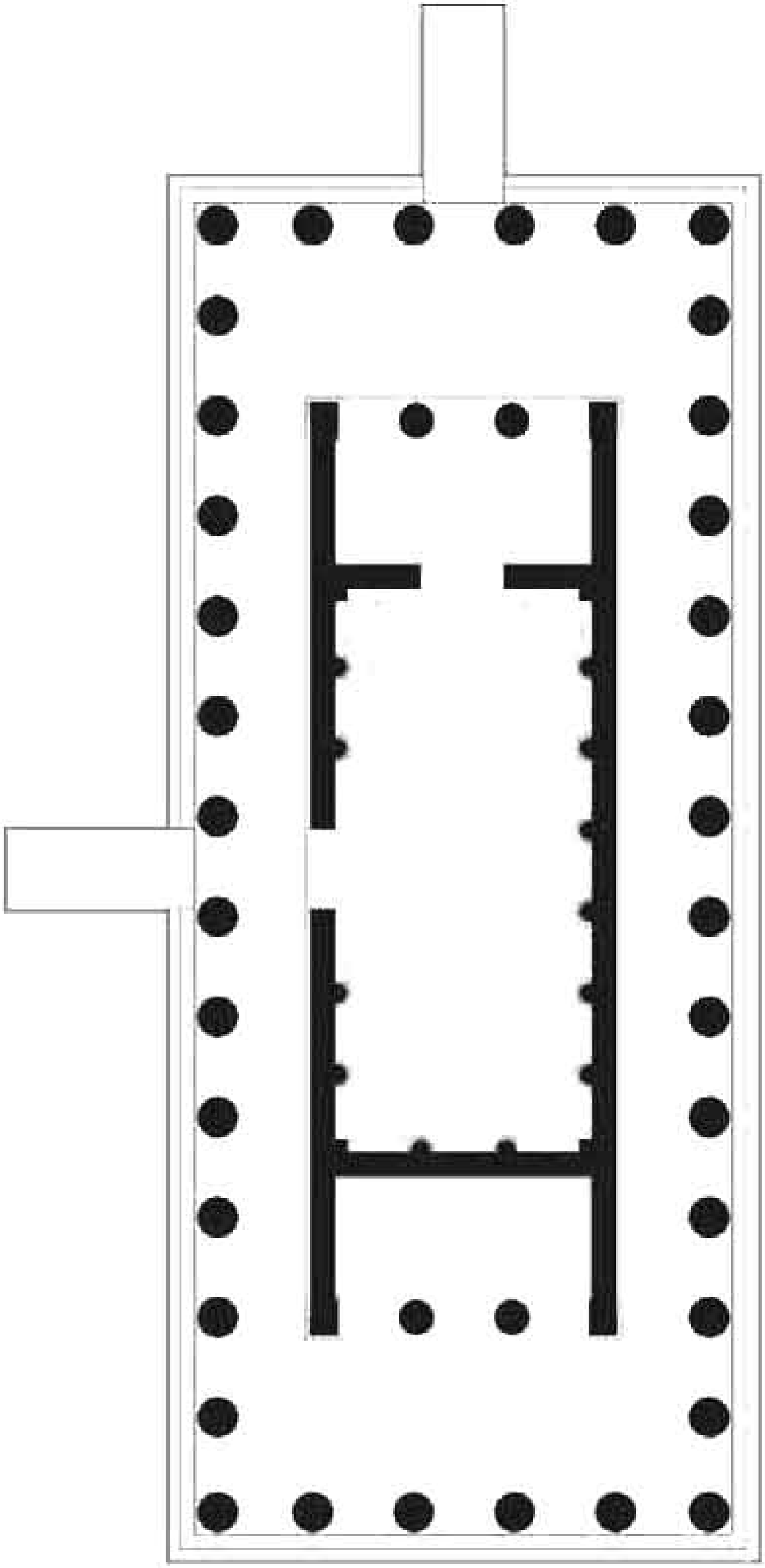

Fig. 3. Ground plan of the temple of Athena Alea. Scale 1:250.

II. Column Drums

Scattered around the temple and lifted back on to the foundations[1] there are 49 column drums which preserve the important dimensions, the full height and both the lower and upper diameters.[2] Clemmensen gives a list of 47 drums, but some are only fragmentary. It has been possible to identify with certainty all but two of these in the sanctuary on the basis of the published measurements and Dugas' and Clemmensen's systematic numbering of the drums.[3]

None of the drums are *in situ*, and only those recently excavated are certainly in the position where they were originally found during the excavations.[4] When Mendel and Rhomaios exposed the foundations of the temple, they excavated to a level ca. 1.5–2.0 m below the Classical earth level marked by the

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1 For the lifting of the drums, see n. 45 on p. 25.

2 There are two exceptions (blocks 48 and 93), but they are the lowest drums of the column shaft, so even though their lower diameter cannot be measured they can be regarded as complete in the sense of preserving their most important dimensions. The peristyle consisted of 36 columns of 6 drums each, so at the site there were originally 216 drums belonging to the exterior order. Since all the 49 drums are from the peristyle (see pp. 27–28), 23% of the original material is well or quite well preserved. In addition to these 49 drums there are 8 blocks at the site which have been listed as whole column drums in App. A (pp. A9–42), but have at least one missing critical dimension; these include two complete drums broken into two halves (blocks 16 and 17, 487 and 495) originally listed as separate drums.

3 Dugas *et al.* 1924, app. II 131–133. On the identification of the blocks, see pp. 20–22.

4 Østby *et al.* 1994, 115. Mendel reported that he had found column drums as part of the foundations of the Byzantine structure to the east of the temple; see Mendel 1901, 244–245.

euthynteria blocks *in situ* on the southern flank of the temple.[5]

The most important information on column drums—measurements, drawings, and some photographs—gathered during the 1993, 1994, 1995, and 1998 seasons is given in Appendix A, which comprises four sections. In the first part, two tables, A1 and A2, list all the diameter and height measurements taken from the 49 well-preserved drums; Table A3 gives the averages and margins[6] of the new measurements, Clemmensen's measurements, and the differences between the two. Listed separately are the cases where the difference is larger than the error margin established on the basis of new measurements (p. A8). The number of blocks in the tables is 53 because it also includes four partially preserved drums whose measurements were taken by Clemmensen.[7] The second part of Appendix A is a catalogue of the column drums and drum fragments found at the site: a short description of the block, its most important measurements, and its coordinates are given, and for well-preserved drums a photograph is also included in order to better illustrate the present state of the block and to facilitate identification of the drum. In addition to the 135 drums and fragments of the exterior order column shaft there are at the site three well-preserved drums and two fragments of the pronaos and opisthodomos column shafts, one cella half-column fragment and one fragment of a small Doric column whose origin is unknown. These are listed in the catalogue for completeness, and to avoid mixing the preserved porch drums and fragments with the exterior order drums.[8] The third part of Appendix A presents the schematic drawings of the bottom and top surfaces of the drums with the empolion cutting and dowel holes.[9] These drawings were used to investigate whether the drums which fit together on the basis of measurements could actually have been a pair. Since they give the direction and flute numbering of the drums, they can be used with the catalogue as a key to where the individual drum measurements given in Tables A1 and A2 were taken.[10] The final part of Appendix A is a list of possible drum pairs: it has been established on the basis of measurements, but also coded in the list is the information gathered by checking the schematic drawings of empolion and dowel holes of the two drum faces.[11]

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[5] Dugas *et al.* 1924, pls. 6–8.

[6] The margins have been determined by combining the following factors: range and number of measurements, the present state of the drum, method of measurement (if it was not possible to use the callipers, usual foldable measure was used), and Clemmensen's measurements.

[7] App. A, pp. A2–8.

[8] App. A, pp. A9–42.

[9] At Tegea the dowels were of iron with molten lead around them. On the use of empolions and dowels to fasten column drums together, see Martin 1965, 291–296 and Orlandos 1968, 112–115. For dowels still in their original position, see p. 24 and Dugas *et al.* 1924, 55 n. 2.

[10] App. A, pp. A43–59.

[11] App. A, pp. A60–61.

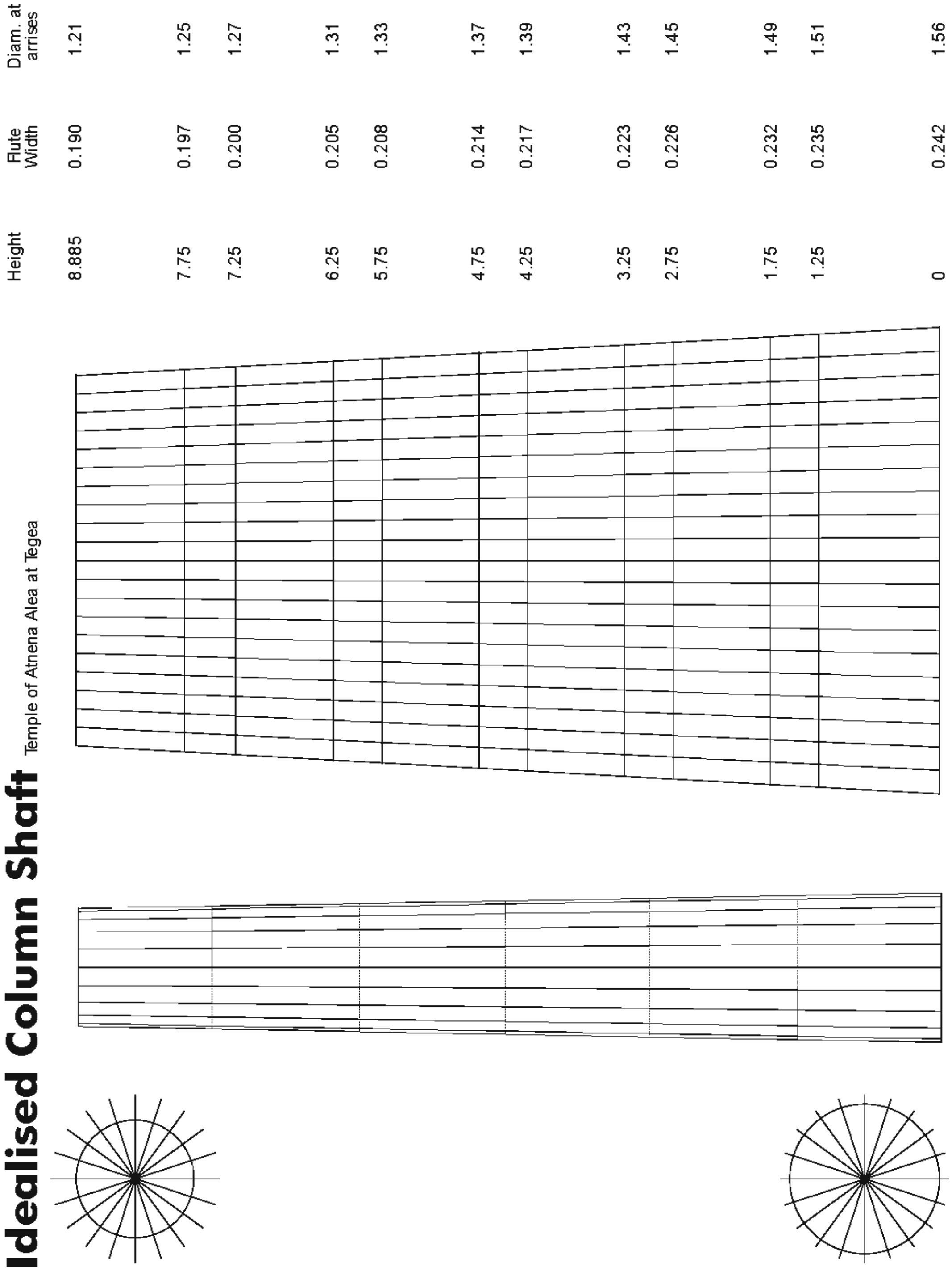

Fig. 4. Idealised column shaft of the exterior column of the temple of Athena Alea at Tegea. Entasis ignored.

