NOTES ON THE ARCHITECTURE OF SOME ROMAN SHIPS: NEMI AND FIUMICINO

The passage from boatbuilding to naval architecture was a quality step, the origin and the procedure of which are difficult to recognize. It appears that the job differentiation between *fabri* and *architecti* was present in Greek time (Plato, *Leges* 803 a-b), Hellenistic and Roman times (Plautus, *Miles* 915-921, CIL XIII 723, CIL X 5371), where the roles played by the executor *(faber)* and by the planner *(architectus)* were well specified.[1] In more recent time (e.g. in the II-III cent. A.D.) it appears that the two jobs were absorbed into a single *collegium* and that they could be somewhat interchangeable (CIL VI 33833). Clearly not all ships were planned by an architect: the *fabri* could well plan the hulls they had to build, in many cases deriving the dimensional and shaping criteria from pre-existing hulls which were considered as satisfactory. For these cases we can assume that they built "by sight" with few main measurements, which may have been derived from concepts used also by architects. The *fabri* most probably were not able to lay down drawings or calculations similar to those performed by the *architecti*. These latter, with the experience of the building technique and of the empirical concepts, used by the *fabri*, applied geometrical concepts and set up theoretical methods of planning, surveying and drawing in line with the generally developed mind of Hellenistic architecture. We have no exact nor complete written evidence about these methods, so we have to derive them from wrecks.

Before describing specific instances it may be worth while recollecting the importance of the observation of nature and the technical tools at the architect's disposal.

Many stories can be told about the attitude towards the observation of nature in Greek and Roman culture: the different legends developed in Greece and in Egypt about the origin of sails are very indicative on this purpose. The Greek legend (origin from nautilus or similar cephalopodes) shows a keen interest to the observation of nature, while the Egyptian legend is more bound to reality. Other examples are the story of the origin of the Corintian capital as told by Vitruvius or of many others told by Pilny. In the case of ships the shapes of fishes and of dolphines may have had some importance, but I would hypothetically consider also the shape of the bone of the cuttle fish (Fig. 1 A). If we draw the shape of this bone as though it was a hull, we obtain a shape much similar to that of the bottoms of the Kyrenia and of the Fiumicino wrecks. It is an hypothesis, but in sufficient agreement with the mind of ancient boatbuilders.

In addition to the concepts of *utilitas, firmitas, venustas* and *eurythmia, symmetria, commensus* and *geometricae rationes*, which in the case of shipbuilding should have had a less rigid meaning than that of modul as used in other buildings, due consideration should be given to the tools the architects used to plan and to lay down their drawings *(formae, lineae)*. Preliminary drawings were made (Plato, Cicero, Plautus) with a scale system. The Egyptians used to divide the figure into squares which were enlarged to full size, but the Greeks developed the proportion calculations. The Egyptians used to draw the plan and the other three views: front, rear and side; similarly Greek and Roman architects drew plan, side and front views of buildings. The *Forma Urbis* is a good example of plan dawing.[2]

The use of models is known as well, however also in the case of models basic drawing principles should be known.[3]

Lines and proportions were traced with a rule *(regula)* and compasses *(circinus)*, as confirmed by the stele of P. Celerius in Ostia (Fig. 1 B). We could assume also the use of the curvilineal, but no figure nor literary evidence of it, to my knowledge, has been preserved.

Units of length may have been different from place to place (as all other units), however we can accept the foot as 295 mm (Fig. 1 B). Submultiples were:

1/2: semis = 147,5 mm
1/3: triens = 98,3 mm
1/4: quadrans = 73,75 mm
1/5: (?) = 59 mm
1/6: sextans = 49,2 mm
1/12: uncia = 24,6 mm
1/16: (?) = 18,4 mm

Multiples were:

× 1,5: cubitus = 442,5 mm
× 2,5: gradus = 737,5 mm
× 5: passus = 1475 mm

These units could be combined, further divided and multiplied arithmetically or with the construction of "dynamic rectangles" or golden sections. Units of capacity were the *amphora* (26,2 l) and the *modius* (8,733 l). No workable unit of weight is documented for ships.

There is a source (Heron of Alexandria, *De mensuris,* 17) which gives the cargo capacity of a ship in Italian *modii* from the hull dimensions evaluated in cubits: 10 × length × breadth × height. But this formula is not of general application, since not all ships had the same coefficients of fineness. This is the basic drawback of such formulas also in recent times due to which widely discrepant data can be obtained. However this formula indicates that rules were known in order to obtain the required cargo capacity.[4]

The Nemi ships. (mid 1 cent. A.D.).

The fire which in 1944 destroyed the two wrecks had also the psychologic effect of blocking the researches on them. Only the consideration of the shell building technique and a revision of the already published material let me overtake the impasse and find the phases and some criteria of construction. The studies performed in the 30's and 40's, although giving for granted the skeleton building technique, could pinpoint the aspects of coefficients of fineness, metacentres and brick-wood construction, but the matter of the design of the hulls had to be reviewed completely.[5]

The presence of such large ships on the Nemi lake is unanimously attributed to worship reasons (Cybele, Diana, Isis) also because on all sacred lakes no craft should have sailed (Pliny the jounger, *Litterae* VIII-20). In addition to the Eastern type of religion (e.g. navigium Isidi) there should have been also the remembrance of the large polyremes of the Ptolemies or of Iero of Syracuse, which few decades after the Nemi ships Athenaeus contributed to keep alive. About at the same age of the Nemi ship we can remember also the ship used by Claudius in the Adriatic, the obelisk carrier sank by Claudius to build the island of the phare of the new harbour of Ostia (Pliny, *Nat. Hist.* III, 16, 149 and XVI, 76) or the leisure ship used by Domitian (Pliny the Younger, *Panegyricus,* 85.1.3) on Lake Albano.

