THE EVOLUTION OF THE IONIC CAPITALS FROM THE HELLENISTIC AGE TO THE ROMAN AGE. A STANDSTILL IN GEOMETRY?

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Some previous studies have pointed out how statistical analyses revealed the distinct group of Hellenistic capitals[1]. In the following we shall concentrate upon the Hellenistic cluster, while reviewing some relevant data on the results of an analysis regarding the evolution of the Ionic capital up to the emergence of the Vitruvian type, and further, during the Roman Age. To this end, we shall resort, on the one hand, to statistical analyses, for their relevance as regards the *external characteristics (variables)*, and on the other, we shall look into the geometric support of the Hellenistic and Roman composition – the *internal characteristics (variables)* – as it is the one that by concentrating in itself the conception upon the composition makes it irradiate to the exterior of the finite artistic work, being from beginning to end the inner generator of proportions (external variables) by which we usually characterize the finite architectural plastic body[2].

The new reference point of statistical analyses is the Vitruvian capital[3]. As that is a direct reflection of the Hellenistic influences[4], we have considered that its presence could be useful at least for two reasons: by relating to it, one can apprehend which was the "target" of the evolution of the Hellenistic capitals, in other words, which were the composition trends up to Vitruvius' age, and, implicitly, whether the trend that found in the Vitruvian capital a repository for its tradition was truly prevailing. Moreover, we'd like to use applied methods to look into the subsequent evolution – during the Roman Age – in the Ionic capital composition, and above all, what happened to the composition of the pattern conveyed by Vitruvius during the Roman time after him[5]. In other words, our interest was to see whether the Vitruvian pattern was a fortuitous reflection of the Hellenistic tradition[6] with no essential consequences – limited to a few particular cases – upon the designing of the Roman Ionic capital or, on the contrary, this pattern had further influences.

I. STATISTICAL ANALYSIS[7] (Figs.1-7)

&1. The *CA*[8] (*Correspondence Analysis*), the *NMDS (Nonmetric Multidimensional Scaling*) and the *Cluster Analysis* have been applied to seventy-four Hellenistic and Roman capitals[9], nine of which new

[1] Mărgineanu-Cârstoiu, 1990, p. 80, Fig.1; Mărgineanu-Cârstoiu, 1997, p. 204; 186-187, Figs. 4-5; p. 198, Fig. 198; p. 202, Figs. 21-22.

[2] Our interpretation of the geometric support ruling over the architectural composition was pointed out for the Doric capitals in Mărgineanu-Cârstoiu, 1994-1995, tackled more thoroughly in Mărgineanu-Cârstoiu, 1996-1998 for the Ionic capitals; the partial aspects detailed in the case of the Ionic capitals in Mărgineanu-Cârstoiu, A. Sebe, 2000, for a monument assemblage, see Mărgineanu-Cârstoiu 2000, p. 166-188.

[3] We do hope that the prevalence of the Eastern capitals in the present study has no upsetting effect over the results, as the Vitruvian design has undoubtedly an Eastern origin.

(P. Gros,*Vitruve. De Architectura, Commentaire Livre III*, 5,7, p. 166).

[4] P. Gros, *op.cit.*

[5] Partial aspects of the issue in Bingöl, 1980, p. 132-152.

[6] Even if it inherited some significant experiments, from the Mausoleum in Halicarnassus, Magnesia on Meandru, Stoa of Attalos, etc. (Hoepfner, 1968, *passim*; P. Gros, *op.cit.*, p. 157).

[7] As can be seen in Annex 2, the list of variables does not include those that – in our previous studies- comprised the lower surface diameter (H). This removal is not the result of a personal choice, but that of the fact that for many (Roman) capitals the diameter sizes were not available (according to Bingöl,1980). However, taking into account that as early as the Hellenistic time the share of variables shifted to the zone of those expressing the relation to the central body (A/L, J/L, K/L,I/L), it is expected that the results should not be seriously damaged. For equally objective reasons, as regards the Roman capitals we focused our attention on the Eastern ones (catalogue in Bingöl, 1980).

[8] Our having explained on other occasions the way applied procedures are handled spares us the task of doing it again (cf. Mărgineanu-Cârstoiu, 1990, Idem, 1997).

[9] A few other pre-Hellenistic capitals can be added, introduced by testing. For the same reasons, two Histria capitals were "doubled". (see Annex 1). As a test element the capital from Termessos was also introduced (no. 53) whose composition does not represent a real capital, but that of an incompletely preserved specimen.

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Histria capitals (supposed to belong to the Roman Age). As shown in Figs.1-2, the *CA and NMDS* analyses dispose most capitals without making up *clusters*, distributing them in a relatively even *cloud*. This distribution – except a few capitals whose composition remains under the influence of the Attic classicism (making up a totally distinct group as against the dense bulk of the "cloud"[10]), capitals no. 9 (Priene/London), a capital from Selinunt (no.19) and the capital of the Leonidaion from Olympia (no.16), having *"satellite"* positions to the *cloud* assemblage, as well as a few others that are to be tackled below – suggests that in the bulk of the capitals spectacular composition transformations could not have occurred. That is to say, instead of the elements of an *evolution* (meaning radical transformations) we are rather going to encounter small variations on the same theme or on very similar ones.

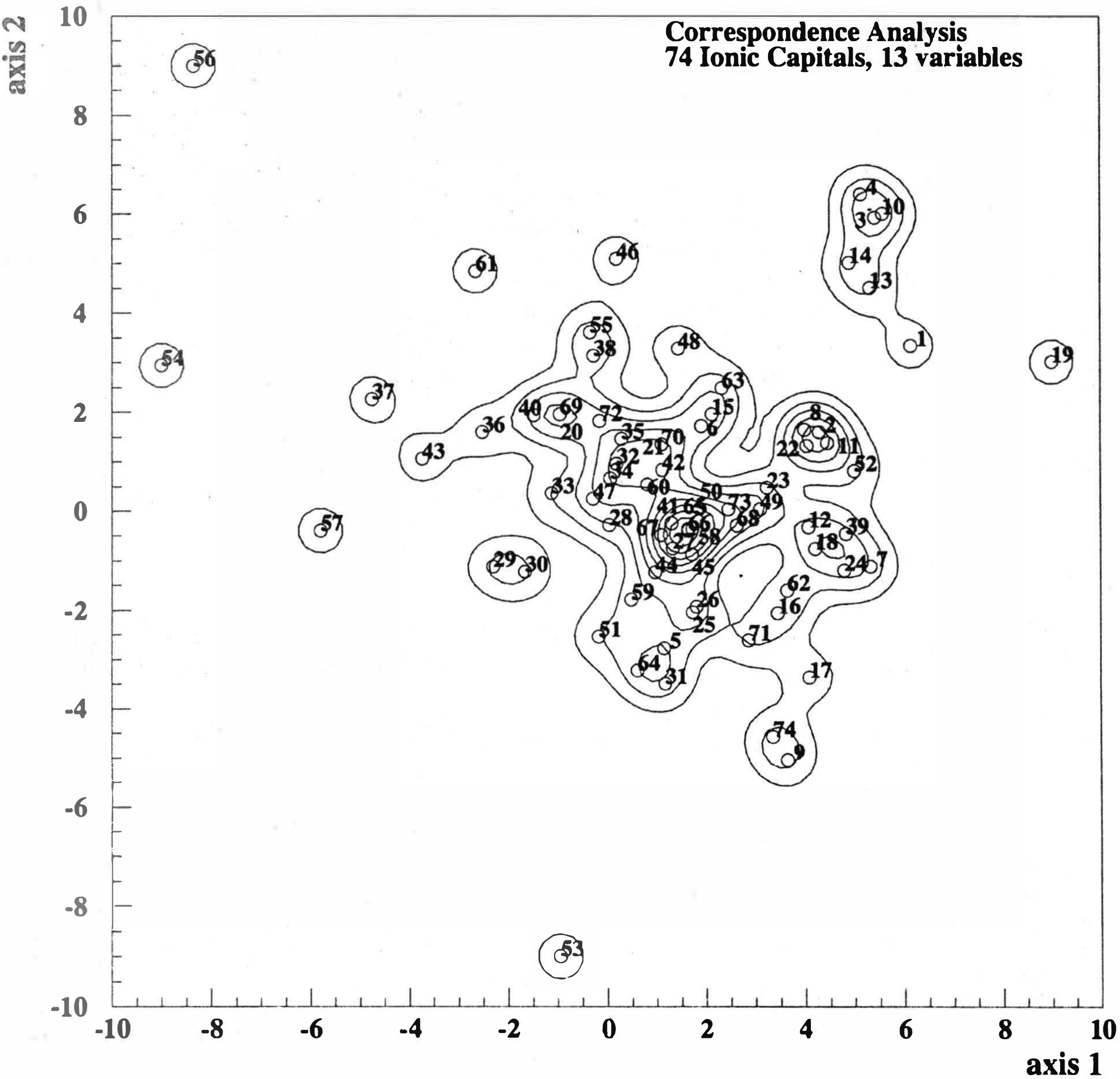

Fig. 1. The *Correspondence Analysis*, 74 capitals, 13 variables.

[10] Namely the specimens introduced as a stability test of the method. It is no surprise that they include the capitals from Sardes (no. 10), Aphrodision (Lesbos/Messa, no. 14), Artemision E (no. 1), Artemision (Kunst.Hist.Muz., Vienne, no. 1), and a capital from the beginning of the 4th century from Selinunt (no. 19), as well as the capital no. 13 (Samos, 4th c.) (according to Mărgineanu-Cârstoiu, Dacia, 1990, p. 98-99; Idem, 1997, p. 186-187, Figs. 4-5, p. 202, Figs. 21-22).

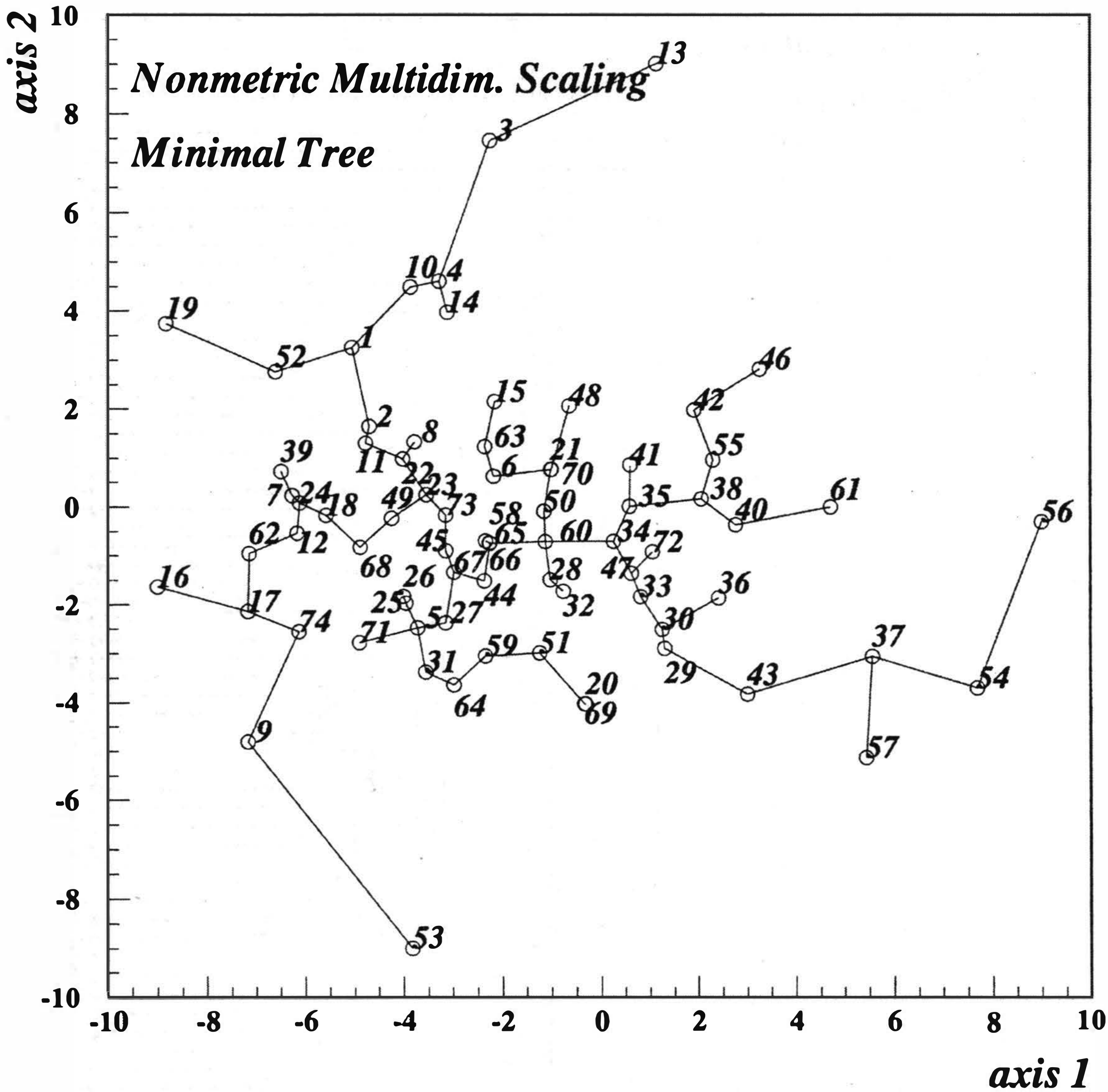

Fig. 2. The *NMDS/Minimal Tree,* 74 capitals, 13 variables.

Therefore, the first important result of the *CA* and *NMDS* resides in the very lack of *cluster*s in most capitals, and in almost the entire homogeneity of distribution: one can notice how the Hellenistic and the Roman capitals make up a common network in the general cloud. That means that the Roman specimens usually intermingle with those of the Hellenistic capitals. Thus, it can be stated that (at least in the case of the specimens tackled in the present study) the Ionic capital composition did not undergo any radical transformations during the Roman Age, even if the chosen specimens are more or less close to the Vitruvian pattern. To put it more bluntly, one could even say that as far as the compositional aspect is concerned, *the way it is described by the external variables*, we cannot expect important changes in the dynamics of the Roman Ionic capitals, or that the Roman capitals failed to evolve towards new clearly definable types, appearing as a whole as variations always stemming from a Hellenistic pattern. For instance: a Roman capital from Histria (no. 63) much resembles the Hellenistic capital at Didyma (no.6), and that from the Phillippeion in Olympia (no.15); an Augustan capital of a temple at Aphrodisias (no. 64) (neighbouring a capital from the same time in the area of the theatre in the same locality) is close to the capital from the end of the 2nd century BC at Didyma (no. 5), to the capital no. 26 from the Hypostyle Hall at Delos, and to no. 25 at Alexandria (end of 3rd c.), etc. (Figs.1-2).

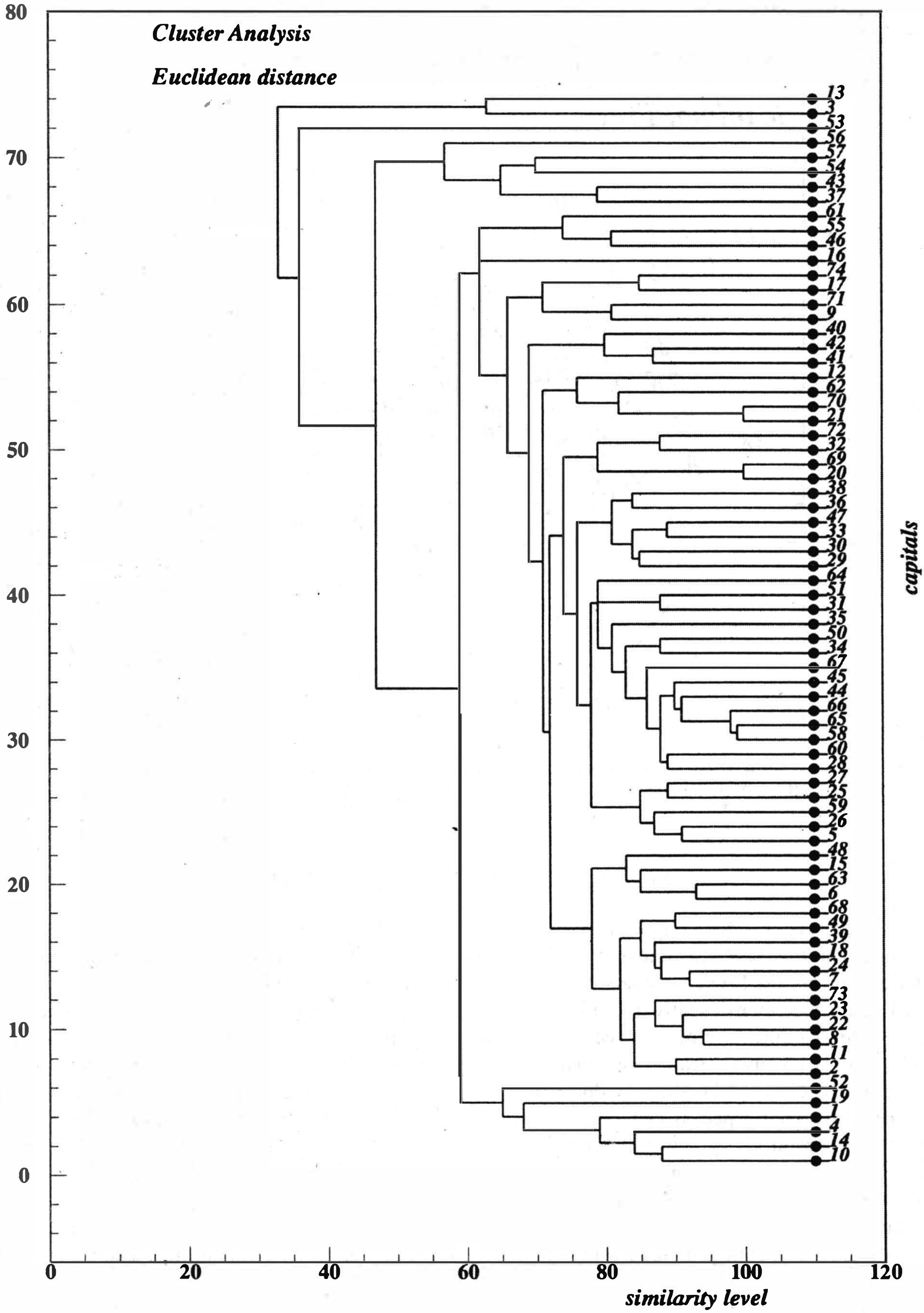

Fig. 3. The *Cluster Analysis*, 74 capitals, 13 variables.

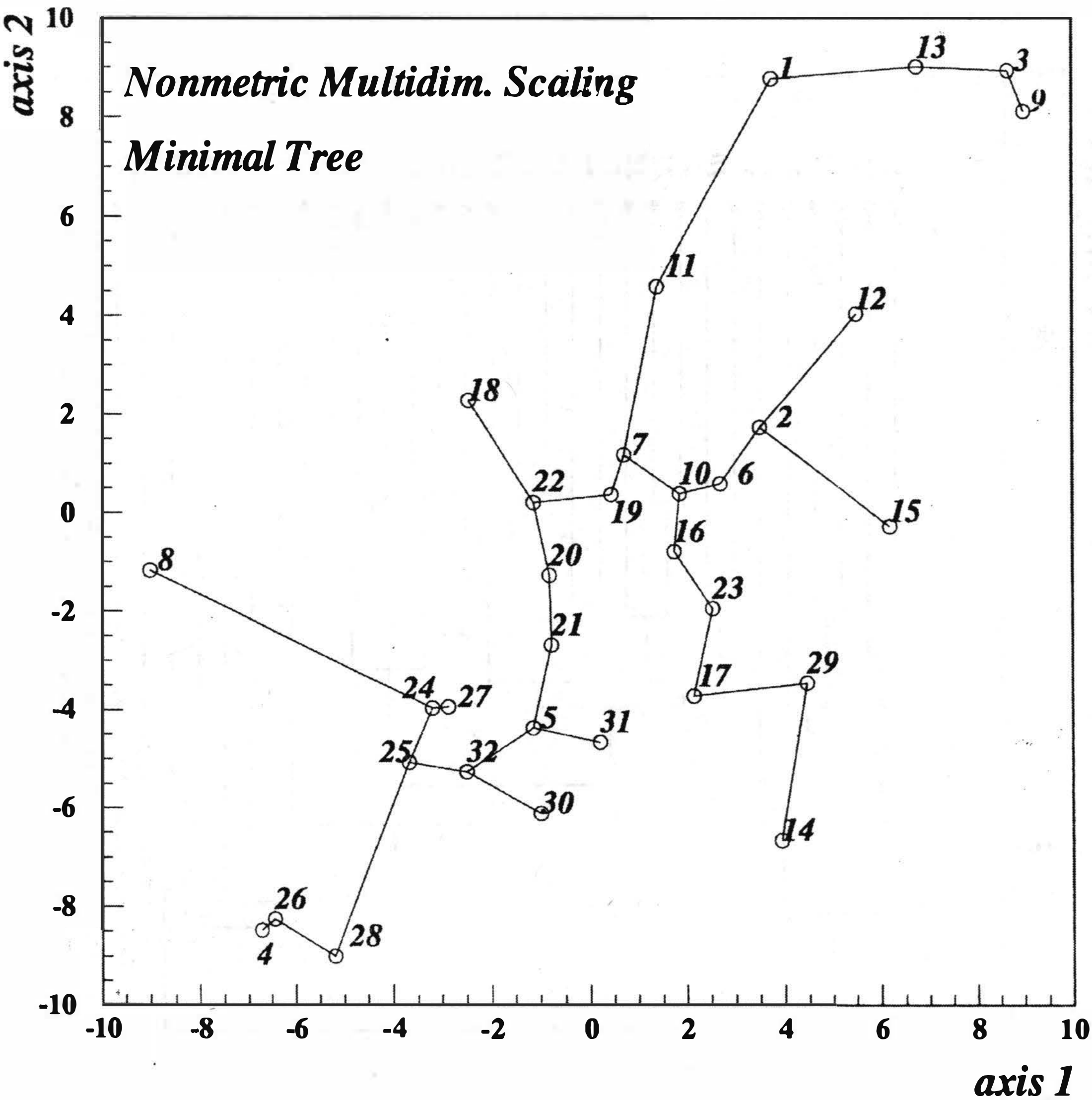

Fig. 4. The *NMDS/Minimal Tree*, 32 capitals, 16 variables.

The second important result of these analyses is linked to the position of the *Vitruvian capital* in the statistical analyses. Both methods (*CA* and *NMDS*) place its composition in the relative centre of the *cloud* made up of the other capitals. This aspect reflects the fact that the Vitruvian pattern is an outcome of all the compositional experiences making up the bulk of the analysed capitals[11]. From a chronological perspective, one can say that Vitruvius' pattern, that encompasses the outcome of the Hellenistic experiences, is the result of the *main trend* of the Hellenistic composition of the patterns, while by its composition it was a source of inspiration for later Roman capitals. In other words, the Roman Ionic capital composition "stands still" in variants applied, more or less consistently, to a pattern fulfilled, in its essential lines, during the Augustan age. While this kind of trend can be assessed as stagnant in the composition as a whole, it can nevertheless be seen as more dynamic in the interpretation tendencies of the central structure. In spite of the remarkable general compositional monotony, it is commonplace that during the Roman Age a wide range of variations added to the exterior of the capitals. Many of those transformations even reached the threshold of formal distortion. An important support of these variations

[11] From a mathematical point of view, in the *CA*, the virtual element found in the centre of the diagram represents an average of all the elements under analysis. The fact that also in the *NMDS* analyses the Vitruvian capital is placed in the relative centre of the diagram does not surprise us, as, to a large extent, this analysis is equivalent to the *CA*. It is worth mentioning that in the case of the *correspondence analysis* applied to 91 capitals (from the Archaic to the Hellenistic), the relative centre of the *CA* diagram is occupied by the Athenian Propylaea capital! (no. 46 in Mărgineanu-Cârstoiu , 1990, 89, Fig. 1; Idem, 1997, p. 187, Fig. 5.).

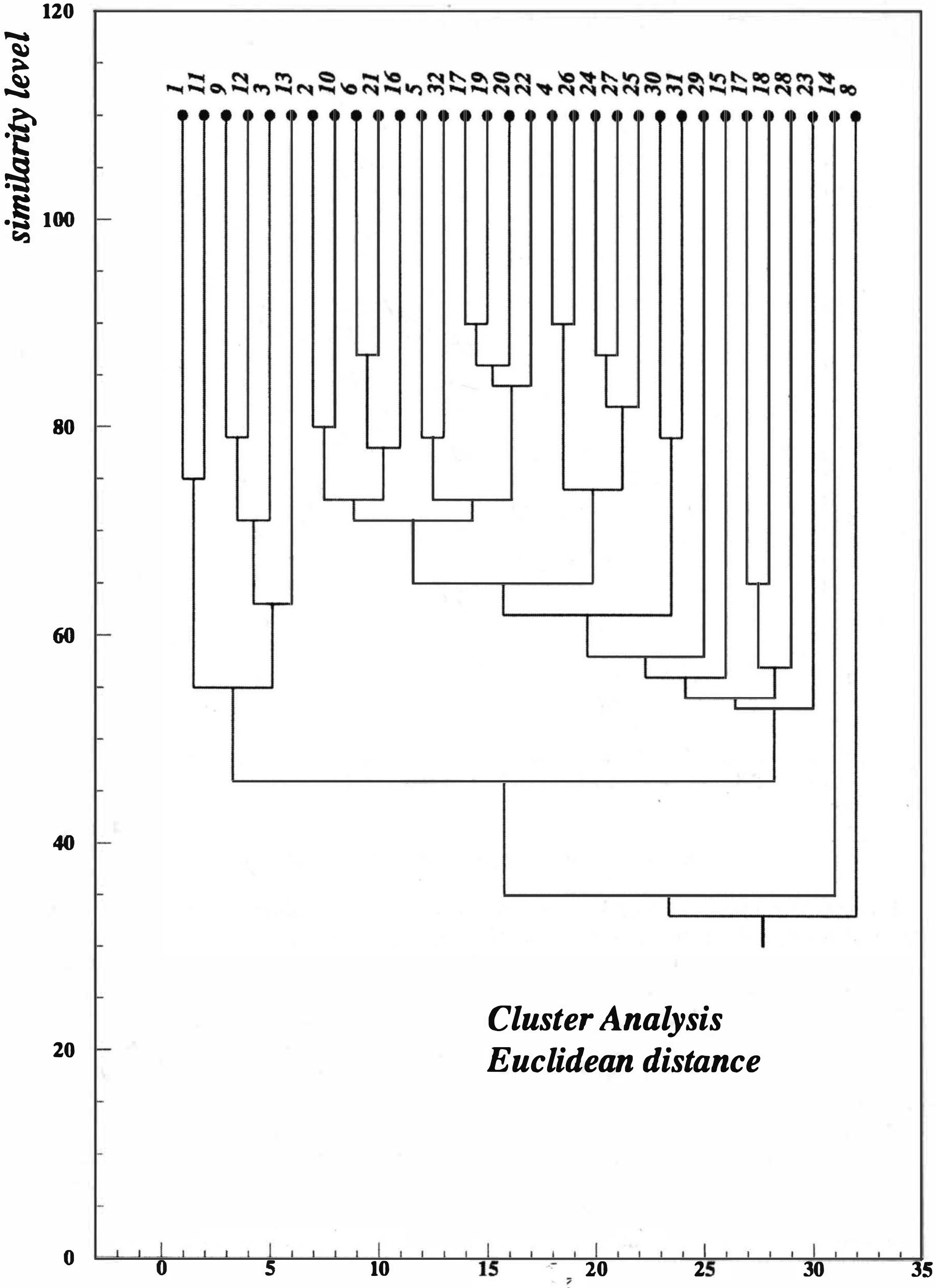

Fig. 5. The *Cluster Analysis*, 32 capitals, 16 variables.

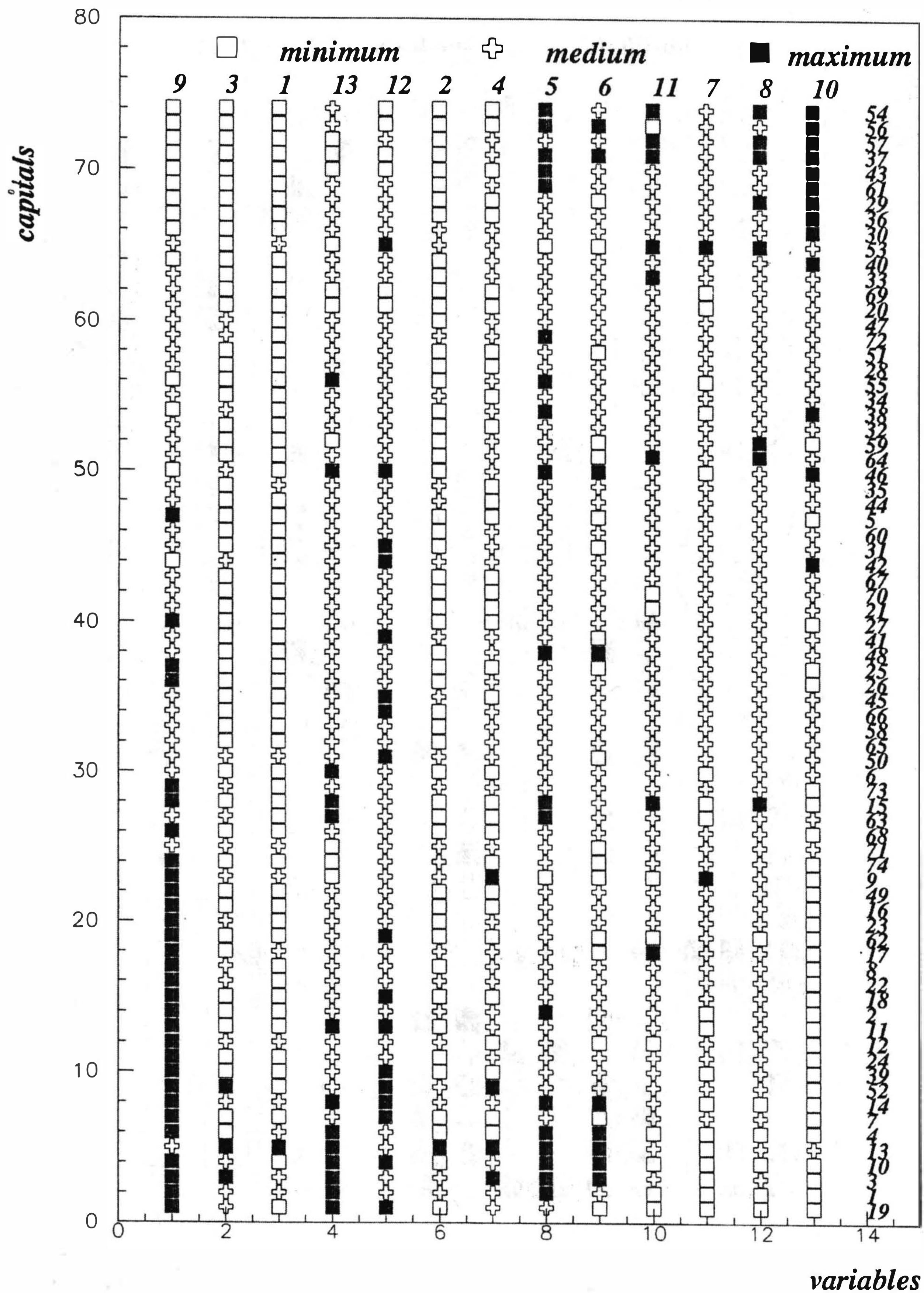

Fig. 6. The *Robinson Matrix*. 74 capitals. 13 variables.

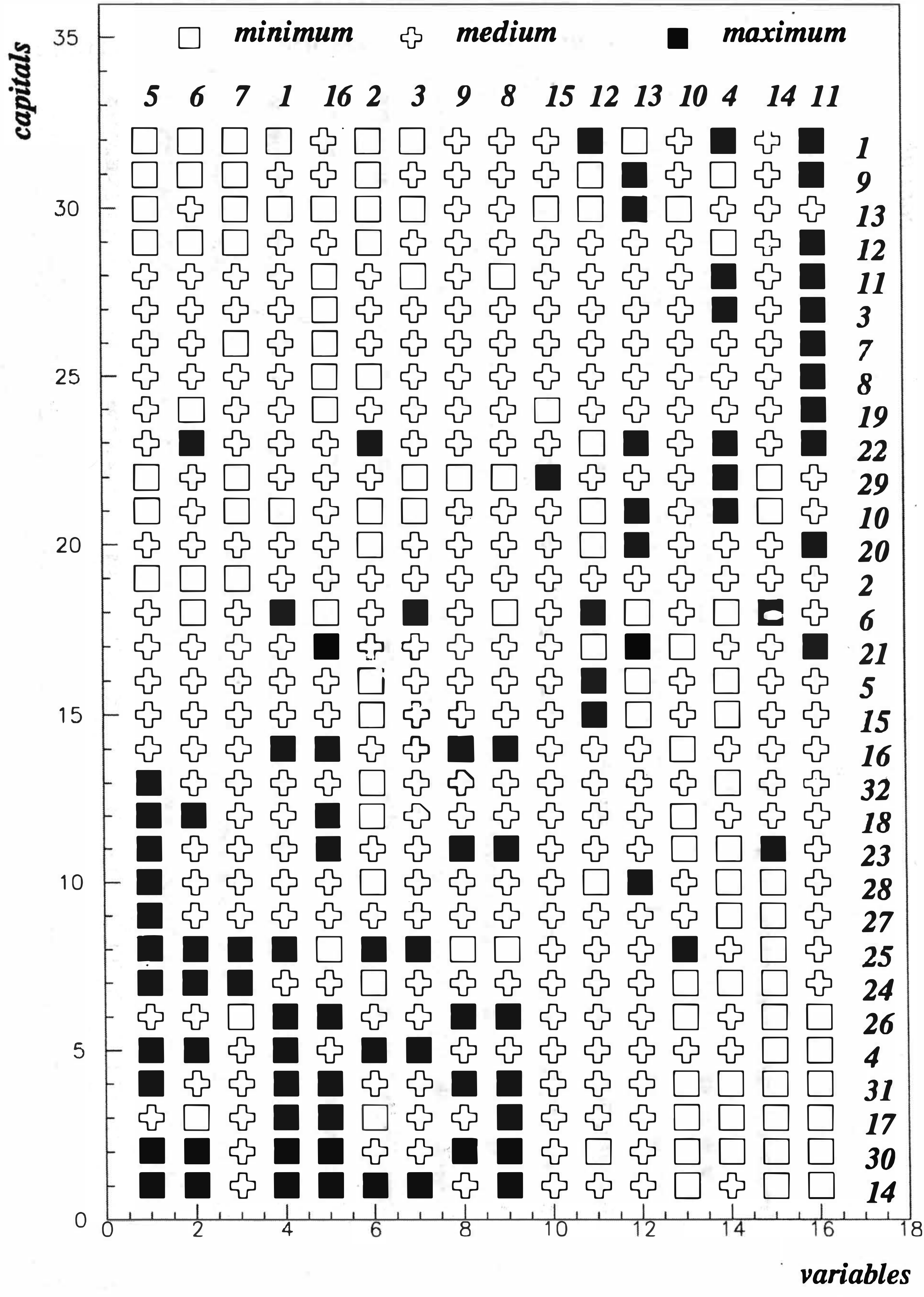

Fig. 7. The *Robinson Matrix*, 32 capitals, 16 variables.

can be deduced from observing the Robinson matrices (Figs. 6-7): it can be noticed that the compositional support of the transformations singling out the variants refers more to the *central structure* (the relation of the eyes line to the height of the central body – implicitly, with the lower surface line – the height of the echinus and that of the *canalis* as related to the height of the central body, and, naturally, the relation of the central structure to the total length of the façade)[12]. That explains why the capitals lacking a *canalis*, or having a very short *canalis*, are usually placed outside the "cloud", namely, they can be singled out as against the Vitruvian capital (and, often as against the bulk of the capitals) in a more nuanced manner. In general, it can be stated that, both in the case of the Hellenistic capitals and the Roman ones, the composition variables characterizing the aspect of the central structure gain in relevance[13]. But only during the Roman Age the tendencies to transform it sometimes became aggresive, so that the most conspicuously detachable from the Hellenistic and Vitruvian tradition are the very capitals where the transformations applied to the central structure are very obvious (Fig. 6): that can be considered to be the only relevant "leap" – as related to the Hellenistic-Vitruvian pattern – perceived until now. The removal of the canalis, and implicitly, the hypertrophy of the echinus height, represent the results of certain excessive tendencies, hovering on the brink of this sphere of interests.