1. Documentation

Before beginning the actual documentation of the column drums at Tegea, one publication proved most useful for the preparation: F. A. Cooper and C. Smith's contribution 'The Reconstruction Project: 1980–1983' in the exhibition guide *Temple of Zeus at Nemea. Perspectives and Prospects*. The exhibition was held in 1983 at the Benaki Museum, Athens. Cooper and Smith describe the documentation of the column drums at Nemea at length.[12]

A. Zone Sheets

At Nemea one of the peristyle columns is still standing, and the reconstruction research group had used this to draw an idealised image of the elevation, omitting the entasis, at a scale of 1:25. This had then been divided into eleven overlapping zones to provide space for the individual column drum drawings: the overlap ensured that each of the drums fitted completely in one of the zones. Eleven different zone sheets were drawn showing bottom and top surfaces, and a rolled-out side view of a drum.[13]

At Tegea I began by using the same method. As Dugas and Clemmensen had shown, all the columns comprised six drums and had twenty flutes.[14] Initially the idealised column was drawn without entasis using the published measurements for column diameter and shaft height,[15] and divided into six overlapping parts (Fig. 4), but the result was not entirely satisfactory. Comparison with Clemmensen's measurements raised some doubts as to how well the middle drums would fit into the idealised scheme: for example, Clemmensen's drum number 78 should fit in the fourth zone, but its diameter between the arrises, 1.403 m,[16] is larger than the 1.39 m provided by the scheme. Therefore, the entasis of the column had to be introduced as far as possible into the zone sheets.

Taking the drum measurements as a starting point the shaft was again divided into six parts, but instead of straight shaft profile, the entasis was approximated by line segments: between the bottom and the top of the shaft the dimensions were calculated as averages of the drum measurements (Table 1).

To provide the overlap needed in the zone sheets, two of these points were taken at a time: For the first zone sheet the values at the height levels 0 and 1.470 m were taken and these were then extrapolated as a straight line up to 1.75 m for the overlap. The second zone sheet dimensions were calculated from the values at the levels 1.470 and 2.946 m, and extrapolated down to 1.25 m and up to 3.25 m.

[12] Cooper—Smith 1983, 42–64.
[13] Cooper—Smith 1983, 56–59.
[14] Dugas *et al.* 1924, 18 and 131–133.
[15] Dugas *et al.* 1924, pls. 21–26, 34, and 35.
[16] Dugas *et al.* 1924, 132.

Therefore, the column shaft consists essentially of overlapping line segments which are not parallel to each other: the angle between the first line segment and the vertical is slightly smaller than the angle between the second segment and the vertical. The next four zone sheets were drawn using the same method for heights 2.75–4.75 m, 4.25–6.25 m, 5.75–7.75 m, and 7.25–8.885 m. In Table 2 the dimensions derived in this way are given, and in parentheses the measurements obtained from the idealised column elevation where entasis is ignored. The differences close to the bottom and the top of the shaft are very small, but in the middle where the swelling was the greatest, the differences exceed 2 cm and justify the additional work necessary before drawing the zone sheets. Figure 5 shows an example of a zone sheet with the bottom and top surfaces of the drum, and the rolled-out circumference. It is drawn at a scale of 1:25. The dimensions above and below the side view of the drum give the height, the flute width, and the two diameters of the column shaft.

Table 1. Average measurements of the column drums (m).

Height	Diameter at the bottom of the flutes	Diameter at the arrises	Flute width
8.885	1.158	1.209	0.190
7.444	1.213	1.278	0.202
5.965	1.272	1.338	0.212
4.444	1.330	1.400	0.220
2.946	1.377	1.455	0.229
1.470	1.420	1.506	0.238
0.000	1.456	1.555	0.242

Table 2. Extrapolated values used to draw zone sheets. Values of the idealised column without entasis in parentheses (m).

Height	Diameter at the bottom of the flutes	Diameter at the arrises	Flute width
8.885	1.158 (1.158)	1.209 (1.209)	0.190 (0.190)
7.75	1.201 (1.196)	1.263 (1.253)	0.199 (0.197)
7.25	1.221 (1.213)	1.286 (1.273)	0.203 (0.200)
6.25	1.261 (1.246)	1.326 (1.312)	0.210 (0.205)
5.75	1.280 (1.263)	1.347 (1.331)	0.213 (0.208)
4.75	1.318 (1.297)	1.388 (1.370)	0.218 (0.214)
4.25	1.336 (1.313)	1.407 (1.389)	0.221 (0.217)
3.25	1.367 (1.347)	1.444 (1.428)	0.227 (0.223)
2.75	1.383 (1.364)	1.462 (1.448)	0.230 (0.226)
1.75	1.411 (1.397)	1.496 (1.487)	0.236 (0.232)
1.25	1.425 (1.414)	1.513 (1.506)	0.239 (0.235)
0.00	1.456 (1.456)	1.555 (1.555)	0.242 (0.242)

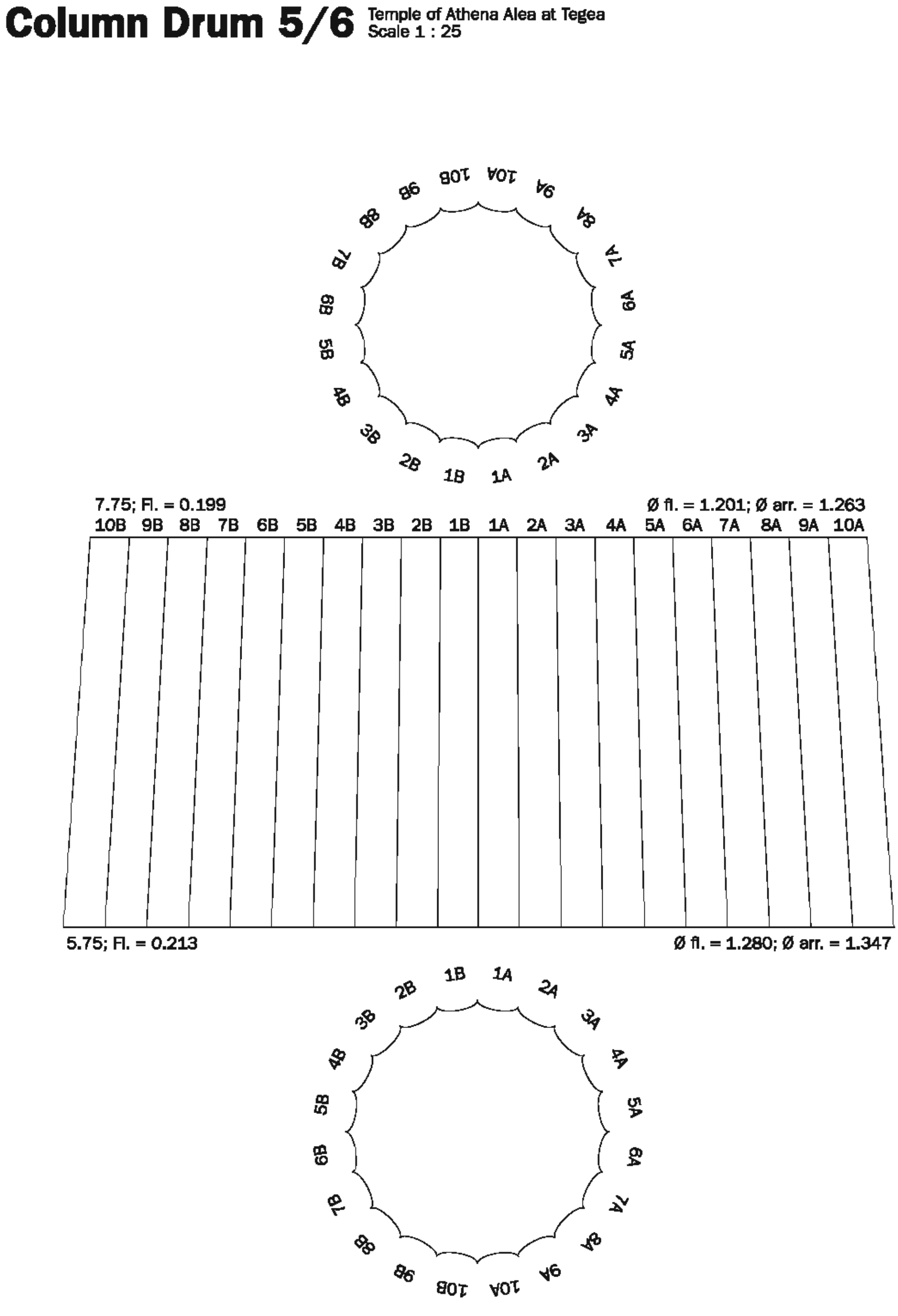

Fig. 5. Zone sheet for a column drum. Original size A4, no longer to scale.

Fig. 6. Measuring the diameter of block 3 with the large callipers.

B. The Method of Taking Measurements and Drawing

Before starting the actual documentation of the column drums in 1994, large callipers with three arms were made by a blacksmith in Tripolis, Arcadia: the length of the main arm is 1.7 m, and the two shorter arms are 1.0 m. The lengths of the arms are freely adjustable and they can be tilted at any angle in order to fit closely to the tapering sides of the drums (Fig. 6).[17] Although slightly cumbersome, the callipers proved very accurate and useful. It was possible to obtain the dimensions more precisely than without the instrument, especially for the partially broken blocks.