The first Nemi ship

The hand of the *architectus,* as we think of him from humanistic tradition, is appreciable from the shape of the stempost (Fig. 2).[6] The bronze parts which were preserved are made of sectors, the junction lines of which converge to a single point Rl, the centre of the main circle of constructin of the profile (arc II-III of Fig. 2). The part under this arc (I-II) was constructed like a scotia, with centre in R2, which is on the same line connecting the main centre R1 to the junction point C. A similar construction could have been made for the upper part. We find therefore the typical Vitruvian method for constructing architectural figures, with the use of rule and compasses only. If we compare this shape to that of the prows of military ships, according to Hellenistic and Roman figures, we appreciate that this profile is somewhat idealized, it is an abstraction of real shapes, which in actual oared ships were more fragmentated by the presence of the *proembolion.*

Coming to the general planning of the ship, the following items are of importance, once we consider that structure should be completed at stern at least by two additional ribs and by others at prow, (vs M. Gatti' survey). (Fig. 3).

- The kell is straigh between about ribs 31 and 111, astern and afore those points its sheer begins.
- At about the same cross sections the curves of the sides and of the wales have a bent which does not follow the natural lines of the central parts of the hull, but show that the boards were forced to follow the narrowing of the hull towards its ends (Fig. 4 A). The deflection points have been confirmed also with models.
- Ribs without *trabes* (floor timbers) are from the stern end to the 9th, from the 140th to the prow end, and all ribs with even numbers, as shown also by the two pits for pumping bilge water (Fig. 3). This is the typical Roman

arrangement and gives the direct link to the building technique as documented by many other wrecks.

— The main section (rib No 68) is not materialized by a complete rib.

— Wales *(cincti)* at amidship section are at exact distances from the keel: that of the second is exactly twice as that of the first (Fig. 3).

— The parts of cross sections enclosed between the keel and the first *cinctus* are always rectilinear (Fig. 4).

— The part of cross sections enclosed between the first and the second *cincti* are rectilinear in the part of hull enclosed approximately by the two auxiliary sections 31 and 111.

— Regular repetitions of distances between ribs can be observed in the following cases:
midship section: 68 intervals from stern post;
auxiliary sections (or "active frames"):[7] 32 intervals from sternpost and 44 intervals from main section (if we consider rib No 112), 80 intervals between them.
Pits for pumping bilge water are at 6 to 8 intervals from auxiliary sections; *apostis* is 40 intervals long and 12 intervals from stern end; main superstructures are 40 and 24 intervals long.

All these details, once they are considered in the frame of the shell building technique, show important design principles.

The construction of the shape of the hull appears to have taken into account the profile, the three "active" or main sections (M and Q of Fig. 3), and the shape of the segments of shell enclosed by the first, the second and the third orders of *cincti*. There is a segmentation of lines of the cross sections which affects the relevant parts and which in consequence means a conceptual subdivision of the shell into segments built around the keel and, in progressive phases, around the flat part of the bottom. This will be shown more clearly by the second Nemi ship, but can be observed also in other Roman wrecks, such as the Comacchio ship.[8]

The internal structures of the first Nemi ship are well coordinated with those of the superstructures: the longitudinal frames which support the cross beams correspond to the bottom wales and this shows a good agreement between the nautical part of the hull and the rather complicated system of superstructures and marble or brick covered parts of the main deck.

The repetitions of regular intervals of ribs shows that the architect placed the elements according to fixed moduli. This is in line with the type of construction of the profile of the prow (Fig. 2), but here may had been also a modular criterion used also in other ships: e.g. in the second Nemi ship and in the Comacchio wreck the jokes for the steering lee boards are at the 12th interval from the stern end.

The general shape of the hull appears wider at stern and thinner at prow, in fact, among the shaping features, the main section (M) is not amidships (around the 74th rib), but it is displaced by 6 intervals (not occasional a distance) towards stern. In my Fig. 3 I had to adjust the shape of the prow, due to some lack of consistency between Gatti's and Rabbeno's drawings,[9] with the result of shortening a little the prow end.

The superstructures appear to have been made of two main blocks, made of two buildings each, connected by stairs and corridors, and of raised parts of the deck at the ends. This distribution gives to the ship a discontinous look, which has no comparison with ancient figures.

The second Nemi ship

The main clues to our understanding of the desing principles of this ship are:

— different directions of the boards of planking (of shell) in the different sections enclosed by the three orders of wales (Fig. 5);
— straightness to the parts of cross sections enclosed by the two orders of wales delimiting the bottom;
— planking board B of Fig. 5, at the most curved part of the sections, receives the parts of the adjacent boards; this means that during construction this board (B) was considered at least as a temporary reference to which to join the other parts of the shell;
— auxiliary sections are ribs No 35, 84 and probably 98 (Fig. 6) if we use the same criterion used for the first ship;
— the keel has an almost continous sheer, with a short straight part which does not correspond to that limited by auxiliary sections;
— like on the first ship, there is a series of ribs without *trabes* at the ends (6 and 7 at prow and at stern) and alternated ribs with and without floor timbers *(trabes),* ribs with *trabes* are the even numbers of Fig. 6, among which there is also the main section (M, III).
— The *apostis* begins at the 12th rib from stern and is 94 intervals long, the main section being at its 46th interval from stern and at its 48th interval from the prow side.
— The distance between ribs in some cases is not regular: it varies from 54 to 61 cms and this indicates that they have been put to fill an empty space of the hull, too short distances having been recovered in order to keep the foreseen number of frames.
— The system for supporting the superstructures does not correspond to the wales (Fig. 5 and 6), but it has been organized by order to obtain the widest possible space and to divide the superstructure system into regular parts (Fig. 7).

The superstructure appear to have been made of a main block, 24 ribs interval long, a heavy building at stern and a smaller one at prow. These two latter buildings are indicated by the shorter distance of the supporting cross beams and by the distribution of ballast. The lack of coordination between the nautical stricture of the hull and that of the superstructures suggests that the *arcitectus navalis* left to his civil colleague that job of making them on the available space, adjusting the final trim with ballast.

The design elements appearing from the above items are similar to those noticed for the first ship, with the only difference that the main section (M) is materialized by a complete rib *trabs* and *statumina*). Other sections could be considered as "active", such as those at the ends of the apostis (12 and 106) or those with the first *trabes* (8 and 110, similarly to Nos 9, 11 and 139 of the first ship).

