

Ancient wrecks and the archaeology of ships

Lucien Basch

Introduction

For years, naval archaeology, here defined as the study of ancient wrecks, has been the almost secret domain of specialists, often amateurs. Today, due to more and more active general interest, it has become the domain of professionals, not always specialists. This growing interest is due for the most part, to the unlooked for expansion of our knowledge through free diving, made possible by the invention of the aqualung.

Even so, we should be wrong to confuse naval archaeology with the activities of divers, whose image as amphora hunters has been popularized by television, illustrated magazines and paper backs.

Naval archaeology and underwater archaeology are far from synonymous. Indeed, the former pre-dates the latter to the most singular degree: since ancient ships have been reconstructed from literary evidence many years before the recovery of a single wreck from the seabed. The value of these reconstructions will be one of the subjects of this study.

Granted, the discovery of ancient hulls is not invariably the result of underwater archaeology: the wrecks from London, Nemi and Pantano Longarini, of which we will speak later were recovered as a result of wet excavations rather than of underwater; while the wrecks of Marseilles and Portus were recovered by excavation on land. Egypt too offers examples of ships preserved on land.

Research and study of ancient wrecks are only two among many other aims of underwater archaeology. Suffice it to recall the contributions of underwater archaeology to:

The history of art. Before the discovery at Piraeus in 1959 of an important hoard of statues all the great Greek bronzes, with the exception of the charioteer at Delphi,

had come from underwater excavations or discoveries: the ephebos of Antikythera found in 1900, that of Marathon in 1925, and the Zeus, so-called of Histiaea, found near Cape Artemision in northern Euboea (Karo, 1948).

The history of technology. The Antikythera wreck, excavated in 1900, yielded a navigational instrument the purpose of which has only recently been understood, and which has revealed an advanced, and even unsuspected state of ancient technology. It was an astronomical computer indicating the movement of the sun within the signs of the zodiac as well as the rise and setting of the principal stars. It is the only ancient instrument with graduated dial plates (Price, 1959).

The history of harbours. The classic study by Lehmann-Hartleben, 1923, *Die antike Hafenanlagen des Mittelmeeres*, Klio. Beih. XIV. Leipzig, must be supplemented and modified on the strength of the partially, or wholly underwater exploration of the harbours of Tyre (1934–36) (Poidebard, 1939), Sidon, 1946 (Poidebard & Lauffray, 1951), Apollonia, 1958–59 (Flemming, 1959, 1961), and certain other ports of north Africa (Yorke, 1967), Athlit in Israel 1965–66 (Linder, 1967), Rouad, also called Arwad, Arados (Frost, H., 1964, 1966, 1969a), Anthedon in Boeotia 1966 (Blackman *et al.*, 1967, 1968) and Cosa (McCann & Lewis, 1969, 1970).

The exploration of former land sites now submerged. (Bull. Corr. Hell, 1968: 799–801; Hall, 1967; Frost, F. J., 1968; Harding *et al.*, 1969, 1970).

The study of ancient anchors, the importance of which we shall speak of later.

The history of international trade. The study of the distribution, dating and composition of ancient cargoes found on the seabed, consisting chiefly of amphoras, enable us to

establish important links between the different regions of the ancient world. Thus, the stamp of the firm "Sestius" has been discovered on the amphoras found in 13 land excavations from Basle to Besançon, and in three underwater excavations. The Grand Congloué wreck near Marseilles has yielded no fewer than 1000 amphoras bearing this stamp.

In all these areas, the results of underwater archaeology have added to our previous sum of knowledge either by simple increase, or on occasion, by revolutionizing our earlier assumptions.

Hence, now that underwater excavation has yielded sufficient material to allow for a provisional survey, it is worth considering how these contributions fit in with the findings of naval archaeology previously obtained from other sources.

It is not the first time such a harmonization of facts has had to be undertaken. The various documentary sources themselves only became available successively: iconography for example, really only developed in the 19th century, although very rich written sources had been available since the 16th century. The results, often preposterous, derived from the latter had to be radically revised in the light of the former.