The documentation was carried out in the same order as the blocks are listed in the preliminary catalogue of all the building blocks at the site. All column drums preserving full height and both lower and upper diameters were taken under closer study. Firstly, the lichen and moss that had gathered on the surfaces since the blocks were excavated was carefully cleaned from places where it was likely to hinder measurement taking or drawing. After cleaning, the diameter between the flutes was measured, and a large metal L-shaped square was used to determine whether the measured surface was the bottom or the top. For lower surfaces the side of the square is tight to the edge of the drum, and further along the distance between the side of the drum and the square increases. For upper surfaces

[17] In the design and manufacture process of the instrument I was greatly assisted by T. Pfauth.

the end of the square touches the side of the drum, and there is a gap at the edge of the drum between the square and the block. On the basis of the diameter measurement the appropriate zone sheet was selected. The best preserved arris or, in an ideal case, two opposite well-preserved arrises were chosen; the base line was then drawn across the surface, and the diameter between the arrises measured. The flutes were also named: The flute to the right of the best preserved arris was called 1A, the next 2A, and so on up to 10A. The flutes to the left were named 1B–10B. The originating arris was called 1A/1B, and the next to the right 1A/2A, and to the left 1B/2B, etc.[18] The names of the visible flutes were written on the block with a marker. Next, additional diameter and height, as well as flute width, measurements were taken and recorded on the zone sheet. The heights of individual column drums are measured along the outer edge: this is actually not the true height of the column drum, but the difference is very small.[19] The positions of the empolion cutting and the two dowel holes were first measured using the drawn base line. A co-ordinate system for the drum surface was established so that the origin was the 1A/1B arris and the base line the x axis. Points 'above' the base line got positive y co-ordinates and 'below' negative.[20] The corner points of the holes were plotted on the sheet and the schematic picture of the drum face completed. The orientation of the block was also recorded on the zone sheet. An example of a finished zone sheet, that for block 454, is presented in Figure 7a.

Since completing the initial study of the drums, it has twice been suggested to me that variation in column fluting could be used to find matching pairs. R. Anderson, in the unpublished study of the Stoa of Attalos at Athens, has used a method which he calls taking 'column fingerprints': it involves drawing the current state of every flute close to both the top and the bottom of the drum with a profile gate. Differences in flute sections (width, depth, and irregularities in the carving) can then be used to search for matching drums. In the spring of 1998, M. Korres suggested a slightly simpler method, only involving measurement of the flute widths of the drums with a special instrument. Such an instrument has been used in the restoration project of the Parthenon and it also allows the broken flutes to be measured accurately.[21] The author has adapted this instrument to suit the fluting of the Tegea temple, and it was used to measure the flute widths in the summer of 1998 (Fig. 7b).

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[18] See Fig. 5 for the zone sheet.

[19] E.g. the measured height of block number 454 is 1.367–1.369 m, lower diameter between the flutes 1.265–1.270 m, and the upper 1.211–1.213 m. If the averages are used to calculate the true height, we get $\sqrt{1.368^2 - [(1.268 - 1.212)/2]^2} \approx 1.368$ m. In this case there is no difference at all. On the effect of the difference on the whole column height see pp. 50–51.

[20] E.g. the co-ordinates for the empolion cutting corners of the block 454 bottom surface are (60,2), (69,6), (64,-8), and (74,-4). See Fig. 7 for the zone sheet of the drum.

[21] Cf. Korres *et al.* 1989, 20, 59 n. 24 and Fig. 3.

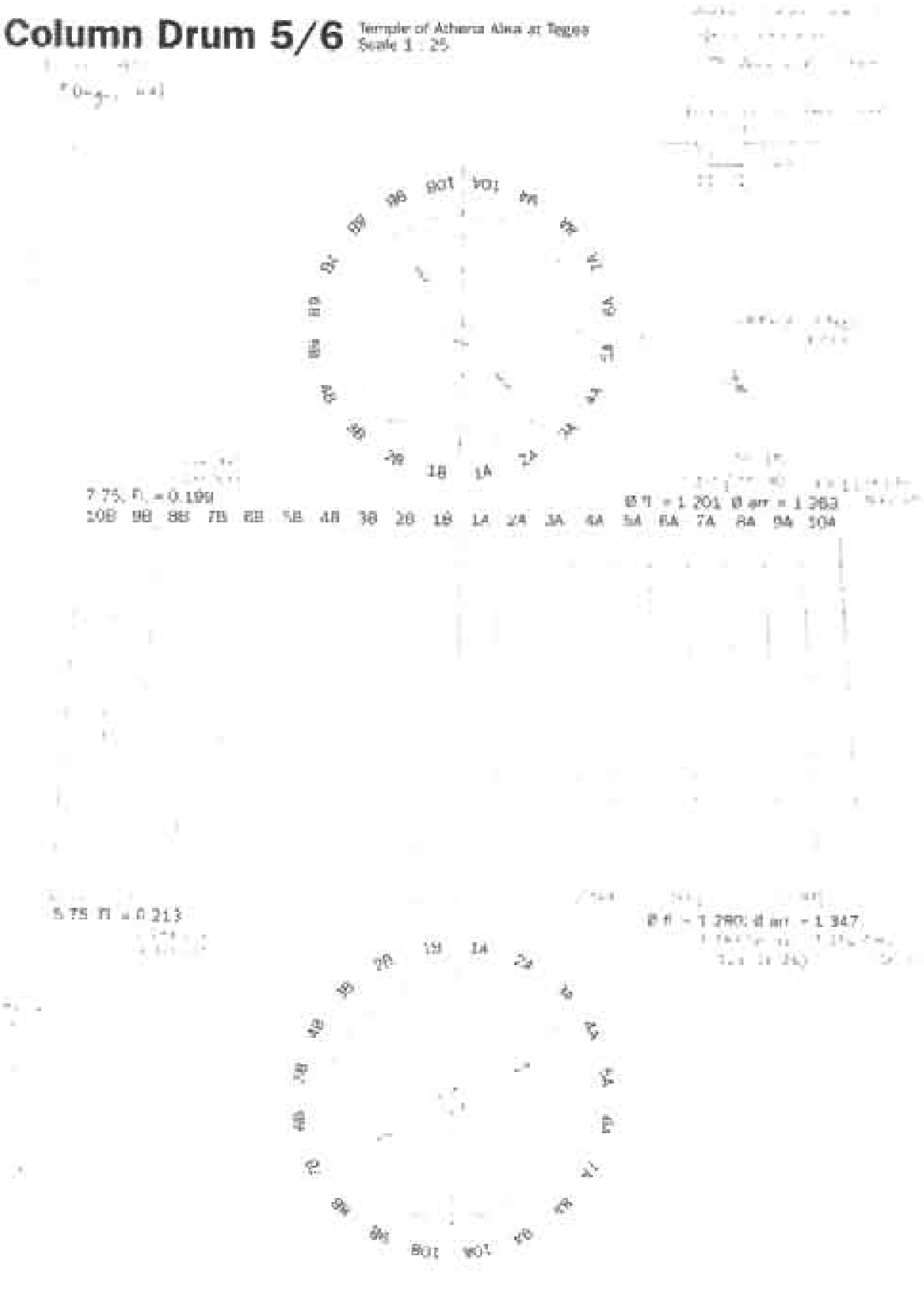

Fig. 7a. The zone sheet for block 454. Scale not the same as in the original.

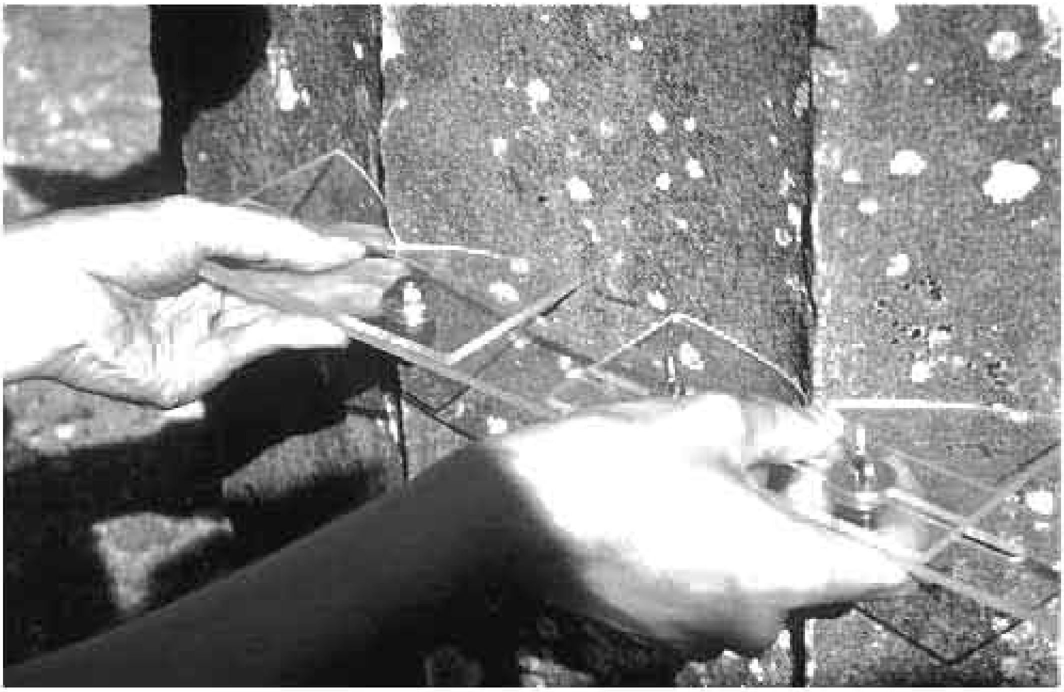

Fig. 7b. Measuring the flute width of block 9 with a special instrument.

2. Identifying the Drums Numbered by Dugas and Clemmensen

The documentation confirmed that each column was made of six drums. Dugas and Clemmensen named the drum levels alphabetically from *A* to *F*, the lowest being *A*;[22] the convention is followed in this study. All *C*, *D*, *E*, and *F* drums have a unique height, so identifying them on the basis of Clemmensen's published measurements was very easy. The problematic drums were those from *A* and *B* levels whose height is almost constant, and the partially preserved drums recorded by Clemmensen—the latter because a large number of fragmentary drums had been omitted in the initial study as of secondary importance.

In order to determine whether it was possible to discover Clemmensen and Dugas' pattern for numbering the blocks, all the identified drums were plotted on a site plan. The pattern of numbering became evident: it started from the east ramp and continued clockwise over the foundations; the next blocks are in the area to the east of the foundations, and from there on the numbering of the drums continues clockwise around the foundations and concludes with the drums in the north-east corner of the site.