As regards the Hellenistic capitals, the line stemming from the compositional type of the mausoleum at Halicarnassus would be the one to focus the most important preoccupations, and, even if it underwent certain changes during the Hellenistic Age up to Vitruvius, those did not substantially alter the composition created by Pytheos. That is to say that the *exterior* transformations[14] we refer to were minimal, the composition of the pattern represented by the (1:2:3) distribution type according to the radius of the lower surface created at the Mausoleum remaining firm and solid during the entire Hellenistic Age[15]; we might even assert that it became a paradigm, since from the prevailing composition concerns did not spring any "stream" generating truly new types[16]. Compositional outlooks represented by the capitals no. 9 (Priene/London) or no.16 (Leonidaion/Olympia) remain isolated experiments, with no significant echoes during the later evolution of the Ionic capital. This situation is suggested by the *CA*, as well as by the *NMDS* and *Cluster Analysis (chi-square distance)* (Figs. 1-3). In the case of *NMDS* (Fig. 2) the *Minimal Tree* method was applied[17]. The result of this method is a *genealogical tree* of capitals. By selecting only the Hellenistic capitals, according to *NMDS* (Fig. 2) one can make interesting remarks: the pattern of the Mausoleum at Halicarnassus (no. 7) and of the Labranda one (no. 24) makes up a *node*[18] to which descend the Ptolemaic votive capital from Olympia (no. 18), the Great Altar capital at Pergamum (no. 12)[19] and an Augustan capital at Ephesus (no. 39). The "descending" line joins the Halicarnassus/Labranda capitals – passing through Olympia/no. 18 – and the next important *node*, brought about by the capital of The Temple of Zeus at Priene (no. 23). That is linked to the South Agora/ Magnesia capital (no. 68), and by the capital of the Temple of Athena at Priene (no. 22). The latter belongs also to a "genealogical" side line, and counts among its "descendants" – along this line – the capital

[12] The variables expressing these characteristics: A/L, J/I, K/L, I/L (see Fig. 6).

[13] As regards the share of the variables linked to the aspect of the central structure up to the Hellenistic Age see Mărgineanu-Cârstoiu, 1990, p. 81, Fig. 2 , p. 84; Fig. 5; Idem, 1997, p. 189, Fig. 70.

[14] The proportions.

[15] Naturally, this statement does not mean that all the Hellenistic capitals entirely observe the 1:2:3 pattern; but the concerns linked to the composition remain concentrated upon it (see also Hoepfner, 1968, *passim*).

[16] Of that kind, for instance, recorded by the very emergence of the Pytheos' composition type at the Mausoleum: in the *CA* and *Cluster Analysis* , applied to the capitals from the Archaic to the Hellenistic, one can see clearly how the Hellenistic cluster *focused upon the Mausoleum capital*, obviously departs from the classical cluster. (Mărgineanu-Cârstoiu, 1990. p. 80. Fig.1, p. 92, Figs. 15-16; Idem, 1997, p. 186-187, Figs. 4-5, p. 198, Fig.16, p. 202, Fig. 22).

[17] *The Minimal Tree* is a comfortable method of visualizing the existing correlations in a point distribution in the plan (in a system collection of objects for which we have a plan representation). We did not apply the *Minimal tree* to the *CA*, due to the more dense aspect of the diagram, which might have rendered the visualization of connecting lines more difficult. (As for the other methods the statistical methods applied here, the practical realization of the mathematical algorithm was performed by dr. Florin Cârstoiu, from the Institute of Atomic Physics, Bucharest).

[18] The nodes emphasized by the *Minimal Tree* represent branch points, where two or more evolution lines are distinctly emphasized.

[19] This remaining, however, relatively isolated from the prevailing line of descents, which might be interpreted as a particular "deviation" (without direct heirs as compared with the Halicarnassus type.

of the Artemisium at Magnesia (no. 11). It is interesting to see how the Artemisium specimen finds itself at a high degree of similarity as related to the altar capital of the Artemisium E /Ephesus (no. 2)[20]. That suggests that both capitals stand at the interference of two influence cores: one stems from the capital of the mausoleum at Halicarnassus, and The Temple of Zeus at Priene, the other one is represented by the capital of the Temple of Athena (no. 22). The last important *node* of similarities that "comes close" to the Vitruvian capital (no. 58) is the capital of the Stoa of Attalos (no. 67). The latter, encompassing also experiences represented by the capital of the Hypostyle Hall at Delos (no. 26), and by an Alexandria capital from the end of the 3rd century (no. 25)[21], is – besides those – the closest to the Vitruvian capital due to its composition of the pattern.

Thus, it can be noticed that the *Minimal Tree* provides the opportunity to distinguish a prevailing trend of the composition "evolution", the "genealogical" line running from the left to the right: the side lines "flow'" into the main line, crossing it into *nodes* like those described above.

While up to the Vitruvian capital, Roman capitals intertwine with Hellenistic capitals, from the Vitruvian capital to the right the line crosses Roman capitals exclusively. The Vitruvian design can be considered similar to the point of identity with that of the capitals at Aphrodisias (nos. 65-66). According to the *NMDS/Minimal Tree*, a larger branch comes off the first important *node* after the Vitruvian capital, *a node* represented by an Augustan capital from Denizli (no. 34): from it stems the Hadrian capital of the Asklepieion at Pergamum (Nordhalle) no. 35, as well as other two Roman capitals from the 2nd-3rd centuries originating in Ephesus, nos. 38 and 40 (Grabungshaus and the marble Street), a Severus capital from Hierapolis (no. 42) , and two specimens from the 3rd century originating in Dydima (no. 46) and Yalvaç/ Museum (no. 55, as well as the Histria capital no. 61 (Histria CD). The right end of the "genealogical" line is represented by the group of atrophied 'canalis' capitals, that, although the most remote from the Vitruvian pattern, they do stem from it. In the hierarchy of descents (to a large extent coinciding with the chronological scale) these specimens are: no. 43 (Izmir, Basmane Muzeum, 2nd century), no. 37 (Denizli, Trajan's age), no. 54 (Side Museum, 3rd-4th centuries) ; the Severus capitals from Laodikeia ad Lycum are more remotely linked to this group.(Fig. 2).

As far as the Histria capitals are concerned, the design closest to the Vitruvian capital is represented by the capital no. 60 (Histria/AC203)[22].

To put the finishing touch on the interpretation facilitated by the *Minimal Tree*, one can say that the "*nodes* " representing the gathering of compositional experiments from different trends unfold along a path of descents comprising at a given moment the Vitruvian composition of the pattern (practically the same with the composition of the pattern of the capitals nos. 65-66). It should be borne in mind that the Vitruvian specimen *does not form a node by itself*[23], but stands between the *nodes* brought about by the capital of the Stoa of Attalos (on the left), and (excepting the node no. 60 expressed by the Histria capital[24]) the Augustan capital no. 34. The *Cluster Analysis* (Fig. 3) reveals even further the closeness between the mentioned capitals: on the one hand, of the Hellenistic capitals the closest to the Vitruvian pattern is the same capital of Stoa of Attalos[25], and on the other hand, in the sequence of specimen groups wich are situated at a very close degree of similarity to the Vitruvian pattern, the capitals no. 65

[20] Aspect confirmed by all the analyses applied.

[21] The *NMDS/Minimal Tree* shows the Stoa of Attalos capital absorbing the side genealogical line comming from the capital no. 5 (Didyma, int. rows); the latter forms the "node" from which departs the branch which links it to no. 26 (Hypostyle Hall) and 25 (Alexandria). All the analyses reveal the close link between the capital of the hypostyle Hall at Delos, and the Alexandria capital.

[22] Regarding the dating of the Histria capital Cφ (no.70/21) its Roman origin seems plausible. while according to the NMDS position it can be considered Hellenistic (descending from the capital no. 6 / Dydima, ext rows. see Mărgineanu-Cârstoiu, 1990). the CA and MDS analyses reveal stronger similarities as compared with the group of Roman capitals. *The Minimal Tree* shows the capital C34 (no. 69/20) situated at the peak of a branch descending from the capital no. 5 (Dydima, int. rows), passes through the Aphrodisias capitals no. 31 (Augustan/ the area of the theatre), and no. 64 (capital 2), the Histria no. 59 and through Hadrianus' capital no. 51 at Perge.

[23] Which might reflect that the *Vitruvian pattern* did not represent anything new in its age.

[24] In fact this can be considered to adopt a *mean* pattern between the one represented by an Epheus capital from the beginning of the 1st c. BC (no. 28). and the specimen no. 50 (Pergamon Museum. not dated).

[25] V. Hoepfner, 1968. p. 230-232.

(Aphrodisias cap.3), no. 66 (Aphrodisias, cap.4), no. 34 (Denizli, Augustan) and the Histria no. 60 (Histria AC203), can be all considered "Vitruvian". Besides these – according to the Cluster Analysis specifications – there are the Augustan specimen no. 44 at Dydima, and the capital no. 28 (the beginning of the 1st c. BC) at Ephesus.

At the beginning of the 1st c. BC[26] and during the Augustan Age the composition of the patterns having degrees of similarity very close to the Vitruvian capital could be found, which leads to the hypothesis that the pattern conveyed by Vitruvius was nothing but an already settled pattern, and, most likely, frequently used at that time (as suggested also by its *NMDS/Minimal Tree* position[27]). That reflects the evolution of a prevailing "genealogical" line substantiated by the *Minimal Tree* as stemming from the capital of the Mausoleum at Halicarnassus, yielding as a last landmark of its "evolution" the capital of the Stoa of Attalos[28].

&2. By its specificity the *Cluster Analysis* (Fig. 3) creates *clusters* that sometimes are not obvious in the structure of the *NMDS* and *CA* diagrams. The *Cluster Analysis* results usually match the *CA and NMDS* analyses: the capitals distanced from the bulk of the general cloud in the diagrams in question are grouped by the *Cluster Analysis* in totally distinct clusters, having degrees of similarity significantly remote from all the others. It is interesting to notice that all the other capitals (that in the *CA* and *NMDS* made up the general bulk of the *cloud*) are grouped in a large *cluster*, in its turn divided into subclusters linked to each other by close degrees of similarity; within the subclusters *items* are in their turn situated at close degrees of similarity. This type of clustering can be interpreted along the line already suggested by *CA* and *NMDS :* the composition variants distinguishing the subclusters are very fine (small). The *Cluster Analysis* specifications are extremely productive for the very fact that this analysis succeeds in grouping the *items* according to the very fine differences. Thus, the *Ca and NMDS/Minimal Tree* suggestions may be nuanced into getting clearer contours.

In Fig. (3) diagram it can be seen that in the bulk of capitals the following capital clusters can be separated:

1) The *Cluster I*, of the capitals at Sardes (no. 10), Aphrodision /Lesbos (no. 14), Ephesus/Izmir Museum (no. 4), Artemisium E (no. 1), Artemisium / Kunst.Hist.Mus. (no. 3), Selinunt (no. 19) and Samos (no. 13). The degrees of similarity of the items no. 19 and no. 13 are so remote from the others that they can be considered "satellites" (outside all the clusters).

2) The *Cluster II*, situated at the most reduced degree of similarity as compared with the large bulk of the other capitals, and, implicitly, as compared with the Vitruvian specimen; dominated by the exclusively Roman capitals, with a reduced or completely atrophiated *canalis* like the Severus ones at Laodikeia ad Lycum (nos. 56 and 57) or the 3rd/4th c. capital in the Side Museum (no. 54); also the capitals with a straight, much reduced 'canalis' and a malformed echinus, in the Basmane /Izmir Museum (nos. 43, 2nd c.) or that from Trajan's Age at Denizli (no. 37)[29].

3) The *Great cluster III*, comprising the capitals whose composition of the pattern stems from the pattern of the capital of the Mausoleum at Halicarnassus, which is made up of the majority of the capitals submitted to analyses. This great *cluster* is made up of a multitude of *subclusters* found at close degrees of similarity as compared with the subcluster comprising the Mausoleum capital. We mention a few of the more important subclusters (families):

– The subcluster III_1; including **the capital of the Mausoleum at Halicarnassus (no. 7),** the capital of The Temple of Zeus at Labraunda (no. 24), the Ptolemaic votive capital at Olympia (no. 18), the capital

[26] According to the Cluster Analysis (Fig. 3) also the capital no. 27 can be considered very close to Vitruvius (Ephesus).

[27] "Il fatto que il primo livello, quello de la *quantitas* venga nei progetti concreti presentato da Vitruvio in termini e valori assoluti, quasi comme *conditio sine qua non* ... conferisce ai precetti vitruviani un che di coercitivo che ha indotto a suporre la supremazia della *symmetria*." (H. Geertman, *Le Projet de Vitruve*, p. 30).

[28] The remarkable conclusions of W.Hoepfner pointed out important similarities between the Stoa of Attalos and Magnesia on Meandru capitals (Artemisium and South Agora). As shown below, the Artemision capital at Magnesia can be considered, in its compositionsl core, as a copy of the one at Halicarnassus (a fact already remarked, in other ways, by Hoepfner, *op. cit., passim*); its position in the statistical analyses (close, but not identical) is due to the unique important "changes" brought by Hermogenes in the compositional register, linked to the aspect of the central structure.

[29] The fact that in statistical analyses (Figs. 1-3) these capitals appear in an exterior "rarefied" area of the cloud is only the result of the small number of specimens of this type introduced in the present analysis; if a large number of capitals with annulled or atrophied canalis were submitted to analysis it is likely that the exterior area of the "cloud" of the capitals be denser. Under the circumstances, for the time being the position of the capital no. 56 should be considered (Laodikeia).

from the 1st century BC in the Ephesus/ Selçuk Museum (no. 39), the capital of **South Agora Magnesia** (no. 68), the votive capital at Olympia (no. 17), a Histria capital (no. 74).

– The subcluster *III₂* comprises three specimen branches: a branch made up of the altar of the Artemisium E/Ephesus (no. 2), and **Artemisium/Magnesia (no. 11),** another one comprises Dydima/Apollonion II, ext. rows (no. 6), Histria (nr. 63), Olympia/Phillipeum (no. 15)[30], and a third branch is represented by Priene/Temple of Athena (no. 8/22), **Priene/The Temple of Zeus (no. 23),** Histria (no. 73).

– The subcluster *III₄* : **Vitruvius (no. 58), Aphrodisias/Augustan (nos. 64, 65, 66**), Histria (no. 60), Ephesus/early 1st c. (no. 28), Dydima/Augustan (no. 44), Dydima/2nd c. (no. 45), the **Stoa of Attalos** (no. 67), Pergamon Museum (no. 50), Claudiopolis/T.Antinous of Hadrian age (no. 32), Histria (no. 72), Kaunos/Augustan (no. 48).

It is worth mentioning the excentric position of the capital no. 16 (Leonidaion) as against the clusters, and the remote position of the capital no. 9 (Priene/London) as against the *great cluster I* [31].

– The *Cluster V*, encompasses the capitals revealing certain tendencies of parting from the great Halicarnassus-Vitruvius cluster, however remaining linked to it at a relatively close degree of similarity. The oldest capital of this cluster is no. 47 (Didyma, 1st c. BC), as the others extending up to the Severus Age. Between the cluster V and the cluster III, there is the great altar at Pergamum (no. 12) : this Cluster Analysis position may indicate either that this capital marks a slight isolation as compared with the Halicarnassus cluster[32], or that its compositional independence, no matter how discrete, was a bridge towards the transformations generating the cluster V[33].

Stability test (Figs. 4-5). The evolution line of the Hellenistic Ionic capital up to the emergence of the Vitruvian pattern was analysed also by the *Minimal Tree* (Fig. 4) and the *Cluster Analysis* (Fig. 5) applied to 32 mostly Hellenistic capitals[34]. Here there are very strong similarities between the Halicarnassus capital (no. 6) and the Magnesia/Artemisium (no. 10) one. At the same time, the Magnesia capital looks like a *node* where the arms of two "balances" meet, one made up of the Halicarnassus capital to which the altar capital of the Artemisium at Ephesus (no. 2) seems very close, the other one of the capitals belonging to the Temple of Athena at Priene (no. 7 and no. 19). The capital of the Temple of Zeus at Priene (no. 20) is also within this diagram an important element of the developments leading to the emergence of the Vitruvian pattern (represented by no. 32). Further on, the filiation goes down through the Didyma/ext. rows capital (no. 5) towards the Vitruvian capital (no. 32). The South Agora/Magnesia capital (no. 31) is close to the Vitruvian capital, but less than the Stoa of Attalos one[35]. The *Cluster Analysis* expresses analogue realities (Fig. 5).

&3. The lack of a significant evolution of the composition can be deduced also from the weak "diagonal" of the Robinson matrix. The corresponding diagrams also provide the opportunity to watch the evolution of the analysis characteristics (variables) (Figs. 6-7).

Therefore, it can be asserted that – as far as the composition of the apparent plastic body is concerned – the spectacle of the evolution, the concerns relating to the compositional structure *considered as a whole*, are no longer characterized by transformations of an all-encompassing span and irradiation force comparable to Pytheos' creations. However, despite seemingly showing a standstill around already concluded experiences, the ideas flow finds another reflection opportunity in conducting the elements of the central body, keeping dynamics in this aspect in the Roman age as well.

[30] In the *NMDS/Minimal Tree*, the capitals stemming from no. 15 stand on the same side genealogical line.

[31] The Histria capital no. 71 and the Hadrianus capital (no. 52) belonging to the Temple of Dionysos at Teos (at a more remote level) form with it a small isolated group (cluster IV).

[32] Analogue to the capitals of cluster V.

[33] The global and minute characteristics of the geometric support belonging to the Ionic capitals (including the Hellenistic ones from Halicarnassus, Magnesia/Artemision, Priene, Olympia, Artemision Ephesus, Pergamum) can be found in M.MC, 1996-1998, p. 190-232. As regards the relation to the 1:2:3 design initiated at Halicarnassus, see above all p. 197-205 and p.232/ tab. 78); Mărgineanu-Cârstoiu, 1997; Mărgineanu-Cârstoiu, A. Sebe, 2000.

[34] See Annex 2.

[35] Close to the Vitruvian capital are also the Hypostyle Hall at Delos (no. 25), remarkably similar to the Alexandria specimen (no. 24), Ephesus (nr. 27).

II. ANALYSIS OF THE INTERNAL VARIABLES (THE GEOMETRIC SUPPORT OF THE COMPOSITION)

We might say that the movement of ideas is "banished" mostly to the less transparent interior of the composition. Barely noticeable when analysing the external variables, the very fine mutations of the forms can be found and recognized by observing the geometric support. We are going to tackle mostly the results presented in several previous studies[36], and try to concentrate them in such a way as to emphasize, as much as possible, the *main geometric nuclei* [37]. In other words, we shall try to eliminate, as much as possible, a large part of the *derived relations*[38].

HELLENISTIC CAPITALS[39]

1. *The Capital of the Mausoleum at Halicarnassus* (no. 7/6)[40] (Figs. 8-9).

a) The façade rectangle is determined by the decagon inscribed in the circle built on the façade diagonal, so that $G \approx l_{10}$. (Fig. 8a).

– The width of the volute is equal to the apothem of the hexagon inscribed in the lower surface[41].

– The height (N) of the spiral after the first unfolding is settled by the pentagon inscribed in the circle with the diameter equal to the distance of the centres (equal to the lower surface diameter), having the centre on the line of the volute eyes[42].

– Between the main diagonal (Dp) and the secondary diagonal (Ds) of the volute[43] there is the relation $(Ds)=(Dp)\sqrt{3}/2$ (Fig. 8c); the side of the octogon (l_8) circumscribed to the same circle (with the radius Dp) is equal to the total height of the capital (G+M)[44].

– The distance between volutes (E) can by approximated by the side of the octogon (L_8) inscribed in the circle built on the length of the plan (façade) (Fig. 8b).

b) The first relation described above can never be perfectly compatible arithmetically, and, implicitly, dimensionally with a (R:G:A) distribution of the (1:1:3) type[45], but is sufficiently close to it to consider that it stood at the basis of the geometric support used by Pytheos: it can be correctly described either as (1: 1: 3.077), or as (1:0.974:3)[46]. Due to the very differences existing between the theoretical values expressed by the pattern described, and the real dimensional values, one can unravel the way in which Pytheos might have worked, by observing the ingenious adjustment as against the radius of the lower surface[47], while founding his entire design on a implicit "beautiful" ratio.

c) *The geometric nucleus generating Pytheos' composition at Halicarnassus* (hypothesis) (Fig. 9).

– The basic "geometric" unit is considered to be the radius of the lower surface (R = 1); a segment equal to $\varphi R = 1.618R = 1.618$ is built.

[36] Mărgineanu-Cârstoiu, 1997, Idem, 1996-1998, Idem, 2000a., Mărgineanu-Cârstoiu, A. Sebe, 2000..

[37] This is not directly brought in the open, remaining *implicit* to the architectural design. Its reflection into the exterior results in *derived* geometric relations, some of which are used later for the transmission for execution. Of these, the relations expressing harmonic or geometric sharings were interestingly revealed in various cases by Louis Frey, who explained how the algebraic formulas could be conveyed for execution by using the *analogia* language (especially for the Ionic capital see L. Frey, *Le projet de Vitruve*, p. 155-157, Fig. 9; Mărgineanu-Cârstoiu, 1996-1998, *passim).*

[38] In Mărgineanu-Cârstoiu, 1996-1998, we presented many derived relations with a view to demonstrating as fully as possible that the Ionic capital composition *relies upon* a *geometric support.* In Mărgineanu-Cârstoiu, 2000a, the analysis of some Archaic capitals (from Histria, Thasos, Nax. Stoa Delos, Paros) follow the simplified procedure, as we shall do in the present study.

[39] Taking into account that in previous studies we checked the hypotheses on the basis of the dimensional control, we shall not repeat this here unless we consider it necessary.

[40] The two numbers we note in each analysed case correspond to those in the statistical analyses with 74 capitals, and 32 capitals, respectively.

[41] Mărgineanu-Cârstoiu, 1997, p. 216-219; Idem, 1986-1987, p. 201, tab. 44.

[42] A resulting (derived) relation is that as against the façade semidiagonal (G:A/2) so that $N = (G:A/2)(\sqrt{2}-1)$. See also Mărgineanu-Cârstoiu -- A. Sebe, 2000, p. 317.

[43] For these denominations, see Mărgineanu-Cârstoiu, 1996-1998, p. 235.

[44] Because $l_8 = 52.563$ cm~53 cm (dif.0.43 cm = 0.7%).

[45] In the 1:2:3 case, the facade diagonal represents $\sqrt{10}$ (= 3.162), and not 2φ (= 3.236), while the angle formed by the diagonal with the facade rectangle base is 18.96° and not 18°.

[46] If l_{10} = G = R, then the length of the façade (A) = **3.077R**; if A = 3G = 3R, then l_{10} = **0.974R** (46.788 cm).

[47] Other implications of this congruity in Mărgineanu-Cârstoiu, 1996-1998, p. 201-203.

[48] It is the same as saying that two pentagons are built (rotated by 90° one as against the other). and the corresponding starred pentagons.

– The circle having the new segment as a radius is built ($\varphi R=1,618$), as well as the decagon inscribed, and the "starred" polygon corresponding to it[48]. The rectangle formed by two opposite sides of the decagon may represent the façade rectangle of a capital, where $l_{10}=G=R=1$, and the length A =3.077 R (Fig.9a,c).

– If at the basis of the plan design had stood the side of the pentagon corresponding to the façade circle, the (R:B) distribution would have been 1:1.902 (Fig.9b).

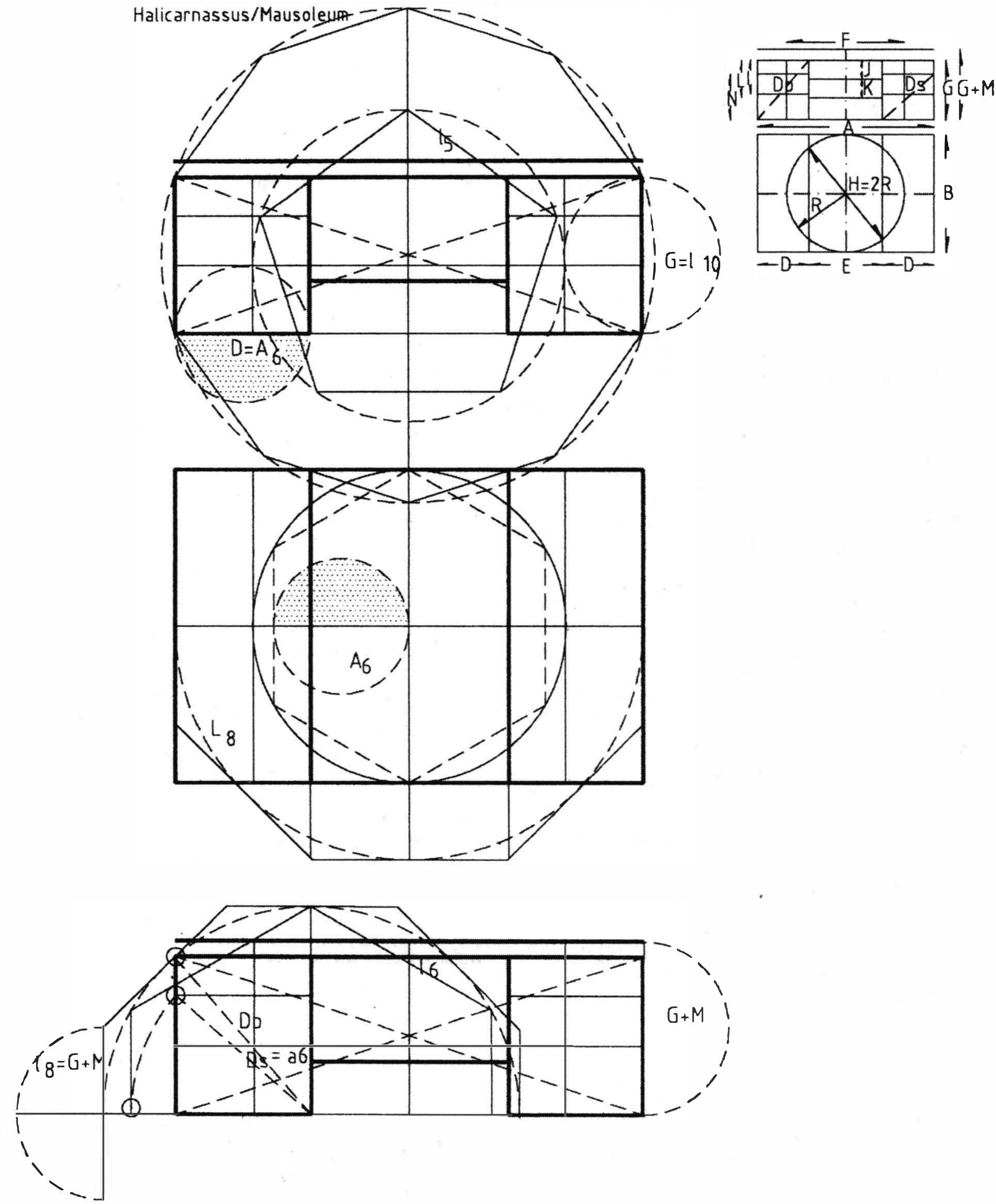

Fig. 8. The Capital of the Mausoleum at Halicarnassus.

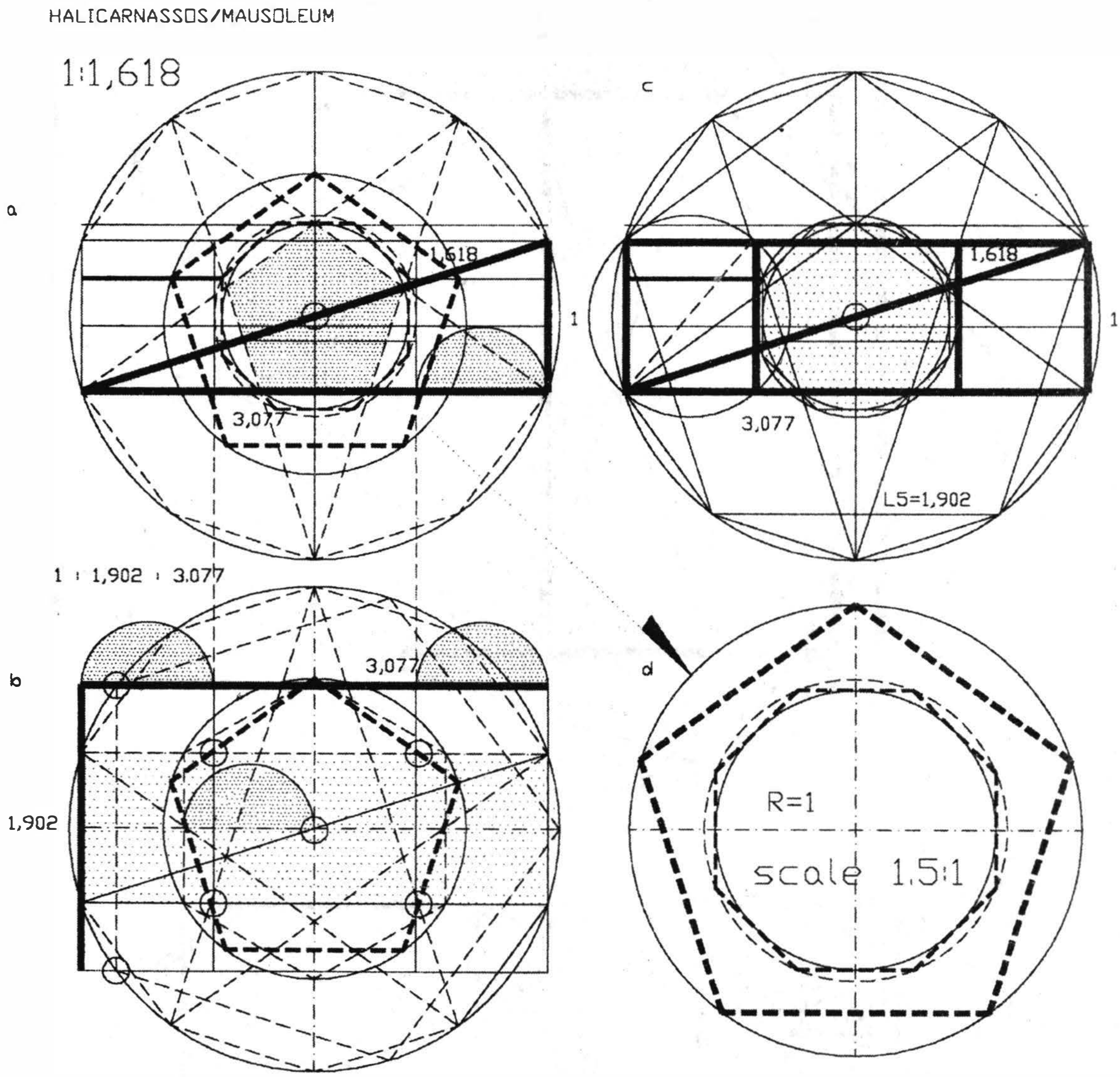

Fig. 9. Halicarnassus: the generating geometric nucleus.
The starred pentagon (decagon): the theoretical capital.

d) *Pytheos' transformation ("corrections") meant to achieve the (1:2:3) distribution (that is from A=3.077 to A=3, and from B=1.902 to B=2)* (Fig. 10).

– It was enough to consider the long sides of the plan determined by the intersection of a pentagon side each with a side of the starred pentagon: the limits of the length of the plan and façade are determined by the intersection points of the sides built with the circumference of the "theoretical" plan circle (that is of the rectangle 1.902 – 3.007) (Fig. 10b). The beauty of the "correction" resides in the fact that, by adapting the length of the cushions as against the extremities of the lower surface diameter, the plan rectangle remains directly adjusted to the decagon and pentagon.

Other observations. From the same pattern (Fig. 10a), results also the position of the height of the spiral after the first unfolding (N): it is settled by the octogon circumscribed to the circle in the "core" of the starred polygon; the horizontal diameter of the circle where this octogon is inscribed settles the inner limits of the fundamental rectangle of the volutes, *before applying the correction of the length (*and it is equal to the main diagonal of the spiral (Dp)). After the "correction", the distance between volutes is settled by the decagon inscribed in the same circle (Fig. 10a,c), while the width of the volute is at the same time equal to the apothem of the hexagon inscribed in the lower surface.

The commensurability of the parts seems to be realized impecably, in the intimacy of the geometric nucleus: while the radius of the lower surface is the unit (1), the radius of the generating circle is

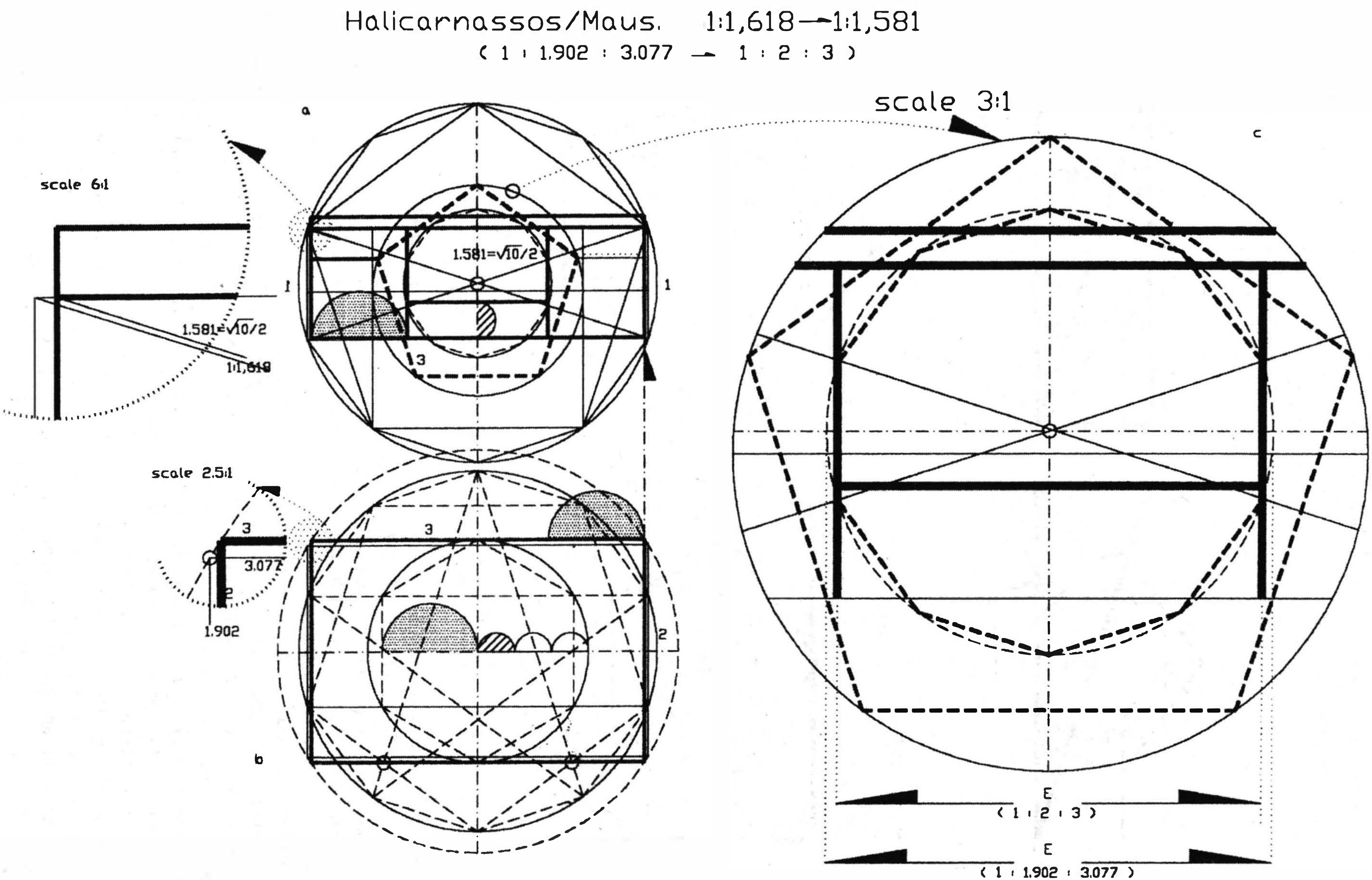

Fig. 10. Halicarnassus: the generating geometric nucleus: the real capital.