The problem posed is particularly acute as regards naval construction in the Mediterranean. Naval archaeology in Western Europe offers relatively few written sources. Iconography however is particularly rich for a period which has left hardly any wrecks^[1], that for instance of the Scandinavian rock carvings. Yet it is poor in a period which has bequeathed us a considerable number of wrecks, far exceeding the remains of ships so far discovered in the Mediterranean. Again, the problem of reconciling our sources is far less complex in northern than in southern Europe. And for a better understanding of the nature of this problem in the ancient Mediterranean, I shall outline very briefly the history of the phases of naval archaeology.

The development of naval archaeology from its origins to the 17th century

How Greek and Roman ships, and particularly the galleys were built, and how the

oars were disposed, quickly faded from the European mind; but their general appearance not so quickly.

A miniature in the Bible of Charles the Bald shows a Roman galley, distorted by a succession of copyists but still easily recognizable^[2].

Dated to about AD 1000, we even find a picture of a Roman galley which shows how the oars worked (Fig. 1). It is quite unreliable,

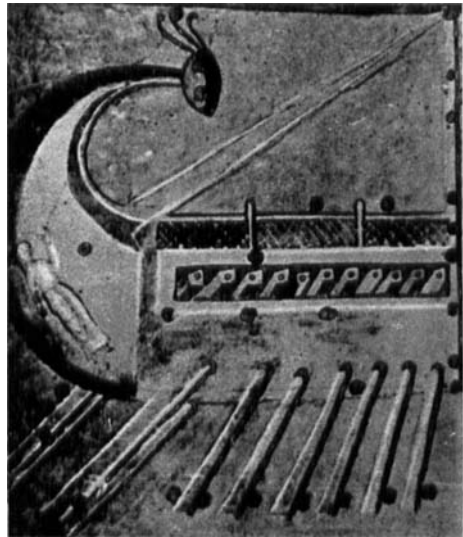


Figure 1. Representation of a Roman galley, c. AD 1000 after a lost Roman original. (After Moll, 1929, pl. G 8 i 6; MS Boulogne 188, *Sammelband*, darin *Germanicae Caesaris Phaenomena* aus St Bertin.)

of course, since clearly the copyist did not understand what he was drawing, but equally clearly he was working from a document belonging to the direct tradition (Moll, 1929, G8, i 6).

This pictorial tradition, even in the distorted form given to it by the copyists, eventually vanished from the medieval mind. For the next several hundred years, contemporary medieval craft served as models for illuminators of classical texts dealing with marine affairs, e.g. Philippe de Mazerolles' *Histoire du Roi Alexandre*, a manuscript of the mid-15th century in the Petit Palais, Paris. The classical texts themselves, on the other hand, were never entirely forgotten, and

in the 12th century Gaufridus Winesalf in his *Richardi Regis Iter* discourses on classical ships, which he had no choice but to reconstruct arbitrarily, basing his assumptions on the *galea* of his own day.

Not until the Renaissance do we see the beginnings of a deep interest in the ships of antiquity. In 1529, the humanist Vettor Fausto, built a quinquereme for the Republic of Venice, affirming it to be a reproduction of its classical prototype. This claim could only be founded on the interpretation of the writings of the Ancients, with which Fausto was very familiar. This galley was not only remarkable for the ambition of its author, but also because it constituted the final point in the evolution of the galley *a zenzile* (a galley in which each rower operated one oar). This type of galley originated in the bireme, which appears not to derive from ancient tradition, but to be a re-invention of medieval Italy. It was developed into a trireme, then into a quadrireme. The quinquereme of Fausto was its final stage and remained the only one of its kind, since a new type of rowing galley was then coming into use, the galley *a scaloccio*, in which each oar was operated by several rowers. This pseudo-ancient galley may even have another claim to fame, having inspired, either directly or by the discussions it occasioned, the first work devoted to classical shipping.

In this same year, 1529, Francis I appointed Lazarus de Baïf as French ambassador to the Serene Republic. In 1536, two years after de Baïf's return to France, he published in Paris his *Annotationes in L. II de captivis et postliminio reversis, in quibus tractatur de re navali*.

The sources available to de Baïf were of two kinds: on the one hand, the texts of the Greek and Roman authors, and it is probable that, in Venice, he had access to good copies though they had not been subjected to the close criticism which was yet to come; and on the other hand, to illustrated documents, these being few and of very inferior quality.