The *A* and *B* drums were then added to the plan; the missing fragmentary

[22] Dugas *et al.* 1924, 131–133.

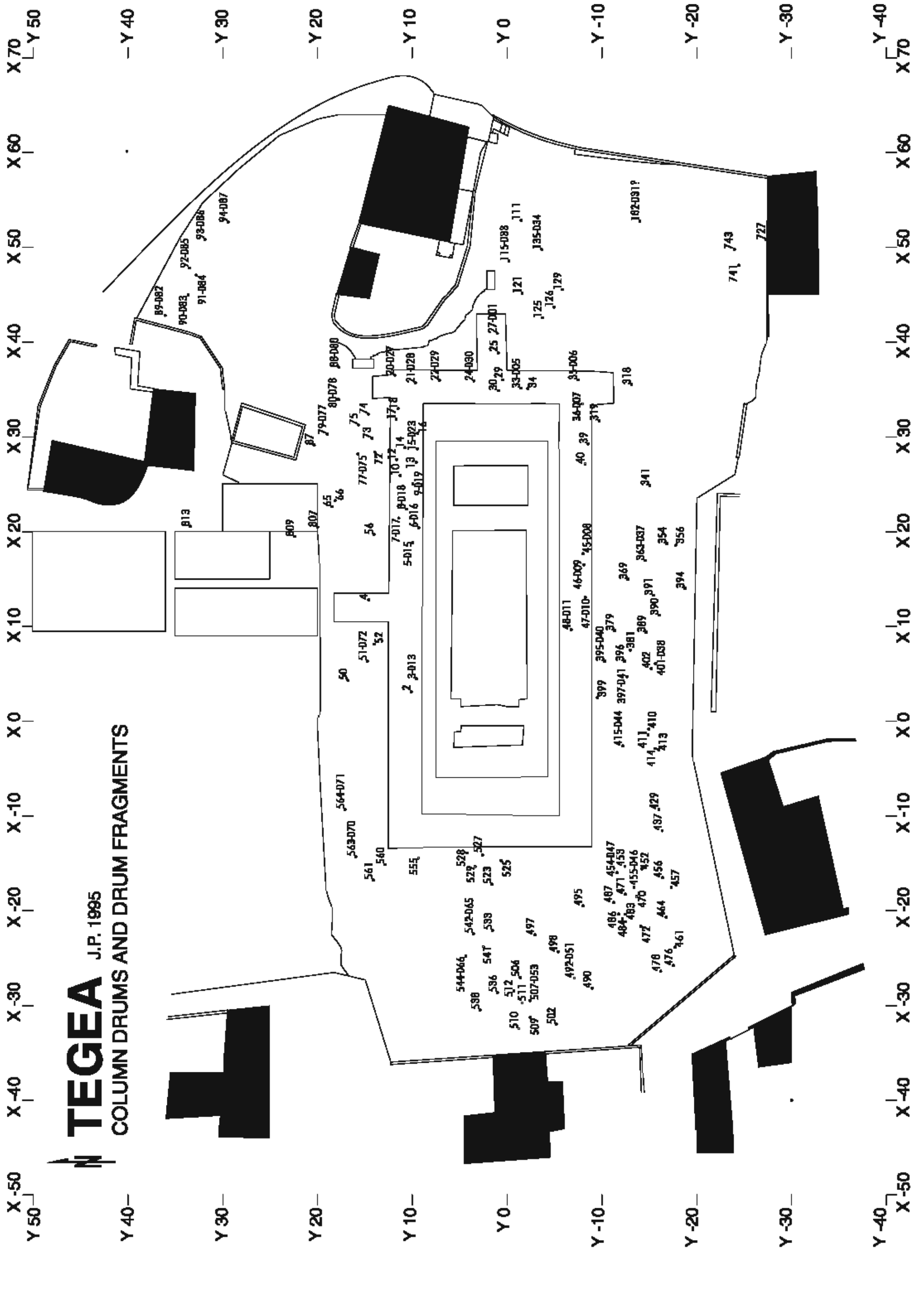

Fig. 8. Plan of column drums and drum fragments with block numbers. Dugas and Clemmensen's numbers marked with prefix D.

drums were sought in the appropriate regions of the sanctuary and identified by taking preliminary measurements. These drums also were later documented on the appropriate zone sheets. Only for Clemmensen's drum number 49—a *C* drum—was it impossible to find a match in the region south-west of the temple where, according to its number, it should have been. Drum 31 is most probably block 182.[23] Figure 8 presents a plan showing the location of all the drums and drum fragments; the column drums identified with Clemmensen's drums are labelled with both the block number and Clemmensen's number prefixed by D.

With the identification of the blocks numbered previously it became possible to compare the new measurements with those taken by Clemmensen. His measurements were discovered to be generally accurate: they usually fall within the error margins established by the new measurements.[24] Furthermore, for the drums which are currently impossible to measure, it became possible to substitute Clemmensen's values for the missing dimensions.

Clemmensen's list of drums does not include all the well-preserved drums at the site: blocks 497, 498, 506, 529, 533, 561, and 809 are missing. Only one of these, block 809, has been discovered during the new excavations, the others are to the west of the temple in an area excavated before Dugas and Clemmensen.[25] It is certain that Clemmensen numbered these drums also, since, in this region, his numbering is from 46 to 70, and only seven of these have been identified (Fig. 8).[26] No secure reason for the omission of complete drums from Clemmensen's list can be given at present.[27]

3. Drum Features

As mentioned previously, the height of the drums in the first two levels (*A* and *B*) is almost constant, but from third to sixth level (from *C* to *F*) there is considerable variation. Taking the error margins of the measurements into consideration, the drum heights are as follows: level *A*, 1.46–1.48 m; level *B*, 1.46–1.49 m. Level *C*, 1.32–1.67 m; level *D*, 1.41-1.71 m; level *E*, 1.34–1.66 m; level *F*, 1.32–1.64 m.[28]

The measured lower diameters of the bottom drums between the centres of opposite flutes vary between 1.453 and 1.460 m,[29] and the maximum measured

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[23] On the block, see p. 26 and App. A, pp. A8, A26–27.

[24] See App. A, Tables A1–A3 and p. A8. Eight blocks were rechecked after the initial identification and in three cases the discrepancies were explained by errors in the new measurements.

[25] Dugas *et al.* 1924, X–XI, pls. 1–2.

[26] In the region there are 44 complete drums and fragments (blocks 452–563 in Fig. 8); 19 of these were left unnumbered by Clemmensen, probably because of their small size.

[27] There are two possible reasons: there was insufficient time to measure all the blocks, or perhaps it was thought that those already measured were adequate for reconstructing the colonnade.

[28] App. A, Table A3.

[29] With the error margins the range is 1.449–1.462 m.

diameter between the arrises is 1.535 m (block 8), but the arrises are not intact. From the two cases where the upper diameter between the arrises can be measured fairly accurately, it is possible to calculate the lower diameter of the bottom drums as ca. 1.54 m.[30] Since the arrises are not perfectly preserved, a slightly larger dimension of ca. 1.55 m should perhaps be preferred.[31] The best preserved flute widths at the bottom of the drums are 0.240–0.242 m (the value calculated from the diameter is 0.242 m). Dugas and Clemmensen's observation that on the bottom drums the arris is not sharp but has a 3 mm wide flat fillet[32] could not be verified, because none of the bottom drums have sufficiently well-preserved arrises.

The upper diameter of the column shaft between the flutes can be measured on five top drums, and the corresponding diameter could also be measured for three capitals. The measurement range for the drums is 1.151–1.158 m, and for the capitals 1.148–1.160 m.[33] Block 544, a column drum, has a pair of opposite arrises intact, and the upper diameter is 1.209 m. For the three capitals the measurement range is 1.196–1.209 m. Clemmensen measured the capital block 562 to have a variation of 1.209–1.213 m in the diameter between the arrises (Fig. 14 on p. 37). Thus, the established measurement range for the upper diameter of the column shaft between the arrises is quite large, 1.196–1.213 m. The best preserved flute widths vary between 0.189–0.193 m on the drums and between 0.188–0.191 m on the capitals (the theoretical range calculated from the diameters is 0.187–0.190 m). The flutes at the top of the shaft are proportionally shallower than those at the bottom.[34]

The quality of the workmanship of the drum fluting is remarkable: very often the greatest differences in the width of the flutes is not more than 2 mm between the narrowest and widest flute.[35] The largest measured flute width variation in a single block is 3 mm.[36]

It has been suggested by W.B. Dinsmoor, and more recently by H. Bankel, that the temple had enlarged corner columns.[37] It has not proved possible, however, to identify any trace of thickened angle columns in the drums,[38] and the

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[30] The lower diameter between the arrises is calculated by solving the following equation for x: x / $\mathrm{Diam}_{\mathrm{UA}}$ = $\mathrm{Diam}_{\mathrm{L}}$ / $\mathrm{Diam}_{\mathrm{U}}$. The blocks used in the calculation are 51 and 93—the lower diameter of block 93 is impossible to measure, so the average value of 1.457 m has been used.

[31] Dugas' and Clemmensen's suggestion for the lower diameter between the arrises is 1.555 m, but when the dimension is calculated from Clemmensen's measurements using the same equation as in n. 30 above, the result is ca. 1.545 m (drums 71 and 72, Dugas *et al.* 1924, 131).

[32] Dugas *et al.* 1924, 18, pls. 34 B and 37 C.

[33] For capital measurements, see App. B.

[34] See p. 73, Table 13, columns *C* and *D*.

[35] E.g. blocks 7 and 9 which are possible to measure all around the perimeter; see App. A, p. A11.

[36] In blocks 506, 542, 563, and 514 (the first three are column drums and the last one a capital); see App. A, pp. A35, A39–41, and App. B, p. B5.

[37] Dinsmoor 1950, 339 even gives the lower diameter of the corner column as ca. 1.575 m; Bankel 1984, 413 n. 3.

[38] Since the heights of the *A* and *B* drums are approximately the same, the diameter measurements of these drums can be used to identify any enlarged corner columns: the measurements of the

capital block 562 (Fig. 12) mentioned above verifies this: it is a corner capital[39] and the maximum diameter between the flutes, 1.160 m, is only 2 mm greater than the maximum value established on the basis of drum measurements.