φ (= 1.618), and the side of the decagon inscribed in the lower surface (l_{10}) is φ_l (0.618)! And by this side (l_{10}) one can realize also the link with the measure unit (l_{10} =29.6cm≈29.4cm=1P). As regards the design unit (pars?), if it is equal to 1/8 of the unit-radius, then the initial ratio (1:1.618) can be conveyed very simply in execution as (8:13)[49]. The rest is known[50].

e_1) *Precursors of the geometric diagram of the (1:2:3) type.* Although it seems that Pytheos realized for the first time a full diagram of the (1:2:3)[51] type, the interest for a "partial" distribution, such as that (1:3), *without involving, however, the adjustment as against the lower surface, emerges* **as early as the Archaic capital of the Artemisium at Ephesus**[52] (Fig. 11). Like the façade, the plan too can be considered a rectangle of the (1:3) type (Fig. 11c,d)[53] (if we consider the length of the cushion measured at the level of the plan of the volute eyes). The façade rectangle can be approximated as inscribed in the decagon[54]. The ratio is established exclusively as against the height (G) of the volute (G=A/3=B') (Fig. 11b). The settling of the height of the inner tangent (N) found at the Mausoleum capital proves to have an Archaic origin itself: the geometric relations between Dp and Ds (Fig.11a), and the settling of the height (N) by the tips of the pentagon (inscribed in a circle having the diameter equal to the distance of the volutes centres (Fig. 11b)[55], and having the centre settled on the line of the centres of the volute eyes) is present also at the Artemisium capital[56].

e_2) An important moment towards the emergence of the Halicarnassus Hellenistic capital[57], was the **Inwood capital**[58], where a distribution of the (1:3) type was experimented, this time adjusted to the radius of the lower surface (Fig. 12). The façade can be considered (1:3), where A/3≈G≈R (Fig. 12a-b). The relation between the diagonals (Dp) and (Ds) of the spiral is of the type described previously (Ds=Dp√3/2) (fig.12c). Also here there is the idea of integrating the façade rectangle into a decagon, but it is achieved otherwise: the decagon is this time *circumscribed to* the circle comprising the façade (Fig.12a), its side being (approximately) equal to the height (G) of the volute. The settling of the height (N) is, however, a little different from those described previously: the circle where the pentagon is inscribed has as diameter the diagonal (F: G), but its centre is placed also on the eyes line. The adjustment as against the radius of the lower surface refers to the width of the volute, that is equal to the *apothem of the octogon* inscribed in the lower surface circle (Fig. 12b). Although still far from the (1:2) relation from the radius, the depth of the plan (B), and even the distance between volutes (E) are subtly adjusted to the radius, by the mediation of the pentagon inscribed in its circle: its tips correspond to the division into (1:3) of the length (B), its side being equal to the distance between volutes (Fig. 12e). This way, the distribution of elements in the façade is complexly adjusted both as against the plan, and as against the lower surface: the distance between volutes is equal to the side of the octogon *inscribed*[59] in

[49] Because 1.618 R=77.65 cm=12.94p≈13p (dif. 0.35 cm); the accordance is achieved also with the measure unit: for 1d=1P/16≈29.4 cm/16=1.84cm it results 1R=26d, and φR=42d =77.28 cm≈77.65 cm (dif. 0.37 cm). One can notice the two types of ratios approximating the numbers φ and φ_l : 13/8, and 42/26=21/13.

[50] See Mărgineanu-Cârstoiu, 1996-1998, p. 202; Mărgineanu-Cârstoiu, A. Sebe, 2000, p. 316, Fig. 18.

[51] We call the *(1:2:3) complete diagram* the one expressing also a perfect adjustment of the main elements (G:B:A) as against the radius of the lower surface (R=1). We regret that we did not have access to B. Lehnhoff's study on the "the 1-2-3 capital" (*apud.* P.Gros, *Vitruve*, p. 166).

[52] D. G. Hogarth, E. Henderson, *Excavations at Ephesus. The Archaic Artemisia*, 1908, Atlas, pl. IV.

[53] Instead of a (2:3) Hellenistic rectangle, where the plan is simply "doubled" (or the "double" of the façade).

[54] Under the conditions in which the *side of the circumscribed decagon> G>the side of the inscribed decagon* (Fig. 10 b, g).

[55] That much exceeds the diameter of the lower surface.

[56] The relations with the radius of the lower surface are, however, completely different. For instance, the width of the volute D = $R\varphi^2/2$, at the same time being equal to half of the semidiagonal of the façade (Fig. 10f).

[57] See also the *CA*, in Mărgineanu-Cârstoiu, 1990, *loc.cit.*; *Ibidem*, 1997, *loc.cit.*

[58] For objective reasons, the observations were carried out exclusively graphically: the conclusions have to be considered taking into account this reality.

[59] This way is clearly pointed out the façade distribution difference found at the Inwood capital as compared to the mausoleum at Halicarnassus: at the latter, the homologous figure is the octogon *circumscribed to* the circle. The difference between the two types of relations does not express a fortuitous preference for an *inscribed* or *circumscribed* polygon, but it obviously expresses a different composisional outlook: the plan of the Inwood capital is much more compact than that of the mausoleum capital, as it reflects influences yet relating to the Attic classicism. The failure to realize a (1:2) distribution - accordance as against the radius of the lower surface - is involved in this outlook, and does not reflect an unrealized "intention": a compact plan does not allow such a distribution. At the same time, certain aspects of the "bridge" position of the Inwood capital - between the classic and the Hellenistic clusters were revealed by the statistical analyses presented in previous studies: this capital is close to the Hellenistic "model" from Halicarnassus, by achieving the accordance with the radius of the (R:G:A/1:1:3) distribution.

the circle built on the length of the plan (façade) (Fig.12d)[60]. The idea of the central square (found at the capital of the Athenian Propylaea under the form E = ~G (see Fig. 37) is maintained under the form E = ~(G + M) (Fig. 12f).

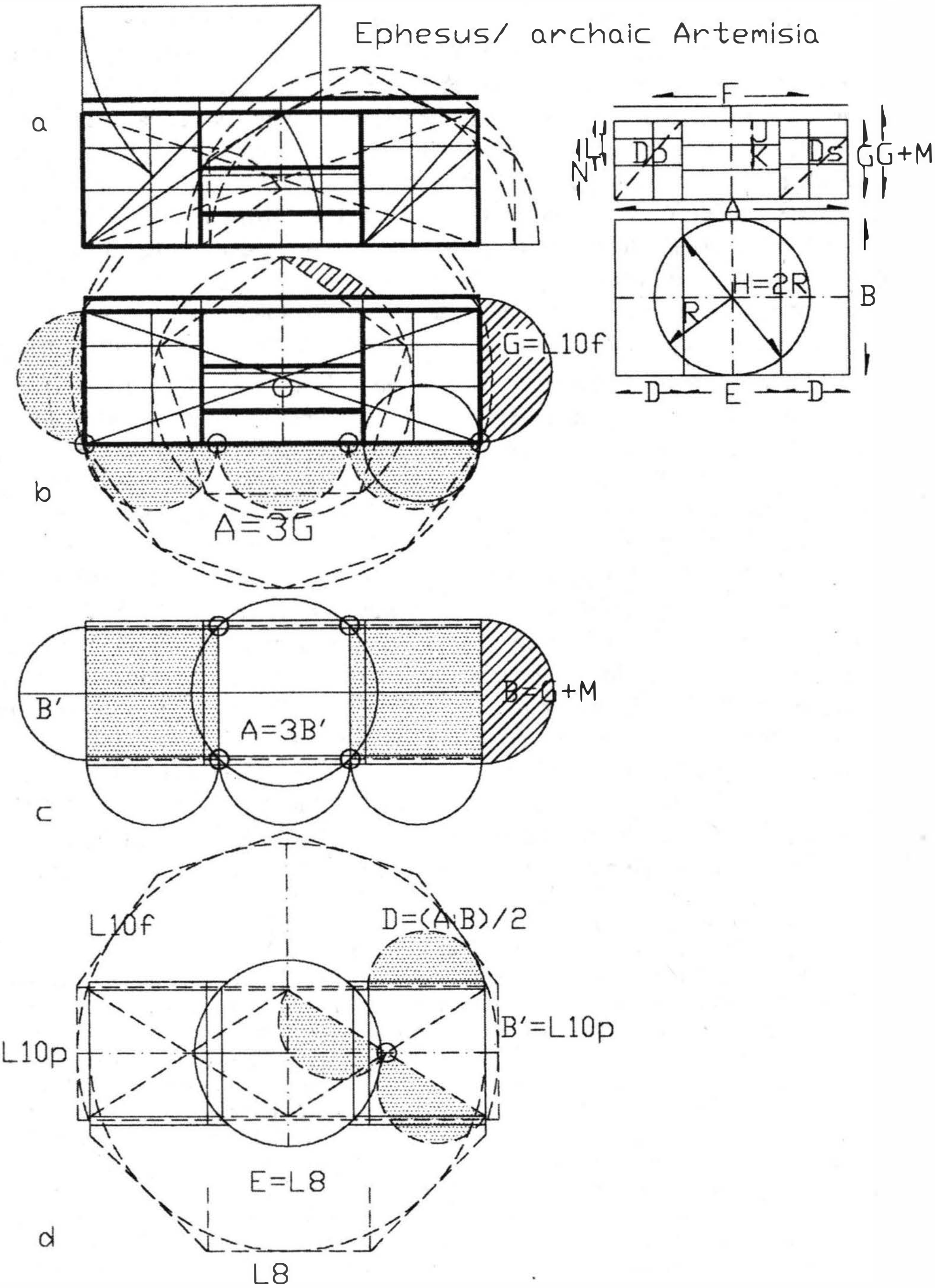

Fig. 11. The Capital of Artemisium at Ephesus (Archaic).

[60] "The square game" in the façade is more "extended" than the (1:3) distribution: there is a square, in the façade, establishing an adjustment of the 1:1 type between the distance between the volutes, and the total height of the capital; the role of the latter is not restricted to the structure of the geometric support, but seems to rule by means of the inscribed circle and of the diagonals, the decorative game of the central structure. The presence of the "central square" is not something new: among other things, we mention (taking into account that we did not have the possibility to perfprn a dimensional control) that it can be found at the capital of the Athenian Propylaea, where, however, it does not involve the height of the abacus too (taking into account the same issues we note that also other procedures analogue to those found earlier can be noticed (Fig. 25).

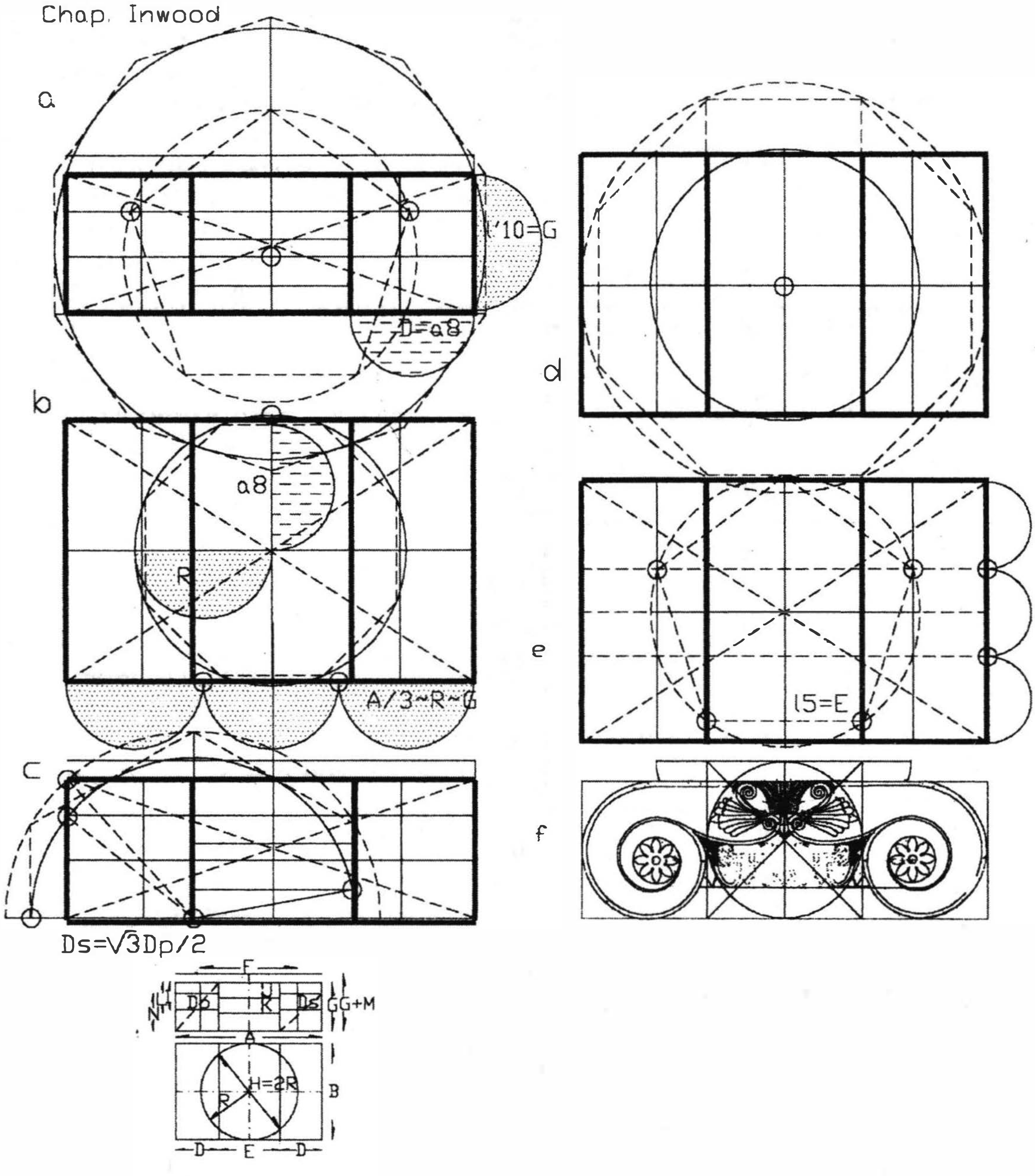

Fig. 12. The *Inwood* Capital.

2. *The Vitruvian Capital* (Fig. 13). The comparison with the pattern of the capital built according to the "Vitruvian" numbers[61] reveals, if still necessary[62], that the Vitruvian pattern is different from the Halicarnassus capital in certain characteristics of the central structure exclusively: the lower surface line coincides in this case with the line of the volute eyes; the height of the echinus – considered in the Choisy, Puchstein, Schlikker, Drerup variant[63] – shifts towards the line corresponding to the height (N)[64], while the height of the abacus is different. *The generating geometric nucleus* (Fig. 14) is identical to the Mausolueum at Halicarnassus. The ratio 1:1.618, conveyable by (8:13)[65], generates a theoretic capital

[61] That obviously are, most of them, "Pytheos numbers" (see Hoepfner; Schwandner, I); Mărgineanu-Cârstoiu, 1996-1998, p. 201, Mărgineanu-Cârstoiu, Sebe, 2000, *loc. cit.*

[62] On the whole, it reiterates the Halicarnassus/Mausoleum "paradigm": the *(1:2:3) complete type.*

[63] *Apud* P. Gros, *op.cit*, p. 166-167.

[64] According to the Hoepfner variant, the difference is minimal (Hoepfner, 1968, p. 232).

[65] The semidiagonal of the façade (A:G)/2, derived from the radius of the circle of the starred polygons, measured after the "correction" 12.94p (≈13p).

possibly described according to the (R:G:B:A:D:L) distribution as (8: 8.03: 16: 23.99: 7.03[66]: 6.07). It is clear that the pattern can be translated by (8:8:16:24:7:6), reiterating the *full 1:2:3 Halicarnassus* capital. In conclusion we might say that the geometric support defined by the Halicarnassus pattern[67], at the same time corresponding to a distribution of the elements in the façade (D:E:D) – described by the mediation of the *pars* unit, as being of the (7:10:7)[68] type or (14:20:14)[69] – represents, at least partially, what Vitruvius used to ignore of the "reason" involved in the compositional type whose simplified "formula" he conveys to us[70].

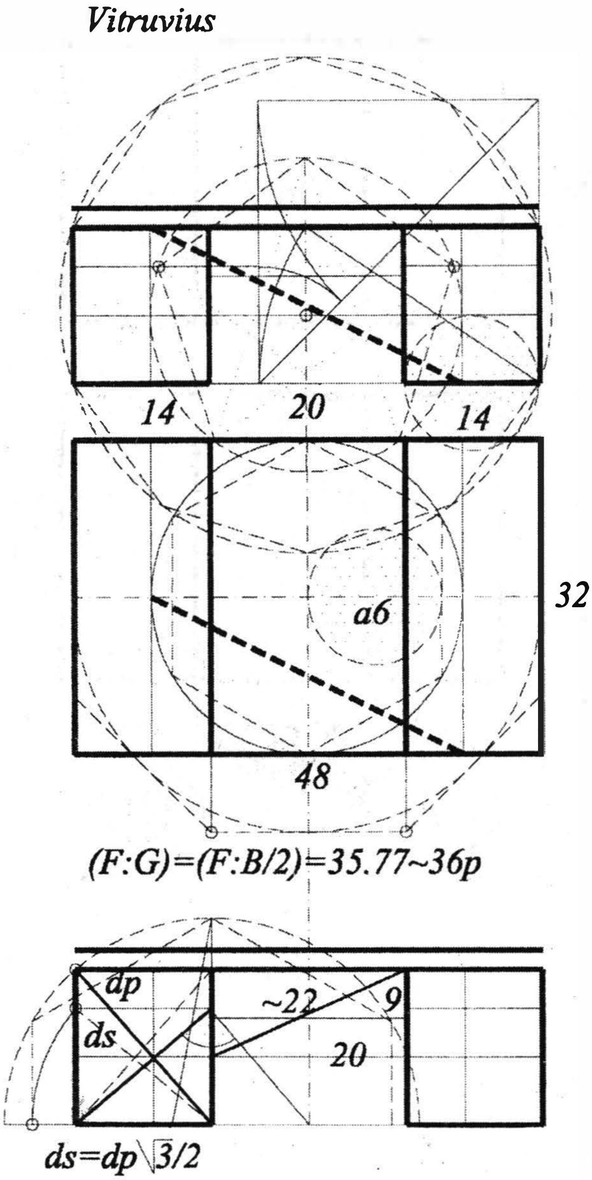

Fig. 13. The Vitruvian Capital.

[66] Depending on the apothem of the plan hexagon D = 6.928 p.

[67] Including the involved adaptation in order to make of the (R:G:B:A) distribution a (1:1:2:3) type one.

[68] Hoepfner, Schwandner, 1986, p. 194; Mărgineanu-Cârstoiu, 1996-1998, p. 201-202.

[69] According to Wesenberg, who geometrically represents the same thing (Wesenberg, apud P. Gros, *loc.cit.*)

[70] «C'est donc bien l'ensemble des éléments ioniques qui vérifie la prescription vitruvienne selon laquelle: "l'ordonnance des édifices religieux est fondée sur la "symétrie". Celle-ci naît de la "proportion", qui se dit en grec *analogia* (III, 1,1, p. 5)...ce terme d'*analogia* est à prendre au sens mathématique le plus strict. Sans doute Vitruve n'avait-il pas une compréhension très claire de la notion de proportion que lui mentionnaient ses sources. Sans doute aussi pensait-il que la *symmetria* reposait essentiellement sur la co-mesurabilité en écrivant: "la proportion consiste en la commensurabilité des composantes en toutes les parties d'un ouvrage et dans sa totalité, obtenue au moyen d'une unité déterminée qui permet le réglage des relations modulaires". Même si la "raison" lui en échappe, il n'en demeure pas moins qu'au travers des nombres vitruviens se rélève une organisation essentiellement fondée sur des rapports proportionnels» (L. Frey, *Le Projet...*, p. 157).

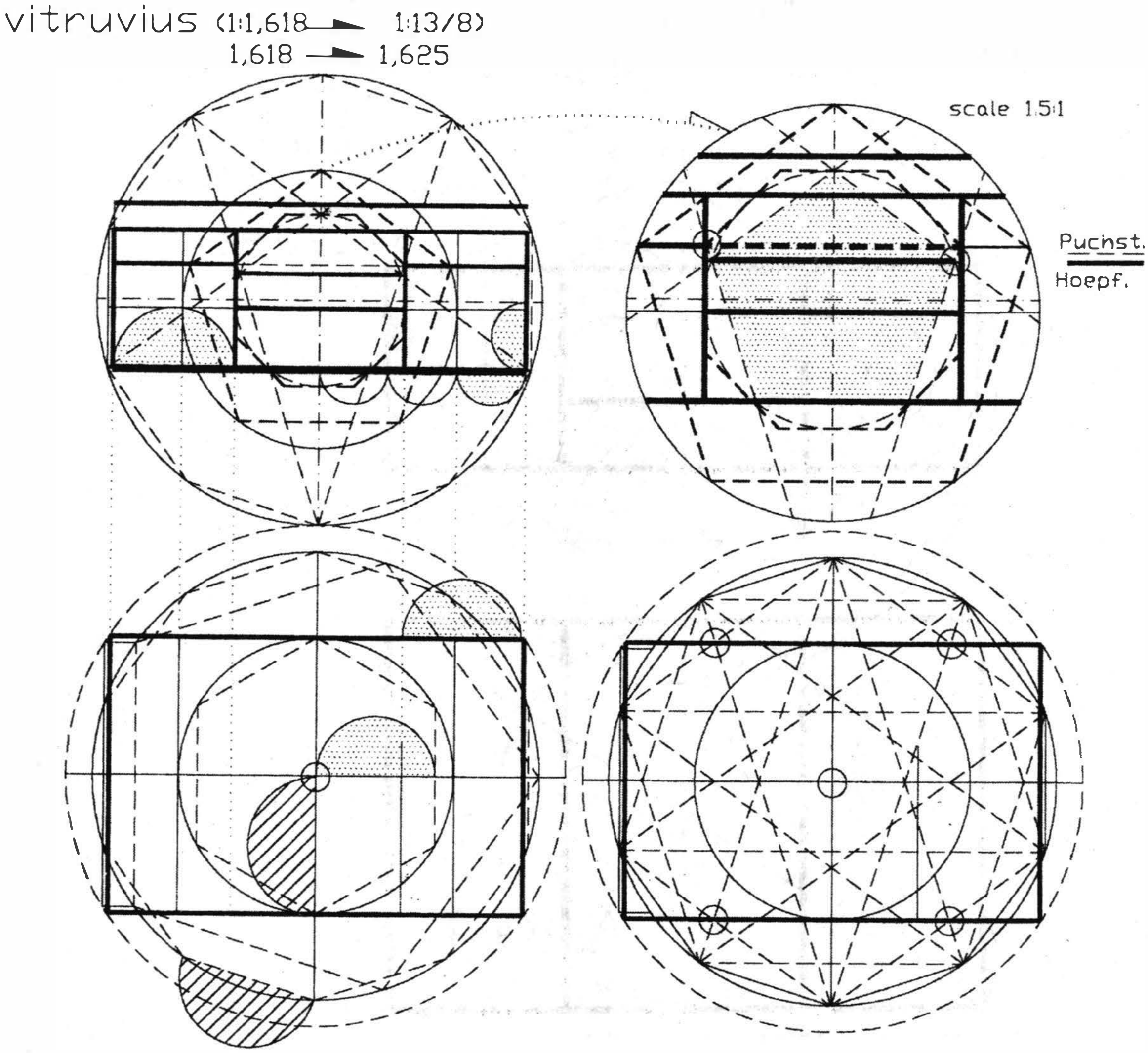

Fig. 14. The Vitruvian Capital: the generating geometric nucleus.

Other observations. The inner "commensurability"[71] is reflected also by the possibility of expressing the core pentagon apothem (= the core octogon side) by an integral (*4p*) significant for the construction of the spiral, and especially by the fact that the diagonal of the rectangle built on the volute eyes (F: G) approximates the diameter of the column base (17.9 partes for G = 8.03 partes or 17.888 p for G ≡ 8p)[72].

3. *The Capital of the Temple of Athena at Priene (Berlin Museum)* (no. 22/19) (Figs. 15-17).

a) In (Fig. 15) the geometric characteristics can be studied[73]. We note: the façade rectangle is inscribed in the decagon inscribed in the circle built on the façade diagonal (without abacus); the height (N) is settled according to the pentagon inscribed in the circle built on the line of the centres distance; the relation between the main and the secondary diagonals (Dp and Ds) of the spiral observes the Mausoleum relation. Unlike the Mausoleum capital, the centres distance is not equal to the diameter of the lower surface, and the width of the volute is equal to the apothem of the *decagon* inscribed in the lower surface circumference (Fig. 15b). The comparison with the Vitruvian capital[74] (fig15c-d) shows

[71] See *supra*, n. 70.

[72] On this subject, see also Mărgineanu-Cârstoiu, an accompaining paper, this issue.

[73] Dimensionally controlled details in Mărgineanu-Cârstoiu, 1996-1998, p. 212.

[74] All the graphic comparisons with this pattern will have as principle an overlapping of patterns of the capitals, after they were first scaled according to a common unit, in the present cases, according to (A). The overlappings were performed after the intersecting points of the diagonals of the façades (without abacus).

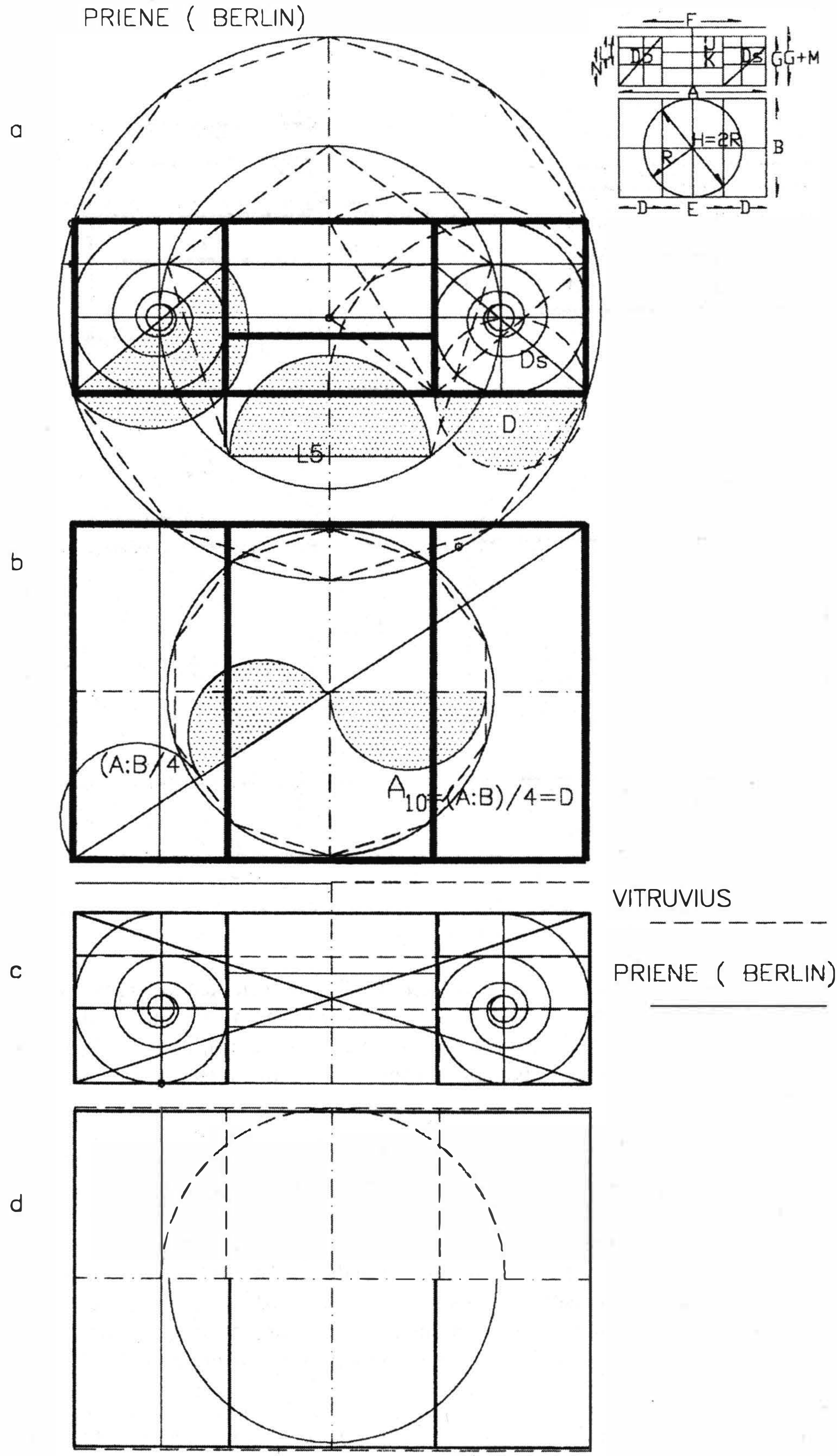

Fig. 15. The Capital of the Temple of Athena at Priene (Berlin Museum).

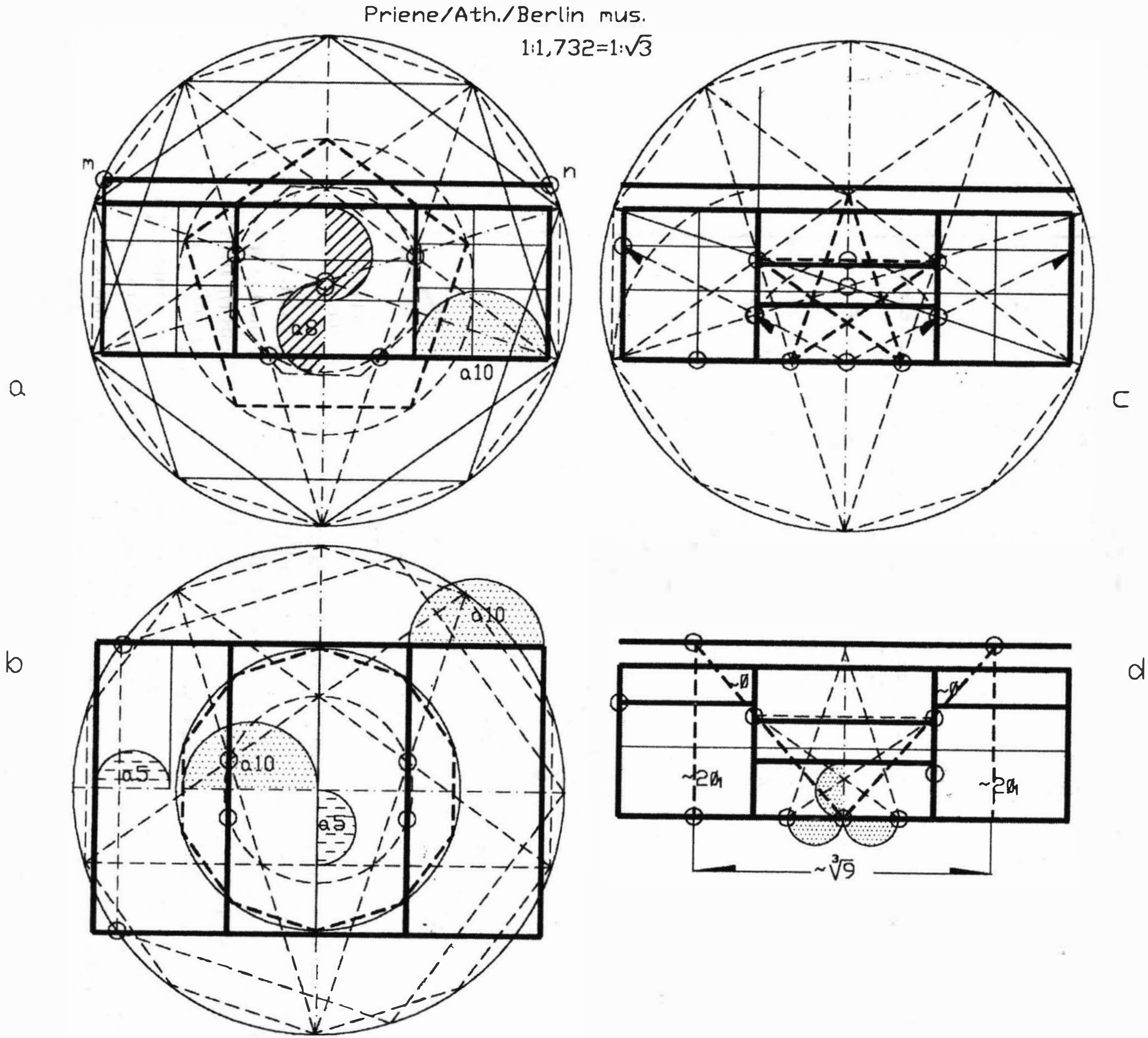

Fig. 16. The Capital of the Temple of Athena at Priene(Berlin Museum): the generating geometric nucleus.

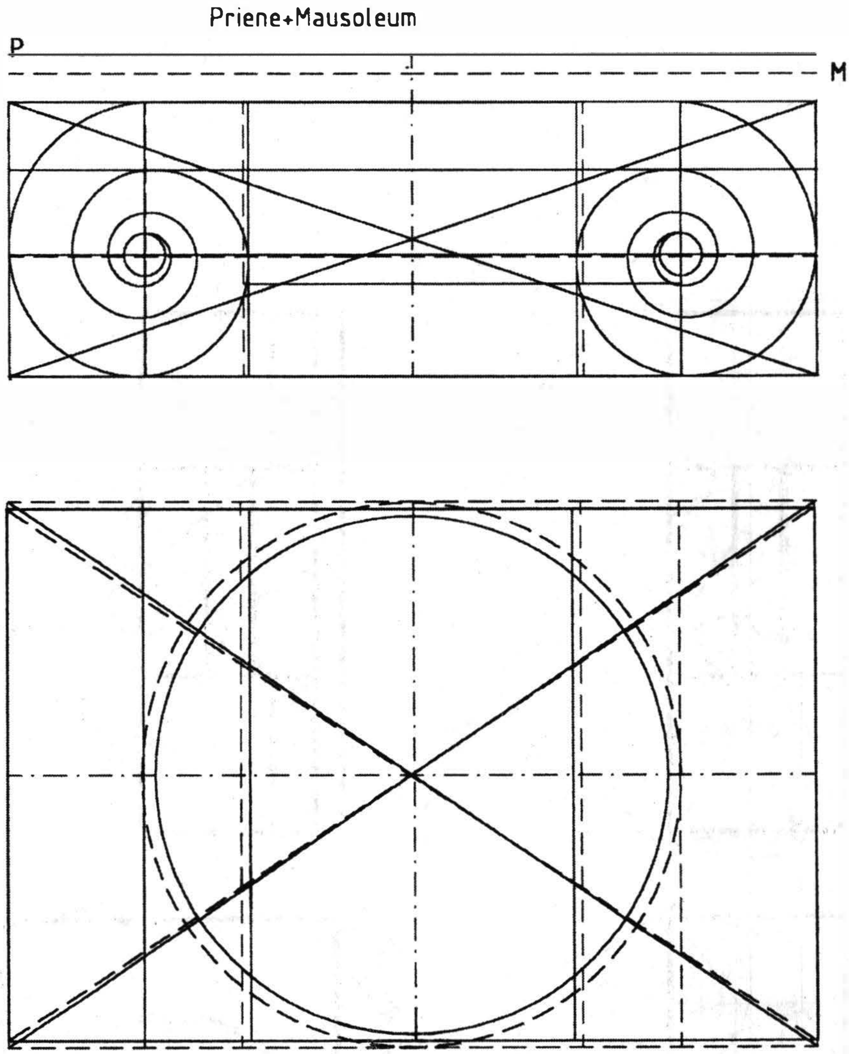

Fig. 17. Comparison between the capital of the Temple of Athena at Priene (Berlin Museum) and the capital at Halicarnassus/Mausoleum.

very small differences at the level of the distance between volutes, and the length of the cushions; instead, the aspect of the central structure is transformed (with Vitruvius), by raising the lower surface line up to the level of the eyes line, and by the difference between the heights of the echinus (in the Puchstein variant). A more important difference can be remarked at the level of the circumferences of the lower surfaces.

b) The structuring of the compositional geometry is based on the same method used for the Mausoleum at Halicarnassus (Fig. 16). The difference resides in the value of the "departing nucleus": it starts from the ratio 1:√3 between the unit-radius (of the lower surface), and the radius of the circle where the starred pentagons are inscribed. In the decagon rectangle, the decagon side is equal to the height (G) of the volute[75], but the length (A) is longer than necessary. The side of the pentagon inscribed determines the length of the cushion (B) (Fig.16.b); the height (N) is settled by the octogon circumscribed to the starred polygon core circle (Fig.16a); the position of the inner line of the volutes rectangle is settled directly by the tips of the small pentagon[76] in the starred polygons core[77] (Figs.16c-d). The width of the volute is also in this case doubly conditioned, however, being equal to the apothem of the *decagon* inscribed in the lower surface circle[78] (Fig.16b).