To this period the word archaeology hardly applies. Only a few surviving Roman monuments had attracted the attention of classical students. Prominent among the few was Trajan's Column, the reliefs on which

represent many naval scenes. So de Baïf's iconography derives essentially from this, and he very inaccurately reproduces its principal representations of ships^[3].

The fact that these documents, by virtue of circumstances, were the first to be studied is not without importance for the future of naval archaeology. For the sculptor of the reliefs on the Column was guilty of many inaccuracies, some due to style, others to his ignorance. From de Baïf till the end of the 19th century the Column continued to be considered as one of the principal sources of representations of ancient ships. However, in an important study of Greek ships, Tarn (1905: 137-56, 204-24, 206 on Trajan's Column) ridiculed these pictures, since when they have been rarely cited. Neither deserved the honour which they had received for three and a half centuries, nor the neglect accorded them today. They should now receive serious scientific attention.

De Baïf made use of other representations too, the originals of which are not all known. The representation of a *hepteres* (Fig. 2)

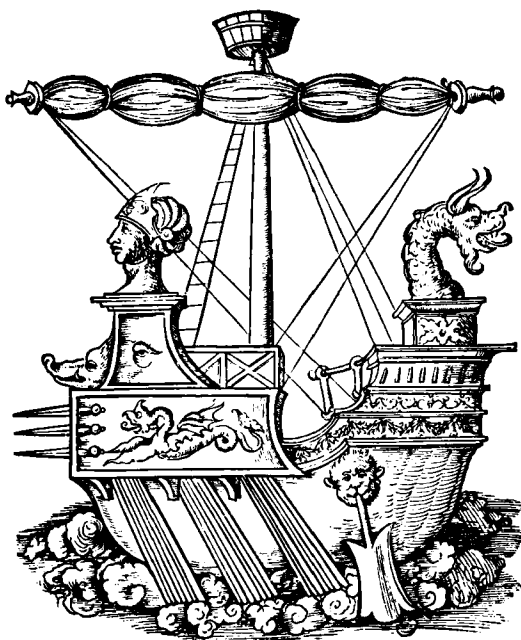


Figure 2. Reconstruction of a hepteres, or galley with seven banks of oars, after de Baïf, L., 1536, *Annotationes . . . de re navali*, the first treatise on naval archaeology.

seems to have been based on a sculptured frieze representing naval remains (prows, anchors, rudders, etc.) now in the Capitoline Museum in Rome (Jones, 1912, pl. LXI–LXII, nos. 99, 100, 102, 104–5, 107). This frieze, sometimes attributed to the reign of Trajan or of Hadrian, or sometimes to the time of Augustus, has been the subject of intense curiosity ever since its discovery. It is reproduced in almost all works on naval archaeology and even, in de Baif's time, in paintings (Crous, 1940: 65–7). Given that the object of de Baif's work is to collect all the facts relating to Greek and Roman ships, the question of how the oars of a galley operated received particular attention. The first book on naval archaeology thus inaugurates a long controversy still going on today⁴¹.

In the 17th century, the number of written sources had hardly increased, but real progress may be noted in the reproduction of illustrated documents already known in the previous century. The reproductions of the frieze in the Capitoline Museum in the work of Rafael Fabretti, *De Columna Trajana Syntagma*, 1683, Rome, are reasonably accurate. Also, more and more use is made of a new and very

rich, pictorial source: coinage. In particular, Johannes Scheffer, in his *De Militia Navalis Veterum Libri IV*, 1654, Upsala, made abundant use of this source.

Unfortunately, coins, after losing detail and precision through use, generally do not lend themselves well to drawn reproduction, and the accuracy of illustrations so obtained is far from perfect, their apparent precision being sometimes misleading.

Furthermore, coins are only of interest from the documentary point of view if they provide numerous points of comparison. Usually, however, the engraver shows only a partial view of the ship, most frequently the prow; or else he is constrained to inscribe the elongated galley within the exigencies of a circle. As a result, these are substantial distortions, analogous to those suffered by ships depicted on seals in the Middle Ages. It was difficult in the 17th century to correct these distortions; hence the reconstitution of those little squat ships riding high in the water, a cross between the ships from Trajan's Column and the galleys shown on Hadrian's coins commemorating his sea voyages.