The anathyrosis rim—the smooth contact band—on the drum surfaces is 0.10–0.17 m wide measured from the bottom of the flute. The drums were joined together by a wooden empolion at the centre and two iron dowels; the lowest drum and the stylobate block were similarly joined together, but the highest drum and the capital were connected with just an empolion. The sides of the square cuttings for empolia are ca. 0.10–0.12 m wide and they are ca. 0.10 m deep. The dowel holes measure ca. 0.02 × 0.08–0.10 m, and their depth is ca. 0.04–0.05 m. Block 9 still has one of its top surface dowels in place, but the drum is presently upside down; the dowel is visible nevertheless, due to a small rock tilting the drum slightly. Some of the drums have a stepped dowel hole profile: in all cases they are on the upper surface.[40]

A. The Lowest Drums

As Clemmensen had previously shown, the height of the bottom drums varies when measured on different sides of the drum: in the new measurements a gradual and consistent change was found, but in only two cases was it possible to take measurements almost completely around the drum. The following ranges of height measurements were recorded: block 47, 1.469–1.475 m; and block 48, 1.468–1.478 m. In three other cases it was possible to take measurements over approximately half of the drum: block 21, 1.464–1.473 m; block 51, 1.472–1.476 m; and block 564, 1.470–1.474 m.[41] Of the two remaining *A* drums, block 8 has the upper anathyrosis rim broken making the measurements unreliable, and for block 93 it was only possible to take measurements over four adjacent flutes. In each case the established ranges fit those established by Clemmensen, except in one significant case: Clemmensen's drum number 10 is reported to have a constant height of 1.471–1.473 m, but it is the same drum as block 47 which clearly shows rather more height variation (see above).

Dugas and Clemmensen suggested that the variation on opposite sides of a drum was introduced in order to incline the columns toward the interior of the

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seven *A* drums and eleven *B* drums show no enlargement (the values are smoothly distributed over the range of measurements, no single substantially greater dimension can be observed). The top diameters of the six *F* drums are similarly distributed.

[39] This is shown by two details on the block: firstly, the 9 cm wide band indicating the position of the architrave blocks at the edge of the abacus goes around the corner, and secondly, the two dowel holes are not parallel but perpendicular.

[40] Blocks 115, 454, 492, and 506: a shallow ledge 0.02–0.03 m long and 0.01–0.015 m deep is always closer to the empolion; otherwise the dimensions of the dowel holes are normal; see Fig. 7 (zone sheet of block 454) top right corner for a sketch of the dowel hole profile. I have not found any comparative material.

[41] App. A, Table A2.

building.[42] A closer study of block 48 presently positioned on the preserved part of the euthynteria on the southern flank of the building suggests a different purpose for the height variation of the bottom drums. There is a convex curve in the foundations of the building, so that if, as is reasonable to suppose,[43] the same curvature was used at stylobate level, the columns would have been standing on an approximately dome-shaped stylobate.[44] Since block 48 lies on an euthynteria slab ca. 2 m to the west of the centre of the southern flank, the slab should be almost level along the long side of the temple (the east-west direction) and slightly rising towards the cella wall. This hypothesis was verified with a levelling instrument. Next the top surface of the drum was checked: it was found to be level on both east-west and north-south axes.[45] When the height of the block was measured, the highest measurements were taken on the south-west to south side of the drum, and the lowest on the northern side of the block. Three flutes at the north-east could not be measured due to breakage of the drum. The height measurements agree with the results from the levelling instrument, and show that the euthynteria slab rises from the edge of the foundations toward the cella. But, more importantly, the height variation of the drum is only enough to cancel the curvature of the foundations, and since the curvature at the stylobate level was probably more or less the same as that of the foundation,[46] the columns must have been standing *vertical* instead of being inclined toward the centre.[47]

This conclusion is supported by the calculated angles of horizontal curvature and column drums. The greatest angles of foundation curvature are found in the corners of the temple: in the south-west corner the angle between the west end foundations and the horizontal is 0.6° and between the south flank and the horizontal 0.5°.[48] The calculated column drum angles range from 0.2° to 0.4°, thus supporting the hypothesis that the height variation of the bottom drums could not

[42] Dugas *et al.* 1924, 19.

[43] See n. 46 below.

[44] On horizontal curvature of the foundations, see pp. 42–43.

[45] It is probably no accident that the drum is placed like this; it was most probably raised on the euthynteria slab during Mendel's excavations and placed as it is. See e.g. Rhomaios 1909, pl. 5.1 where the block is already shown standing in its present position.

[46] If the curvature was to be less pronounced at the stylobate, there is no reason for the trouble of introducing curvature into the foundations, and if it was more pronounced, then the shafts would have inclined *outward*. This conclusion is also supported by the fact that the certainly identifiable blocks of the krepidoma have fairly constant height: first step, 0.340–0.347 m (9 blocks); second step, 0.358–0.366 m (15 blocks); stylobate, 0.375–0.380 m (10 blocks).

[47] On the general procedure of erecting columns and on how the refinements were executed, see Bundgaard 1957, 133–140 and especially Korres 1993b, text corresponding to figs. 27–28. Bundgaard's 'down to earth' approach can now be supplemented by Korres' proof for the use of surface plates to grind the drum surfaces to have a perfect match; see Korres 1993a, 107–109.

[48] These small angles cannot be measured directly; the given angles are calculated from theodolite measurements, see nn. 8 and 9 on p. 43.

have been used to incline the columns inward.[49]

B. The Top Drums

Height variation in the top drums was also documented, but in only a single case was it possible to take measurements almost completely around the circumference of the block: the measured range for block 22 is 1.318–1.323 m. Again, it is a drum reported by Clemmensen to have a constant height (drum 29, 1.322–1.324 m). Clemmensen's second *F* drum with constant height (number 31) is most probably block 182: the height difference of 98 mm between the new measurement and the published figure can then be explained by a printing error of 10 cm in the 1924 publication. In the new measurements the block was discovered to have a constant height of 1.477–1.479 m over 11 flutes. In addition, the two other blocks where it was possible to take measurements over part of the circumference gave the following results: block 542, 1.497–1.504 m (over seven flutes); and block 544, 1.480–1.487 m (over 10 flutes). The others are not presently accessible for verification of Clemmensen's measurements, but according to him they all—blocks 77 (Clemmensen number 75), 89 (82), and 507 (53)—have a height variation of 9 mm.

Dugas and Clemmensen gave a clear explanation for the varying height of the top drums: they were used to tilt back the inclination of the column shaft, so that the abacus top surface of the capitals would be horizontal.[50] But since it has been demonstrated above that the columns were standing vertical, another expla-

[49] For inward inclination the angles should be greater than the angles of horizontal curvature. The angle between the bottom of the drum and the horizontal is calculated as following: the bottom diameter is the hypotenuse (*h*) and the greatest difference in height measurements (*a*) is taken as the length of the opposite side of the triangle, and then a is solved from the equation sin a = *a* / *h*. E.g. the angle of block 47 is ca. 0.2° and of block 48 it is ca. 0.4°.

Geographically and chronologically similar cases do exist: vertical peristyle columns can also be found in the temple of Apollo at Bassai (end of 5th cent. BC; see Cooper 1996, 184) and the tholos at Epidauros (mid 4th cent. BC; see Pakkanen 1996b, 152f.). G. Roux (1961, 138 and 184) suggests that structurally the temple of Athena Alea and the tholos are so similar, that the same workers could have worked on the Tegea temple and the first phase of the tholos. Tegean workmen are actually recorded in the tholos building accounts (*IG* IV.1 103B lines 51–54; see also Burford 1969, 66). Cooper and Smith report inward inclination at Nemea (1983, 76), but this is not beyond doubt: a lower drum height variation of 0.013 m is given, and when the angle is calculated as above (bottom diameter 1.524 m from fig. 44) the result, 0.5°, is only slightly larger than at Tegea. The authors claim that they have taken into consideration the curve of the stylobate, but certainly their figure for the total inward tilt of the column, 0.081 m, has been calculated only from the height variation of the bottom drum, with the stylobate curvature being disregarded. Cooper has also written an article on some of the refinements found at Nemea, but does not discuss column inclination; see Cooper 1988. At Nemea there is also a standing peristyle column, and the original publication states that "The possibility of a designed inclination of the columns seems to be excluded." Hill 1966, 9.

[50] Dugas *et al.* 1924, 19 and pls. 21–26.

nation for the height difference must be sought. The only possible solution is that the top drums were adjusted in this way so that the abacus tops would *not* be horizontal: the curvature of the foundations and krepidoma was in this manner transferred into the entablature of the building.[51] The reason for block 182 having a fairly constant height is that it is most probably from the centre of the colonnade where very little or no adjustment is needed. The range of the angles calculated from the height variation is from 0.1° (block 182) to 0.4° (blocks 77, 89, and 507).

C. Are All the *E* and *F* Drums from the Peristyle?

The lower diameters of the pronaos and opisthodomos columns are not known, but an upper diameter can be measured from a pronaos capital (0.998 m between the flutes, 1.052 m between the arrises).[52] The taper of the column shaft was probably approximately the same as in the exterior column,[53] so that a rough estimate can be obtained by solving the following equations for x (lower diameter of the porch column between the flutes) and y (lower diameter of the porch column between the arrises):[54]

$$\frac{x}{\mathrm{Diam}_{L}} \approx \frac{\mathrm{Diam}_{U}\mathrm{Porch}}{\mathrm{Diam}_{U}} \text{ and } \frac{y}{\mathrm{Diam}_{LA}} \approx \frac{\mathrm{Diam}_{UA}\mathrm{Porch}}{\mathrm{Diam}_{UA}}.$$

The result is that x is ca. 1.25–1.27 m and y ca. 1.34–1.36 m.

The provenance of the *F* drums is clear: even though on the basis of their lower diameters between the flutes (1.20–1.22 m) they could be from the porch orders, they all have only the empolion cutting and no dowels connecting them to a capital. Therefore, they are all from the exterior order.

Determining the original position of the *E* drums is more difficult. According to their lower diameters between the flutes (1.26–1.28 m) they could well be the lowest drums of the porch columns, but because the columns had entasis, the provenance of the *E* drums can be resolved: due to curving shaft profile, the taper of the bottom porch columns is less than the taper of the exterior order *E* drums.[55] The tapers of the preserved *E* drums are fairly uniform (range 3.7–

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[51] There is ample evidence for horizontal curvature in the architrave and frieze; see pp. 42–47 and esp. Fig. 18 for exaggerated distortions of the west colonnade at Tegea.

[52] Dugas *et al.* 1924, pl. 57.

[53] E.g. at Nemea the proportions of the top and the bottom diameters between the arrises are approximately the same for the peristyle order (0.80) and the pronaos order (0.79), even though the pronaos columns are more slender (the height is 6.8 times the lower diameter) than the peristyle columns (the height is 6.3 times the lower diameter). For the values used in the calculations, see Hill 1966, 9 and 22.

[54] For abbreviations see p. iii. Diam_{L} = 1.453–1.460 m; Diam_{U} = 1.148–1.158 m; Diam_{LA} = ca. 1.55 m; Diam_{UA} = 1.196–1.213 m (for the values, see pp. 22–23).