[75] L_{10} = 61.548 cm~61.61.3 cm = G (dif. 0.24 cm = 0.39%).

[76] Thus marking the difference between the façade distributions of this capital and the one of the Mausoleum at Halicarnassus.

[77] The difference as against the real position is 0.17 cm).

[78] Mărgineanu-Cârstoiu, 1996, 1998, p. 205.

c) *The correction (transformation) for the length of the plan and façade (A).*

In order to "restrict" length (A) as related to the basic geometric diagram, this time it was possible to act directly according to the plan (Fig. 16b) or to the façade (Fig. 16a), by performing an adaptation as against another type of relation than the Halicarnassus one: the total height (considered together with the *abacus)* is in a ratio of $1: 0.618$ as against the unit-radius ($G + M = R\varphi_1$) (Fig. 16b). Brought into the starred geometric nucleus, the upper line of the abacus determined by the height ($G + M$), crosses the generating circle into two points (m, n), which determine in their turn the side limits of the real length of the capital[79].

d) The differences between the patterns of the Mausoleum and the capitals of the Temple of Athena are graphically described also in (Fig. 17): firstly, the sizes of the lower surface differ. Less significant is the difference between the lengths of the cushions and the widths of the volutes. Within the "visible" structure, the general façade rectangle (without abacus) is practically the same, while the plan rectangle undergoes a slight compression at Priene. The more relevant novelty comes, as already mentioned, from the abacus being much higher (at Priene).

4. *The Capital no. 9/8 (Priene/London)* (Fig. 18)

a) By observing the geometric support and by a direct comparison (Fig. 18a-b), one finds essential differences, justifying the hypothesis of its emergence as an isolated experiment, remote from other items[80].

The height of the volute is equal to the side of the decagon inscribed in the circle built on the *length of the plan (façade)*[81], while the relation of the width of the volute as against the radius of the lower surface is the same with that of the Halicarnassus capital ($D=a_6$). The result is a completely distinct composition of the capitals of the (1:2:3) type represented by the Mausoleum and the Vitruvian pattern, as can be noticed also in Figs. 18c-d. In spite of that, in order to reach this most special result, one could start from a *generating geometric nucleus* analogue to the Mausoleum and Priene one (Berlin).

b) *The generating geometric nucleus.* (Fig. 19). The already known configuration is considered, except that one starts from a ratio of 1:1.75 between the unit-radius (=1=the radius of the lower surface), and the circle where the starred pentagons are inscribed.

The rectangle where the façade will be inscribed has the length settled by the horizontal diagonal of the decagon[82], the side of the decagon being, however, larger than that necessary for (G) (Fig. 19a).

In the plan, besides the length already settled, the depth (B) – as at the other Temple of Athena specimen – can remain settled by the side of the pentagon[83] (Fig.19b). The double correlation of the width of the volute results from its settling through the tips of the pentagon inscribed in the lower surface as well (Figs. 19a-c).

What remains to be "corrected' is the height of the volute (G), that includes in the configuration the value of 1.08R, at the real capital being of 1R. That can be done by a simple approximation from 1.08 to the value of 1 (possibly maintaining the upper line of the abacus settled by the pentagon inscribed in the circle of radius equal to the unit). An interesting possibility of "correcting" the height G can be seen in Figs. 19a,c-d.

c) *The Mausoleum Capital – prototype.* In spite of the essential differences between this Priene capital and the Mausoleum one, between the two specimens there is a direct link: the Priene pattern, using the starting ratio of 1:1.75, does nothing else but integrating a relation originating in the *mean and extreme ratio* :

$R_{Halic.}/R_{Priene} = 77.66\ \text{cm}/96.25\ \text{cm} = 0.80685 = 1.6137/2 \approx \varphi/2$ (or $R_{Priene}/R_{Halic} = 1.239 = 2\times0.619 \approx 2\varphi_1$). Of course, at the real capitals, this ratio undergoes a change[84]. Its result is spectacular, as the diagonal of the Priene façade is equal to four radiuses of the lower surfaces at the Halicarnassus capital[85]:

[79] This correction turns the initial length of 184.405 cm into 181.8 cm ≈ 181cm = A (diff. 0.8 cm = 0.44%). As regards the total height of the central structure, it's possible to use directly the measure of the radius of the capital at Halicarnassus/Mausoleum: $(L + M)_{Priene} = 48.1\ \text{cm} \approx R_{Halic}$ (diff. 0.1 cm).

[80] See the statistical analyses.

[81] The others have the circle built on the *diagonal* of the façade.

[82] With a difference of 0.37 cm at each corner of the decagon (therefore overall 0.74 cm = 0.65%).

[83] The side of the pentagon = 113.347 cm ≈ 113.9 cm = B (diff. 0.55 cm=0.48%).

[84] $(A{:}G)_{Priene}/(A{:}G)_{Halicarnassus} = 191.44\ \text{cm}/151.409\ \text{cm} = 1.264 = 2\times0.632$ (or vice versa, Halicarnassus/Priene = $\sqrt{10/4!}$).

[85] Both the width of the volute and the height of the central structure each equal to the Halicarnassus radius.

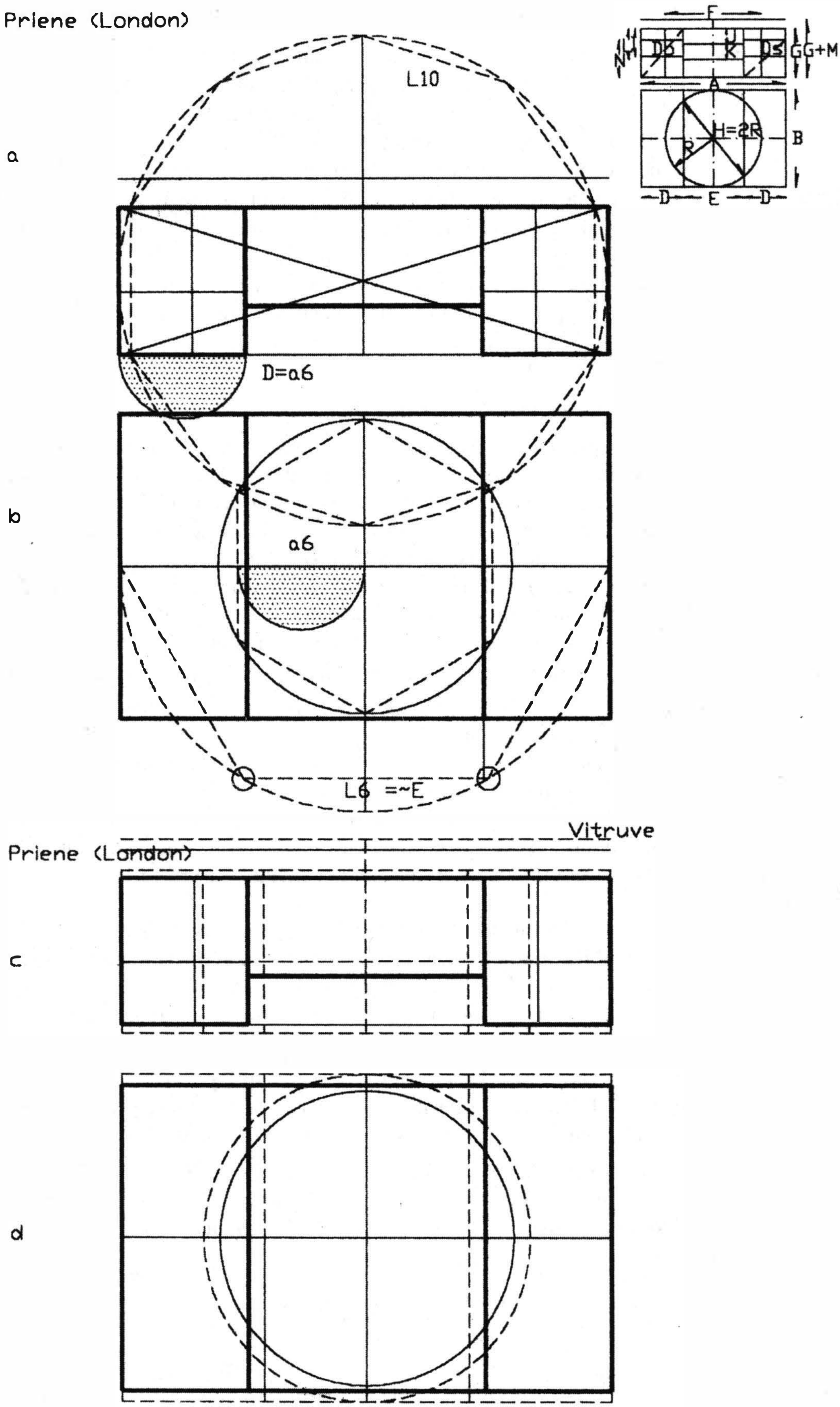

Fig. 18 . The Capital at Priene/Temple of Athena (London Museum).

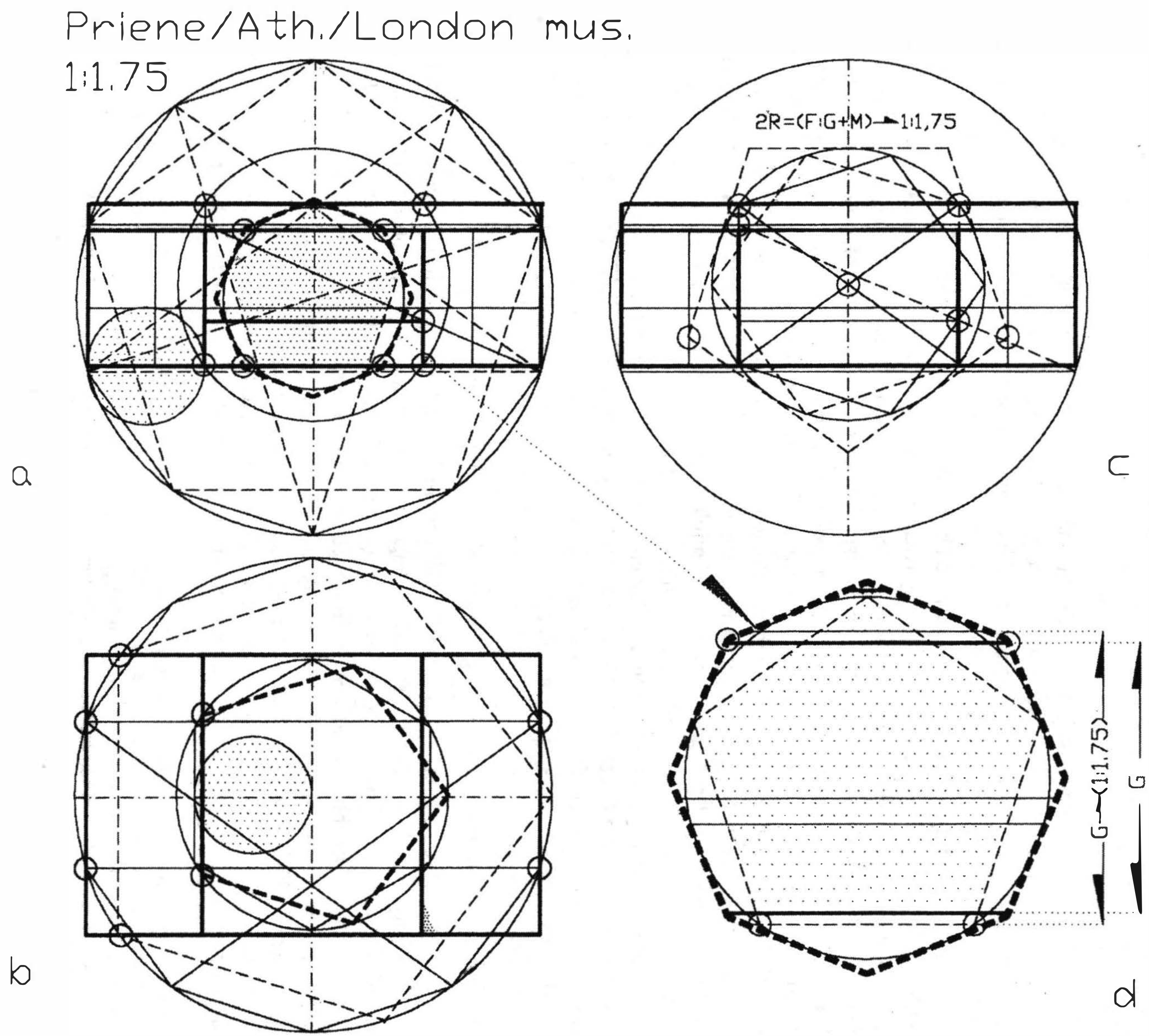

Fig. 19. The Capital at Priene/Temple of Athena (London Museum): the generating geometric nucleus.

191.44 cm/4 = 47.86 cm ≈ $F_{Halic}/2$ (diff. 0.11 cm) ≈ G. = R_{Halic} (diff. 0.14 cm)[86]. Under the circumstances, the "corrections" made at the geometric and compositional pattern at Priene, may compensate, at least partially, also for the necessity to achieve that "commensurability" mentioned later by Vitruvius: the main sizes, including those where intervenes the height of the abacus[87], are correlated to the design unit measure[88] by which can be expressed (at the Halicarnassus capital) the (1:2:3) distribution type as (8:16:24) and the (D:E:D) distribution as (7:10:7)[89], but especially to the measure unit[90] (probably used also at Halicarnassus[91]).

Other observations:

– The share of the central structure in the façade, at the two Priene capitals practically remains the same as at the Mausoleum capital (although there is a very slight increase in the height of the Berlin specimen[92]): both the capitals of the Temple of Athena have central heights adjusted as against the radius of the lower surface at the Mausoleum capital[93].

– Using a generating geometric support where all the main elements can be built starting from a single unit (radius of the lower surface in the cases discussed until now) ensures the premises of achieving what might be called the "geometric commensurability" of the parts; at the same time, once a *design unit* is established as a *whole part* of this unit, the commensurability itself can be reached, as Vitruvius must have understood it, when he refers to the *symmetria*, *proportio (analogia)*[94]. Of course, that needed sometimes dimensional roundings. In such cases, the source of some apparent differenciations between the compositions of some capitals can be the very rounding procedure, applied differently for each case.

– The fact that at the origin of the geometric support of some compositions lies a common principle such as that of the starred polygons – which we might call *generating geometric nucleus* – cannot be interpreted as the exclusive result of the conception of one and the same architect. It is very likely that such configurations belonged to the common "arsenal" by which the architectural composition used to be instrumented[95] during the Greek Age. As regards the analysed capitals, the numerous relations involving the numbers φ and φ_1, detectable in the arithmetic expressions of the geometric correlations between the various dimensional elements, are (to a large extent) geometric/arithmetic derivatives of the starred system of pentagons/decagons[96].

5. *The Capital of the Temple of Zeus/Priene* (no. 23/20) (Fig. 20).

a) The geometric support is similar to the Halicarnassus one ($G=l_{10}$), with the following differences: the relation between the main and the secondary diagonals of the spiral no longer observes the Mausoleum relation, which indicates a completely different aspect of the unfolding of the volute spiral; the width of the volute is equal to the apothem of the *octogon* inscribed in the lower surface circle (Figs.20a-b).

b) The comparison with the Vitruvian capital (Figs. 20c-d) cannot contradict the position of the capital of the Temple of Zeus in statistical analyses: the fundamental plan rectangle, and that of the façade, including the façade distribution are practically identical to the two specimens. The aspect of the central structure is closer to the Vitruvian pattern than the capital at Halicarnassus: the upper line of the

[86] See the hypothesis regarding the "entangling" of some links between the Mausoleum, Labranda and Priene capitals (where we note for instance the link $D_{Priene} \approx R_{Halic.}$) in Mărgineanu-Cârstoiu, 1996-1998, p. 213, 215-216. We mention that these relations are reciprocally valid (indifferent to the chronological order of the capitals).

[87] Whose correction (G+M) can be determinant – in the structure of the generating geometric nucleus – for the correction made at the height of the volute (G).

[88] 1u = ~6 cm (Mărgineanu-Cârstoiu, 1996, 1998, p. 201).

[89] For instance: A = 183.4 cm = 30.5u (dif. 0.4 cm); B = **19u** (diff. 0.1 cm); D = 8u (diff. 0.6 cm); E = 14.5u (diff. 0.6 cm); F = 21.5u (diff. 0.1 cm); **G + M = 11u** (diff. 0.1 cm); L + M = 8u (diff. 0.6); H = 2R = 18.333u (diff. 0.00 cm).

[90] For 1 Foot /16 = 29.44 cm/16 = 1d ≈ 1.84 cm: A = 183.4 cm = 100d (diff. 06 cm); B = 62d (diff. 0.18 cm); D = 26d (diff. 0.4 cm); F = 70d (diff. 0.1 m; G = 30d (diff. 0.3 cm); G + M = 35d (diff. 0.4 cm); H = 60d (diff. 0.4 cm); L + M ≐ 8d (diff. 0.4 cm).

[91] Mărgineanu-Cârstoiu, 1996, 1998, p. 202 (variant 1).

[92] We refer to the ratio (L+M)/A): At Priene/Berlin the ratio is 0.265, while at Priene/London 0.258, and at Halicarnassus 0.256.

[93] $(L + M)_{Priene/Londra}$ = 47.4 cm ≈ 48 cm = $R_{Halic.}$ (diff. 0.6 cm); $(L + M)_{Priene\ Berlin}$ = 48.1 cm ≈ 48 cm = $R_{Halic.}$(diff. 0.1 cm).

[94] See *supra*, n. 70.

[95] See *supra*, n. 59.

[96] See Mărgineanu-Cârstoiu, 1996-1998, p. 203, 212//n106, 214 for the Mausoleum and Priene; 220/Table 64 for the Artemisium E; 222/Fig. 36, 223/Table 67 for the capital of the Great Altar at Pergamum, etc.

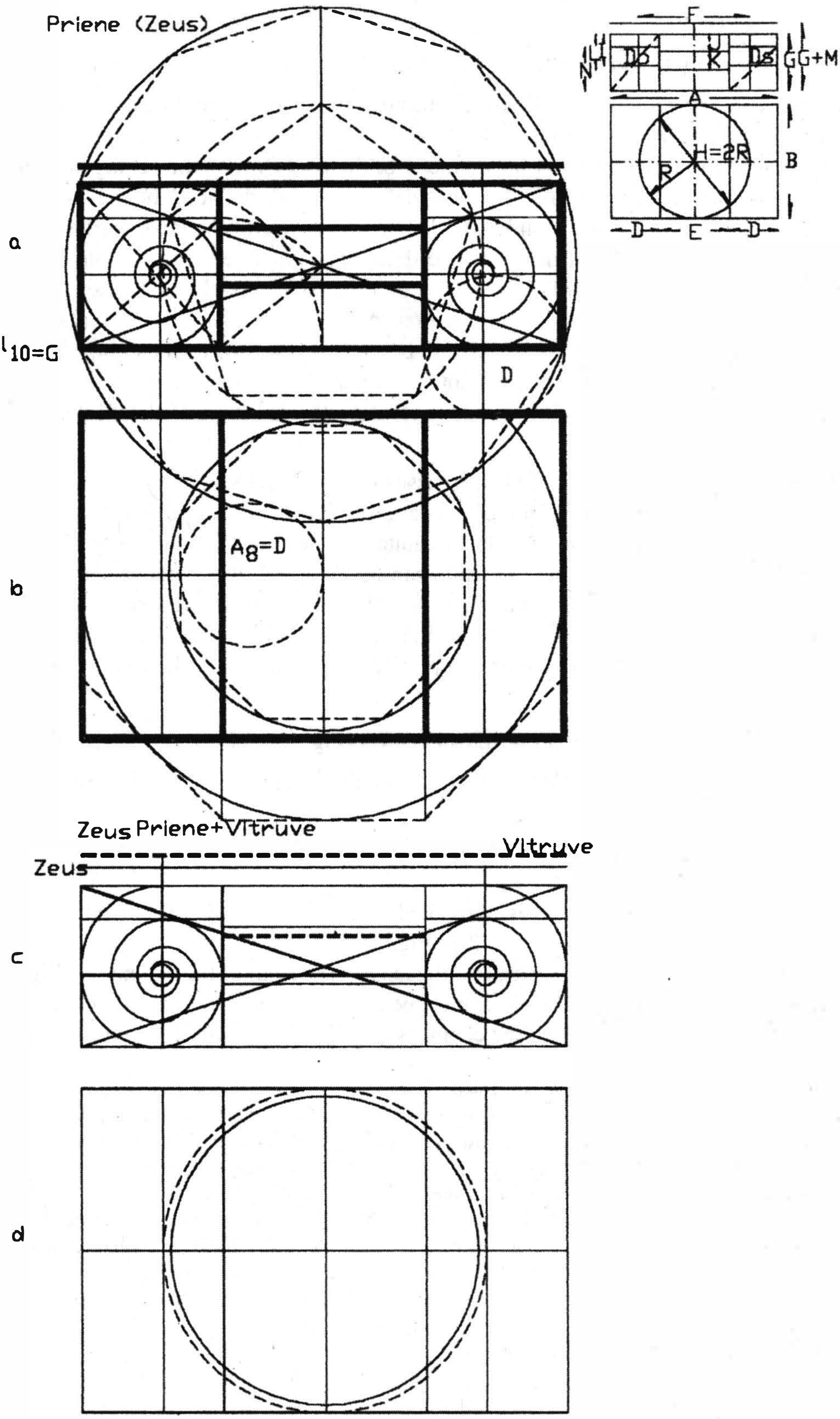

Fig. 20. The Capital at Priene/Temple of Zeus.

echinus is closer to the Vitruvian capital one – as compared with the other cases[97] – while the lower surface line is also closer to the eyes line.

6. *The Capital of the Artemisium/Magnesia ad Meandrum* (no. 11/10) (Fig. 21).

a) Similarly with the capitals of Pytheos, the façade rectangle in inscribed in the decagon (Fig. 21b). That is also the relation between the diagonals Dp and Ds of the volute. The settling of the height (N) is of the same type, with the difference that the diameter of the circle where the pentagon is inscribed, being equal to the distance of the eyes centres, is not equal also to the diameter of the lower surface[98]. The façade distribution, however, is directly linked to the circumference of the lower surface, the width of the volute being equal to the apothem of the inscribed decagon, as at Priene/the Temple of Athena (Berlin) (Fig. 21d). Following the example of the capitals at Priene, the height of the abacus is much more significant than the Halicarnassus one: its correlation to the façade element distribution is described in Fig. 21a. As it is a capital (1:2:3)[99], also the relation between the side of the octogon circumscribed to the circle built on the length of the plan is transparent, as well as the distance between the volutes (Fig. 21d), while the diagonal of the rectangle (F:G) is very close to the measure of the diameter at the column base[100] (Figs. 21a,c).

b) A comparison with the capital at Halicarnassus justifies the hypothesis of the "copy"[101] (Fig. 22); except the height (more significant) of the abacus and the *lower position of the lower surface line*, the rest of the pattern seems traced (copied) after a capital of the Mausoleum[102] (Fig. 22b). Implicitly, as regards the general assemblage, the same results can be obtained by a comparison with the Vitruvian pattern; remarkably, the height of the abacus at the Vitruvian capital preserves the Artemisium line. The important difference again proves to be in the pattern of the central structure, where the lower surface line is "raised", in the Vitruvian case, up to identification with the eyes line of the volutes[103] (Fig. 22b)

7. *The Capital of Magnesia/South Agora* (no. 68/31) (Figs. 23-24).

It is an interesting experiment, that created an *incomplete capital of the (1:2:3)* type (unadjusted to the radius of the lower surface)[104].

a) The similarities to the Mausoleum pattern are recognizable in Fig. (23a,c).

Peculiarities:

– the relation between Dp and Ds is correlated with the diagonals of the semifaçade without and with an abacus (Ds/Dp = (G : E/2)/(G +M : E/2); (Fig. 23a);

– the width of the volute is geometrically adjusted to the height of the echinus[105] (Fig. 23a);

– the diagonal (F:I) has a special significance, being equal to the diameter of the lower surface[106], as it reflects an accordance (adjustement) of the elements (F) and (I) as against the radius (Fig. 23b).

[97] Aspect valid in both variants for the Vitruvian capital.

[98] This capital is a (G:B:A) specimen of the (1:2:3) type, however without this pattern being adjusted as against the radius of the lower surface. We called it *1:2:3 incomplete type*. This composition of pattern could have been copied after the Mausoleum capital, however without taking into account this adjustment. For a hypothesis regarding the Artemisium capital – a possible copy after Halicarnassus, see also Mărgineanu-Cârstoiu, A. Sebe, 2000, p. 321.

[99] See *supra*, n. 98.

[100] The difference is of ~1%, that is ~0.5% at each corner of the diagonal.

[101] Or simply the density of the 1:2:3 model, even when the accordance with the radius of the lower surface lacks.

[102] As a matter of fact, if we overlap graphically the patterns of the two capitals (considered with real dimensions) so that the *intersections of the diagonals of the façades (A.G) may coincide*, one finds that the Artemisium capital can be simply considered a scale enlargement (by a *geometric procedure using the diagonals)* of the Mausoleum capital (Fig. 22a).

[103] In the Hoepfner variant for the height of the echinus, it is equal to the Artemesium one except that the "base" of the echinus is raised to a higher level (to the eyes line); in the Puchstein variant, the height of the echinus reaches the height (N) line, *common* to both capitals.

[104] Major reason for which it comes close to the *paradigms of this type (Halicarnassus /Vitruvius), but it is also singled out as against it.*

[105] By the diagonal (E/2 : L-K).

[106] Because (F:I) = 68.32 cm ≅ 68 cm = 2R (dif. 0.32 cm). We mention that, besides the fact that the *apothem of the hexagon inscribed in the circle of the* radius R = 34 cm, it represents an important way to integrate the radius into the compositional structure.

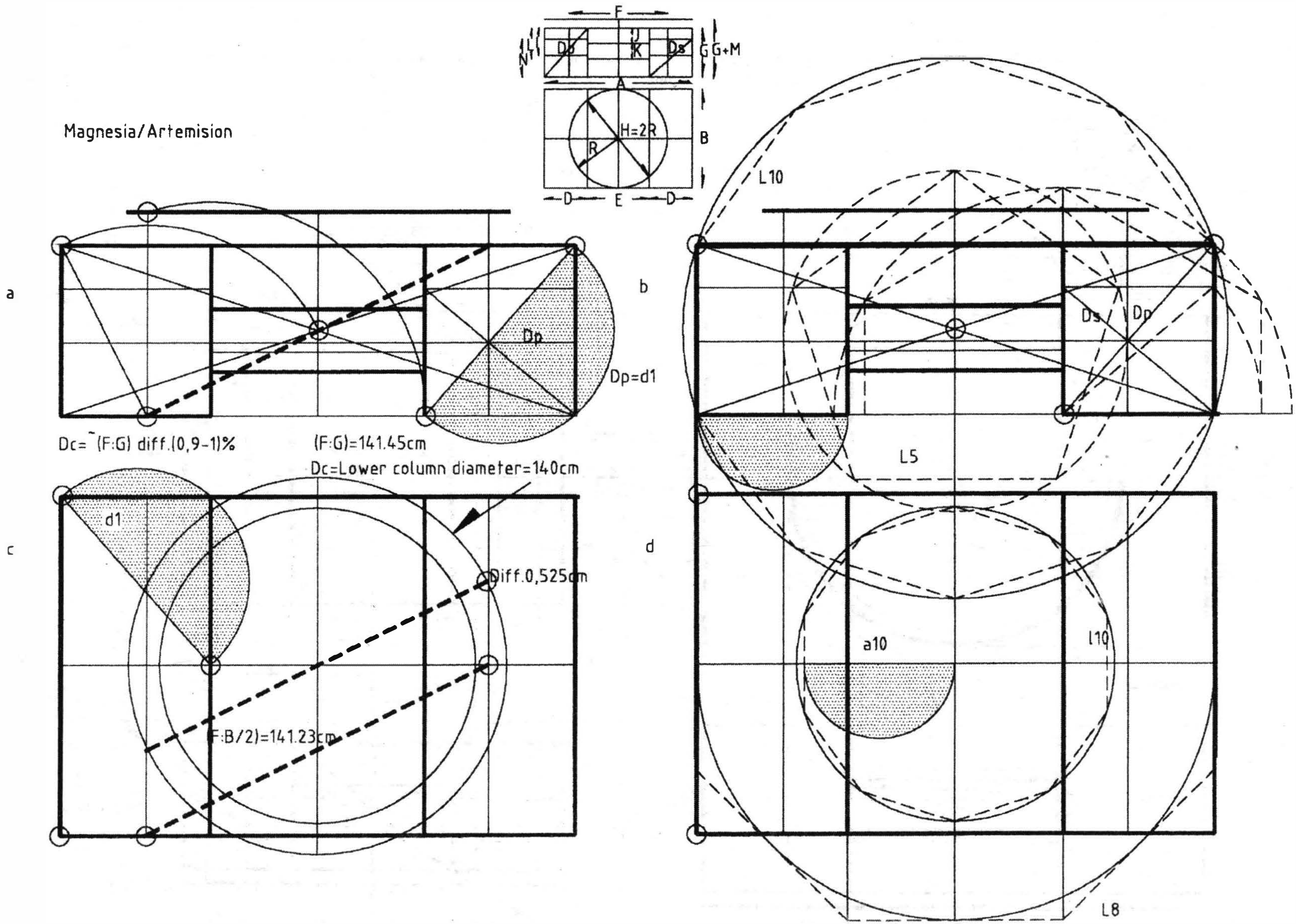

Fig. 21. The Capital of Magnesia/Artemisium.

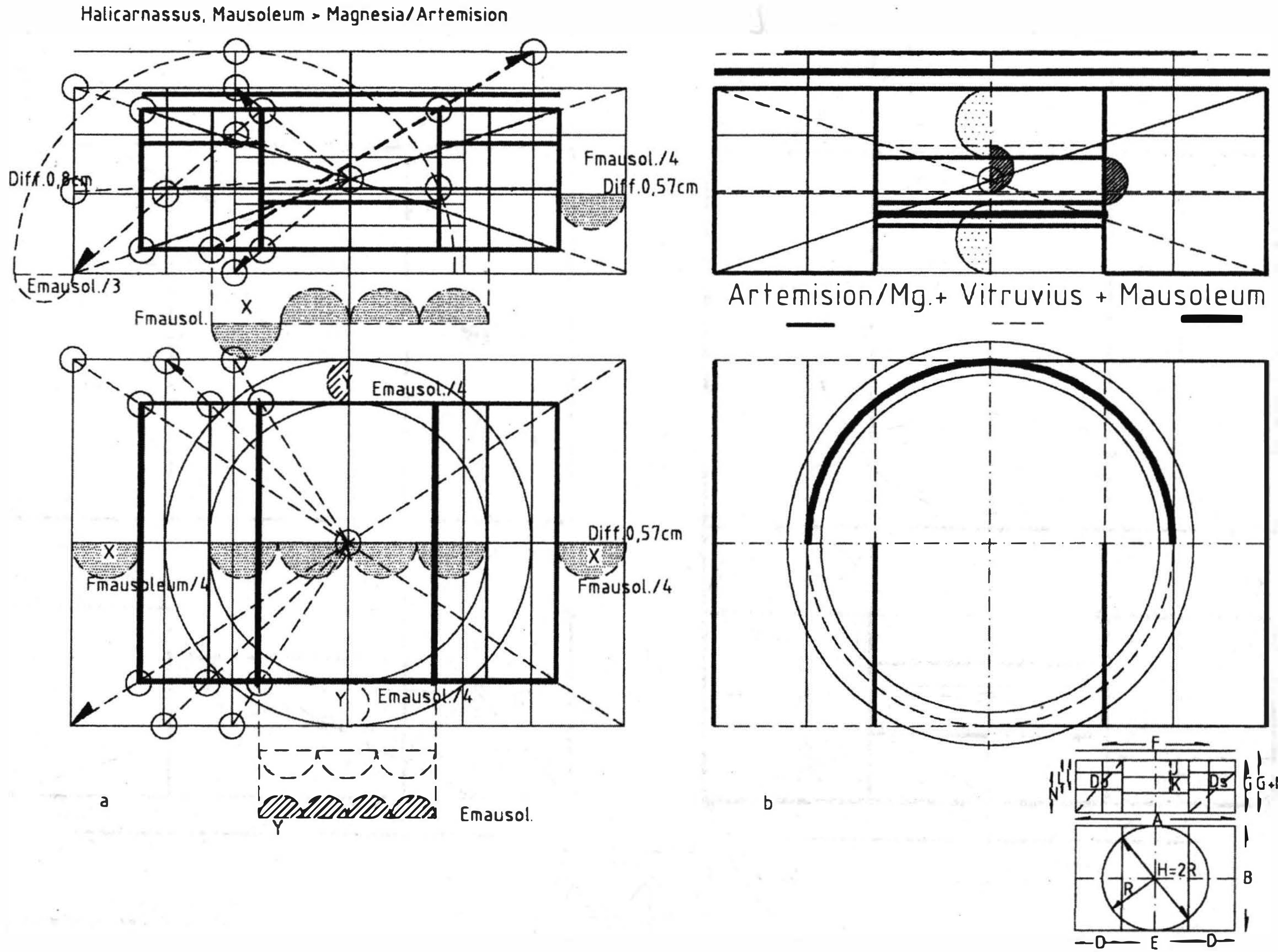

Fig. 22. The Capital of Magnesia/Artemisium:
a) scale increase – according to the diagonal – from Halicarnassus pattern (hypothesis); b) comparison with the Vitruvian pattern.

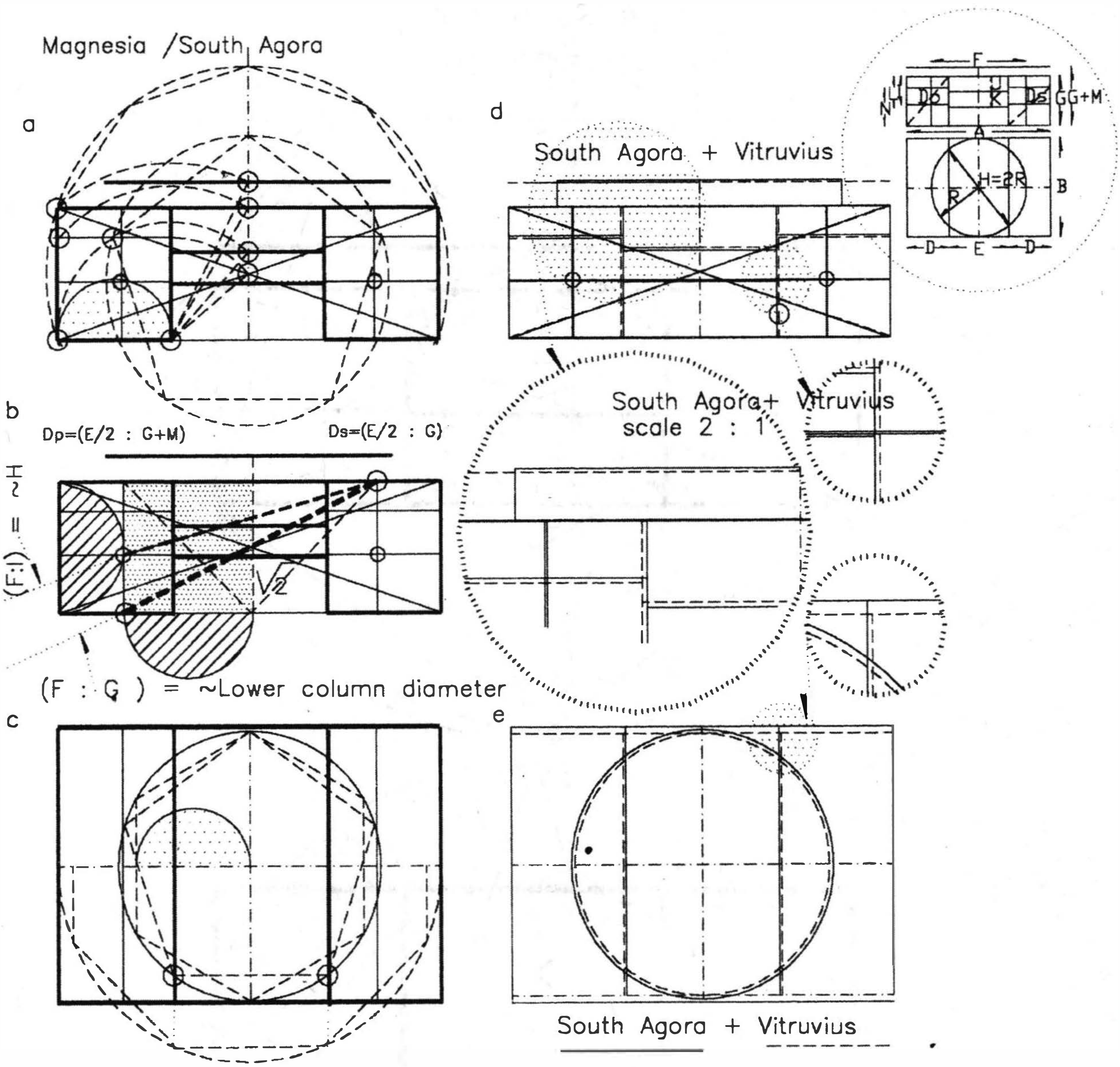

Fig. 23. The Capital of Magnesia/South Agora.

b) *The generating geometric nucleus* (Fig. 24). It is analogue to the Halicarnassus-Priene (Berlin) ones, but the (1:1.6) ratio was used[107]. Interestingly, the author of the composition *took the liberty to change the reference unit*: the starting unit *is no longer the radius of the lower surface, but the height (G) of the volute*[108]. In Fig. 24a one can notice that the small octogon circumscribed to the circle of the core[109] determines not only the distance of the volutes (thus implicitly the widths of the volutes), but also the total height of the capital (together with the abacus). In the plan, the lengths of the cushions are determined, like at Priene, by the intersections of the sides of a pentagon with those of a starred pentagon (Fig. 24b).