1671 saw the publication in Amsterdam

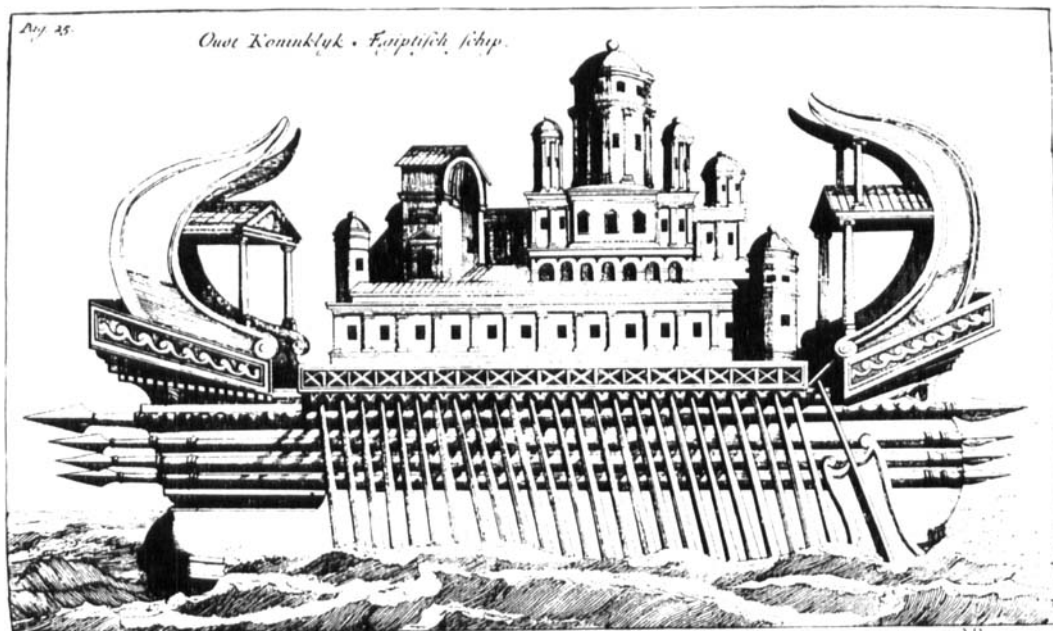


Figure 3. A Royal Egyptian ship. (After Witsen, N., 1671, *Aeloude en Hedendaegsche Scheepsbouw*, pl. XIV.)

of a remarkable work in the history of naval architecture, *Aeloude en Hedendaegsche Scheepsbouw* by N. Witsen, a compendium of naval information for the period. Witsen was not content to describe the vessels and boats of his own time, but also traced the history of their origin. It does not appear to contribute anything new concerning classical shipping, but it has the merit of assembling and synthesizing all the information previously published (for example, pl. I, the coins; pl. VIII, Trajan's Column). Further, Witsen summarizes a whole period and on this count several comments must be made:

The first is that the prestige of the Greek and Roman navy, of which they knew almost nothing in the 17th century, is immense, which suffices to explain the vast number of works on the subject published throughout learned Europe. This prestige clearly has a literary and cultural basis, but it is none the less surprising that it should have impressed Amsterdam in 1671, when the average ship of that port (for example pl. XLV) surpassed in construction, rigging and evidently in armament all ancient ships known up to that time. Paradoxically, this prestige had never been so strongly manifested as in Witsen's book. His chapter on ancient ships is delightful for the fantastic reconstructions which demonstrate that in the view of this enlightened connoisseur of naval construction, antiquity was the golden age of ship building. Nothing, in his eyes, was inconceivable either to the Greeks or to the Romans and he seems to vie in exaggeration with the descriptions which Athenaeus has left us of gigantic Hellenistic ships.

Thus, he astounds us with a *trieres* bristling with towers looking like lighthouses (pl. V) or "Nero's ship" which surpasses the former by the presence of eight towers in the form of pagodas, six of which are surmounted by a mast (pl. XIII). His "ancient royal Egyptian ship" (*Oudt Koninklijk Aegyptisch Schip*) demonstrates the quasi-magic reputation, which then, as later, adhered to all that came out of Egypt; apart from minor details, one would believe the Brussels "Palais de Justice" to be afloat (pl. XIV) (Fig. 3).