[55] Cf. Korres *et al.* 1989, 15–16 and diagram 4.

4.1%)[56], and the taper of the *complete* porch shaft can be estimated as 3.1–3.5%.[57] The range also defines the taper of each drum in the unlikely situation that the porch columns did not have entasis. Therefore, it is virtually certain that the taper of the bottom porch drums was less than the range determined above. Since the preserved *E* drums have a taper of more than 3.5%, we may safely conclude that they all were originally placed in the peristyle columns.

This conclusion is also supported by the different depths of porch and peristyle fluting: for example, in block 527, an opisthodomos drum, the depth of the fluting is 34 mm, whereas in the exterior order, for a drum with the same flute width, the depth is only ca. 26–27 mm. The difference in the depth of the porch and exterior column fluting is actually large enough for visually distinguishing the two orders without measurements.

4. Arris Repairs

On two drums there are traces of ancient repairs of broken arrises: block 7 has a large rectangular cut on the south-east side, and the recently excavated block 809 has had two damaged arrises. Interestingly, one of the fixed arrises of the latter block still retains most of the marble repair pieces in place. Figure 9 shows the present state of the arris, and Figure 10 a reconstruction of the repair procedure: the broken part of the arris was cut into a rectangular shape probably with a ledge at each end.[58] Then three pieces of marble were made for the repair: two with a cutting at one end corresponding to the ledges in the rectangular cut. The left side of each of these two pieces is 3 mm longer than the right side, and the third, smaller, piece is shaped almost like a wedge (Fig. 10). The large pieces were inserted into the cutting, and the third was used to lock them into place. Finally, the repair pieces were cut down to the level of the fluting. Apparently no small dowels or lead were used to fasten the pieces together. The quality of workmanship is displayed by the fact that, even though the top part is now mostly missing, the two lower pieces remain tightly in their original places.

The second repair on block 809 and that on block 7 are larger repairs close to the end surfaces of the drums. The repair cutting on block 809 is mostly broken

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[56] Calculated using the formula 100% × ($Diam_L$ – $Diam_U$) / DrH and the data for *E* drums in Table A3.

[57] The height of the porch column is not certain, but the shortest suggestion is by Dugas and Clemmensen (8.176 m; Dugas *et al.* 1924, pls. 12–14) and the tallest by Norman (8.471 m; Norman 1984, 173). Taking into account the new peristyle column height of 9.544–9.580 m (see pp. 59–62), we get a height range of ca. 7.74–8.07 m for the porch shaft: 8.176 m + [9.544 m – 9.474 m] –0.509 m (capital height; Dugas *et al.* 1924, pl. 57) = 7.737 m and 8.471 m + [9.580 m – 9.474 m] = 8.068 m. The lower limit for the taper of the complete pronaos shaft can be calculated as 100% × (1.25 m – 0.998 m) / 8.068 m ≈ 3.12% and the upper as 100% × (1.27 m – 0.998 m) / 7.737 m ≈ 3.52% (for the pronaos shaft diameters, see p. 27).

[58] Only the top ledge is now visible, the lower only probable.

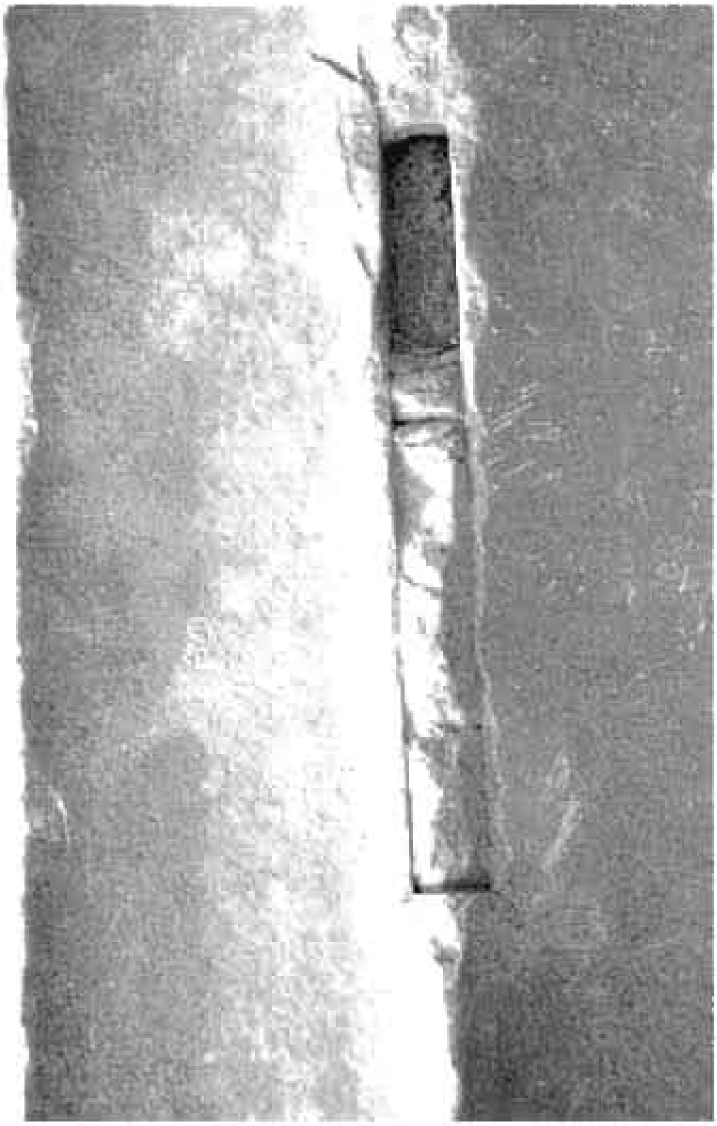

Fig. 9. Arris repair on block 809.

away with the edge of the bottom surface; the remaining part is 0.077 m wide and 0.067 m deep from the arris. The cutting on block 7 starts ca. 0.60 from the top of the drum, and has a width of 0.17 m and a depth of ca. 0.12 m from the arris. In this case the cutting itself tapers so that 0.28 m from the top surface it is only 0.145 m wide.[59] The rest of the repair cutting is broken.

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59 A tapering arris repair is recorded from the 6th cent. temple in the sanctuary of Athena Pronaia at Delphi: in this case the repair extends over two drums; see Demangel 1923, 21 and fig. 28. A triangular repair piece was used to mend the bottom of a flute in the temple of the Athenians on Delos, but there the widest part of the triangle is level with the bottom surface and the tip of the triangle is on the arris between the two flutes. The repair piece is held in place by a small clamp; see Vallois 1978, 507 n. 2 and Courby 1931, 198.

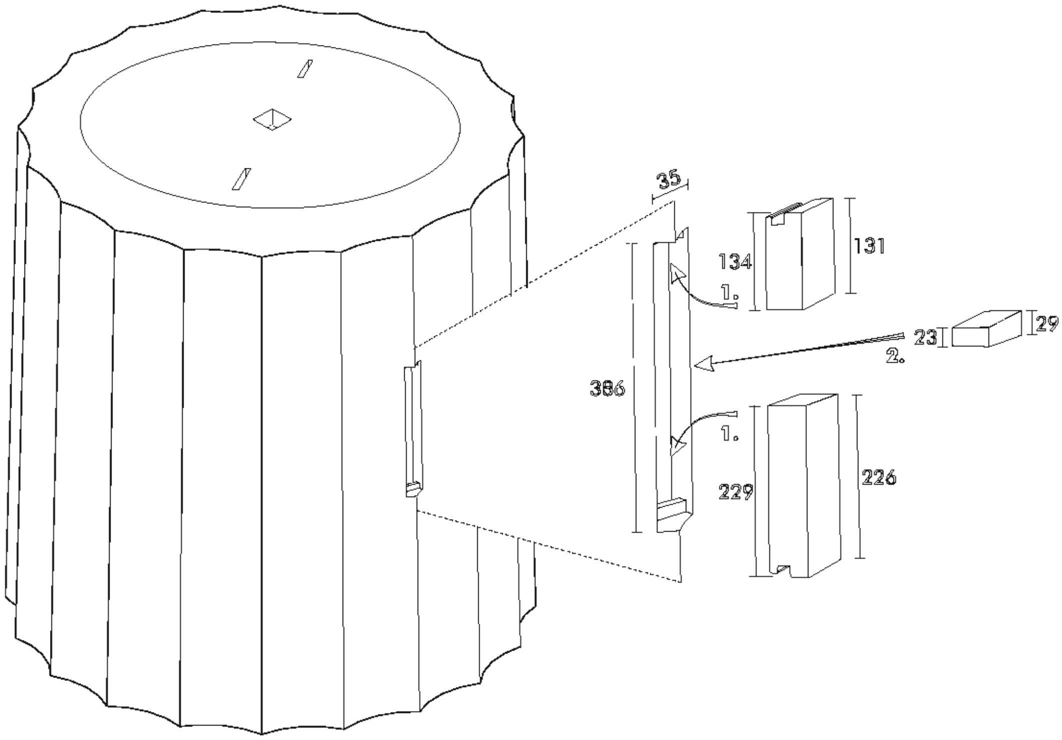

Fig. 10. Reconstruction of a largely preserved arris repair. Outer surfaces of the repair pieces hypothetical (finished when in place). Dimensions in millimetres.

III. Capitals

Ten capitals and seven fragments of the exterior order have been preserved in the sanctuary.[1] The locations of these blocks and the preserved pronaos capital are shown in Figure 11; descriptions, measurements, and co-ordinates of individual blocks are given in Appendix B.

The anathyrosis band of the bottom of the capital has a relieving edge, 3–4 mm high and recessed 20–31 mm from the flute (Fig. 12). The capital has four annulets, and the capital flutes meet the bottom ring. The profile of the capital follows the fourth-century trend: the sides of the echinus are almost straight and the groove marking the junction of the echinus and the abacus is not pronounced. In all cases where measurement was possible, the abacus face was found to be vertical, not inclined as shown in Clemmensen's drawing of the capital profile.[2] The top of the abacus has bands at the edges marking the position of the architrave blocks, and this, together with the information given by the dowel holes and pry marks, makes it easy to determine the orientation of the block (Figs. 13 and 14).

[1] The number is given as thirteen in Dugas *et al.* 1924, 20, but most probably some of the blocks listed here as fragments are included in that figure. One capital is located in the courtyard of a small chapel ca. 1 km south-east of the sanctuary (south of the main road from Alea to Stadio, ca. 500 m to the east of Alea). The abacus edges have been cut and the top hollowed to serve as a basin, but the flutes are still visible; their width of 0.19 m makes the identification of the block certain.

[2] Dugas *et al.* 1924, pl. 37.