Building phases and the relevant design principles may have been:

1- construction of the profile;
2- construction of the flat bottom, up to the second order of *cincti,* in two phases;
3- construction of the shell up to the third wale (or topgallant bulwarks) with the intermediate reference of the board of planking at the knee of the section.

For shaping the corresponding sections the profile, the lines of the wales and the three M and Q "active" sections could have been sufficient, but with such large hulls it is possible that other "active" frames could have been put.

4- Insertion of the ribs, first those with *trabes* and then those without them, in pre-fixed patterns between the "active" frames. The wider space between ribs 80 to 85 was recovered with shorter distances between others (from 75 to 80).

Also in the case of this ship some modular repetition of ribs intervals appears to have been used by the architect to distribute the various parts (Fig. 6).

The distribution of superstructures (Fig. 7 B) may be compared to that of the marble fountain in front of S. Maria in Dominica in Rome or to the three shrines indicated on an Isian lamp in the Museum of Ostia.[10] Both documents rely to the Isis worship and this may not be occasional. The two pairs of steering leeboards appear in a ship symbol in the catacumb of Priscilla, in paintings in the same catacumb and in that of SS Pietro and Marcellino in Rome. (About III cent. A.D.).

The Fiumicino largest boat. (III cent. A.D.)

Out of the five boats and the two fragments of sides which now are in the Museo delle Navi in Fiumicino, I consider in detail here the largest one, the so-called second large merchant ship. The state of distortion of the wrecks and the lack of published surveys made during the excavations made it necessary to interprete the photogrammetric drawings, published in scale 1:20,[12] and to evaluate the extent of distortion from the observation of the wrecks, from the continuity and symmetry of cross sections, from the shape of some water lines and from obliquous sections. The results are promising (Fig. 8) even if completion of the survey of technical details is pending.

Contrary to what was first proposed, the Fiumicino boats are not river crafts: there is not the large portion of flat bottom which would have been typical of river boats; on the contrary the hulls are nicely curved and shaped. This does not mean that the Fiumicino boats could not sail on the Tiber up to Rome.

The shape of the hulls and the way of putting together the planks of shells is common to all boats and even for three of them we can induce that they came out of the same yard. The largest of these crafts gives clues of nautical architecture:

— The profile of the keel was obtained with straight segments of the keel (A, B and C of Fig. 9 B) and with the round posts.
— The shell of the lower part of the hull (that which was preserved) was made in three sections: a central and two end parts, with almost rectilinear boards. The junction between the adjacent sections corresponds to the "active" or reference frames.
— Reference frames appear to have been complete ribs No 3 and 16 (Fig. 8) because of the change of direction of the boards of the shell, of the abrupt curvature they induce to the shape of the hull and of the fact that they are the only ones nailed against the keel.
— The position of the reference frames is nearly at 1/4 of length at the floating line from the ends and their distance from the midship section (M) is exactly the same. This justifies their definitions as *quarti* (Q) in analogy to similar references of traditional crafts.[13]
— Midship section (or main section) does not correspond to a complete rib.
— Complete ribs (those numbered in Fig. 8) were considered different from the intermediate half ribs; in the so-called large merchant ship I, the ledger ceiling plank is nailed with two nails against the complete rib and with one nail only against the half ribs.[14]
— The sides re-enter in their upper parts.
— The ratio between length and breadth is almost exactly 3/1, the breadth of the reference sections are the same and midship breadth is 5,9 m, i.e. exactly 20 Roman feet (295 mm).
— The cargo was fairly huge: first approximation graphical integration shows a total coefficient of fineness = 0,65. This means a displacement of about 110 tons, 82 of which devoted to the cargo (gross).
— The shape of the hull shows a cut-water shaped prow and a wide round stern (see also Fig. A): the drift features of the prow are not balanced by the shape of the stern, but probably, by the surface of the steering lee-boards.
— The mast appears to have been between ribs 7 and 8.

This wreck, better than others, shows the importance of auxiliary sections (Q) of the *quarti*. Moreover it confirms that the main section was not materialized by a frame (as in the first Nemi and in the Comacchio ships), but it was only imagined, and also that in a boat less important than the Nemi ships concepts of symmetry and exact measures have been used. They may have been "rules of the thumb", as known for more recent times, but they betoke a design system which was common, with due adjustments, to larger hulls and certainly *architecti navales* had taken them into account.

Segmentation of the shell and of the lines of the keel appear to be in line with geometric constructions generally used by ancient architects.[15]

Conclusions

The elements discussed above and their comparisons to wreck and figurative documents suggest the following design procedure, which was tested with a model shaped mainly according to the relief of Altino of the 1 cent. A.D.:[16]

1 Profile, midship (or main) section, plan.
2 Auxiliary sections (Q), and general layout of internal framing.
3 Lines of the wales, dividing the building phases of the shell into sections.
4 Definitive layout of internal framing with distribution of volumes and superstructures, considering first complete ribs (with *trabes*)and then half ribs (*statumina* only).

Within each design phase there were symmetries of details and segmentations which followed rules made with the aim of simplifying both design and the physical execution by the *fabri,* or of obtaining "nice" or "well proportioned" drawings. Proportions of course were different according to the types of crafts, however in Fiumicino we find a not occasional approximation to the ration 3/1 (length/breadth):

fishing boat
3

I small boat
3

II small boat
2,9

I large boat
2,9

II large boat
2,94

If now we read again Vitruvius' passage (*Architectura* I, II-4) we can observe that really internal framing was planned with a certain amount of regularity, with the preference of 3, 4 and their multiples. However this does not mean that *moduli* based upon the distances between ribs were used as a strict rule. Vitruvius' passage instead appears to inherite an ancient principle based upon oared ships, with the tholes 2 cubits (88,5 cms) far from one another.

The design principles indicated above suggest also the type of survey it is adviseable to perform on ancient wrecks. No water lines nor vertical longitudinal sections are used, but, in addition to the profile, main sections and plan, the lines of the wales and of the sections of the shell. These latter are also well approximated by obliquous sections touching the flat (or nearly flat) portion of the hull and the most curved parts of the transverse sections.