[107] That can be considered a more brutal approximation of the number φ (8/5 = 1.6 and 5/8 = 0.625).

[108] As according to it – and not as against the radius – the capital respects the (1:2:3) distribution. The geometric support is not, however, "neutral" or "freed" by the radius (see *supra*, n. 106).

[109] It is the circle where is inscribed the pentagon formed in the centre of the starred pentagons.

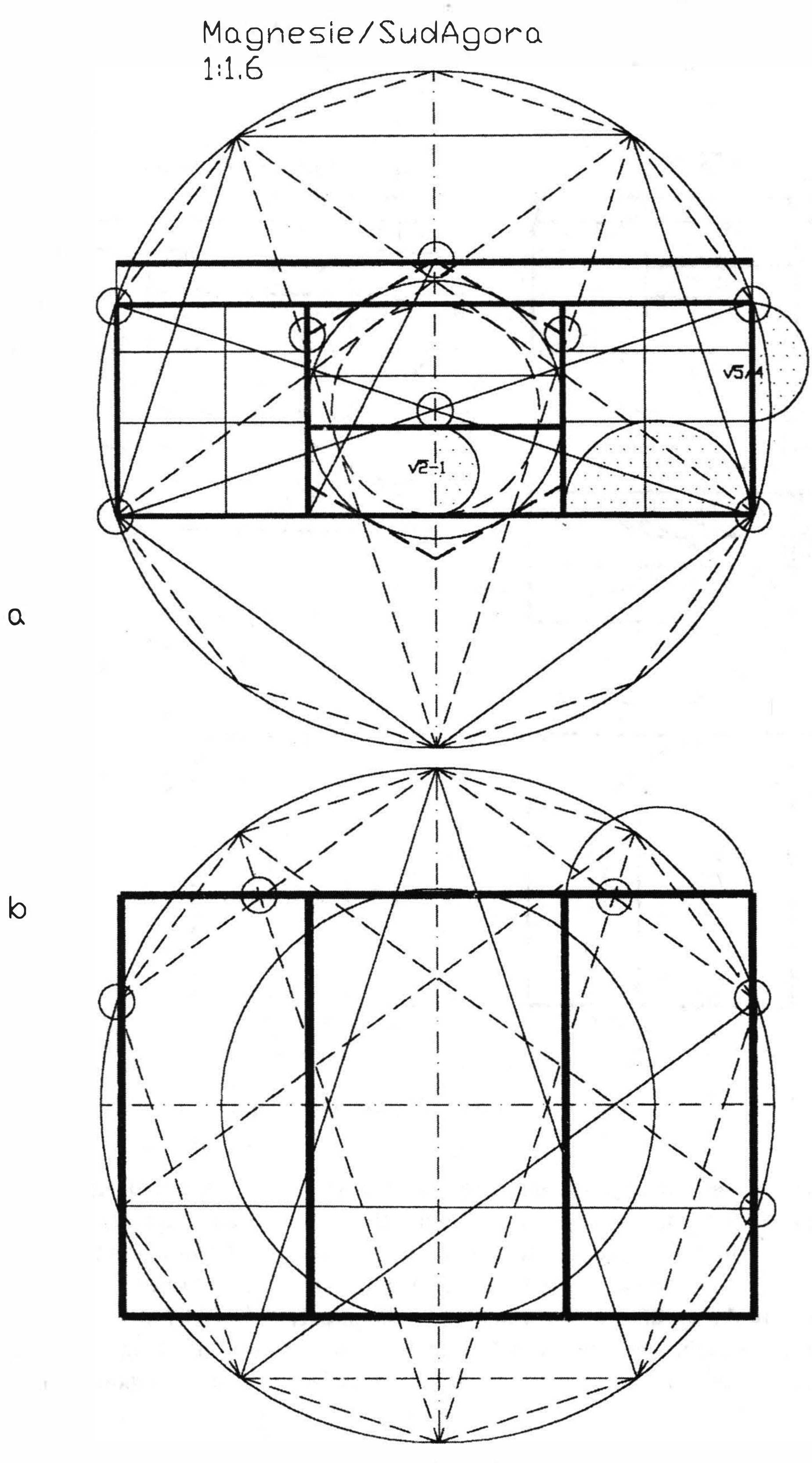

Fig. 24. The Capital of Magnesia/South Agora:
the generating geometric nucleus.

Corrections: as the length (A) resulted as longer (3.04G)[110] than the necessary one (corresponding to the real capital) it was obviously adjusted according to the diagonal (G + M : E/2); the height of the volute proved to be close enough to the real one (0.9889G)[111].

Realizing the commensurability (hypothesis): the issue is finding out a unit likely to express coherently the (1:2:3) distribution according to (G), and likely to be in accordance also with an "explicit" measure unit. Consequently, we cannot expect this (pars?) unit to be accorded by an integral both as against the radius of the lower surface and as against the elements (1:2:3).

Variant 1. Excellent and simple, it was proposed by Hoepfner[112]. This variant, however, instead of making the accord as against the starting unit, in our case (G), makes it against the width of the volute (D). This apparent disadvantage can be annulled by the fact that, in reality, this variant reflects the realization of an adjustment between the geometric support and the measure unit, integrating also the radius: *the apothem of the hexagon inscribed* in the radius circle 34 cm (=R), is equal to 29.44 cm, that is exactly the value of the measure unit proposed by Hoepfner (left side of Table 1).

Variant 2. It would be useful to present also a variant likely to express the basic characteristic of the generating geometric support, that is the ratio (1:1.6) according to the geometric "unit" (G)[113] (right side of Table 1).

1u = (1.6G)/16 = 52.8 cm/16 = 3.3 cm. The accordance as against the measure unit can be realized if we consider the measure of 52.8 cm (≈52,5 cm) as Cubit of a Ionian foot [35.2 cm (≈35 cm)]

Table 1

	1u ≈ 3.3 cm					1d ≈ 2.2 cm			
	Dimens. cm	Dimens. 1u	Control cm	Diff. cm		Dimens. cm	Dimens. 1d	Control cm	Diff. cm
A	99.1	**30**	99	0.1	A	99.1	45	99	0.1
B	66.1	**20**	66	0.1	B	66.1	30	66	0.1
D	29.5	**9**	29.7	0.2	D	29.5	13.5	29.7	0.2
E	40	**12**	39.6	0.4	E	40	18	39.6	0.4
F	65.8	**20**	66	0.2	F	65.8	30	66	0.2
G	33	**10**	33	0.0	G	33	15	33	0.0
H	68	20.5	67.65	0.35	H	68	31	68.2	0.2
I	18.9	5.75	18.97	0.07	I	18.9	8.5	18.7	0.2
L	19.2	6 5.75	19.8 18.97	0.6 0.2	L	19.2	8.5 8.75	18.7 19.25	0.5 0.05
G+M	39.5	12	39.6	0.1	L+M	39.5	18	39.6	0.1
N	25.6	7.75	25.57	0.02	N	25.6	11.5	25.3	0.3
cII cIII cIV	16.7 14.7 12.9	5 4.5 4	16.5 18.85 13.2	0.2 0.15 0.3	CII CIII CIV	16.7 14.7 12.9	7.5 6.5 6	16.5 14.3 13.2	0.2 0.4 0.3
Hc	75-80	23	75.9 79.2		Hc	75-80	36	79.2	

Observations. The flow of ideas resulting from this conjecture, is surprising: the author of the design achieved a façade distribution of the (9 : 12 : 9) type, equivalent to (3 : 4 : 3)! Namely, he tried to "accord" the Mausoleum prototype (that is a composition of the 1:2:3 type) with a façade distribution usual in more

[110] That is with a difference – as against the real capital – of 0.65 cm at each corner of the decagon.

[111] That is, 32.6337 cm (diff.0.36 cm). If we consider the difference too great (*in this case*, as the measure (G) represents the *unit =1)*, one can apply a correction that makes the height of the volute eyes (I) reach in ratio √5/4 as against (G), and the segment determining the position of the lower surface line be in a realtion originating in the harmonic ratio as against the unit [(√2-1)G].

[112] Hoepfner, 1968, p. 228.

[113] On the geometric nature, at least in some cases, of the design unit, see Mărgineanu-Cârstoiu, 1996-1998; Mărgineanu-Cârstoiu, A. Sebe, 2000, p. 316, Fig.18; p. 318, Fig. 20; p. 320, Fig. 22; p. 322, Fig. 23; p. 327, Fig. 27, Idem, Mărgineanu-Cârstoiu, *2000b*, p. 170-171, tab. 4-5; p. 173, Fig.1. As, in this case, the unit (G) "replaced" in geometry the radius-unit, rather a division by 8 must have been involved, but we considered it too great as against the dimensions of the capital.

ancient times. The two distribution types not being geometrically compatible, he realized the most interesting *incomplete (1:2:3) type*, replacing in the internal geometry the role of the *radius*-unit with the *height of the volute*-unit. In order to integrate the radius into the geometric support he used, however, also a relation characteristic of the *(1 : 2 : 3) complete paradigm* (Halicarnassus/Vitruvius), connecting the width of the volute as against the apothem of the inscribed hexagon[114].

c) The differences as against the Vitruvian capital can be read in (Figs. 23d-e): being of the (1:2:3) *incomplete type,* it is natural for the differences to be recorded in the largenesses of the lower surfaces and in the widths of the volutes (implicitly in the distances between them). The lower surfaces lines are extremely close[115]. However, as a whole, the differences between the two capitals are small enough not to make transparent at all the difference – substantial at the level of ideas – between the two capitals[116], so clearly emphasized by the analysis of the geometric support.

In order to suggest the dimensional nature of the differences between the two capitals[117], after the Vitruvian pattern was brought to the scale of the capital of Magnesia (scaling according to the length of the façade), the following differences are obtained: between the radiuses of the lower surfaces 1.105 cm; between the widths of the volutes 0.5 cm; between the widths of the tangents after the unfolding of the spiral (N) 0.8 cm; between the lower surfaces lines 0.63 cm, and between the eyes lines 0.16 cm.

8. *The Capital of the Stoa of Attalos* (no. 67/30) (Fig. 25).

All the statistical analyses point to this capital as the closest to the Vitruvian pattern of the Hellenistic capitals: indeed, as regards the aspect itself the two capitals are practically identical (Fig. 25c). The same goes for the central structure: both have the lower surface line identical to the eyes line; in the Puchstein variant for the height of the Vitruvian echinus, the identity extends to the central structure as well[118]. In spite of that, in the configuration of the geometric support there is an important difference, that, however, does not explicitly "propagate" to the exterior of the plastic body ; it derives from the different relation as against the radius of the lower surface[119] (Fig. 25d): the width of the volute is equal to the apothem of the *pentagon* inscribed in the circle of the lower surface (Fig. 25b)[120].

9. The comparison between the *Vitruvian capital* with the capital of the *Hypostyle Hall* at Delos (no. 25/26) and with the *votive capital at Olympia* (no. 18/16) (Figs. 26-27).

a) *The Capital of the Hypostyle Hall* (Fig. 26), although it has no spirals, has a composition close to the Vitruvian pattern (Figs. 26a-b). If in the façade rectangle there are slight differenciations (the only significant one being at the height of the abacus), the plan rectangle, as considered at the lower level of the cushions, is identical to the Vitruvian one (Figs. 26c-d); however, there is a difference between the diameters of the lower surfaces.

b) The differences of the geometric support of the capital at *Olympia* (Fig. 27) as against the Vitruvian pattern, as regards the fundamental façade and plan rectangles of (including the D/E/D) distribution, are insignificant (Fig. 27a,c). The relevant differences refer to the heights of the abacuses, and to the circumferences of the lower surfaces (Figs. 27b,d): that means that the height of the volute as against the radius of this lower surface will be related to the apothem of the inscribed *pentagon*.

[114] In the Hoepfner variant, the distribution appears as (8 : 11 : 8) equivalent to (3 : 4 : 3). As general data, it results that a distribution described as (8:11:8) originates in (3:4:3).

[115] By that the Agora capital marks an important step towards "coming close" to the Vitruvian pattern.

[116] Naturally, the statistical analyses, using *exterior variables*, cannot reveal these things. They have placed the capital in a subgroup at a very close degree of similarity as against the Vitruvian specimen, failing to suggest the nature of the transformations undergone in the intimacy of the compositional outlook.

[117] By this particular example we wish in fact to make more transparent the fineness of the compositional movements often singling out the capitals studied here.

[118] In the Hoepfner variant, the height of the echinus is smaller than that of the capital of the *Stoa of Attalos*.

[119] Also this capital represents the (1:2:3) *incomplete pattern* (unadjusted to the radius of the lower surface).

[120] Analogue to the capital at South Agora/Magnesia.

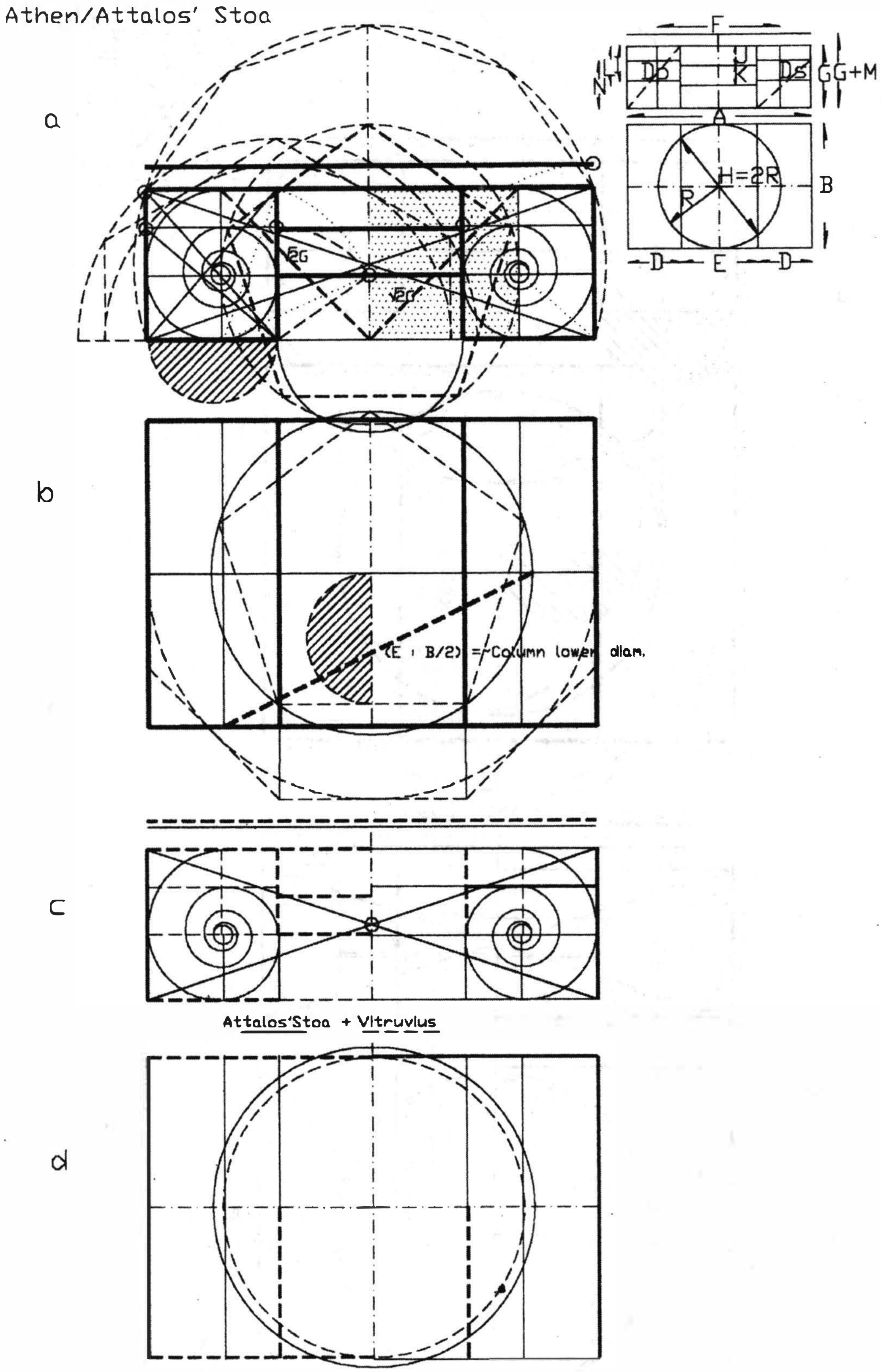

Fig. 25. The Capital of the Stoa of Attalos/Athena.

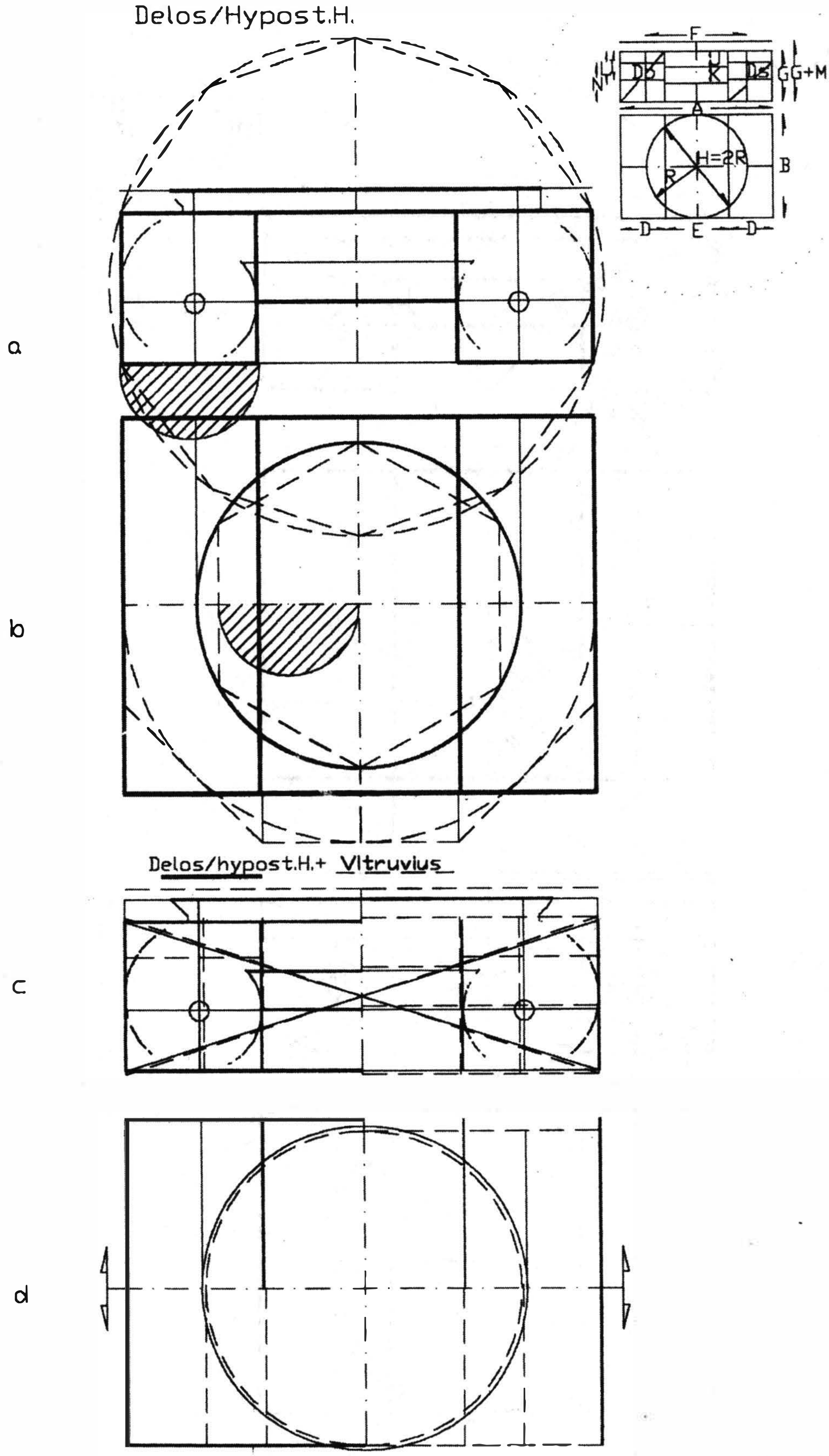

Fig. 26. The Capital of the hypostyle Hall/Delos.

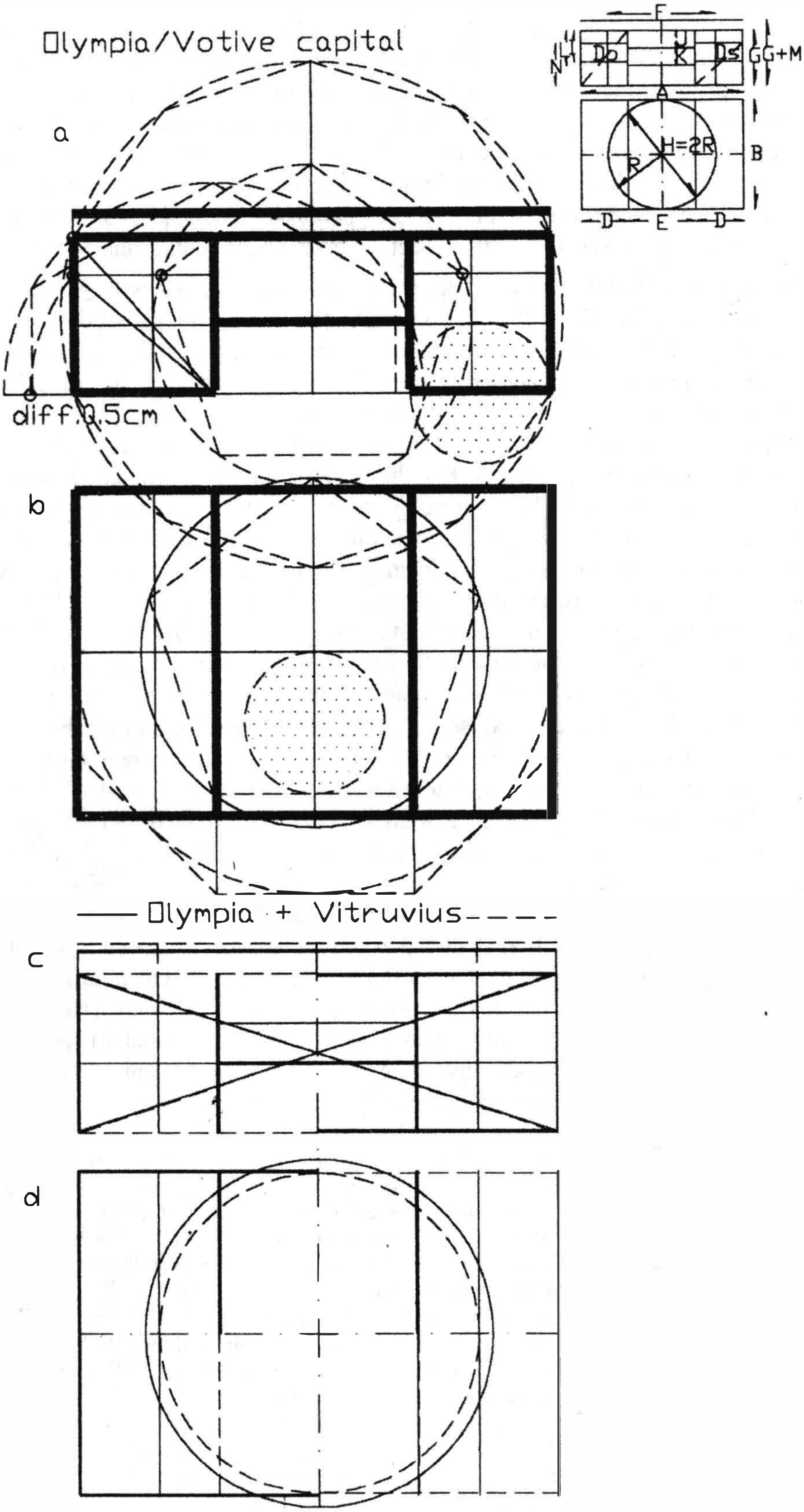

Fig. 27. The Votive Capital at Olympia.

10. *A capital of the Great Altar at Pergamum* (no. 12/11) (Figs. 28-29).

a) The elements responsible for the relative isolation of this capital from the other items along the Halicarnassus-Vitruvius line of descents reflected in the *NMDS/Minimal Tree*, refer above all to the layout of the central structure (including the height of the abacus), and to the much more prolonged plan, as the circumference of the lower surface is itself proportionally, more restricted Figs. 28c-d. These differenciations are a direct reflection of the realization of a totally particular type of distribution, containing "traditional" elements of the 1:2:3 type, but they intermingle in a peculiar way. Thus, while in the façade is realized (approximately[121]) a (G:F:A) distribution of the (1:2:3) type[122], but *incomplete*, the plan reflects a (R: B) distribution of the (1:2) type, however, failing to respect the (1:3) adjustment as related to the length (A).

b) The isolation of the capital from the "Halicarnassus" family[123] is based on the particular use of the *generating geometric nucleus* (Fig. 29). The starting ratio for the construction of the circle of the starred polygons is (1:1.6), the radius of the lower surfaces being the unit (=1). The side of the inscribed decagon will no longer represent the façade rectangle (Fig. 29b), but the *circumscribed* decagon and the *circumscribed octogon* will settle by its tips the depth and the length of the plan (Fig.29a); the façade rectangle is determined by the same decagon *circumscribed* to the circle, while the upper line of the abacus is settled by the *circumscribed* octogon (Fig. 29d). The diameter of the circle circumscribed to the octogon[124] of the "core" (of the *inscribed* starred pentagon) settles the distance between the volutes (accorded also by the apothem of the decagon inscribed in the lower surface (Figs. 29c)); the circle built on the side of the circumscribed decagon (considered as radius) settles the distance of the centres: the pentagon inscribed in this circle, reproduced in the façade, settles the height (N)[125]. If in the small core-pentagon we build also a starred pentagon, one can obtain the position of the eyes line[126], etc.

c) No matter how innovative is the introduction of the *circumscribed* polygons in the handling of the starred generating nucleus, it is far from being an innovation of the author of the capital at Pergamum[127]. Looking into the statistical analyses, we find the *Cluster Analysis* applied to the Hellenistic capitals (Fig. 5) indicates the capital of the Great Altar in a relation of a certain similarity as compared with the Artemisium at Ephesus. As it is completely foreign to the "Halicarnassus" cluster[128], we might find inside the geometric pattern some procedures used at Pergamum. Indeed, in the hypothesis presented in (Fig. 30) it is possible to observe how, by using the starred generating nucleus, based here on the ratio 1:1.66 (when the radius of the lower surface = the unit = 1), the *capital of the Hellenistic Artemisium can be built*: the length of the façade and of the plan results as the length of the rectangle of the *inscribed* decagon. Nevertheless, the height (G) can be deduced exactly like in the Pergamum case, being settled by the *circumscribed* decagon. The length of the cushion[129] and the distance (E)[130] are settled with intersections or with the tips of the convex or starred *pentagons*. A direct comparison of the two capitals (Fig. 30c) proves that the differences involve increases almost proportional to the difference of the radiuses, between the widths of the volutes (involving distinct types of façade distributions), and their heights. Surprisingly, the plan is more compact at the Pergamum capital.

[121] A/3=F/2≅G (Mărgineanu-Cârstoiu, 1996-1998, p. 262-265).

[122] The corresponding geometric support is obviously analogue to the traditional one, with the mention that the relation between the width of the volute and the lower surface is of the type of the Temple of Athena at Priene (no. 22), and not of the Halicarnassus type: the width of thc volute is determined by the apothem of the inscribed *decagon*. One can remark the use of the same relation between the secondary diagonal Ds and the diagonal (G: E/2) like that found at the South Agora capital.

[123] See the Cluster Analysis (Fig.5); The isolated position is much more pronounced in the analyses carried out with the capitals from the Archaic Age to the Hellenistic Age (Mărgineanu-Cârstoiu, 1990, p.180, Fig. 1; Idem 1997, p. 186-187, Figs. 4-5).

[124] Or to any regulated polygons circumscribed to the same circle.

[125] The side of the *circumscribed* octogon settles itself the distance between volutes (by the intersecting points of the long sides of the plan with the vertical line of the rectangle of the decagon). The level of the differences between this theoretical pattern and the real capital is: 0.03 cm for (G); 0.05 cm for (A); 0.0 cm for (E); 0.0 cm for (F).

[126] Some capitals of the Pergamian Altar have differences between the positions of the eyes line (max. 0.5 cm) and the height of the central structure (L) (max.0.4 cm). (Mărgineanu-Cârstoiu, 1996-1998, p. 221).

[127] See also Mărgineanu-Cârstoiu, 2000a, *passim*.

[128] The capital is found in the area of classic influence, giving also the legacy of some of the geometric and compositional procedures.

[129] At the lower part.

[130] Which is correlated to the apothem of the decagon inscribed in the lower surface.

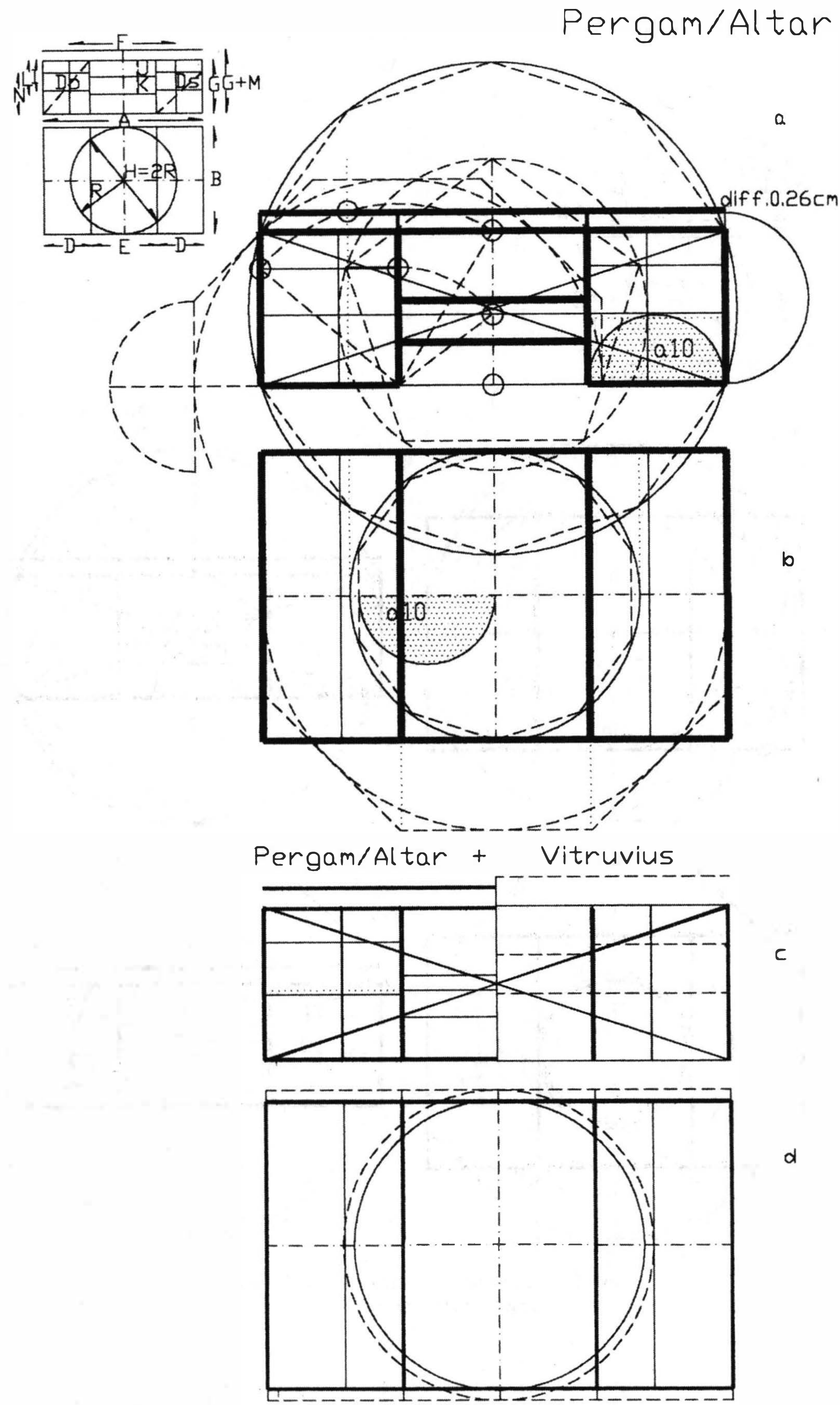

Fig. 28. The Capital of the Great Altar at Pergamum.

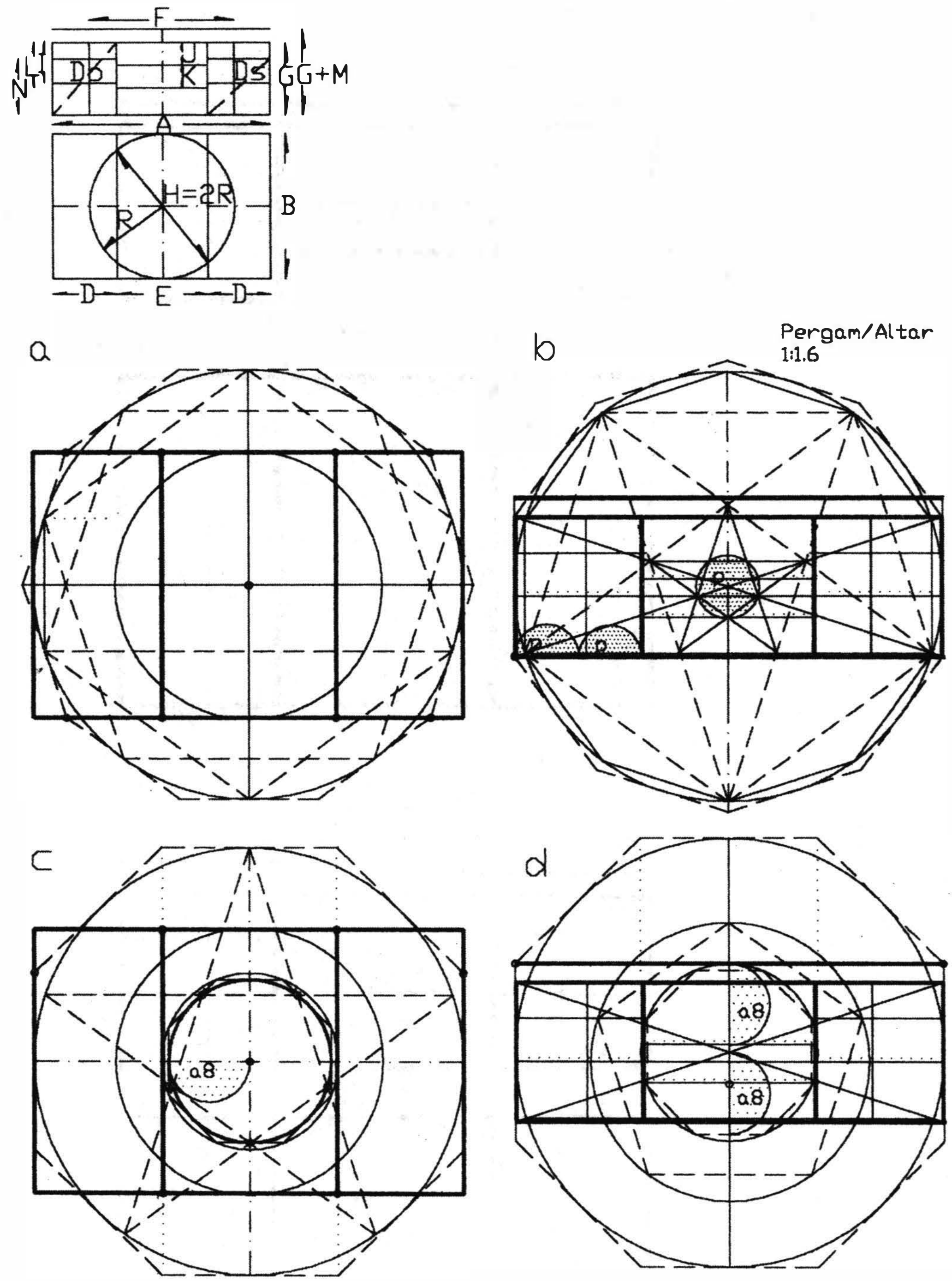

Fig. 29. The Capital of the Great Altar at Pergamum:
the generating geometric nucleus.