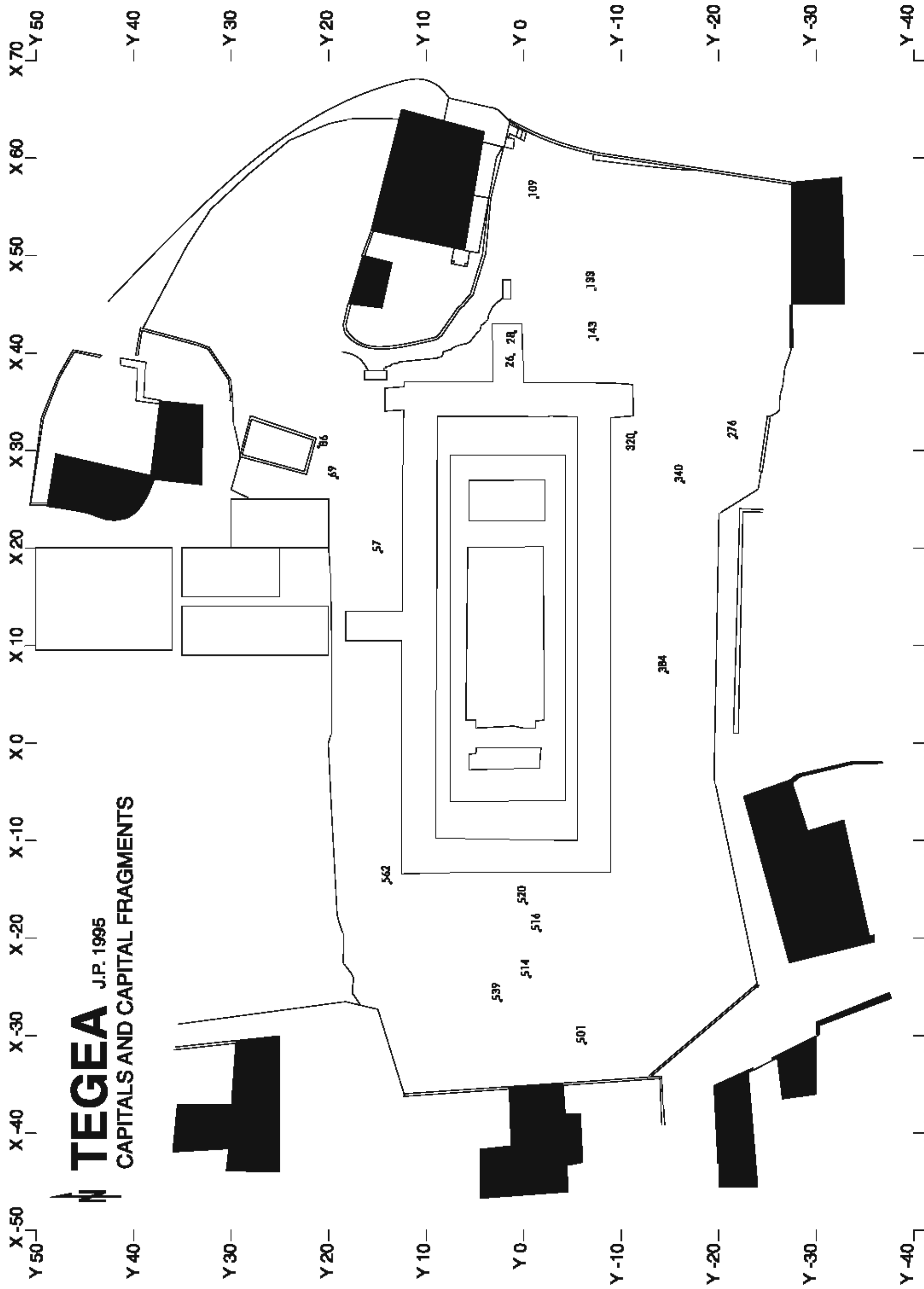

Fig. 11. Plan of capitals and capital fragments with block numbers.

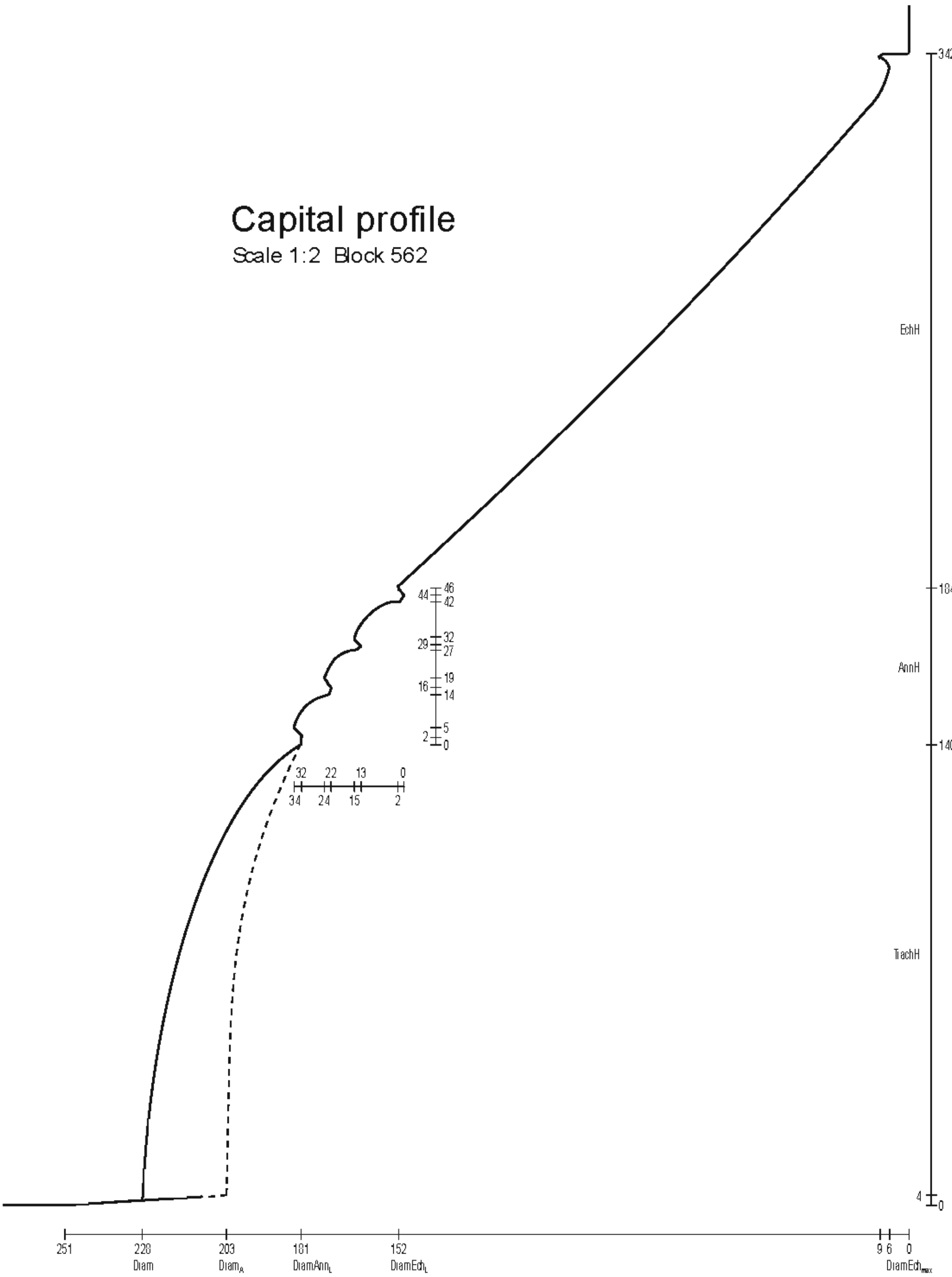

Fig. 12. Capital profile, block 562. Scale 1:2. Dimensions in millimetres.

Table 3. Capital measurements at Tegea.

	Average	No. of meas.	Range
Total height	0.596	10	0.588–0.609
Abacus height	0.246	6	0.243–0.251
Echinus height	0.161	8	0.158–0.167
Annulet height	0.047	8	0.044–0.050
Trachelion height[3]	0.138	8	0.136–0.140
Abacus width		3	1.609–1.610 × 1.615–1.616[4]
Maximum diameter of echinus	1.596	5	1.588–1.604
Lower diameter of echinus	1.304	5	1.288–1.313
Lower diameter of annulets	1.248	5	1.234–1.255
Diameter between the arrises	1.206	3	1.196–1.213
Diameter between the flutes	1.157	5	1.148–1.165
Flute width	0.189	47	0.187–0.191

Table 4. Capital proportions at Tegea.

Block number	*A.*	*B.*	*C.*	*D.*	*E.*	*F.*
28			0.414			
133		0.499	0.407	0.280	0.687	
276		0.492				
501	0.366	0.488	0.419	0.273	0.652	0.7509[5]
516			0.422	0.269	0.636	
520			0.417	0.274	0.657	
539	0.377		0.399	0.263	0.658	
562	0.365	0.486	0.420	0.268	0.637	0.7506

A. Capital height : abacus width
B. Capital height : diameter between the arrises
C. Abacus height : capital height
D. Echinus height : capital height
E. Echinus height : abacus height
F. Diameter between the arrises : abacus width

In Table 3 a summary of the measured dimensions is given: it was not possible to take all measurements on all of the capitals, so in addition to the range of measurements and their average, the number of measurements is given. The range of the total height measurements is quite large, 0.588–0.609 m. Likewise, all the individual elements of the capital have slight variation in their dimensions. But surprisingly, perhaps, the variation is not proportional: Table 4 presents some of the main proportions of the individual capitals, and, for example, the variation in column *C* shows that the capitals do not have proportionally equally high abaci. Another good example is block 133 which has a low abacus (column *C*) and a

[3] Includes the height of the relieving edge at the bottom of the capital; see e.g. Fig. 12.

[4] The three measurable abaci all have the same dimensions, but one of them is from the corner of the building (562), one has the longer abacus side outward (501), and one the short side outward (539). On determining the orientation of the capital, see also n. 39 on p. 24.

[5] The reason for the varying number of significant figures in the data of Tables 4 and 5 is due to the number of significant figures in the numerator and denominator of the proportion: e.g., in Table 4, columns *A–E* have three significant figures because at least one of the measurements used in the proportion calculation has three significant figures; column *F* has four significant figures because both the numerator and denominator have four significant figures.

Table 5. Capital proportions (from end of fifth to end of fourth century BC).