Personal experience on drawing the hulls of the Nemi, Fiumicino and other wrecks and studies revealed that drawing the shape of the hull with obliquous sections or with the lines of the wales is quicker and more accurate than with water lines.

Design principles discussed above are outlined in Fig. 9, which is based upon the model from the Altino relief and upon the largest Fiumicino boat, with their building phases (I, II, III).

Still there is much room for research, mainly as far as loads and shapes are concerned.

The position of the buildings and of ballast in the Nemi ships (Fig. 7) indicate that the effects of loads and of uplifts on the stresses of the hulls were foreseen only to a certain amount. In the first ship the distribution of loads is consistent with that of uplifts, while in the second ship there is a discrepancy between the heaviest buildings at stern and the others, which was balanced with ballast and with a smaller building at prow, but from the point of view of stresses it was not.

Only the complete reconstruction of these ships will help us to solve also the problems of volumes, of the positions of the centres of gravity, of sails and of lateral resistance.

The calculations of the volumes of the largest Fiumicino boat according to the coefficients of fineness (a), for example, give not so discrepant values, vs those we can obtain with Heron's of Alexandria formula (b):

a) 15,95 (L. × 5,9 (l) × 1,8 × 0,65 (φ) = 110 m^3 (displacement);
28 tons = weight of the empty ship; 82 tons = cargo (gross)

b) L × l × h × 10 (in cubits, 1 cubit = 0,4425 m):
36 × 13,3 × 4,07 × 10 = 19.487 *modii* (1 *modius* = 8,733 l) = 170,180 m^3, for a net weight of corn of about 70 tons.

So we can say that Heron's of Alexandria formula can be used only if the coefficient of fineness is not far from 0,65, and if we consider the stowage factor of corn of about 400 kgs/m^3. These conditions, to be rechecked case by case, are far from being general, since for large seagoing ships coefficients of fineness were most probably higher.

Hydrodynamics should have adviced a wide prow and a thin stern, while in these cases (and in many others in Antiquity) we have the contary. The bone of the cuttle-fish may have been an example (Fig. 1), however, as hinted before, this shape should be considered in terms of balance with the surface of the steering leeboards, but also of partial volumes in different trim conditions. Tests on the test tank could give a definite answer to this problem.

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SOMMARIO

Dopo un cenno ai mezzi tecnici di disegno e di calcolo a disposizione degli *architecti* romani per il progetto degli scafi ed al rapporto con i *fabri,* vengono presi in considerazione i criteri per la conformazione degli scafi antichi, prendendo come esempio le navi di Nemi e la più grande delle barche di Fiumicino, in relazione alla tecnica costruttiva a guscio ed alle sue fasi di costruzione.

Il pofilo della prima nave di Nemi appare delineato con una tipica costruzione architettonica, idealizzata rispetto al profilo delle navi militari a remi. Lo studio delle forme a della ripetizione regolare di distanze tra le ordinate ha consentito d'individuare le linee di riferimento (profilo, andamento delle cinte) e le sezioni trasversali di riferimento (maestra ed ausiliarie), consentendo di formulare ipotesi solide sulle fasi costruttive e di progetto.

La seconda nave di Nemi presenta spunti simili di ricerca, confermando quanto osservato per la prima. Le sovrastrutture di questa nave non sono però coordinate con la struttura dello scafo, allo scopo di ottenere uno spazio maggiore (esigenza non sentita per la prima nave). Queste sovrastrutture ricordano monumenti isiaci (marmo di S. Maria in Dominica a Roma e lampade votive), ma dal punto di vista strutturale hanno mantenuto sollecitazioni allo scafo, non compensate strutturalmente, ma solo staticamente con la zavorra.

Le barche di Fiumicino appaiono piuttosto simili ed alcune sono certo uscite dallo stesso cantiere. La più grande presenta un andamento delle tavole del guscio ed una curvatura delle fiancate che confermano la posizione di due sezioni trasversali di riferimento ai "quarti". Vi è una segmentazione delle linee (chiglia e guscio) ed una simmetria rispetto alla sezione maestra ed ai "quarti" che, unita alla larghezza di esattamente 20 piedi romani, confermano l'ipotesi di regole di costruzione basate su simmetrie d'insieme e di dettaglio, con un rapporto lunghezza/larghezza di 3/1 per questi tipi di barche. Anche la formula di Erone d'Alessandria pare confermata, ma essa non può essere considerata di carattere generale.

E' ancora da definire lo studio completo della forma, con la prua più sottile ed avviata della poppa.

Footnotes

1. L. Basch, *Elements d'architecture navale dans les lettres grecques,* in, "L'Antiquité Classique", XLVII (1978) fasc. 1, pp 5-36, Bruxelles. P. Pomey, *Plaute et Ovide architectes navals!,* in "Mél. Ecole Franç. Rome", t. 85, 1973.2, pp 483-515.

Enciclopedia dell'arte antica, Ist. dell'Enciclopedia Italiana, Roma 1958, Vol I, pp. 572-sgg, ad vocem *architetto, architettura.*

2. I can recollect the drawings on Egyptian papyri at the Museum of Berlin, which report the division into squares of the statues, the studies by Archimedes about the increase of three and two dimensional figures with any proportionality ratio.

3. Enciclopedia dell'arte antica, cit, Vol V, pp 132-137 ad vocem *modelli;* L. Basch, *Eléments d'architecture navale,* cit, pp 33-34.

4. M.A. Levi, *Roma Antica,* Società e costume, vol II, UTET, Torino 1963, pp 392-396; P. Pomey/A. Tchernia, *Le tonnage maximum des navires de commerce romains,* in "Archaeonautica", 2 (1978) pp 233-251, CNRS; for similar formulas used in the Renaissance: F.C. Lane, *Navires et constructeurs à Venise pendant la Renaissance,* SEVPEN, Paris 1965, p 239, however table D, pagr 224-225 show that the same formula cannot be used for instances n. 2b an 8.