A second comment must emphasize the complete indifference to all which pertains to

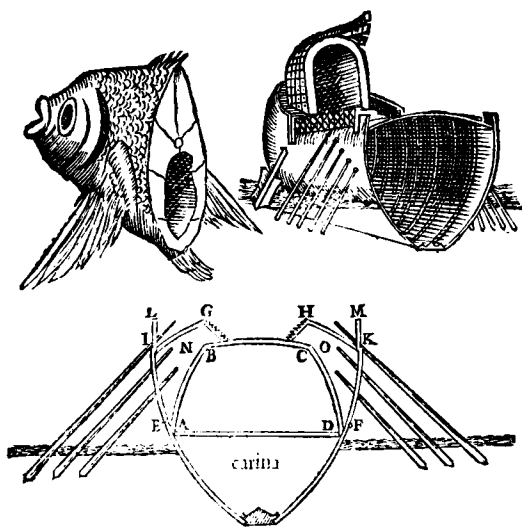


Figure 4. The 16th and 17th century humanists were usually indifferent to structural problems, though R. Fabretti, author of *De Columna Trajana Syntagma*, 1683, was an, albeit timid, exception. The drawings here reproduced give some idea of his preoccupations; structural problems chiefly in relation to the working of the oars.

the structure of classical ships. How else could it be otherwise, if the Ancients were thought to be capable of any technical achievement?

Also, when a writer gives the section of a galley, even in detail as Fabretti (1683: 134) does, such a drawing has no pretensions beyond showing the functioning of the oars; the structure of the hull has no reality except in the imagination of the author. The only means of evading arbitrary forms for such draftsmen is to relate ship structure to "natural" structures, i.e. those of fish (Fig. 4)^[5].

In Witsen's case the comments apply further, since, unlike many Renaissance humanists who seem never to have seen a shipyard, he was perfectly familiar with the ship building of his own period, and had illustrated it very well (see especially pl. LIX). Furthermore, he was equally interested in non-European methods of ship building, of which he gives, for the period, relatively faithful reproductions.

From comparisons between primitive craft like the pirogue (pl. LXXXVIIA) and kayak

(pl. XCIV), and those having reached their final evolutionary form, such as the junk (pl. LXXXVIII, Nankinsche Jonck), the idea of a relatively complex form evolving from a very simple craft could have been deduced and applied to classical naval construction; the comparative elements were already present but the time had not yet come.

As regards the history of ideas, it would be interesting to make a detailed analysis of the books succeeding that of Witsen, but I confine myself to mentioning the appearance of new sources of documentation (Marstrand, 1922), the most important being iconography, which was to prove extremely fruitful. In the 18th century the excavations at Herculaneum and Pompeii, of great importance to archaeology, were to have repercussions on naval archaeology. O. A. Bayardi published *Le Pitture antiche di Ercolano* in 1757 at Naples in which are found, faithfully reproduced this time, the frescoes showing Roman galleys, drawn with some fantasy but already nearer reality than the illustrations available before.

In the field of sculpture, Montfaucon in his *Antiquité expliquée*, 1719–24, had published a remarkable relief from Seville showing a naumachy (IV, pl. CXLII; Pijoan, 1949–67, V; 416, fig. 586). Winckelmann, in his *Monumenti antichi inediti spiegati e illustrati*, 1767, Rome, reproduced rather badly (II, fig. 207) the celebrated bas-relief from the site of the Temple of Fortune at Praeneste, now in the Vatican Museum. Even today, this monument, showing a galley with two superimposed rows of oars, remains one of the principal evidences as regards Roman ships. The 18th century also gave birth to a new idea: the evolution of classical naval construction. In the plates of *La marine des anciens peuples, expliquée*, 1777, Paris, J. Leroy relates primitive contemporary craft (pl. II), Erythraean and Indian rafts made of reeds, Indian skiffs made from split cane, monoxyles of logs dug out by hand, to the mythical beginnings of navigation: the raft of Chrysor, followed by that of Ulysses (pl. I, 1–4).