	A.	*B.*	*C.*	*D.*	*E.*	*F.*
Bassai, t. of Apollo (type A)	0.434	0.576	0.382	0.322	0.843	0.754
Bassai, t. of Apollo (type B)	0.453	0.593	0.382	0.322	0.843	0.763
Bassai, t. of Apollo (type C)	0.427	0.557	0.379	0.305	0.805	0.768
Argive Heraion, 2nd t. of Hera	0.41	0.55–56	0.40–42	0.30	0.72–74	0.74
Delphi, tholos	0.395	0.526	0.402	0.275	0.68	0.751
Epidauros, t. of Asklepios	0.375	0.502	0.401	0.273	0.68	0.747
Delphi, 4th cent. t. Apollo	0.380	0.524	0.43	0.24	0.56	0.7246
Delphi, 4th cent. t. Athena	0.374	0.499	0.395	0.262	0.66	0.7497
Epidauros, tholos	0.37	0.49–51	0.42	0.28	0.660	0.74–75
Tegea, t. of Athena Alea	0.365–77	0.486–99	0.399–422	0.263–80	0.636–87	0.7506–9
Megalopolis, Thersilion	0.367	0.48	0.42	0.26	0.63	0.76
Nemea, t. of Zeus	0.355	0.477	0.401	0.266	0.664	0.743
Stratos, t. of Zeus	0.371	0.505	0.400	0.269	0.673	0.735
Olympia, Metroon	0.388	0.53	0.406	0.278	0.69	0.73

A. Capital height : abacus width
B. Capital height : diameter between the arrises
C. Abacus height : capital height
D. Echinus height : capital height
E. Echinus height : abacus height
F. Diameter between the arrises : abacus width
For dimensions (and their sources) used to calculate the proportions in Table 5, see Appendix D.

high echinus (column *D*), thus creating an echinus–abacus proportion significantly larger than those of the other capitals (column *E*).

Visually the differences are insignificant: all the capital profiles can immediately be recognised as coming from the same building. However, when the proportions of capitals at Tegea are compared with the proportions of the fourth-century buildings listed in Table 5, especially on the basis of total height, abacus and echinus height proportions, the individual capitals at Tegea could be placed almost anywhere on the list. This shows not only that the variation in capital proportions at Tegea is significant, but also that no general trends can be seen in the 'development' of capital proportions during the fourth century. These observations should be compared with the conclusions reached by J. J. Coulton in his analysis on the proportions of Doric capitals: He suggests that proportional rules were used to design the capitals, and that when a change occurs it does so in discrete steps and not as a continuous evolution. The proportions of the fourth-century capitals were discovered to be coherent and distinct, thus implying that they were probably designed by application of the same set of rules. Evidently, the capital proportions cannot be used as evidence for dating a single capital *within* the group to which it belongs.[6]

In the light of the peristyle capitals at Tegea, Coulton's observation that the homogeneity of the fourth-century capitals is a result of the use of proportional

[6] Coulton 1979, 82–103.

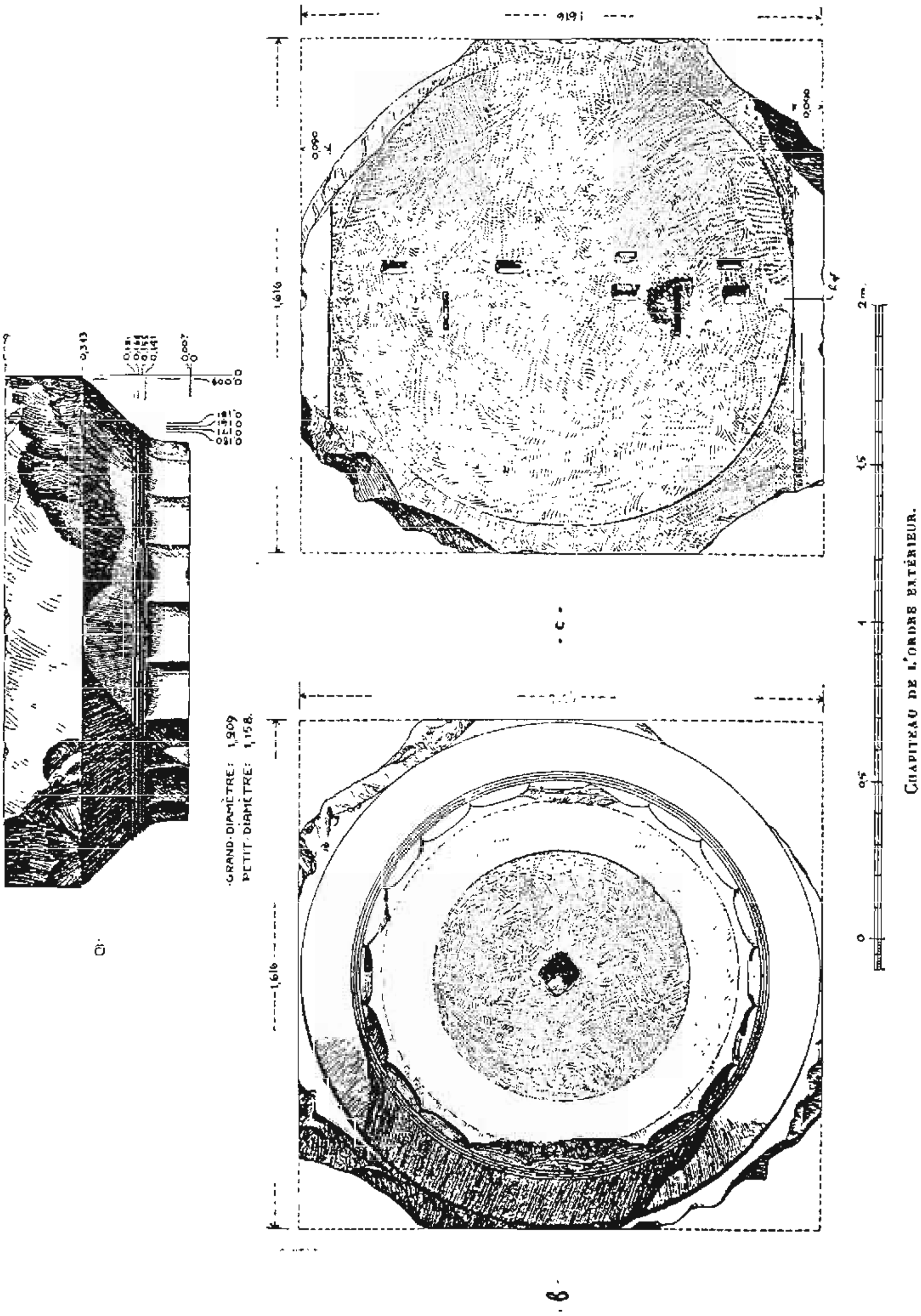

Fig. 13. Peristyle capital, block 501. (M. Clemmensen, Dugas *et al.* 1924, pl. 35.)

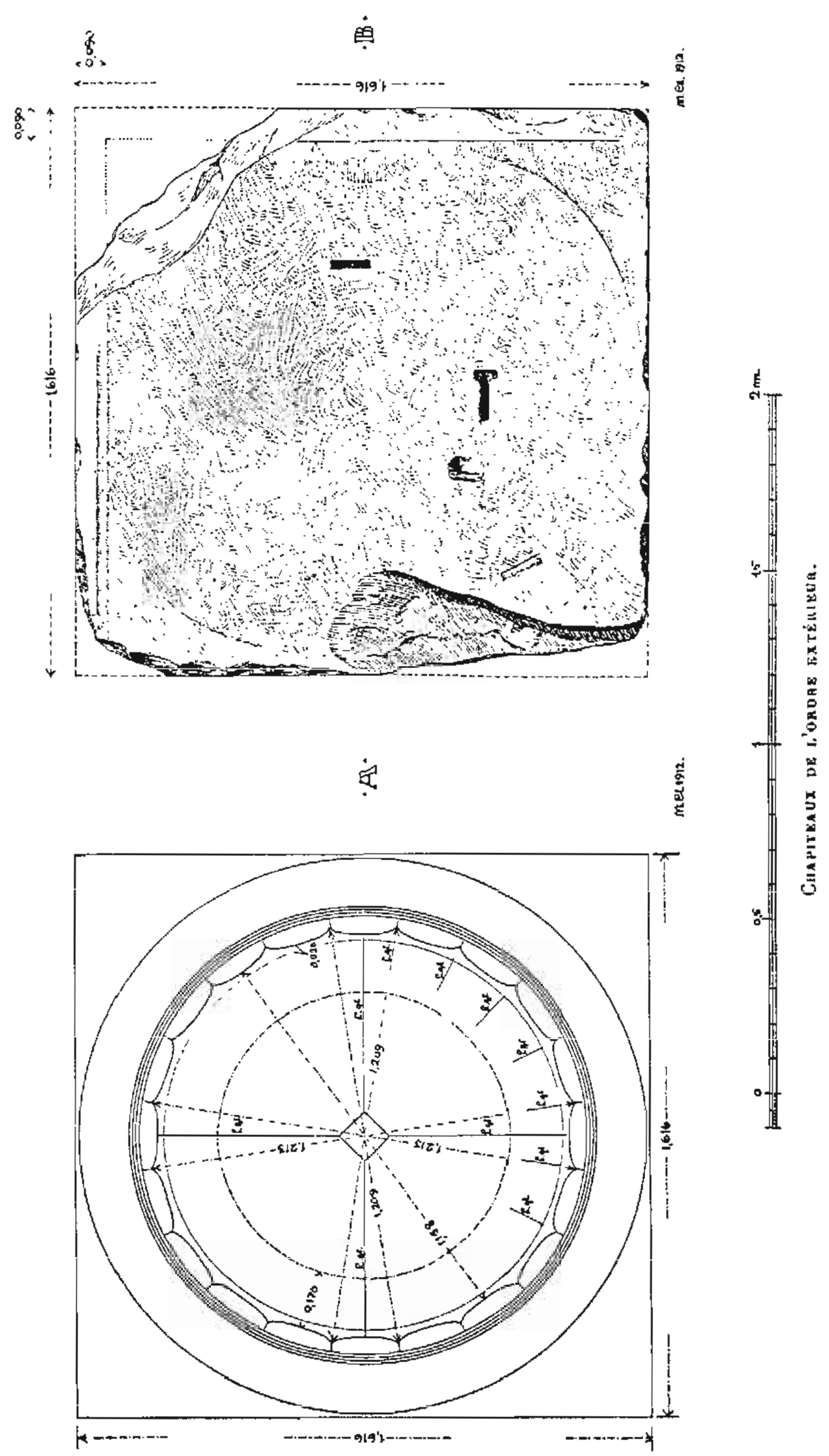

Fig. 14. Peristyle capital, block 562. (M. Clemmensen, Dugas *et al.* 1924, pl. 36.)