5. G. Ucelli, *Le navi di Nemi,* Libreria dello Stato 1950, Roma, tav. II-X; S. Milosa, *Intorno alle navi imperiali del Lago di Nemi,* in "Rivista di cultura marinara", Roma Maggio-giugno 1938; G. Rabbeno: G.C. Speziale, *Die Forschungen im Nemi See in ihrer Bedeutung für die Geschichte der Schiffbaukunst.* Verlag: Schiffbautechnische Geselschaft, Berlin, November 1931; *M. Bonino, Una barca costruita dal faber navalis P. Longidieno nel I sec. d. C.,* in "Felix Ravenna", IV s. III-IV, Ravenna 1972, pp 19-54; M. Bonino, *La tecnica costruttiva navale antica, esempi e tipi dell'Italia settentrionale,* in *Plinio, i suoi luoghi, il suo tempo,* Noseda, Como 1984, pp 187-226; M. Bonino, *Le navi di Nemi, storia di una perdita irreparabile,* in "Archeologia Viva", a. II, No 1 (gennaio 1983), p. 14; G.B. Rubin de Cervin, *Mysteries and nemesis of the Nemi ships,* in "The Mariner's Mirror" Vol 41, London 1955, pp 38-42.

6. G. Ucelli, *Le navi di Nemi,* cit, fig. 151, p. 148.

7. L. Basch, *Ancient wrecks and the archaeology of ships,* in "The International Journal of Nautical Archaeology and Underwater Exploration", Vol. I, London 1972, pp 1-58, particularly p. 39.

8. M. Bonino, *Sewn boats in Italy, sutiles naves and barche cucite,* in Conference on sewn boats, Greenwich 1984, chapter 7 (forthcoming).

9. G. Ucelli, *Le navi di Nemi,* cit, tav. II-IV and Fig 151 vs tav V.

10. M. Bonino, *Una barca costruita,* cit, Fig. 11; L. Casson, *Ships and seamenship in the ancient world,* Princeton 1971; lamp at the Museo Ostiense, inv. 3218, Neg No. E 27268 of the former Gabinetto Fotografico Nazionale, Rome; a similar Isian lamp with three shrines was at the exhibition *GREECE AND THE SEA,* Athens 1985, No 451, 4th century A.D., Athens, Keramikos Museum.

11. M. Bonino *Barche, navi e simboli navali nel cimitero di Priscilla,* in "Rivista di Archeologia Cristiana", a. LIX, n. 3-4, pp 277-311 Roma 1983, nn 11-12.

12. O. Testaguzza, *Portus,* Roma 1970; V. Scrinari, *Le navi del porto di Claudio,* Tip. Centenari, Roma 1979.

13. M. Bonino, *Le barche del Po, della valle e del mare,* in *Mestieri della terra e delle acque,* Cultura popolare dell' Emilia-Romagna, Vol. 3, Fed. Casse di Risparmio, Pizzi Ed. Milano 1979; M. Bonino, *Sewn boats in Italy,* cit.; in the Adriatic area the *cao di sesto* is the reference for the curvature of the ends, as described also by Stefano de Zuanne, *L'archittettura navale,* manuscript at the British Museum, Add 38655, Venice 1686.

14. V. Scrinari, *Le navi,* cit, Fig. 16.

15. Among many instances we can recollect the segmentated parts of the routes of Roman roads, both within and outside the townwalls.

16. M. Bonino, *La tecnica costruttiva navale,* cit, fig. 9-11.

Captions to figures

Fig. 1. A: sections of the bone of a cuttle fish (sepia officinalis);
B: stele of P. Celerius, Ostia I cent. A.D.

Fig. 2. Geometric construction of the stempost of the first nemi ship.

Fig. 3. First Nemi ship: criteria of shape and symmetry.

Fig. 4. Cross sections of the Nemi ships, the arrows point out the sections corresponding to the deflesctions of the shell.

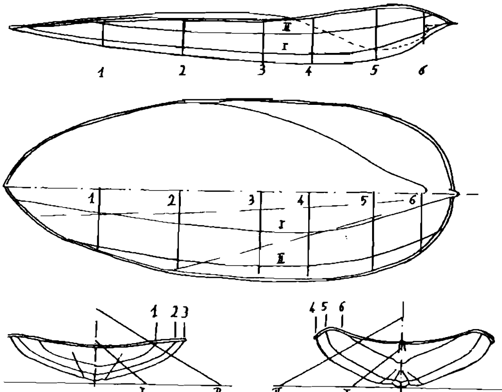
Fig. 5. A: Second Nemi ship: shape of the shell planks, A and B being the references;
B: Second Nemi ship: midship cross section.

Fig. 6. Second Nemi ship: criteria of shape and of symmetry.

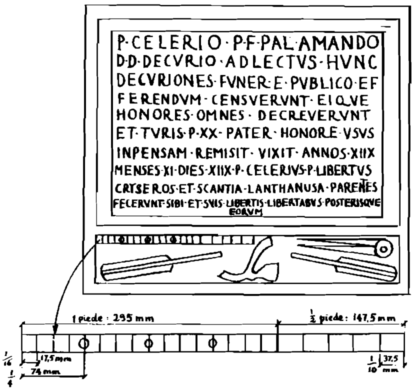
Fig. 7. Layout of the superstructures of the Nemi ship:
A: first ship
B: second ship, with the repetitions of regular intervals (A and B) in the main cross section.

Fig. 8. Fiumicino largest boat reconstruction.

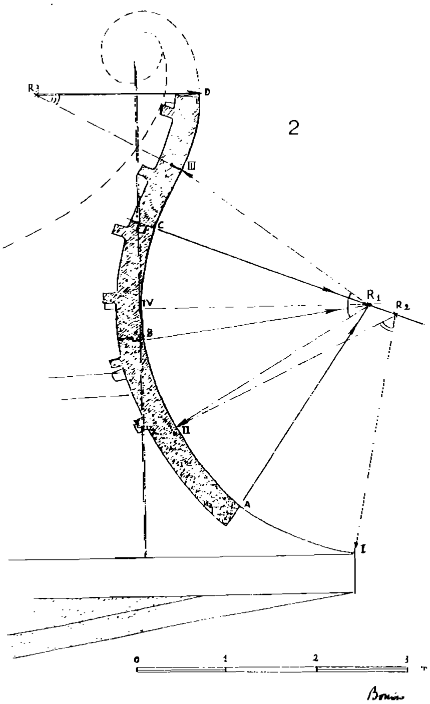
Fig. 9. Criteria for shaping Roman hulls in connection to shell building technique and phases:
A: study from a relief of Altino (I cent. A.D.)
B: segmentation of shapes defining the first building phases of the largest Fiumicino boat (II-III cent. A.D.)