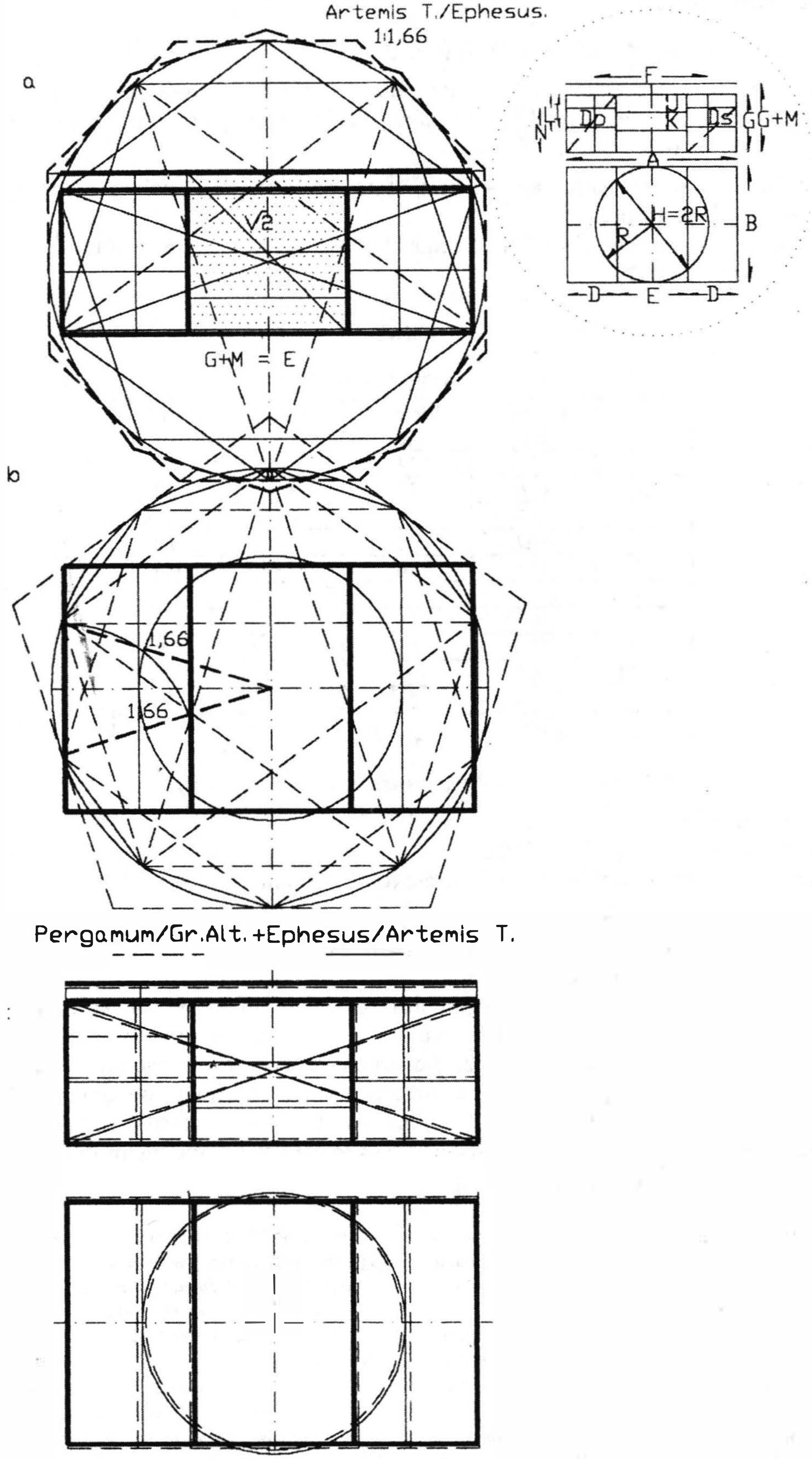

Fig. 30. The Capital of the Artemisium "E"/Ephesus:
the generating geometric nucleus.

ROMAN CAPITALS

1. *The Capital no. 66 (Aphrodisias / T-4)* (Fig. 31).

a) The geometric support of the capital of the Temple at Aphrodisias is identical to the one underlining the Vitruvian composition[131]. The direct graphic overlapping undoubtedly emphasizes the same reality.[132] (Figs. 30a-b)

b) Being above all a "Vitruvian" capital, it is interesting to analyse some aspects of the "*commensurability*"[133] of the parts.

Hypothesis : if we consider a (*pars* ?) unit equal to $l_6/8$ = 49.3 cm/8 = 6.1625 cm[134], all the Vitruvian numbers are obtained (Table 2).

Table 2

1p=6.1625cm

	Dimens. cm	Dimens. 1p	Control cm	Diff. cm
A	147.9	24	147.9	0.00
B	98.6	16	98.6	0.00
D	43.1	7	43.13	0.03
E	61.7	10	61.62	0.07
F	98.6	16	98.6	0.00
G	49.3	8	49.3	0.00
H	98.6	16	98.6	0.00
I = L	27.7	4.5	27.73	0.03
L + M	36.9	6	36.97	0.07
J	15.4	2.5	15.40	0.00
N	36.9*	6	36.97	0.00

c) *The link between the "pars" unit and the measure unit (hypothesis).*

Variant 1 (Table 3).

It is considered 1 Foot = 29.7 (±0.2) cm

It results that 1 p = φ_1 1 Foot/3 cm = 6.1182 cm (diff. 0.04 cm for $\varphi_1 = 0.618$)

Variant 2 (Table 3).

We consider the measure unit as the Cubit of a Foot of ~32.8 cm.

It results that 1 Cubit = 49.2 cm = 1C

This hypothesis is interesting because it presupposes a full accord between the unit numbers (*partes?)* and the measure unit, as well as between the *radius of the lower surface and the measure unit.* The following are directly pointed to the (1:2:3) distribution according to the *radius identifiable at the same time as measure unit.* According to the conjecture, the 1 *pars* (?) unit is equal to 1/8 of the Cubit: 1C/8 = 6.15 cm ≈ 6.16 cm (diff. 0.01 cm)[135]. This way the mathematically constituted architectural structure of the capital of the Temple of Aphrodite seems to meet the *ordinatio* imperative, without which no architecture worth its name can exist[136].

[131] By traditional methods D. Theodorescu already noticed that the capitals of the temple at Aphrodisias respects the Vitruvian pattern (D. Theodorescu, *Le Projet de Vitruve...*, p. 109).

[132] Regarding the height of the echinus, the statement is valid for the Choisy, Puchstein, Schlikker, Drerup variant (for the entire issue of the height of the echinus at the Vitruvian capital, see P. Gros, p. 166-167).

[133] "Il disegno *(compositio)* dei templi, dice Vitruvio, si basa sulla *symmetria*, qualcosa di cui gli architetti devono molto accuratamente tener conto. *Symmetria* viene da *proportio*, greco 'analogia'. *Proportio* a sua volta è il fenomeno di commensurabilità tra le parti – le singole parti di un edificio e l'insieme – ottenuto in base a un elemento calcolato o modulo." (H. Geertman, *Le Projet de Vitruve*, p. 26)

[134] According to the method applied at the Mausoleum at Halicarnassus (Mărgineanu-Cârstoiu, 1996-1998, p. 201. See also D. Theodorescu, *Le Projet de Vitruve*, p. 108).

[135] In the case of 1 Cubit = 49.3 cm, 1 *pars(?)* = 6.1625 cm.

[136] "La *Ordinatio (la taxis)* si ottiene nell'edilizia quando ci sia commensurabilità tra le diverse parti, se cioè le dimensioni delle singole componenti sono calcolate in base a unità modulari, così que l'insieme ci sia un'analogia, una concordanza, basata sulla *proportio.*" (H. Geertman, *op.cit.* p. 17)

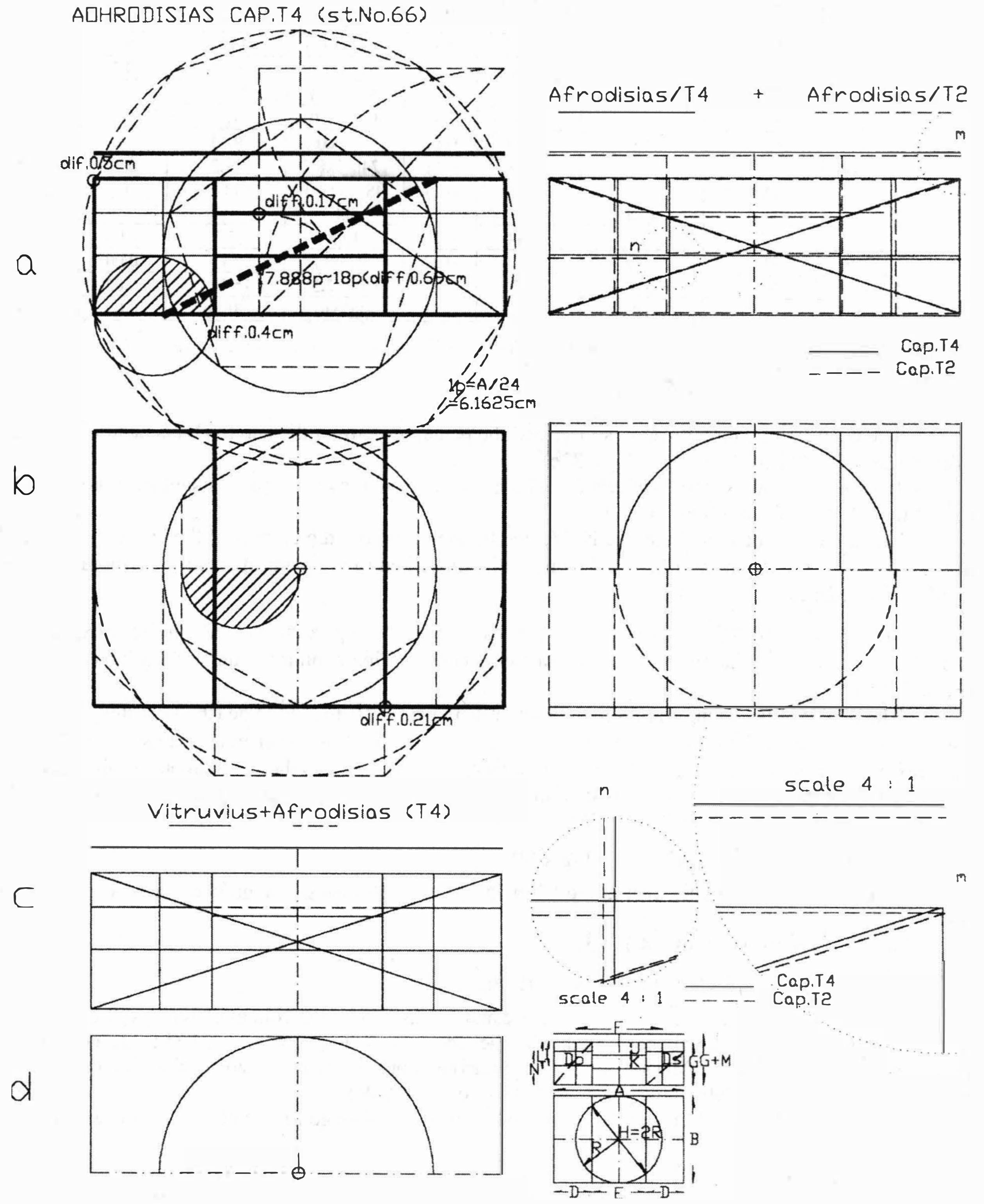

Fig. 31. The Capital at Aphrodisias (st. nr. 66).

Table 3

ld = 29.7 (±0.2) cm/16 ≈ 1.856 cm *ld₁ = 32.8 cm/16 = 2.05cm(≈ 6.16 cm/3 = lp/3)*

	Dimens. cm	Dimens. ld	Control cm	Diff. cm	Dimens. ld_1	Control cm	Diff. cm
A	147.9	79.5	147.55	0.35	72(=3x**24**)	147.6	0.3
B	98.6	53	98.36	0.23	48(=3x**16**)	98.4	0.2
D	43.1	23	42.68	0.41	21(=3x**7**)	43.05	0.05
E	61.7	33	61,248	0,45	30 (=3x**10**)	61,5	0,2
F	98.6	53	98.36	0.23	48(=3x**16**)	98.4	0.2
G	49.3	26.5	49.18	0.11	24(=3x**8**)	49.2	0.1‘
H R	98.6 49.3	53 **26.5**	98.36	0.23	48(=3x**16**) **24**	98.4	0.2
I=L	27.7	15	27.84	0.14	13.5	27.67	0.03
L+M	36.9	20	37.12	0.22	18(3x**6**)	36.9	0.00
J	15.4	8.5	15.776	0.37	7.5(3x**2.5**)	15.375	0.02
N	36.97*	20	37.12	0.15	18(3x**6**)	36.9	0.07

Notes: In the variant 2, the façade distribution of the 7:10:7 type perfectly matches the measure unit.

2. *The Histria 17 Capital* (no. 59)[137] (Fig. 32)[138].

– The centre of the circle where is inscribed the pentagon settling the height (N) is positioned at the intersection of the diagonals (A:G) (Figs. 32c).

– Between Ds and Dp the “Vitruvian” relation does not exist, as the façade is slightly more flattened than in the Vitruvian pattern (Figs. 32a,d).

– The layout of the plan rectangle is directed by the pentagon: the lengths of the cushions are equal to the side of the pentagon inscribed in the circle circumscribed to the plan; the result is a more compact plan[139] (Figs. 32b,e).

3. *The Histria AC203* (no. 60) (Fig. 33). It used to be an important node along the *Minimal Tree* genealogical line, immediately next to the Vitruvian capital. This similarity can be clearly seen also in (Figs. 33c,d).

– The height of the echinus tends to goes slightly above the ‘Vitruvian” line (the Puchstein variant); a slight increase in the width of the volute (Fig. 33c) is manifested in its adjustment as against the apothem of the octogon inscribed in the lower surface[140]: this adjustment involves also the semidiagonal of the façade.

– The central façade rectangle is determined by an equilateral triangle: its side is adjusted to the secondary diagonal of the volute[141](Fig. 33a).

4. *The Histria C29 Capital* (no.73) Fig. (34).

– The height “N” is higher than in the Vitruvian pattern expressing a singling out aspect of the spiral tracing (Fig.34c).

For other aspects, see Figs. 34.1-b,d).

5. *An Augustan Capital at Dydima* (no. 44) (Fig. 35).

– More amplitude granted to the lower surface and the distance of the volutes eyes (Figs. 35c-d)

– The total height is doubly correlated: with the side of the octogon circumscribed to the circle of the radius Dp (Fig. 35a) (as at the Mausoleum at Halicarnassus), but also with the side of the octogon inscribed in the circle built on the length of the plan (fIG.35b) (or of the façade).

– The width of the volute is equal to the apothem of the pentagon inscribed in the lower surface[142] (Fig. 35b).

[137] According to the *CA, NMDS* and the *Cluster Analysis* it is close to the Augustan capitals no. 44, Dydima, nr. 31, Aphrodisias/ the area of the theatre, but also to the Hadrian capital no. 51 at Perge.

[138] From now on we shall note only the difference as against the Vitruvian pattern.

[139] In the Vitruvian pattern, the length of the cushions is shorter than the that of the corresponding pentagon.

[140] As for instance at the capital of the Temple of Zeus/Priene.

[141] Analogue the capital at Magnesia/South Agora.

[142] Analogue the capitals of the Stoa of Attalos, Magnesia /South Agora, and the altar of the Artemisium at Ephesus.

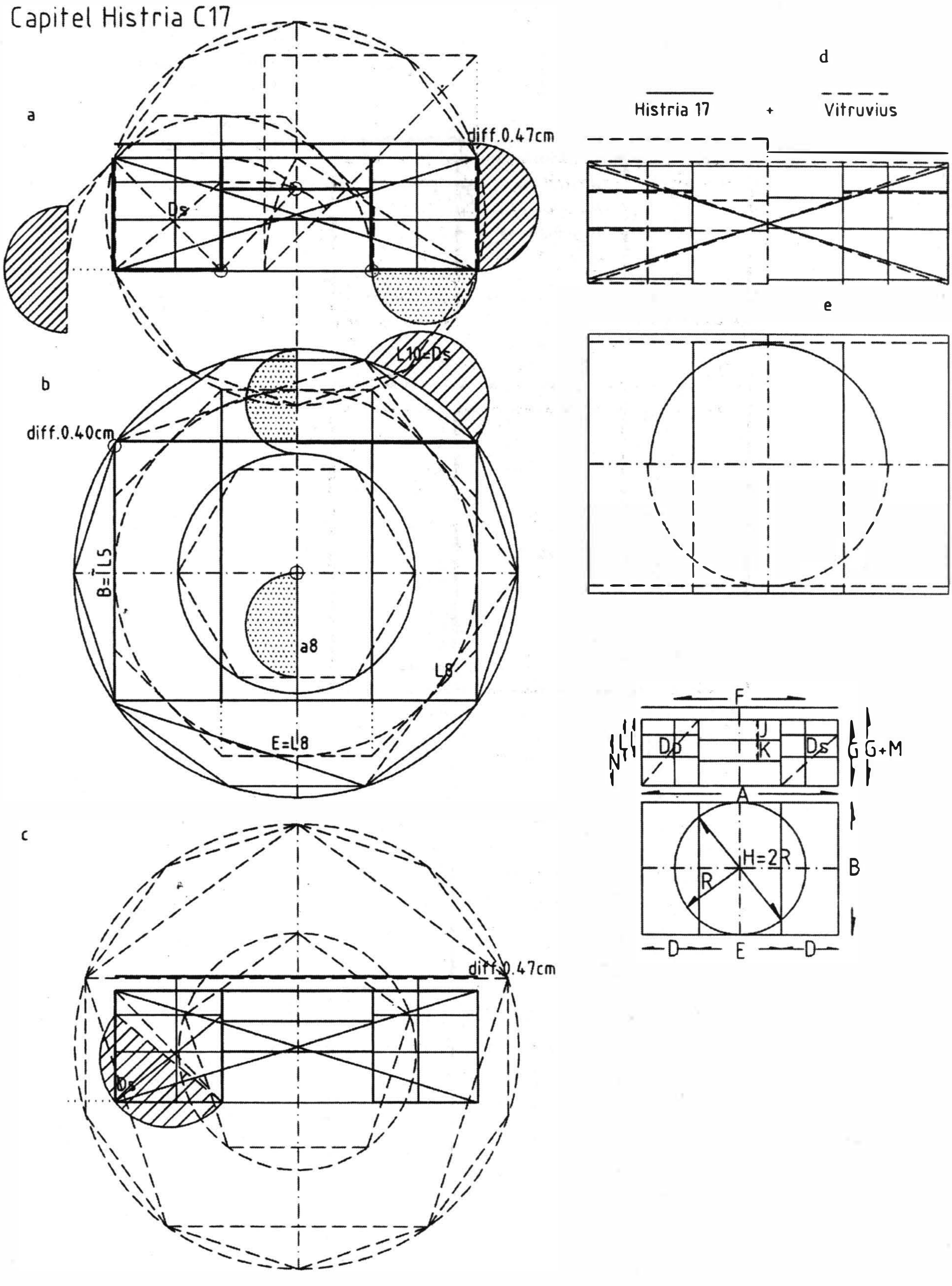

Fig. 32. The *"Histria 17"* Capital.

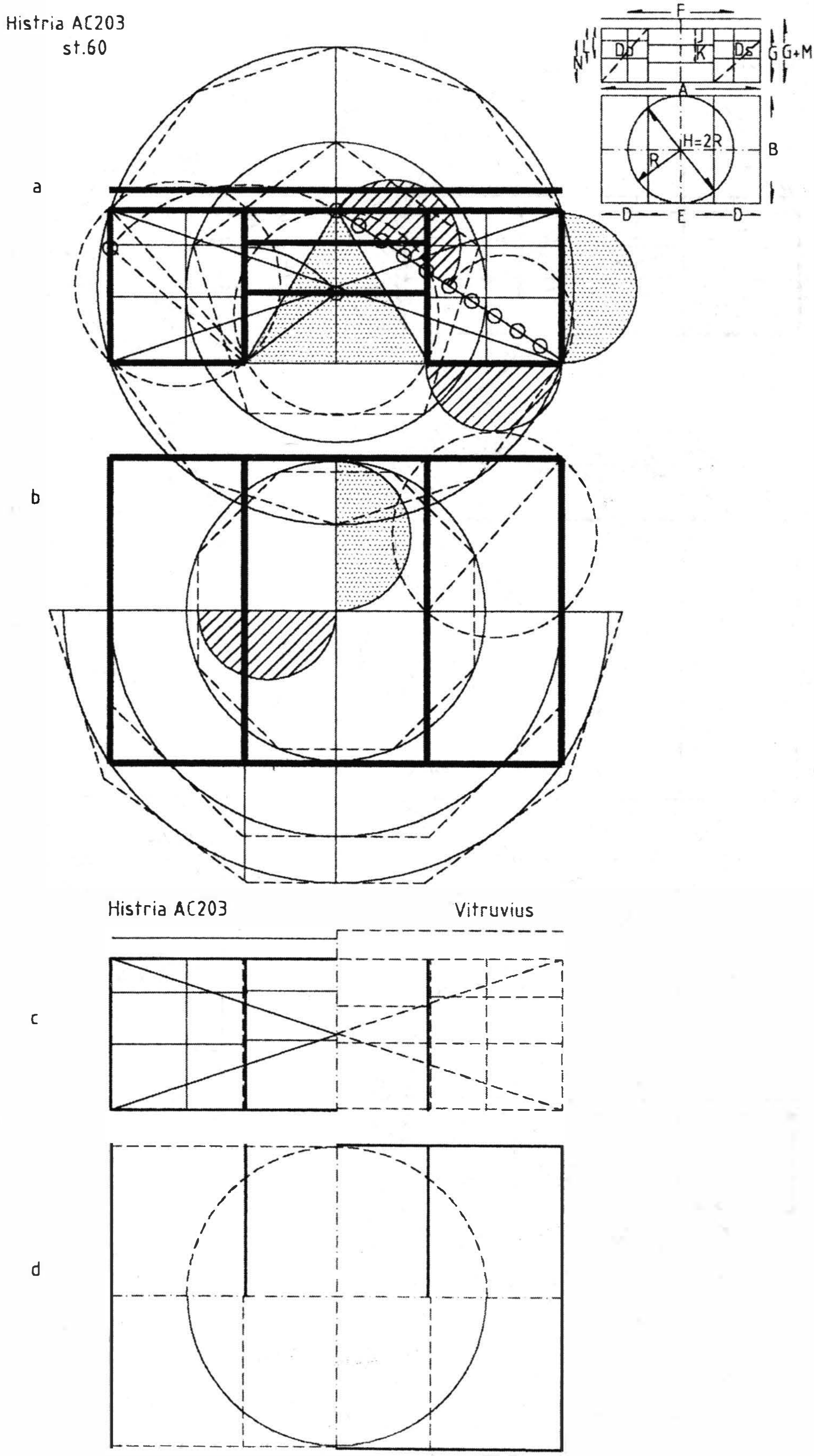

Fig. 33. The "Histria AC203" Capital.

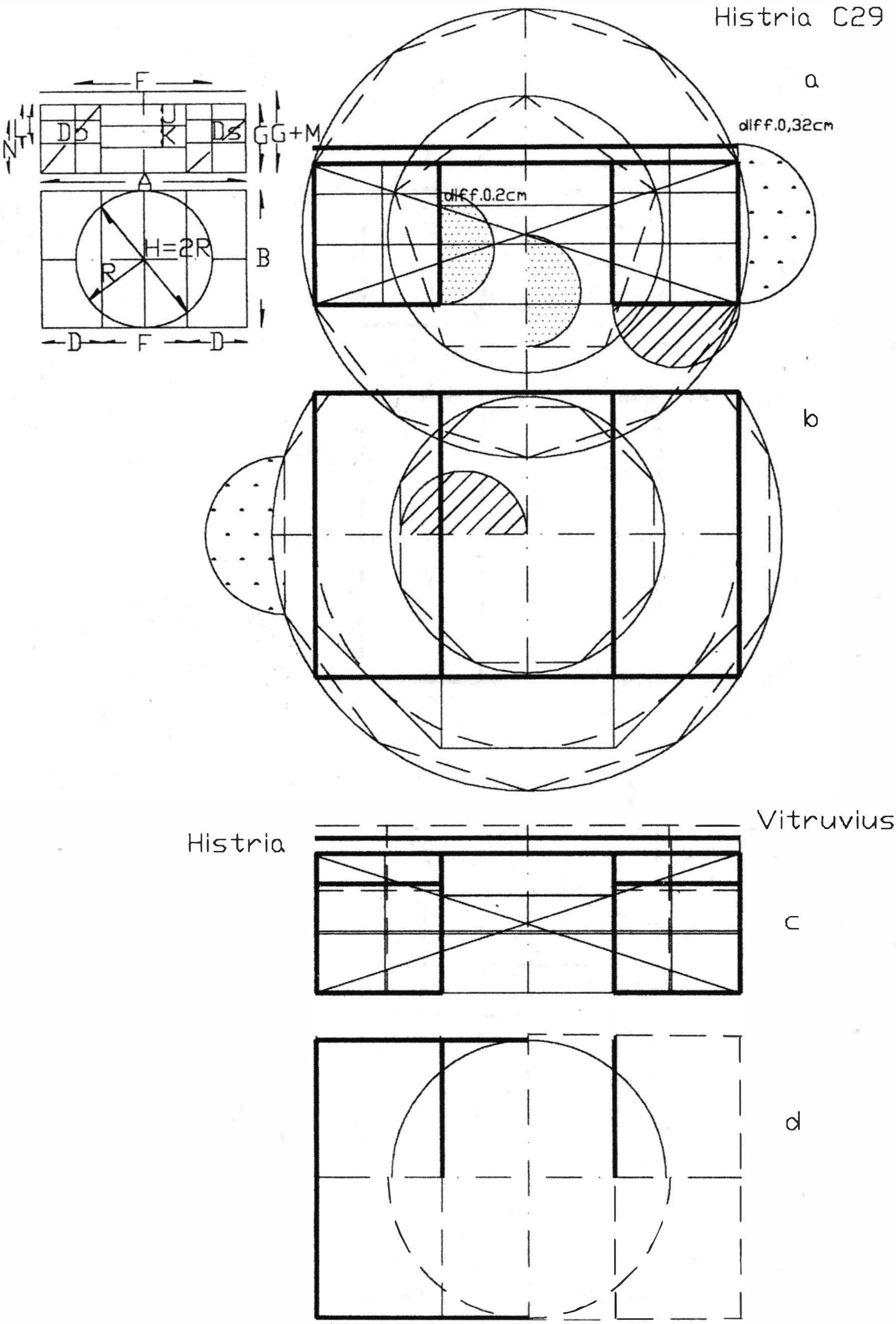

Fig. 34. The "Histria C29" Capital.

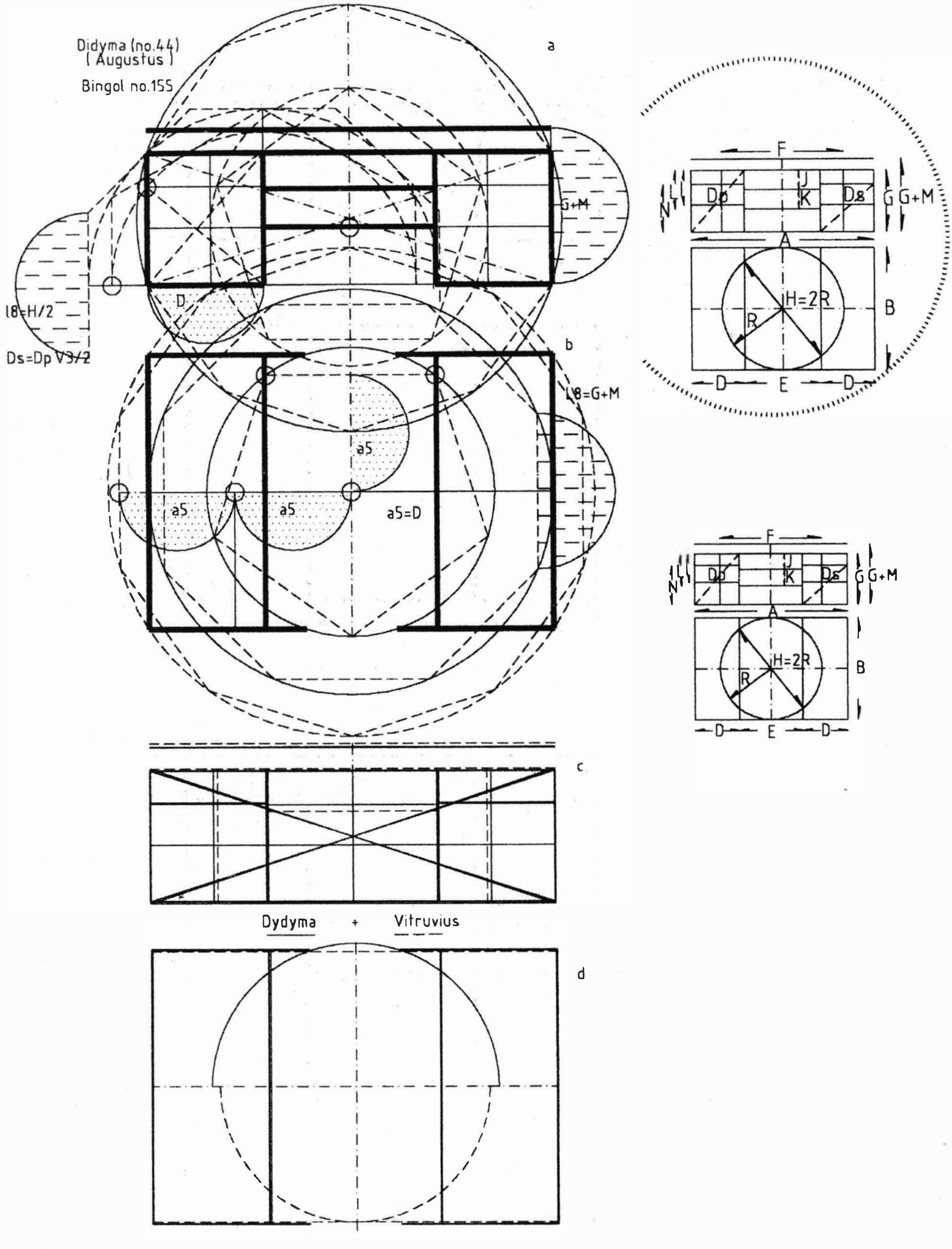

Fig. 35. The st. no. 44 Capital (Didyma).

6. *Capital from Laodikeia ad Lycum* (no. 57) (Fig. 36).

– There is an accordance of the total height as against the plan: the side of the decagon inscribed in the circle raised on the plan diagonal = (G + M) (Fig. 36b).

– The comparison with the Vitruvian pattern shows that the plan is a little more compact while the façade is more flattened (Figs. 36c-d).

– The share of the central structure increased significantly[143], the lower surface line descending a lot below the eyes line of the volute, and the tendency to hypertrophiate of the echinus disadvantages the canalis. Consequently, the correlation of the central structure to the volute spiral is no longer analogue to the "traditional" Vitruvian cases[144] (Fig. 36a).

III. CONCLUSIONS

The geometric support expresses – at least in part – that "privileged game of mathematical origin"[145] controlling the relations between the parts and the parts with the whole, in fact directing the architectural composition.

It may be presupposed that the Hellenistic capitals – or part of them – are based on the geometric support of a common generating nucleus, which is the convex or starred pentagon (decagon) inscribed in a circle. Such a directing of the composition generates a multitude of *derived* geometric relations, that especially by their arithmetic expression were sometimes tackled in previous researches (partially quoted also in this study). It seems that the tendency to realize variants of the composition of the (1:2:3) type was "abused", in other words it constituted one of the main concerns, probably prevailing. As the realization of this type in its *complete* form (created at the Capital of the Mausoleum at Halicarnassus and later by Vitruvius) is not possible without involving an accordance (adjustment) as against the radius of the lower surface considered as a unit, distributions that we called *incomplete* were created: they can be achieved either in the absence of a (1:2:3) accordance depending on the radius, or by realizing a partial adjustment as against it. As to the composition thus definable, one may say that the Mausoleum pattern "crossed" the Hellenistic Age as one of its essential paradigms, as is the *archetype* that was conveyed to us also through the Vitruvian pattern. As regards the evolution of the aspect of the central structure, the filiation passes, obviously, as already mentioned, through the capitals of Magnesia/South Agora, and the capitals of the Stoa of Attalos[146].

The "exterior" composition of the capitals – except, sometimes, the details of the central structure – undergoes small changes of the forms. We may believe that the purpose was not a completely innovating restructuring of the compositional characteristics, as the differences are involved by an element that is not necessarily apparent – as seen from the exterior – as belonging to the capital, but rather to the shaft of the column. In this conjecture, even the realization of the (1:2:3) *incomplete* types (at the Hellenistic capitals) can be interpreted as a proof of the influential force of the type realized at the Mausoleum at Halicarnassus. The failure to realize the (1:2:3) *complete congruity*, does not mean, however, that the composition remains neutral as against the radius of the lower surface: in the cases analysed here the differences occurring in the handling of the geometric support are to a large extent linked to the differences between the radiuses of the lower surfaces (involving the upper diameter of the column, and the general aspect of the column, thus the ordonance), while the latter are always significantly involved in the distribution of compositional elements[147]. As regards the *generating geometric nucleus*, although apparently the compositional geometry from Halicarnassus to Vitruvius seems to have "stood still" by

[143] See the position in the statistical analyses.

[144] The circle of the pentagon (*circumscribed*) is built on the diagonal of the central rectangle.

[145] "Mais cette analyse des données vitruviennes révèle (à l'évidence, nous semble-t-il) que, pour certains architectes du moins, la composition d'une façade, l'ordonnance de ses éléments, le rapport entre leurs parties étaient réglés par un jeu des relations privilégiées d'origine mathématique et dans lesquelles les partages harmoniques et géométriques notamment jouaient un rôle prédominant. Le texte du *De architectura* en est le témoin ou le reflet, mais un témoin tardif transmettant un héritage dont son auteur ne percevait sans doute plus la signification" (L. Frey, *Le Projet de Vitruve*, p. 168).

[146] Hoepfner, 1968; p. 214-231; P. Gros, *op.cit.* p. 157.

[147] For instance, by the apothem of a polygon inscribed in the circumference of the lower surface, the radius is involved in the (D:E:D) distribution. See also Mărgineanu-Cârstoiu, 1996-1998, *passim*.