1a


P·CELERIO·P·F·PAL·AMANDO
D·D·DECVRIO·ADLECTVS·HVNC
DECVRIONES·FVNERE·PVBLICO·EF
FERENDVM·CENSVERVNT·EIQVE
HONORES·OMNES·DECREVERVNT
ET·TVRIS·P·XX·PATER·HONORE·VSVS
INPENSAM·REMISIT·VIXIT·ANNOS·XIIX
MENSES·XI·DIES·XIIX·P·CELERIVS·P·LIBERTVS
CRYSEROS·ET·SCANTIA·LANTHANUSA·PARENTES
FECERVNT·SIBI·ET·SVIS·LIBERTIS·LIBERTABVS·POSTERISQVE
EORVM
1 piede : 295 mm
1/2 piede : 147,5 mm
17,5 mm
74 mm
37,5 mm

1b



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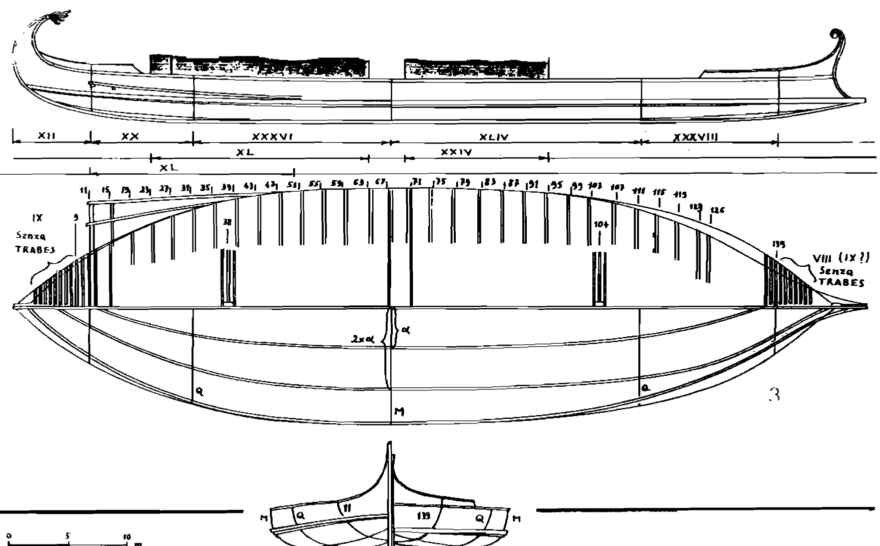
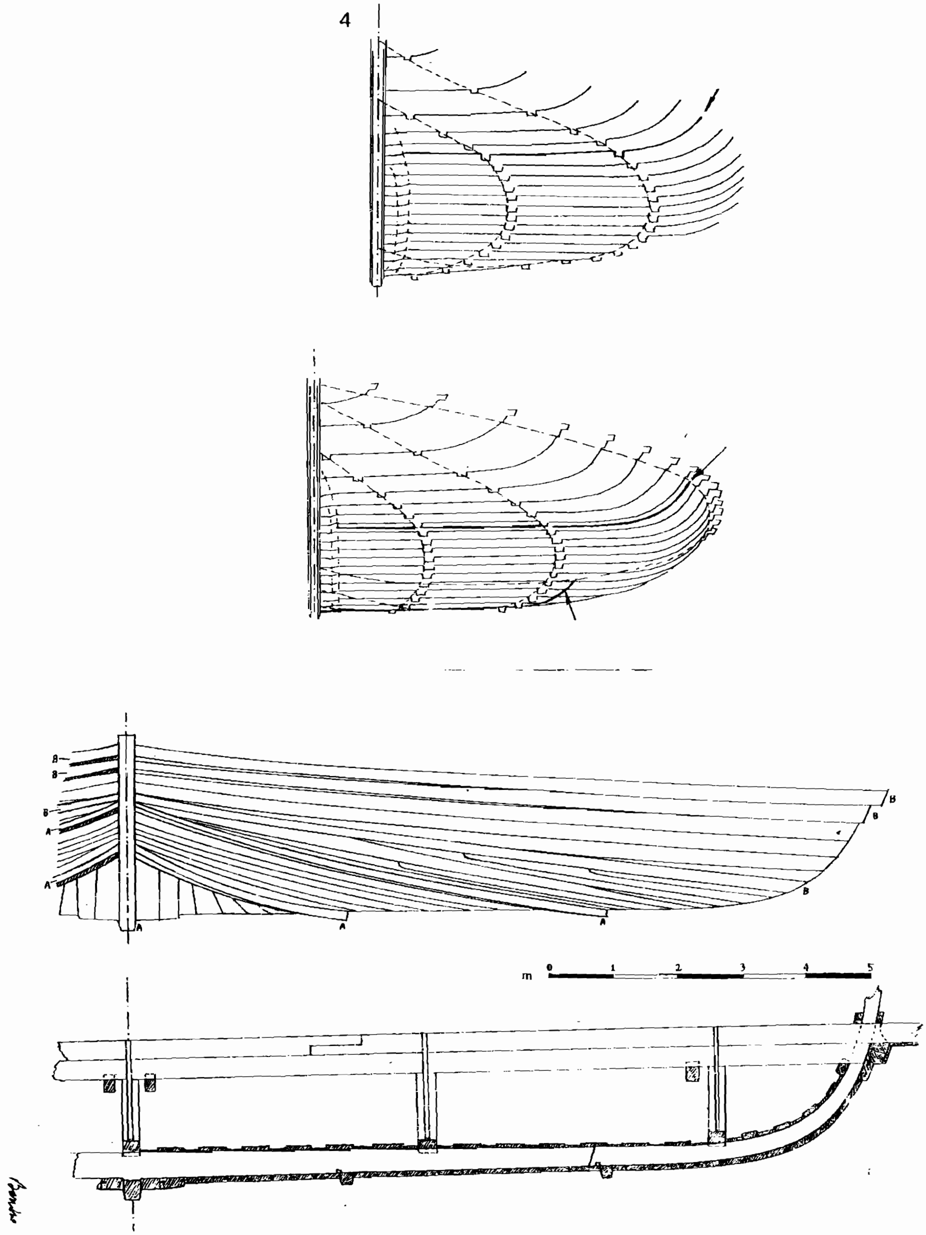
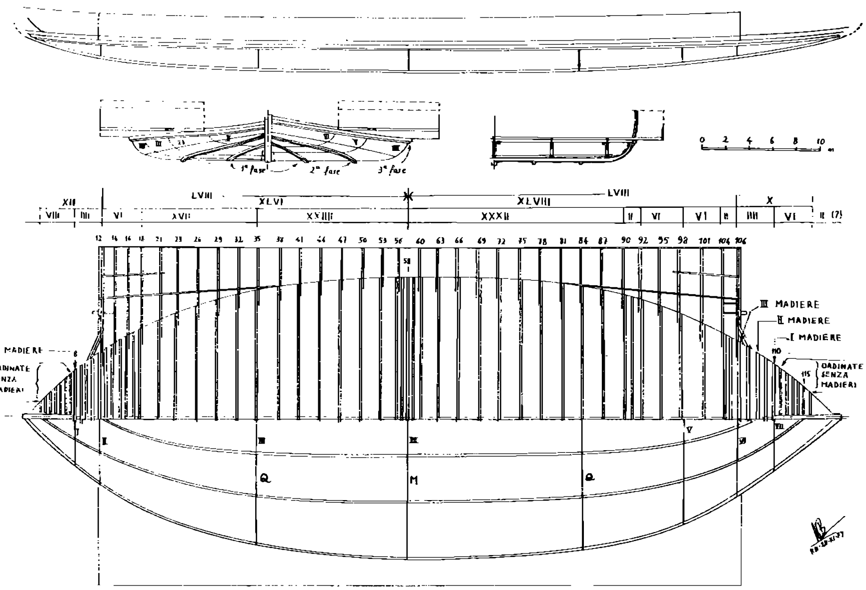