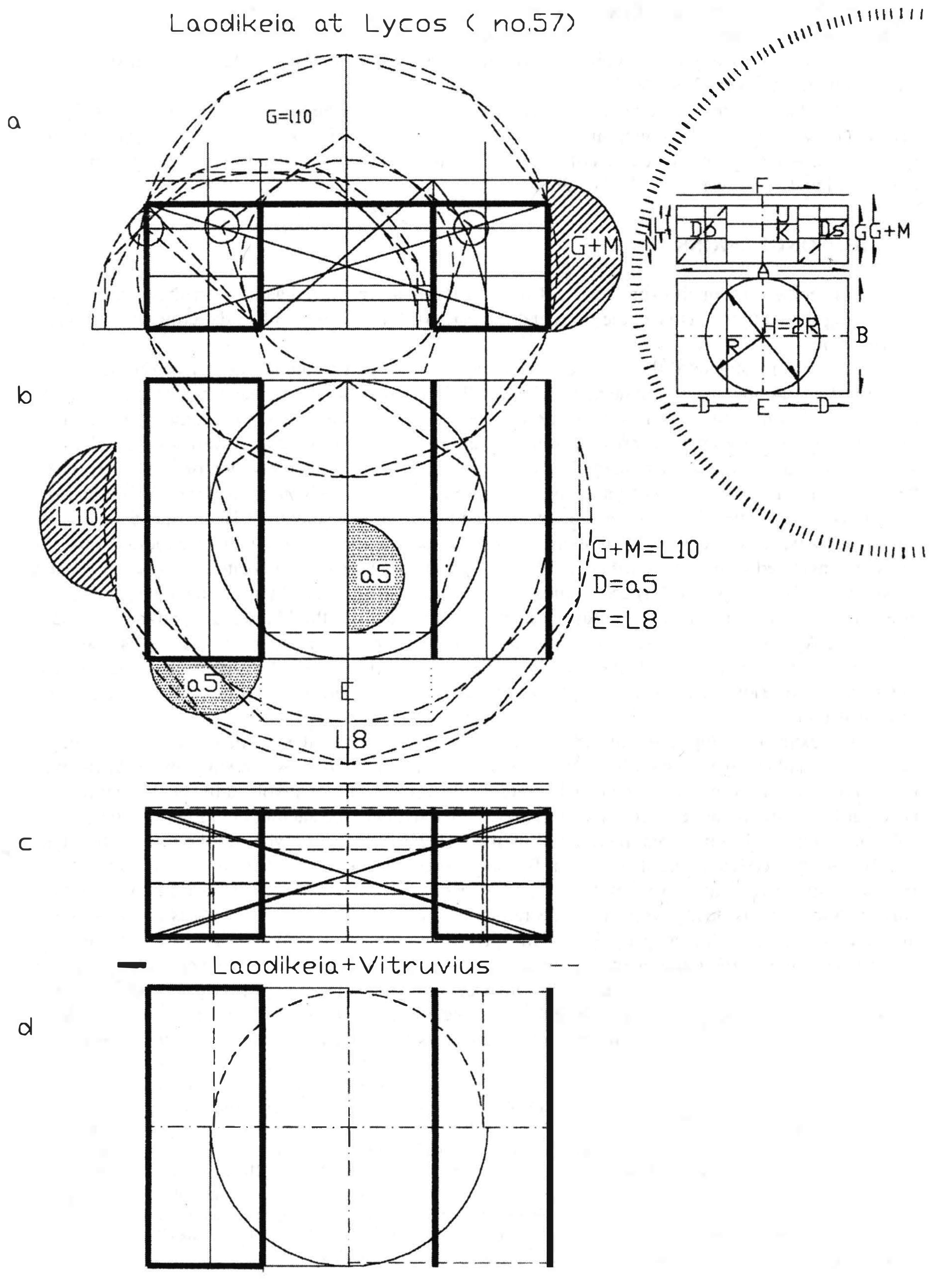

Fig. 36. The st. no. 57 Capital/Laodikeia at Lycos.

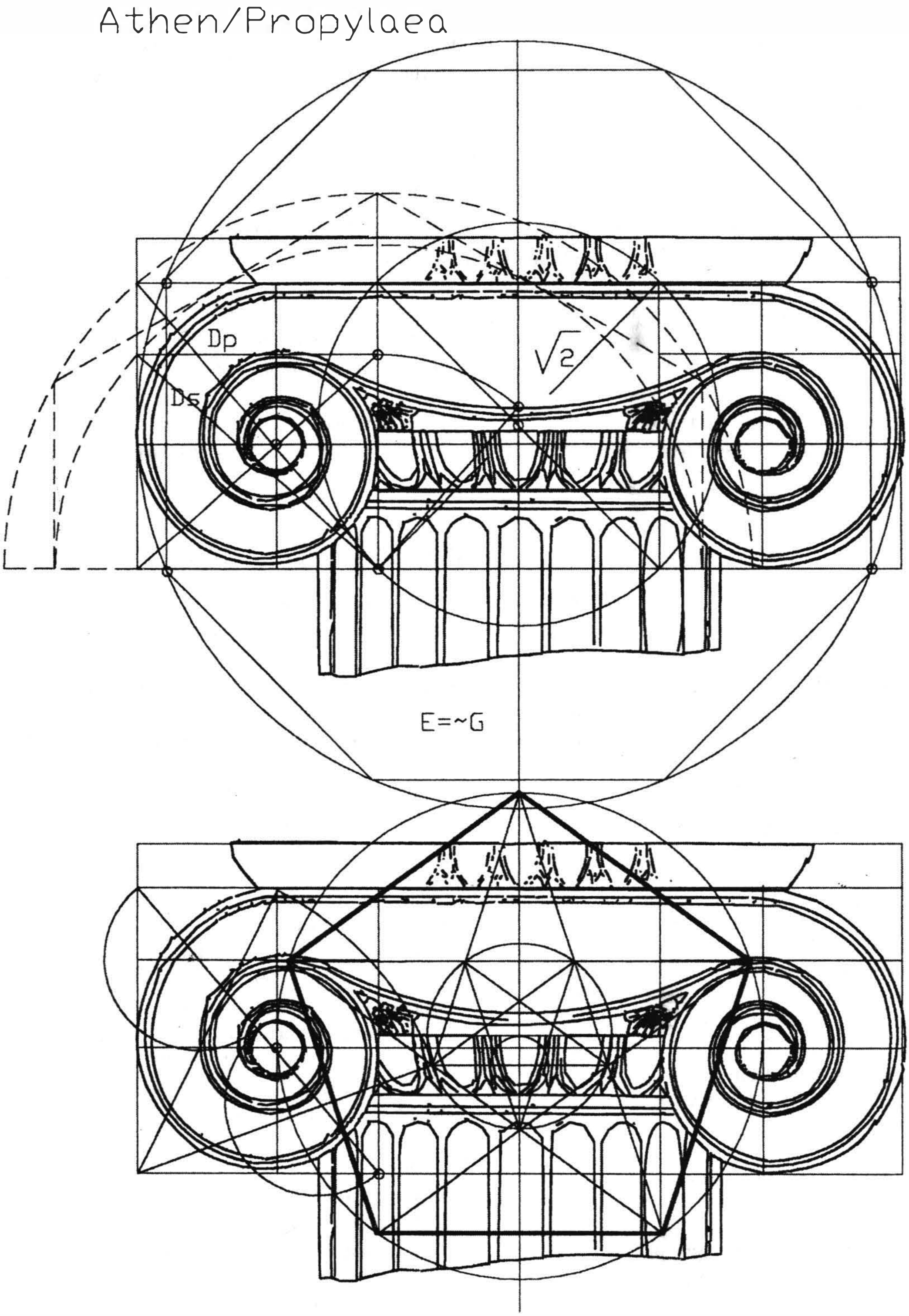

Fig. 37. The Capital of the Athenian Propylaea.

using one and the same type of starred polygon, the differences of "handling" – which start from the modification of the basic ratio – provide the opportunity to unravel the origin of the fine mutations occurring in the register of the forms constituting the precious testimony of a particular type of mobility in artistic ideas.

As regards the post Vitruvian Roman capitals, it may be presupposed that in the case of the capitals with a very tight degree of similarity as against the Vitruvian pattern, the composition may be directed especially on the basis of the numerical "formula" conveyed by the Vitruvian pattern, while the geometric support that we might find is to a large extent implicit to it, as the Vitruvian pattern one involved the Mausoleum geometry. However, that does not mean in the least that we witness the sunset of the use of geometric procedures in Roman architecture.

APPENDIX 1

List of variables used in statistical analysis (numerical correspondence);
74 Hellenistic and Roman capitals

1. **A/B** = total façade length/cushion length
2. **F/B** = eyes spacing/cushion length
3. **A/H** = total façade length/lower surface diameter
4. **F/H** = eyes spacing/lower surface diameter
5. **D/A** = volute width/total façade length
6. **F/E** = eyes spacing/volutes spacing
7. **F/G** = eyes spacing/volute height
8. **A/L** = total façade length/central body height
9. **K/L** = canalis height/central body height
10. **J/L** = echinus height/central body height
11. **I/L** = eyes height/central body height
12. **G/D** = volute height/volute width
13. **G/A** = volute height/total façade length

APPENDIX 2

List of 74 Hellenistic and Roman capitals
(numerical correspondence, chronology, bibliography)

1. Ephesus, Artemisium " E " (330-320):
A. BAMMER,"Die Architektur des Jüngeren Artemision von Ephesos",(1972), p. 17 sq., fig. 22, 23; H .C. BUTLER, *Sardis* II, 1, (1925), Atlas, pl. XII-XIII

2. Ephesus, Altar/Artemisium (350-325):
W. ALZINGER, *JOAI*, 46, (1961-1963), FIG. 73 86

3. Ephesus, (Kunsthist. Mus Wien), (I, 1637) (400-370)·
W. ALZINGER. *JOAI*, 46, (1961-1963), p. 105-107, fig.71, 72

4. Ephesus, chap. dans le Musée d'Izmir (320-300):
W. ALZINGER, *JOAI*, 46 (1961-1963), fig. 93-94

5. Didyma, hellen. Apollo T. / int.row (end 3rd c.):
TH.WIEGAND, *Didyma* I, I^3, pl. 52, Z 408, 409, 410

6. Didyma , hellen. Apollo/ ext. row (2nd c.):
TH. WIEGAND, *Didyma* I, pl. 53, Z 422, 423, 424

7. Halicarnassus, Mausoleum (~ 350):
W. HOEPFNER, E.-L. SCHWANDNER, *Haus und Stadt im Klassischen Griechenland*, I^1 (1986), p. 161-166: O. BINGÖL, *Das ionische Normalkapitell in hellenistischer und römischer Zeit in Kleinasien*, IM, Beiheft 20, (1980), p.195

8. Priene, Athena (~ 330):
TH. WIEGAND, H. SCHRADER, *Priene, Ergebnisse der Ausgrabungen 1895-1898*, Berlin (1904), fig. 58-59

9. Priene, Athena (~. 330):
O. RAYET, A. THOMAS, *Milet et le Golfe Latmique*, I, Paris, (1877), p.22; Atlas, pl.14: H DRERUP, "Pytheos und Satyros...", *JdI*, 69, (1954), p.18

10. Sardis, Artemisium (before 300):
H. BUTLER, *Sardis* II, 1, (1925), fig. 70, 73, 77. 80: Atlas, pl.VIII, X.

11. Magnesia, Artemis T. (220-200 ?):
C. HUMANN, J. KOHTE, C. WATZINGER, *Magnesia am Meander,Bericht über der Ausgrabungen 1891-1893*, Berlin, (1904), fig. 35

12. Pergamum, Great Altar (168-159):
(layout by) M. Mărgineanu-Cârstoiu

13. Samos (~ 350):
M. SCHEDE, Zweiter vorläufiger Bericht... Samos, Abh. der Preuss. Akad., Phil.- Hist. Klasse, (1929), fig. 20

14. Lesbos (Messa), Aphrodite (~ 280):
R. KOLDEWEY, *Die antiken Baureste der Insel Lesbos*, Berlin, (1900), pl. 17

15. Olympia, Philippeum (338-336):
E.KURTIUS, F.ADLER, *Olympia (Ergebnisse)*, II, Berlin (1896), pl. LXXXI; E.KUNZE, (~.H.SCHLEIF, *Das Philippeion, Olympische Forschungen*, I, (1941), pl.7

16. Olympia, Leonidaeum 325):
E. KURTIUS, F.ADLER, *Olympia (Ergennisse)* II, 1892, pl. LXV

17. Olympia, votive (350-300):
E.KURTIUS, F.ADLER *op.cit*, pl. LXXXIX/25, XC/7a-b

18. Olympia, votive (early 3rd c.)
Hoepfner, Zwei Ptolemaierbauten, Das Ptolemaierweihgeschenk in Olympia und ein Bauvorhaben in Alexandria, IM, Beiheft 1, (1971)

19. Selinus, votive (V, Palermo/Museum, n° 338) (4th c.)
D. THEODORESCU, (1974), pl. IX, XVII

20. Histria, cap."C34":
M. MĂRGINEANU-CÂRSTOIU. Xenia. 25 (1990), p. 117-123. fig. 6, 12-13

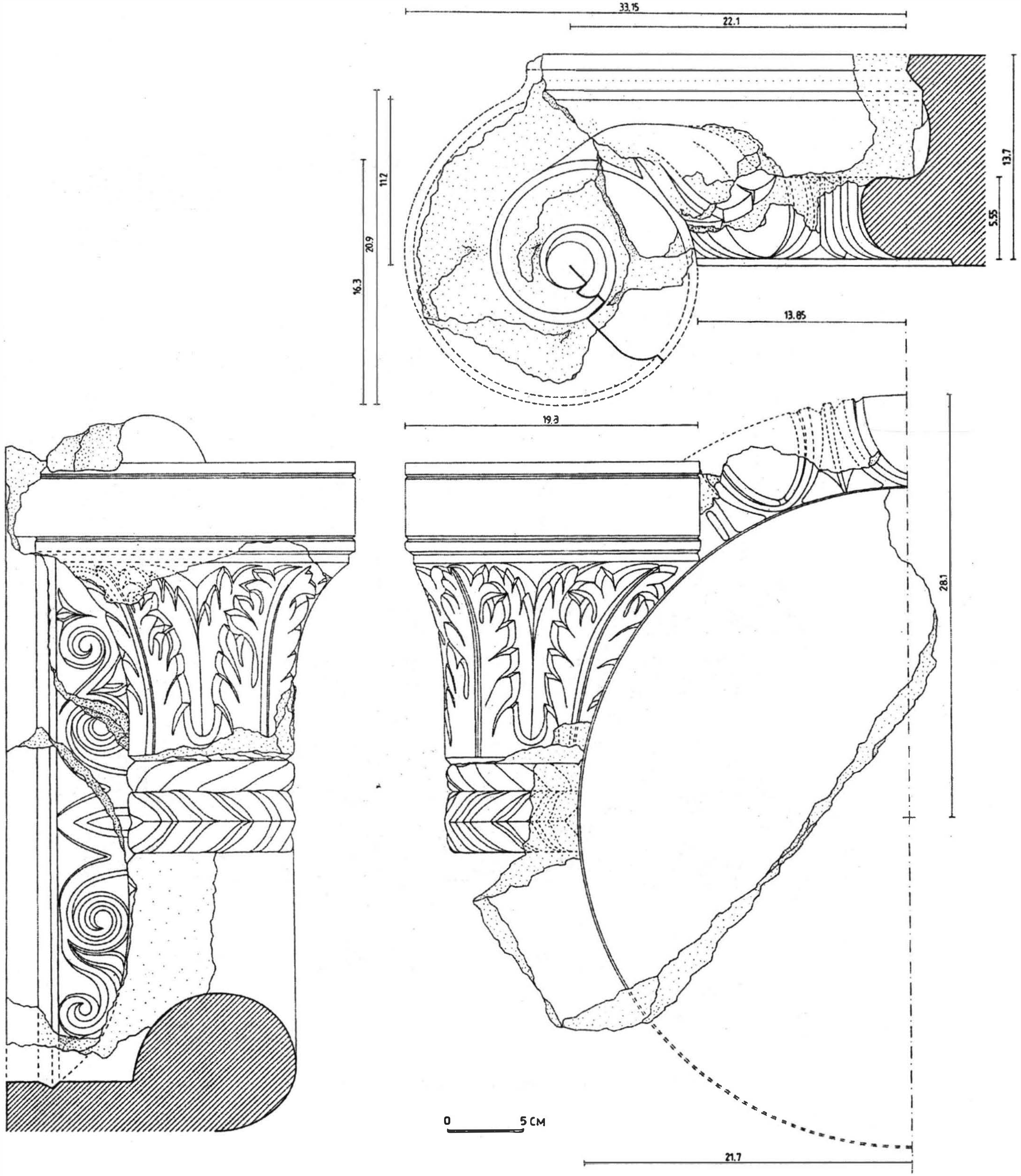

Plate 1. The *Histria 17* Capital.

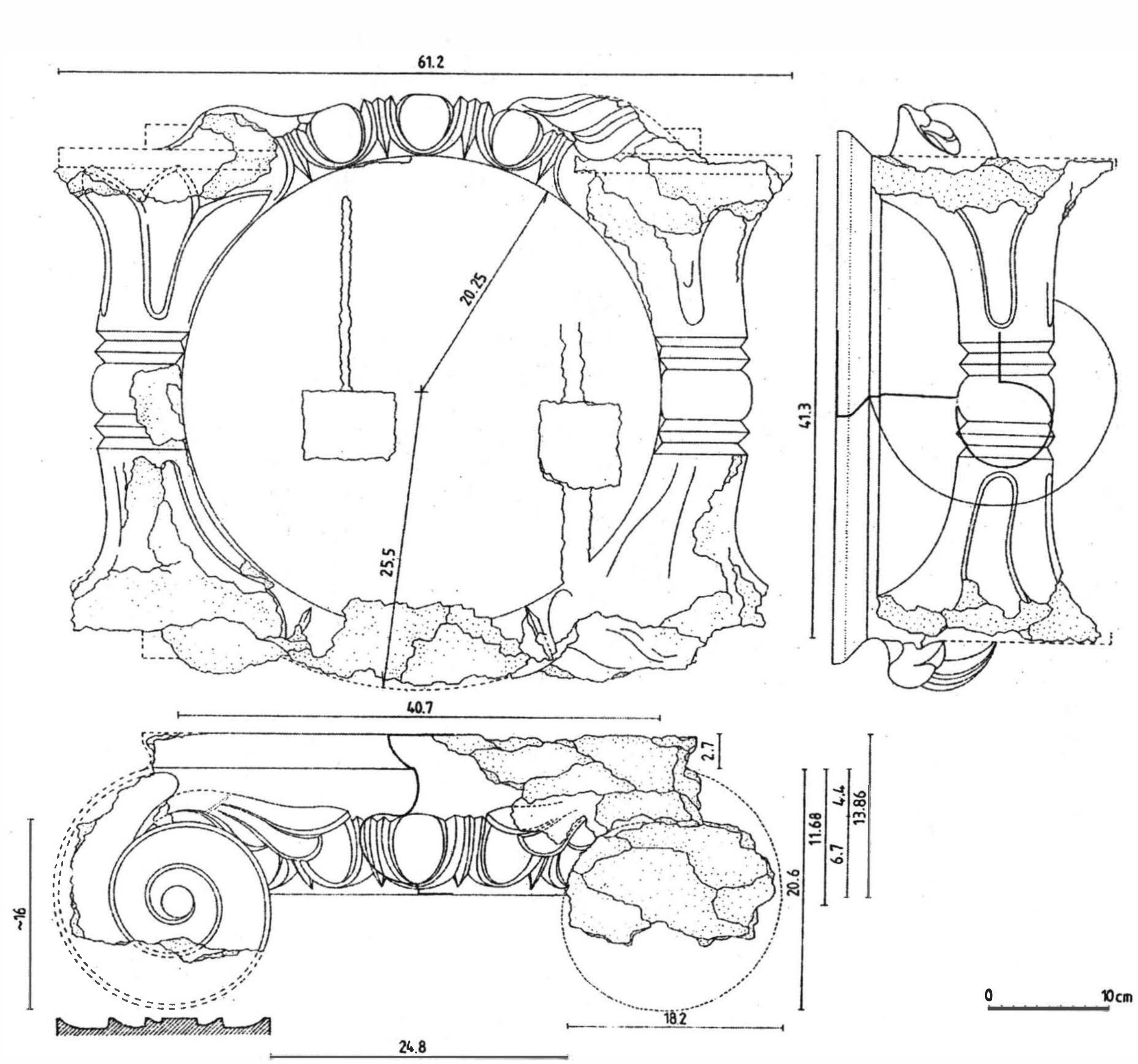

Plate 2. The *Histria Ac203* Capital.

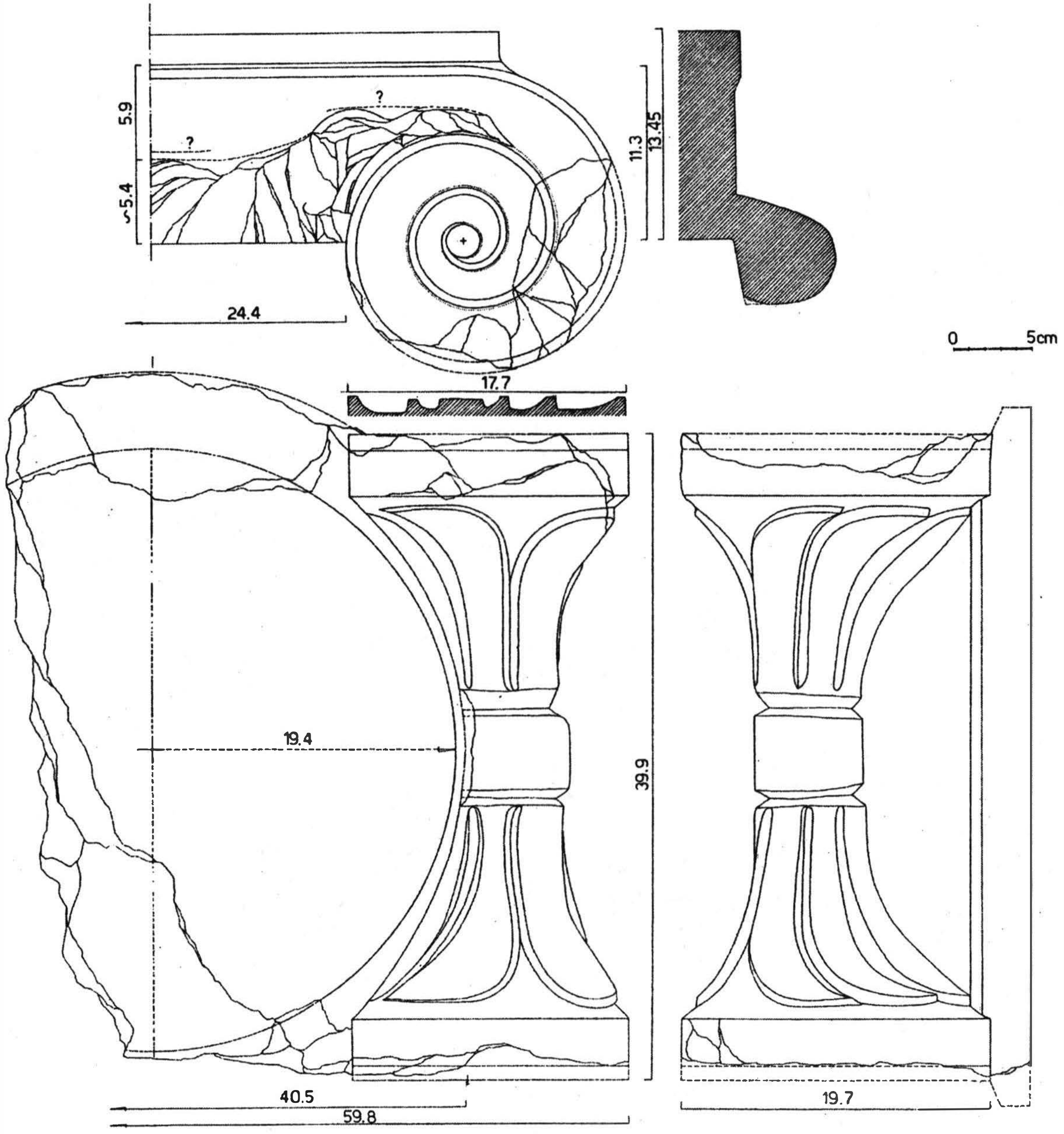

Plate 3. The *Histria C29* Capital.

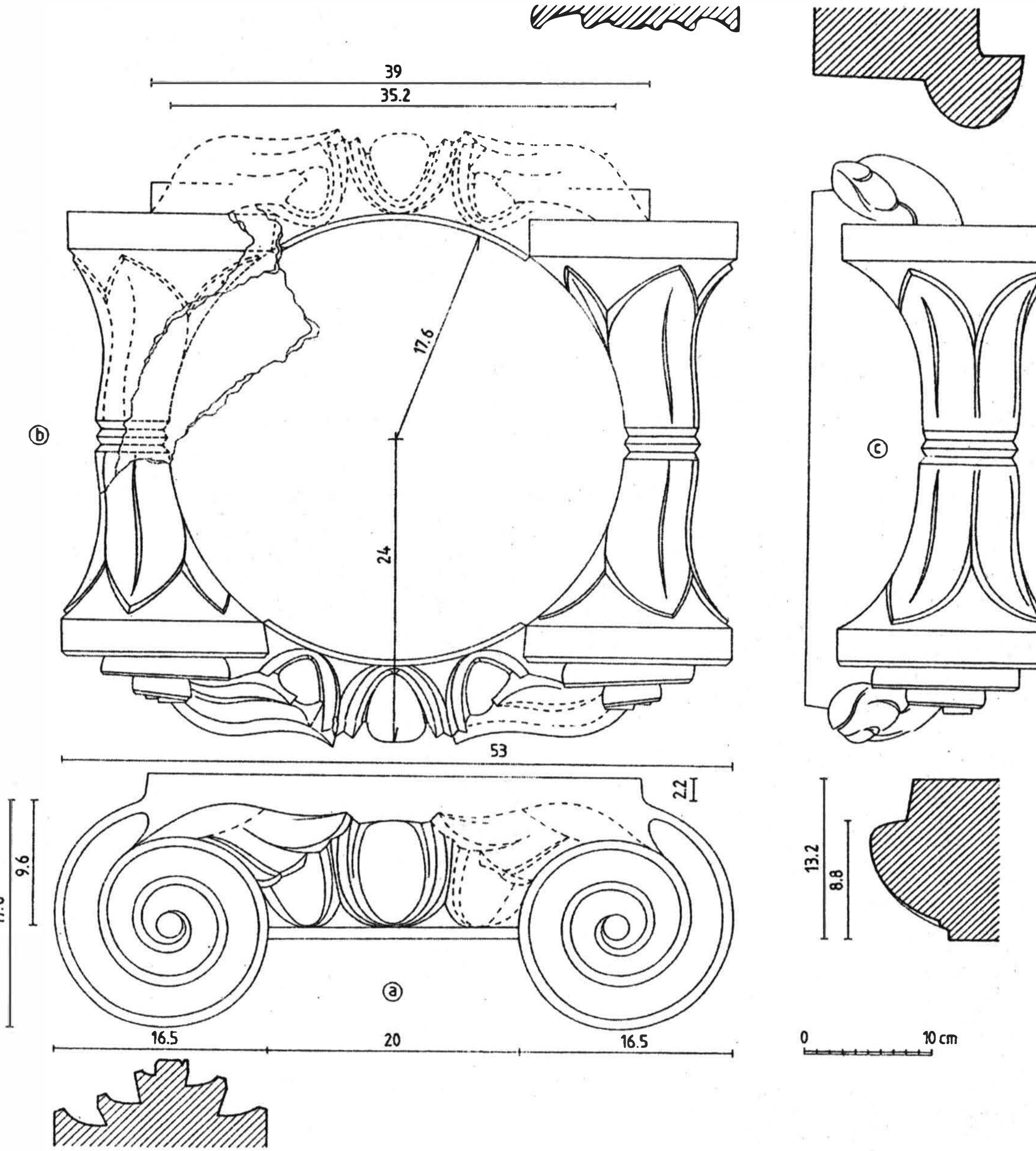

Plate 4. The *Histria CD* Capital.

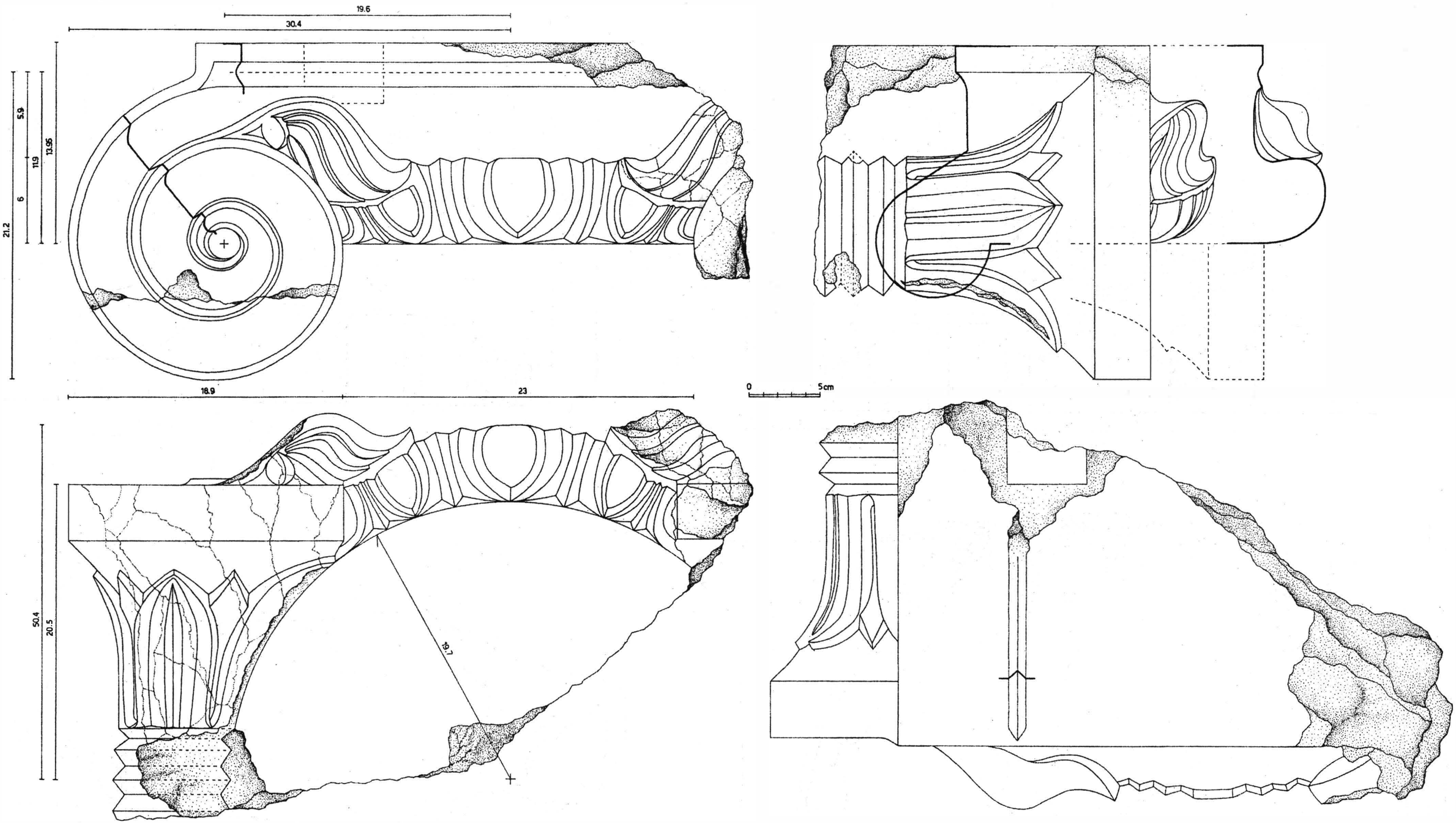

Plate 6. The *Histria 0536* Capital.

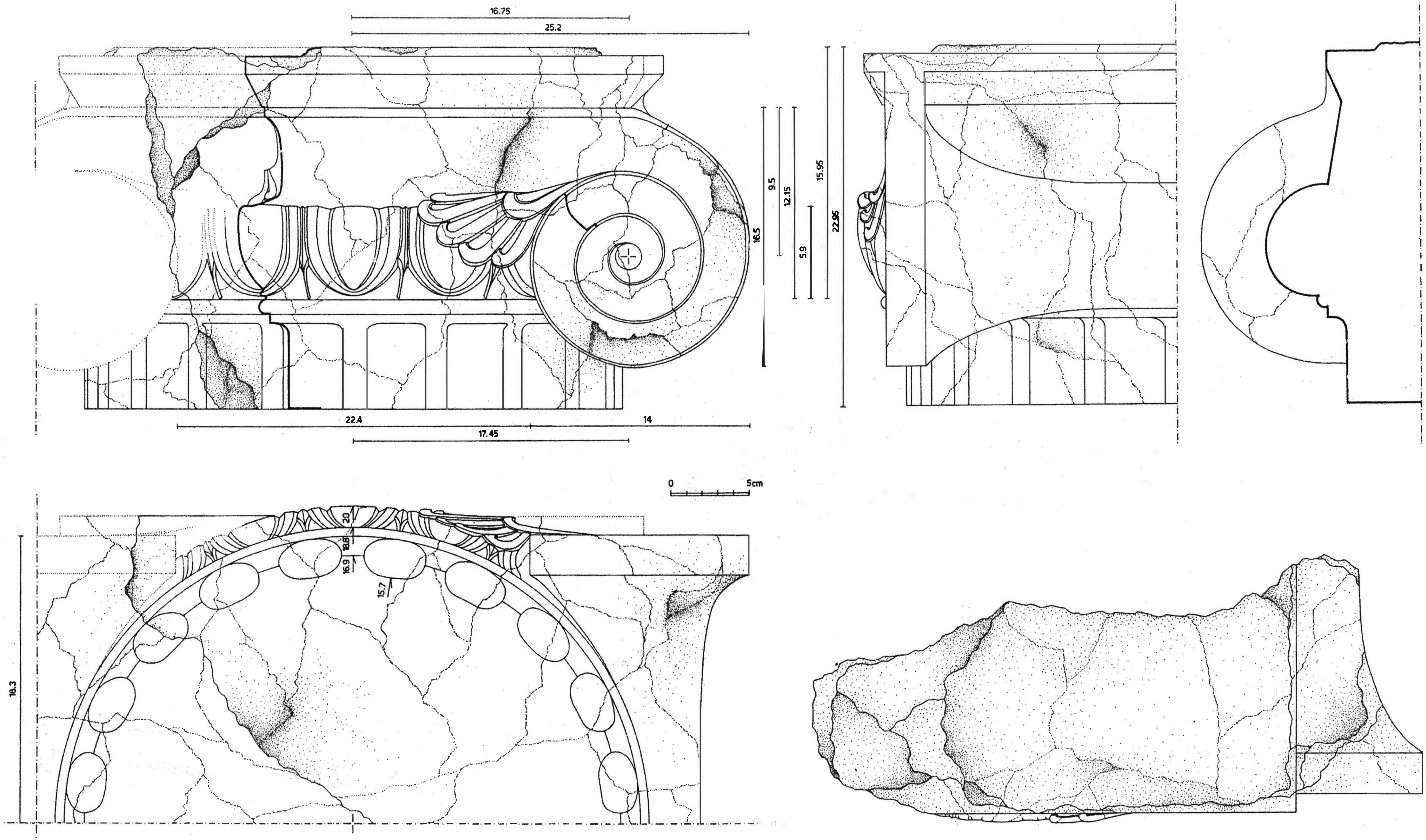

Plate 5. The *Histria 39* Capital.

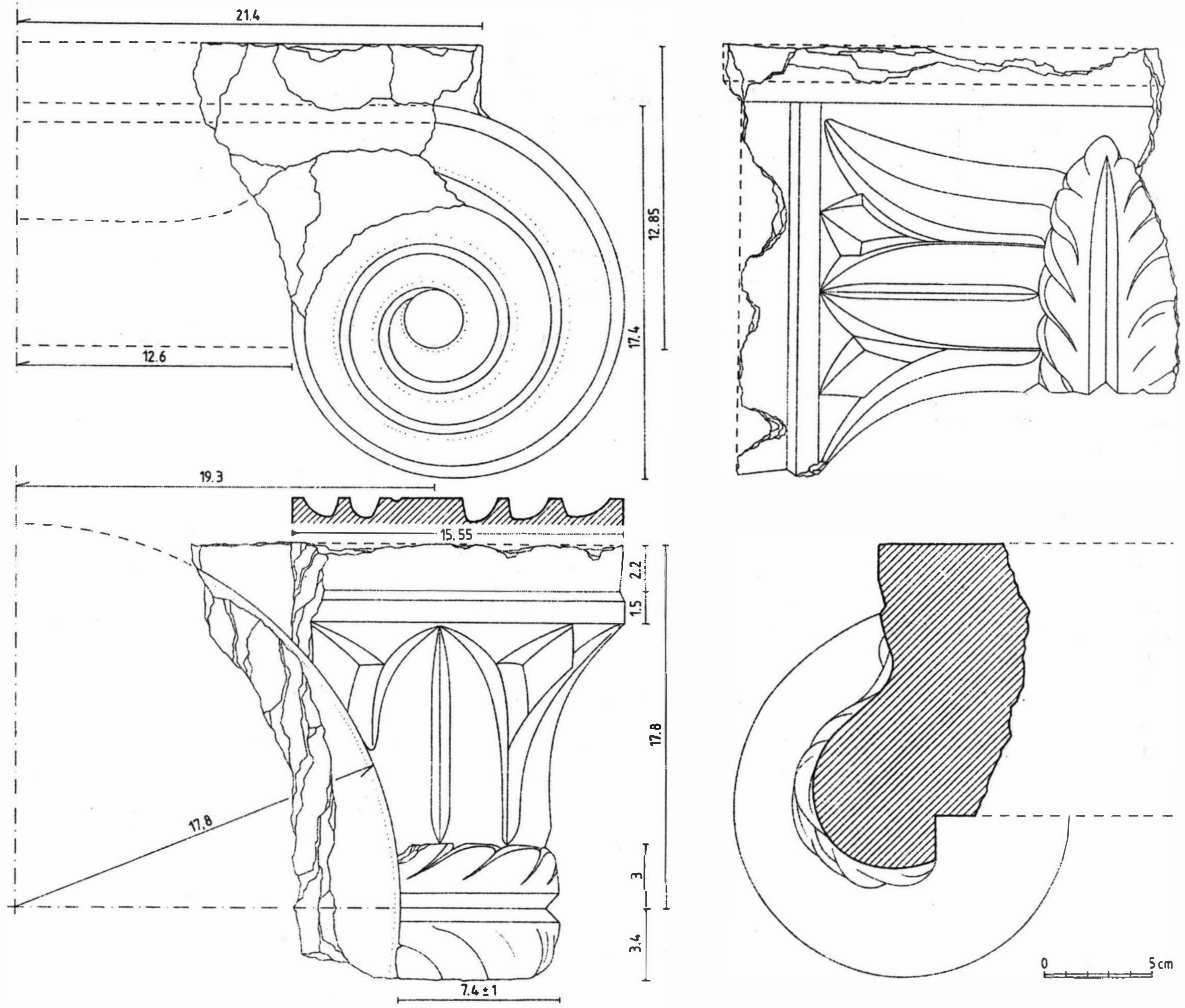

Plate 7. The *Histria 0475* Capital.

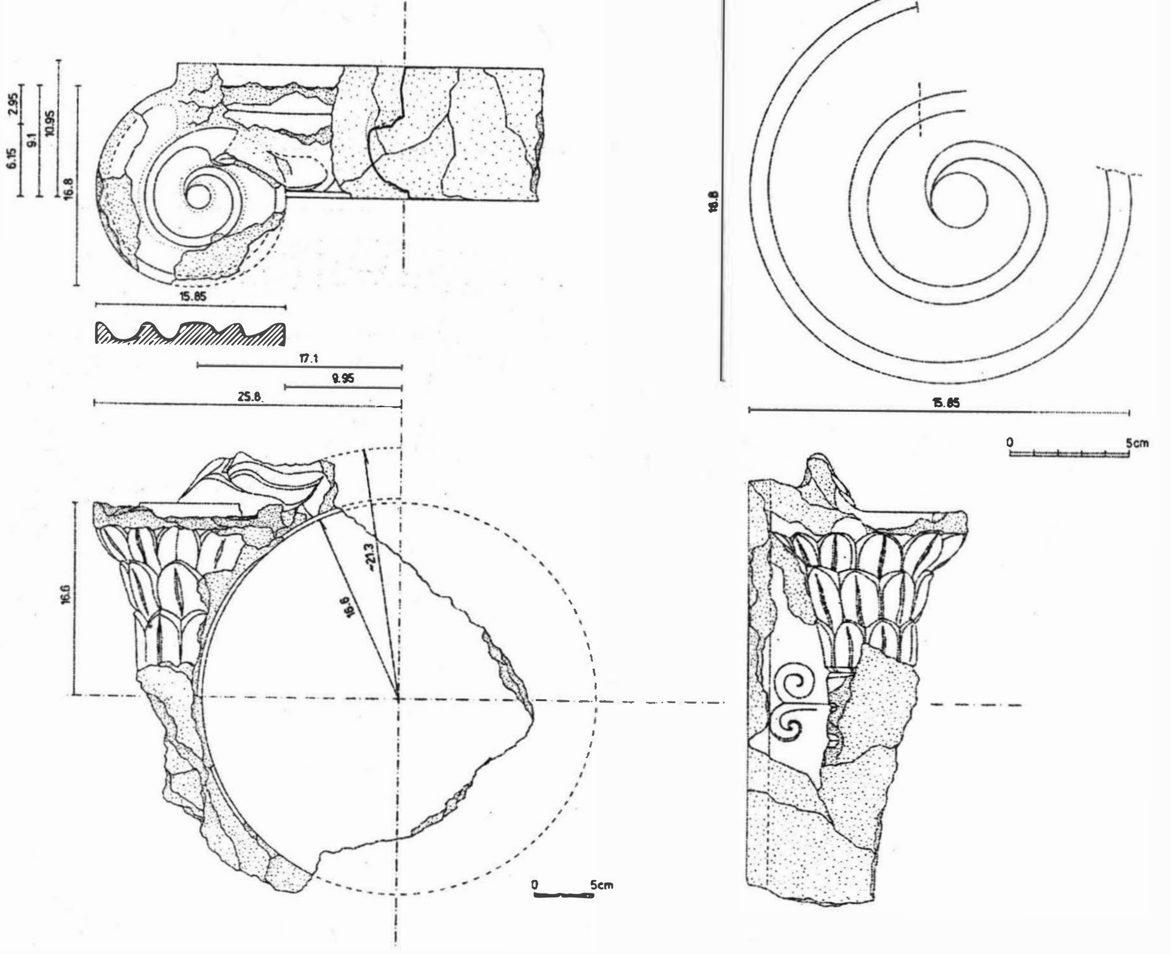

Plate 8. The *Histria C 32* Capital.

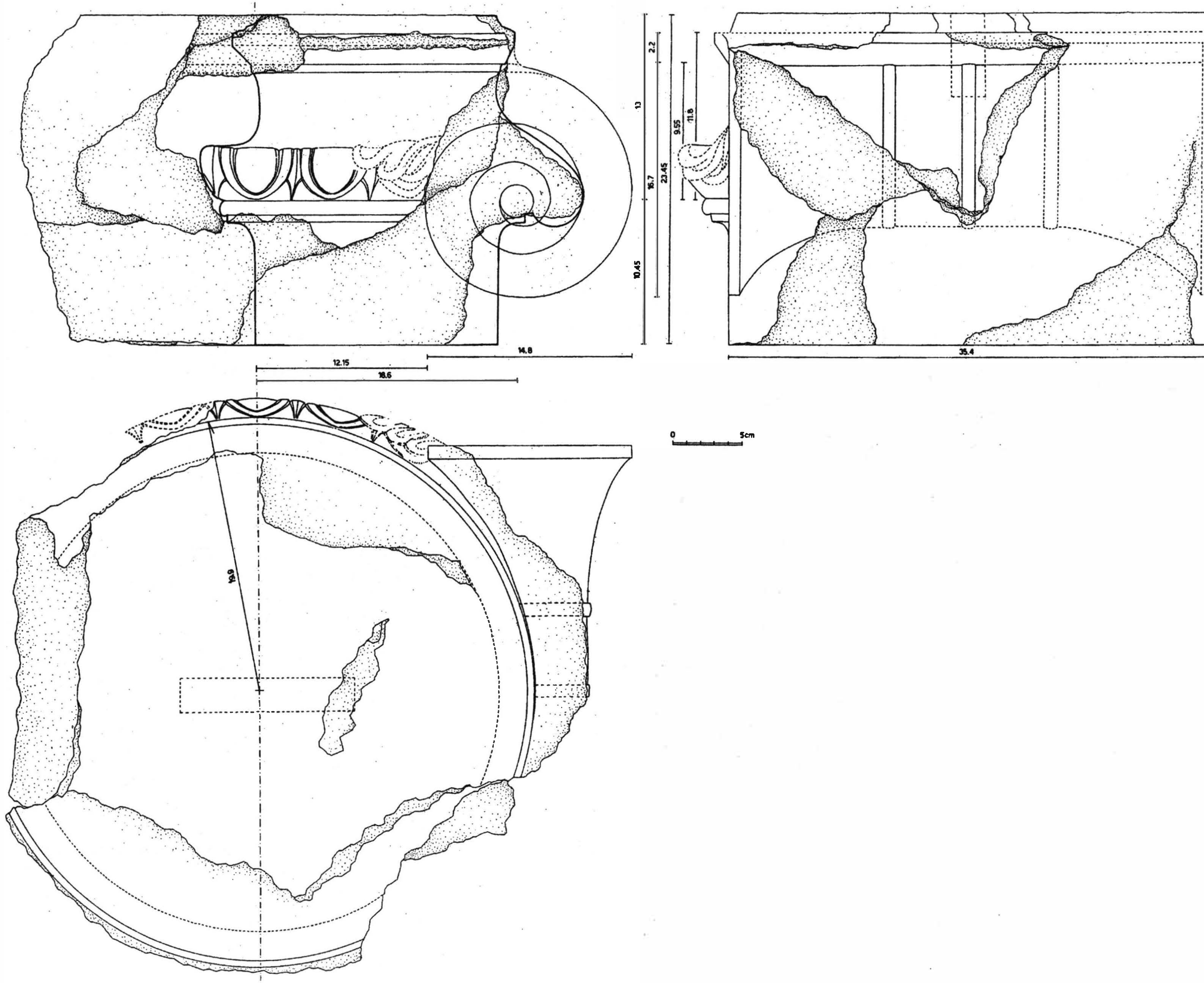

Plate 9. The *Histria 91* Capital.

21. Histria, cap. "Cφ"
M. MĂRGINEANU-CÂRSTOIU, *Computer analysis of ionic capitals*, *Dacia*, NS., 34, 1990, p. 78 n. 6, p. 108, fig. 25, p. 109, fig. 26

22. Priene, Athena (~330):
W. HOEPFNER, E-L. SCHWANDNER, *Haus und Stadt im klassischen Griechenland, Wohnen in der klassischen Polis*, I[1],1986, p 166; *ibidem*, I[2], (1994), p. 232-233

23. Priene, Zeus (4th c.):
W. HOEPFNER, E-L SCHWANDNER, I, p. 166

24. Labranda, Zeus (4th c.):
W. HOEPFNER, E-L. SCHWANDNER ,I, p. 194

25. Alexandria (end 3rd c.):
W.HOEPFNER, *Zwei Ptolemaierbauten, Das Ptolemaier-weihgeschenk in Olympia und ein Bauvorhaben in Alexandria*, IM, Beiheft 1, (1971), p. 56, 71-75

26. Delos, Hypostyle Hall (3rd c.):
G. LEROUX, *EAD*, 2, (1909), p. 26-27, fig. 40-41

27. Ephesus, cap.K_2 (early Ist c.):
A. BAMMER, *Hellenistische Kapitelle aus Ephesusesos*, AM., 88, (1973), p.222/fig.3; p.231

28. Ephesus, cap. K3, (early 1st c.):
A. BAMMER, AM., (1973) p. 224, fig. 4; p. 231

29. Afyon Museum (278-280),
BINGÖL No. 1 p. 159

30. Dojymaion (Iscehisar), (. 278-280),
BINGÖL No. 4/p.167

31. Aphrodisias (theater zone) (Augustus)
BINGÖL no. 43, p.168

32. Claudiopolis (Antinous T., Hadrian)
Bingöl NO.80, P.176

33. Burdur Museum (2nd c.)
BINGÖL no. 85, p. 178

34. Denizli (Augustus)
BINGÖL no. 86, p. 179

35. Asklepieion, Pergam, North hall,(Hadrian),
BINGÖL no.70, p. 174

36. Denizli (Trajan)
BINGÖL no. 88, p.180

37. Denizli, (Trajan),
BINGÖL no. 91/p.181

38. Ephesus (2nd-3rd c.),
BINGÖL no. 97, p. 183

39. Ephesus, Selcuk Museum (1st c. BC),
BINGÖL no. 100 p.184

40. Ephesus, Marble Street (2nd-3rd AD),
BINGÖL no. 111, p. 188

41. Ephesus (end 4th c. AD),
BINGÖL no. 136, p.194

42. Hierapolis (S. Severus)
BINGÖL no. 146, p. 196

43. Ismir/ Basmane Museum (2nd c. AD),
BINGÖL no. 154, p. 200

44. Didyma (Augustus),
BINGÖL no.155, p. 200

45. Didyma (2nd c.),
BINGÖL no 157, p. 201

46. Didyma (3rd c.)
BINGÖL no.158, p. 201

47. Didyma (1st BC),
BINGÖL, no. 159, p. 202

48. Kaunos (Augustus),
BINGÖL no.165, p. 204

49. Magnesia/ Agora/ South hall (end 3rd c)
BINGÖL no.196, p. 212

50. Pergamon Museum,
BINGÖL no. 217, p. 219

51. Perge (Hadrian)
BINGÖL no. 234, p. 224

52. Teos, Dionysus (Hadrian)
BINGÖL no. 296, p. 236

53. Termessos (near Odeion)
BINGÖL no. 300, p. 238

54. Side Museum (3rd-4th c. AD),
BINGÖL no. 294, p.235

55. Yalvaç Museum (3rd c. AD),
BINGÖL no. 314, p. 242

56. Laodiceea ad Lycum (S. Severus),
BINGOL no.170, p. 206

57. Laodiceea ad Lycum (S. Severus)
BINGÖL no. 172, p. 206

58.VITRUVIUS
P. GROS, *Vitruve.Commentaire*, *III*, p. 167-168, Figs. 33-34

59. Histria 17 (layout by M. Mărgineanu-Cârstoiu)

60. Histria AC.203 (layout by M. Mărgineanu-Cârstoiu)

61. Histria CD (layout by M. Mărgineanu-Cârstoiu)

62. Histria 39 (layout by M. Mărgineanu-Cârstoiu)

63. Histria 0536 (layout by M. Mărgineanu-Cârstoiu)

64. Aphrodisias
D. THEODORESCU, *Le Projet de Vitruve*. chap. T2, p.8)

65. Aphrodisias, cap.T3
D.THEODORESCU, *loc.cit*)

66. Aphrodisias, cap. T4
D. THEODORESCU, *loc.cit*)

67. Attalos Stoa (~150)
HOEPFNER, 1968, p.230

68. South Agora Magnesia (HOEPFNER, 1968, p. 228)

69. Histria *C34*
M. MĂRGINEANU-CÂRSTOIU, Xenia, 25 (1990), p. 117-123, fig. 6, 12-13

70. Histria *Cφ*
M. MĂRGINEANU-CÂRSTOIU, "Computer analysis of ionic capitals", Dacia, NS., 34, (1990), p. 78 n. 6, p. 108, fig. 25, p. 109, fig. 26

71. Histria *0475* (layout by M. Mărgineanu-Cârstoiu)

72.Histria *C32* (layout by M. Mărgineanu-Cârstoiu)

73. Histria *C29* (layout by M. Mărgineanu-Cârstoiu)

74. Histria *91* (layout by M. Mărgineanu-Cârstoiu)

APPENDIX 3

List of 32 Hellenistic capitals (numerical correspondence, chronology, bibliography)

1. Ephesus, Artemisium " E " (330-320):
A. BAMMER,"Die Architektur des Jüngeren Artemision von Ephesos",(1972), p. 17 sq., fig. 22, 23; H.C. BUTLER, *Sardis* II, 1, (1925), Atlas, pl. XII-XIII

2. Ephesus, Altar/Artemisium (350-325):
W. ALZINGER, *JOAI*, 46, (1961-1963), fig. 73, 86

3.Ephesus, chap. dans le Musée d'Izmir, (320-300):
W. ALZINGER, *JOAI*, 46 (1961-1963), fig. 93-94

4. Didyma, hellen. Apollo T. / int.row (end 3rd c):
TH. WIEGAND, *Didyma* I, I^3, pl. 52, Z 408, 409, 410

5. Didyma , hellen. Apollo/ ext. row (2nd c.):
TH. WIEGAND, *Didyma* I, pl. 53, Z 422, 423, 424

6. Halicarnassus, Mausoleum (~ 350):
W. HOEPFNER, E.-L. SCHWANDNER, *Haus und Stadt im Klassischen Griechenland*, I^1 (1986), p. 161-166; O. BINGÖL, *Das ionische Normalkapitell in hellenistischer und römischer Zeit in Kleinasien*, IM, Beiheft 20, (1980), p.195

7. Prieue, Athena (~ 330):
TH. WIEGAND, H. SCHRADER, ***Priene***, *Ergebnisse der Ausgrabungen 1895-1898*, Berlin **(1904)**, fig. 58-59

8. Priene, Athena (~ 330):
O. RAYET, A. THOMAS, *Milet **et le Golfe** Latmique*, I, Paris, (1877), p.22; Atlas, pl.14; H DRER"**P**, *"Pytheos und Satyros..."*, *JdI*, 69, (1954), p. 18

9. Sardis, Artemisium (before 300):
H. BUTLER, *Sardis* II, 1, (1925), fig. 70, 73, **77**, **80**; **Atlas**, pl. VIII, X.

10. Magnesia, Artemis T. (220-200 ?):
C. HUMANN, J. KOHTE, C. WATZINGER, *Magnesia am Meander,Bericht über der Ausgrabungen 1891-1893*, Berlin, (1904), fig. 35

11. Pergamum, Great Altar (168-159): MMC

12. Lesbos (Messa), Aphrodite (~ 280):
R. KOLDEWEY, *Die antiken Baureste der Insel Lesbos*, Berlin, (1900), pl. 17

13. Inwood capital,
H. W. Inwood, *The Erechteion at Athens. Fragments of Athenian Architecturen and a Few Remains in Attica, Megara and Epirus*, 1831, pl. 24

14. Olympia, Leonidaeum (~ 325):
E. KURTIUS, F. ADLER, Olympia, Ergennisse II , 1892, pl. LXV

15. Olympia, votive (350-300):
E. KURTIUS, F.A DLER *op. cit*, pl. LXXXIX/25, XC/7a-b

16. Olympia, votive early. 3rd c.)
W. HOEPFNER, *Zwei Ptolemaierbauten, Das Ptolemaier-weihgeschenk in Olympia und ein Bauvorhaben in Alexandria*, IM, Beiheft 1, (1971)

17. Histria, cap."C34":
M. MĂRGINEANU-CÂRSTOIU, Xenia, 25 (1990), p. 117-123, fig. 6, 12-1318. Histria, chap. "C$_\varphi$"
M. MĂRGINEANU-CÂRSTOIU, *Computer analysis of ionic capitals*, Dacia, NS., 34, 1990, p. 78 n. 6, p. 108, fig. 25, p. 109, fig. 26

19. Priene, Athena (~330):
W. HOEPFNER, E-L. SCHWANDNER, *Haus und Stadt im klassischen Griechenland, Wohnen in der klassischen Polis*, I^1, (1986), p 166; *ibidem*, I^2, (1994), p.232-233

20. Priene, Zeus (4th c.):
W. HOEPFNER, E-L. SCHWANDNER, 1986, p. 166

21. Labranda, Zeus (4th c.):
W. HOEPFNER, E-L. SCHWANDNER, *Haus und Stadt*, p. 194

22. Samothrace (Propylon) (2nd c.)
J. BOUZEK, I. ONDREJOVA, Samothrace 1923/1027/1978, The results of the Czechoslovak excavations in 1927 conducted by A. Salac and J. Nepomucky and the unpublished results of the 1923 Franco Czechoslovak excavations conducted by A. Salac and F. Chapouthier, 1985, p.78, figs. 45-46; PH. W. LEHMANN, D. SPITTLE, *The Temenos*, Samothrace V, 1982, p. 62-63, fig. 47; p.58 fig. 42, pl. XVII-XVIII (cap. n^o 49414); A. FRAZER, Samothrace X, 1990, p. 158, fig. 1-2.

23. Cos, Asklepios, (2nd-3rd c.)
P.SCHAZMANN, Asklepieion I, 1932, p. 37-38, p. 20 Figs. 1-2

24. Alexandria (end 3rd c.):
W.HOEPFNER, *Zwei Ptolemaierbauten, Das Ptolemaier-weihgeschenk in Olympia und ein Bauvorhaben in Alexandria*, IM, Beiheft 1, 1971, p. 56, 71-75

25. Delos, Hypostyle Hall (3rd c.):
G. LEROUX, *EAD*, 2, 1909, p. 26-27, fig. 40-41

26. **Milet/Didyma,**
BINGÖL, p. 181

27. Ephesus, cap.K$_2$ (early 1st c.):
A. BAMMER, *Hellenistische Kapitelle aus Ephesus*, AM., 88, 1973, p. 222/ fig. 3; p. 231

28. Ephesus, cap. K3, (early 1st c.):
A. BAMMER, AM., (1973) p. 224, fig. 4; p. 231

29. Chryse, Apollo Smintheus
apud F. RUMSCHEID, *Untersuchungen zur kleinasiatischen Bauornamentik des Hellenismus*, Beitrage zur Erschlissung hellenistischer und keiserzeitlicher Skulptur und Architektur, Band 14, Mainz, 1994, pl. 18/31

30. Attalos Stoa
HOEPFNER, 1968, p. 230

31. South Agora Magnesia
HOEPFNER, 1968, p. 228)

32. VITRUVIUS

APPENDIX 4

Database;74 Hellenistic and Roman ionic capitals
(numerical correspondence: 1-74 rows /capitals; 1-13 columns/variables)

1	2	3	4	5	6	7	8	9	10	11	12	13	
1.681	1.079	1.667	1.067	0.306	1.676	1.838	3.820	0.578	0.422	0.751	1.140	0.349	1
1.565	1.042	1.500	1.000	0.306	1.718	1.920	4.500	0.625	0.375	1.000	1.132	0.346	2
1.800	1.167	1.982	1.175	0.344	1.925	1.550	4.770	0.634	0.366	1.012	1.115	0.383	3
1.580	1.005	1.455	0.928	0.323	1.820	1.725	3.680	0.555	0.445	0.756	1.140	0.368	4
1.420	0.925	1.430	0.980	0.280	1.580	2.180	5.750	0.520	0.480	1.000	1.127	0.314	5
1.500	0.990	1.490	0.980	0.304	1.680	1.920	5.200	0.458	0.542	1.000	1.128	0.351	6
1.494	0.993	1.495	0.994	0.288	1.575	1.989	4.612	0.645	0.322	0.903	1.156	0.333	7
1.500	0.998	1.621	1.080	0.300	1.666	1.940	4.630	0.545	0.456	0.875	1.127	0.338	8
1.640	1.180	1.639	1.177	0.258	1.487	2.475	5.080	0.528	0.470	0.815	1.130	0.292	9
1.570	1.000	1.610	1.038	0.325	1.817	1.688	3.750	0.510	0.390	0.802	1.161	0.363	10
1.512	0.994	1.537	1.005	0.302	1.660	1.880	4.680	0.610	0.390	0.950	1.155	0.349	11
1.632	1.115	1.632	0.885	0.288	1.582	2.100	4.520	0.520	0.480	0.815	1.137	0.327	12
2.315	1.439	2.141	1.331	0.330	1.839	1.688	4.597	0.472	0.527	0.941	1.118	0.369	13
1.656	1.040	1.640	1.030	0.314	1.845	1.745	4.300	0.575	0.425	0.857	1.145	0.360	14
1.500	0.940	1.540	0.945	0.315	1.710	1.800	5.800	0.550	0.450	1.100	1.112	0.350	15
1.240	0.825	1.240	0.825	0.295	1.618	2.020	5.200	0.750	0.250	1.000	1.118	0.330	16
1.610	1.125	1.450	1.015	0.278	1.580	2.200	4.600	0.666	0.334	1.130	1.140	0.317	17
1.505	1.004	1.382	0.922	0.289	1.611	2.002	4.757	0.614	0.384	0.896	1.151	0.333	18
1.550	0.963	1.690	1.050	0.298	1.545	1.730	3.100	0.632	0.378	0.646	1.212	0.361	19
1.367	0.904	1.374	0.908	0.303	1.680	1.894	4.990	0.442	0.553	1.000	1.004	0.304	20
1.381	0.929	1.375	0.925	0.296	1.650	2.118	4.530	0.414	0.585	0.792	1.118	0.331	21
1.531	1.015	1.573	1.043	0.300	1.652	1.960	4.713	0.554	0.445	0.856	1.127	0.338	22
1.508	0.989	1.576	1.034	0.295	1.606	1.968	4.906	0.514	0.485	0.906	1.129	0.333	23
1.500	1.000	1.511	1.007	0.291	1.600	2.000	5.050	0.703	0.323	0.947	1.142	0.330	24
1.467	0.997	1.387	0.942	0.285	1.579	2.163	5.191	0.528	0.471	0.915	1.100	0.314	25
1.402	0.958	1.463	1.000	0.287	1.604	2.156	5.315	0.552	0.447	1.000	1.103	0.316	26
1.492	0.997	1.422	0.951	0.292	1.659	2.156	5.185	0.533	0.466	0.955	1.058	0.310	27
1.492	1.007	1.450	0.978	0.300	1.654	2.106	5.722	0.388	0.611	1.000	1.119	0.319	28
1.483	1.000	1.435	0.967	0.288	1.589	2.119	6.286	0.238	0.762	1.047	1.105	0.318	29
1.428	1.020	1.458	1.042	0.278	1.613	2.273	5.384	0.231	0.769	1.000	1.128	0.314	30
1.441	1.000	1.509	1.047	0.269	1.500	2.220	5.333	0.400	0.600	0.933	1.163	0.312	31
1.470	D.974	1.483	0.983	0.302	1.676	2.073	5.212	0.424	0.576	1.000	1.058	0.319	32
1.500	1.000	1.500	1.000	0.298	1.652	2.054	5.700	0.300	0.700	1.100	1.088	0.324	33
1.545	1.027	1.491	0.991	0.294	1.614	1.989	5.484	0.258	0.677	0.968	1.136	0.334	34
1.640	1.060	1.390	0.898	0.293	1.656	1.948	4.823	0.294	0.706	0.941	1.133	0.332	35

1	2	3	4	5	6	7	8	9	10	11	12	13	
1,434	0.921	1.535	0.986	0.303	1.628	2.000	5.737	0.210	0.789	1.000	1.061	0.321	36
1.452	0.986	1.472	1.000	0.311	1.800	2.250	5.889	0.167	0.833	1.111	0.969	0.302	37
1.555	1.000	1.628	1.046	0.307	1.667	1.915	5.185	0.222	0.778	0.926	1.093	0.336	38
1.500	0.983	1.500	0.983	0.300	1.616	1.903	5.294	0.706	0.294	1.000	1.148	0.344	39
1.365	0.948	1.472	1.022	0.290	1.654	2.116	4.679	0.179	0.821	0.857	1.132	0.328	40
1.525	1.075	1.488	1.049	0.279	1.593	2.150	4.518	0.296	0.703	0.852	1.176	0.328	41
1.512	1.073	1.589	1.128	0.282	1.629	2.095	4.593	0.222	0.778	0.889	1.200	0.339	42
1.421	0.987	1.513	0.961	0.305	1.630	2.142	5.619	0.238	0.762	0.952	0.972	0.296	43
1.480	1.015	1.404	0.963	0.288	1.617	2.113	5.457	0.457	0.543	1.000	1.127	0.325	44
1.522	1.022	1.400	0.940	0.286	1.620	2.000	5.385	0.461	0.538	1.038	1.175	0.336	45
1.500	1.000	1.644	1.096	0.317	1.818	1.818	5.454	0.182	0.818	0.909	1.158	0.367	46
1.474	1.000	1.583	1.074	0.292	1.633	2.071	5.700	0.300	0.700	1.034	1.120	0.327	47
1.500	1.000	1.518	1.012	0.317	1.822	1.952	5.347	0.478	0.521	1.000	1.076	0.341	48
1.499	0.995	1.457	0.967	0.297	1.645	1.993	5.161	0.583	0.416	0.955	1.118	0.332	49
1.622	1.075	1.563	1.036	0.290	1.583	1.965	5.375	0.375	0.625	0.937	1.160	0.337	50
1.490	1.000	1.447	0.971	0.276	1.500	2.125	5.428	0.321	0.678	0.928	1.142	0.315	51
1.531	1.021	1.858	1.238	0.291	1.600	1.959	4.500	0.593	0.500	0.875	1.166	0.340	52
1.636	1.200	1.500	1.100	0.222	1.434	2.693	6.666	0.296	0.703	1.185	1.225	0.272	53
1.237	0.800	1.356	0.876	0.313	1.729	2.064	7.071	0.000	1.000	1.071	1.000	0.313	54
1.565	1.014	1.542	1.000	0.314	1.750	1.842	5.400	0.250	0.750	1.050	1.117	0.351	55
1.200	0.800	1.263	0.842	0.322	1.882	2.064	4.800	0.000	1.000	0.800	1.000	0.322	56
1.448	1.000	1.448	1.000	0.285	1.705	2.230	7.000	0.000	1.000	1.250	1.083	0.309	57
1.500	1.000	1.500	1.000	0.291	1.600	2.000	5.333	0.444	0.555	1.000	1.142	0.333	58
1.410	0.940	1.527	1.018	0.291	1.595	2.156	5.972	0.495	0.500	1.000	1.062	0.309	59
1.491	0.985	1.511	1.004	0.298	1.641	1.975	5.513	0.387	0.604	1.052	1.131	0.336	60
1.505	1.000	1.505	1.000	0.311	1.760	2.000	4.953	0.000	0.822	0.897	1.066	0.332	61
1.377	0.953	1.340	0.928	0.277	1.558	2.115	4.148	0.514	0.485	0.781	1.178	0.327	62
1.482	0.956	1.543	0.994	0.310	1.704	1.849	5.109	0.495	0.504	1.000	1.121	0.348	63
1.420	0.966	1.470	1.000	0.286	1.507	2.104	6.060	0.469	0.530	1.163	1.129	0.323	64
1.499	1.000	1.499	1.000	0.291	1.602	2.000	5.328	0.442	0.553	0.996	1.142	0.333	65
1.493	1.000	1.500	1.000	0.291	1.600	2.000	5.339	0.444	0.556	1.000	1.143	0.333	66
1.475	0.978	1.330	0.882	0.293	1.607	1.979	5.320	0.460	0.539	1.000	1.139	0.334	67
1.499	0.995	1.321	0.877	0.297	1.645	1.993	5.160	0.583	0.416	0.958	1.118	0.332	68
1.367	0.904	1.374	0.908	0.303	1.680	1.894	4.990	0.442	0.553	1.000	1.004	0.304	69
1.381	0.929	1.375	0.925	0.296	1.650	2.118	4.530	0.414	0.585	0.792	1.118	0.331	70
1.581	1.084	1.581	1.084	0.276	1.531	2.218	4.960	0.488	0.511	0.881	1.118	0.309	71
1.554	1.030	1.554	1.030	0.307	1.718	2.035	5.670	0.324	0.625	1.000	1.059	0.325	72
1.498	1.015	1.573	1.065	0.295	1.659	2.055	5.292	0.522	0.477	1.000	1.112	0.329	73
1.522	1.050	1.392	0.961	0.274	1.530	2.227	5.109	0.639	0,360	1.000	1.128	0.309	74

APPENDIX 5

Database; 32 Hellenistic ionic capitals (numerical correspondence: 1-32 rows/capitals; 1-16 columns/variables)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.681	1.176	1.079	0.699	1.667	1.164	1.067	0.306	1.676	1.838	3.820	0.578	0.422	0.751	1.140	0.349
2	1.565	1.083	1.042	0.693	1.500	1.040	1.000	0.306	1.718	1.920	4.500	0.625	0.375	1.000	1.132	0.346
3	1.580	1.095	1.005	0.695	1.455	1.010	0.928	0.323	1.820	1.725	3.680	*0.555*	0.445	0.756	1.140	0.368
4	1.420	1.040	0.925	0.765	1.430	1.050	0.980	0.280	1.580	2.180	*5.750*	0.520	0.480	1.000	1.127	0.314
5	1.500	1.030	0.990	0.685	1.490	1.020	0.980	0.304	1.680	1.920	5.200	0.458	0.542	1.000	1.128	0.351
6	1.494	1.000	0.993	0.669	1.495	1.001	0.994	0.288	1.575	1.989	4.612	0.645	0.322	0.903	1.156	0.333
7	1.500	1.000	0.998	0.666	1.621	1.080	1.080	0.300	1.666	1.940	4.630	0.545	0.456	0.875	1.127	0.338
8	1.640	1.128	1.180	0.687	1.639	1.125	1.177	0.258	1.487	2.475	5.080	0.528	0.470	0.815	1.130	0.292
9	1.570	1.050	1.000	0.668	1.610	1.090	1.038	0.325	1.817	1.688	3.750	0.510	0.390	0.802	1.161	0.363
10	1.512	1.000	0.994	0.677	1.537	1.080	1.005	0.302	1.660	1.880	4.680	0.610	0.390	0.950	1.155	0.349
11	1.621	1.132	1.076	0.702	1.602	1.119	1.064	0.295	1.625	2.044	4.281	0.617	0.382	0.750	1.098	0.324
12	1.656	1.065	1.040	0.640	1.640	1.050	1.030	0.314	1.845	1.745	4.300	*0.575*	0.425	0.857	1.145	0.360
13	1.560	0.970	0.995	0.620	1.500	0.932	0.955	0.308	1.658	1.805	3.700	0.600	0.400	0.754	1.145	0.353
14	1.240	0.920	0.825	0.740	1.240	0.915	0.825	0.295	1.618	2.020	5.200	0.750	0.250	1.000	1.118	0.330
15	1.610	1.060	1.125	0.666	1.450	0.970	1.015	0.278	1.580	2.200	4.600	0.666	0.334	1.130	1.140	0.317
16	1.505	1.022	1.004	0.704	1.382	0.970	0.922	0.289	1.611	2.002	4.757	0.614	0.384	0.896	1.151	0.333
17	1.367	0.985	0.904	0.720	1.374	0.990	0.908	0.303	1.680	1.894	4.990	0.442	0.553	1.000	1.004	0.304
18	1.381	1.000	0.929	0.727	1.375	0.998	0.925	0.296	1.650	2.118	4.530	0.414	0.585	0.792	1.118	0.331
19	1.531	1.015	1.015	0.662	1.573	1.043	1.043	0.300	1.652	1.960	4.713	*0.554*	0.445	0.856	1.127	0.338
20	1.508	0.989	0.989	0.656	1.576	1.034	1.034	0.295	1.606	1.968	4.906	0.514	0.485	0.906	1.129	0.333
21	1.500	1.000	1.000	0.666	1.511	1.007	1.007	0.291	1.600	2.000	5.050	0.703	0.323	0.947	1.142	0.330
22	1.500	1.000	1.000	0.666	1.594	1.062	1.062	0.295	1.629	2.046	4.748	0.467	0.532	0.863	1.102	0.325
23	1.391	1.014	0.927	0.729	1.383	1.008	0.922	0.265	1.422	2.031	4.848	0.595	0.404	0.808	1.235	0.328
24	1.467	1.013	0.997	0.696	1.387	0.977	0.942	0.285	1.579	2.163	5.191	0.528	0.471	0.915	1.100	0.314
25	1.402	0.972	0.958	0.688	1.463	0.987	1.000	0.287	1.604	2.156	5.315	*0.552*	0.447	1.000	1.103	0.316
26	1.420	1.054	0.976	0.737	1.426	1.031	0.980	0.281	1.589	2.173	5.725	0.523	0.476	0.995	1.125	0.316
27	1.492	1.020	0.997	0.685	1.422	0.975	0.951	0.292	1.659	2.156	5.185	0.533	0.466	0.955	1.058	0.310
28	1.492	1.127	1.007	0.759	1.450	1.095	0.978	0.300	1.654	2.106	5.722	0.388	0.611	1.000	1.119	0.319
29	1.538	1.014	0.985	0.659	1.630	1.074	1.045	0.316	1.750	1.750	5.032	0.586	0.414	1.069	1.156	0.366
30	1.475	0.978	0.978	0.663	1.330	0.882	0.882	0.293	1.607	1.979	5.320	0.460	0.539	1.000	1.139	0.334
31	1.499	0.998	0.995	0.666	1.321	0.880	0.877	0.297	1.645	1.993	5.160	0.583	0.416	0.958	1.118	0.332
32	1.500	1.000	1.000	0.700	1.500	1.000	1.000	0.291	1.600	2.000	5.332	0.444	0.555	1.000	1.142	0.333

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