XII
XX
XXXVI
XLIV
XXXVIII
XL
XXIV
IX
Senza
TRABES
VIII (IX?)
Senza
TRABES

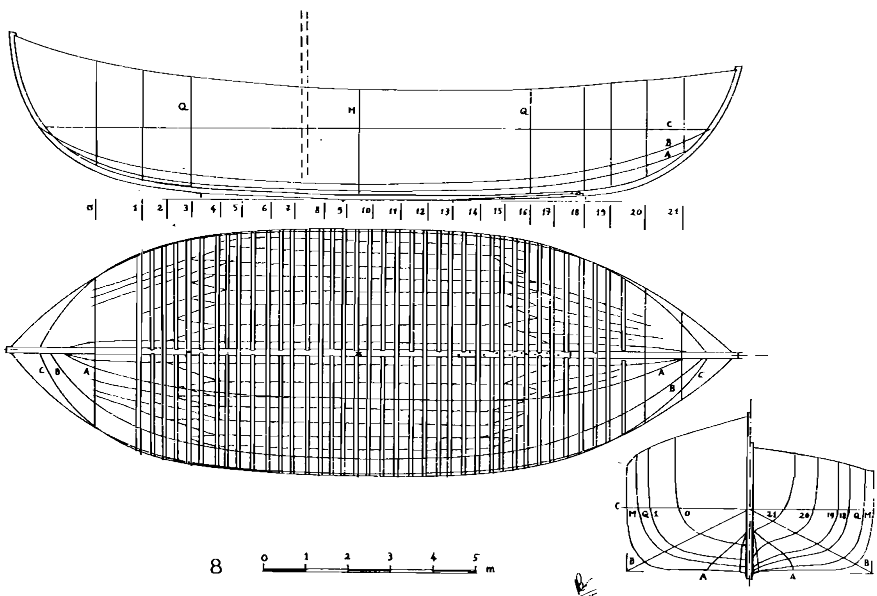
3

4





6 — *Seconda nave di Nemi, criteri di forma e di simmetria.*



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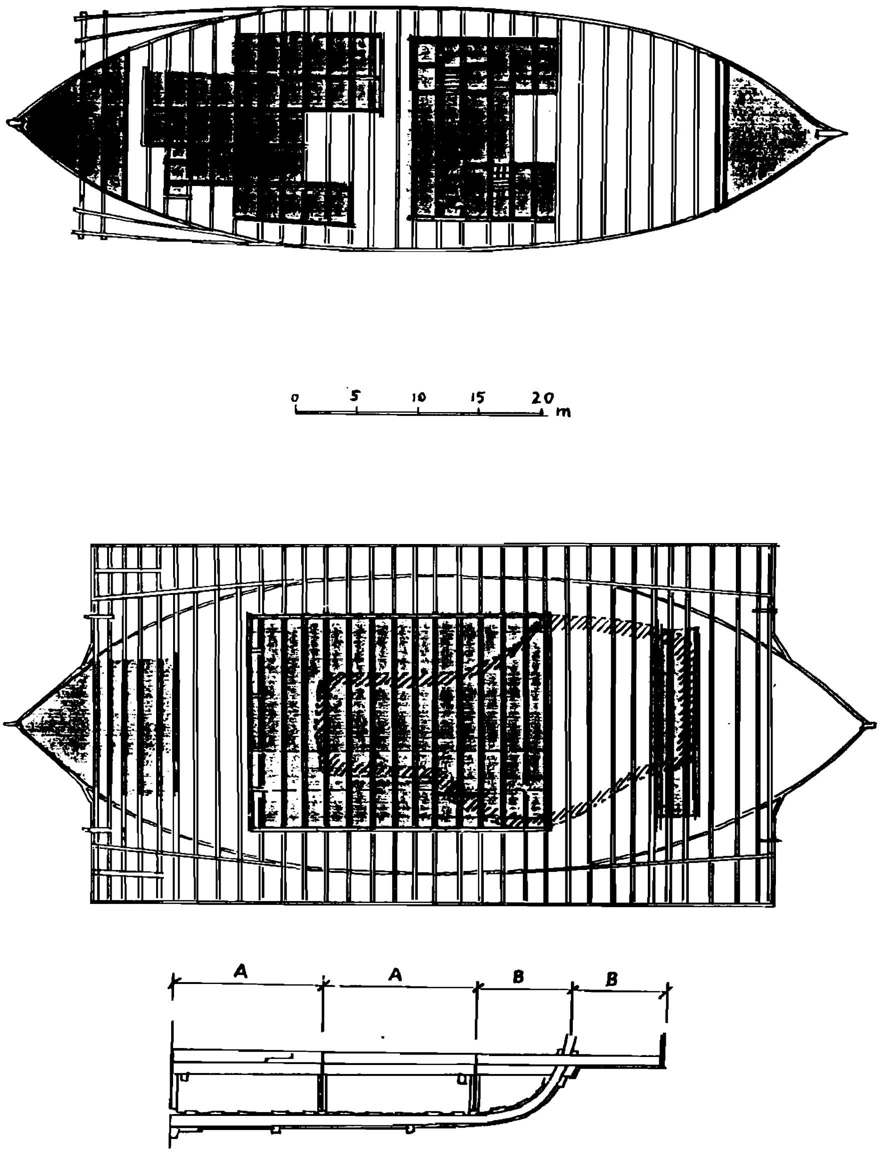
7



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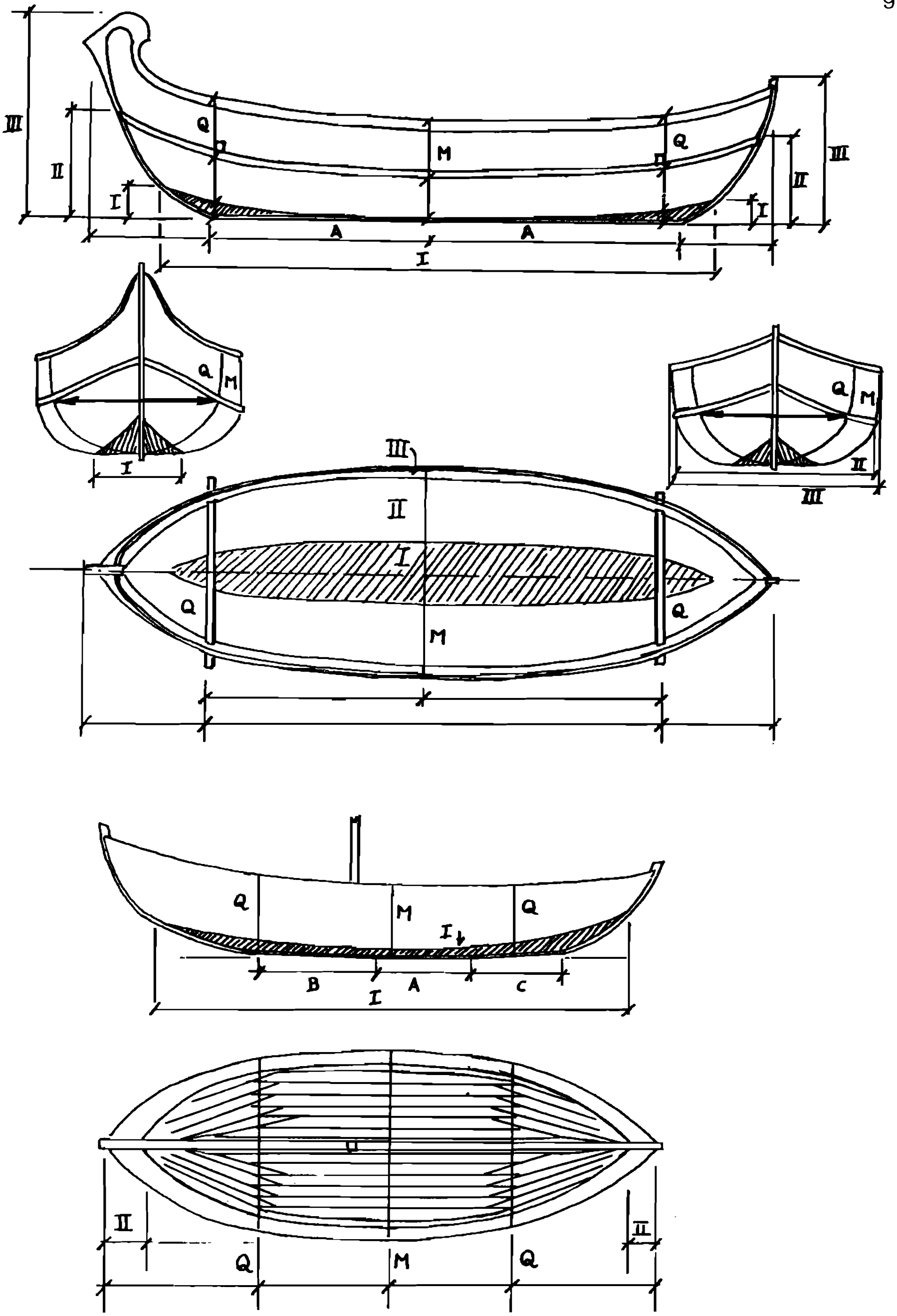

1st INTERNATIONAL SYMPOSIUM

ON

SHIP CONSTRUCTION IN ANTIQUITY

PIRAEUS, 30 AUGUST — 1 SEPTEMBER 1985

PROCEEDIGNS

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Published by the Organizing Committee of the Symposium, Athens 1989.
Editor: Harry E. Tzalas.
Cover design and layout: Yannis Pantzopoulos.