Another innovation of Leroy's was that originally, the Greeks were no more than pupils of the Phoenicians and Egyptians and

their first attempts were unsure. The invention of the ship with 50 rowers is attributed to an Egyptian, Danaos (conforming also with Greek mythology). There follow, in chronological order of their invention various types of galley which evolve one from another: the open *trieres*, then the decked (pl. III), the *tetreres*, the *penteres*, the *hexeres*, (pl. IV) etc.

The 19th century

Although at the beginning of the 19th century, the pictorial evidence had increased considerably, particularly through the discovery, in Etruscan cemeteries, of archaic Greek vases depicting ships; and although the texts of ancient authors had become, due to advances in criticism, better established than those of which Renaissance writers had made use, these two sources remained the only ones until 12 September 1834, the date of the discovery, during the construction of the Custom House at Piraeus, of the marble plaques on which were engraved what have been called the "naval inscriptions". These inscriptions, archives in reality, dated c. 373–323 BC consist notably of inventories of *triemeis* and their rigging. There the information is first hand, but the interpretation is sometimes rendered difficult by uncertainty as to the meaning of terms. These documents can only be used with the utmost caution for anything outside the 4th century BC. A term which had a precise technical significance in the 4th century BC, could have another in the centuries before or after.

The 19th century, particularly fruitful in works on ancient navigation, was the golden age of controversies regarding the arrangement of oars in Greek, Hellenistic and Roman galleys. The fascination exercised over so many minds by this enigma, the components of which were for the most part philological, is astonishing.

As there existed as many theories as authors, these scholarly jousts, though apparently sterile, had at least the effect of compelling those who took part to scrutinize the ancient texts in the most exhaustive manner, if only to support their arguments. Unfortunately the revolutionary concept of

naval construction only impinged slowly, and scholars did not hesitate in suggesting reconstructions based on a synthesis of the naval inscriptions, of Thucydides, of later lexicographers like Pollux (2nd century AD), Hesychius (6th century), Suidas (10th century), Zonaras (12th century) or even of the great Etymology, a lexicon of the second half of the 10th century.

Thus Jal, who may be rightly called the father of naval archaeology, thought fit to write of the galleys on Trajan's Column: "the Column represents ships with three superimposed rows of oars, others with two. For the biremes, even if they are badly drawn, there is no difficulty: I accept the biremes, the text of the Emperor Leo is very clear, too definite to admit of doubt" (Jal, 1840, I: 34).

Certainly the *Tactica* of the Emperor Leo VI mentions dromons with two rows of oars, but no one today would think of discussing a monument of Trajan's reign in the light of a Byzantine text of about 900.

Another fault is attributable to most authors of the 19th century: they reasoned as arm-chair scholars, not as naval architects, hence the reconstructions they proposed are hardly less preposterous than those of Witsen, even though they appear more scholarly and less naive.

None was more at fault than the German scholar, B. Graser, who in his *De Veterum Re Navali*, 1864, Berlin, bravely and ignorantly placed his rowers systematically one above the

other, each rower operating a single oar. Graser's rowers on the quinquereme dip their oars in the sea at an angle of more than 45°, an angle that would have defeated the brawniest galley-slave. As for the stability of the craft, the least ripple on a duckpond could have capsized it.

But Graser's oddest reconstruction of all is that of Ptolemy Philopator's ship with 40 lines of rowers, the existence of which is known, but the mechanics of which remain a mystery. Graser supposes a wall literally carpeted with rowers, staged and boxed in, one between the other (Fig. 5).

As regards rigging, Graser's philological ingenuity knew no limits and allowed him, by synthesizing his texts, to elaborate a rigging comprising a bewildering number of masts and yards. One gasps at his three-mast *trieres* of "the time of Demosthenes" (Graser, 1864, pl. V): she had two lateen sails superimposed on the fore and mizzen masts and three square sails on the main mast. Such aberrations would have been avoided had he paid more sustained attention to the structure of the ship, which of its nature must be more restrained.

This aspect of classical naval construction began nevertheless to emerge from the shadows and it is only right, in this respect, to salute the imperial amateur archaeologist, Napoleon III. The Emperor had a Roman trireme reconstructed, not on paper but to full size. The construction was not given to a

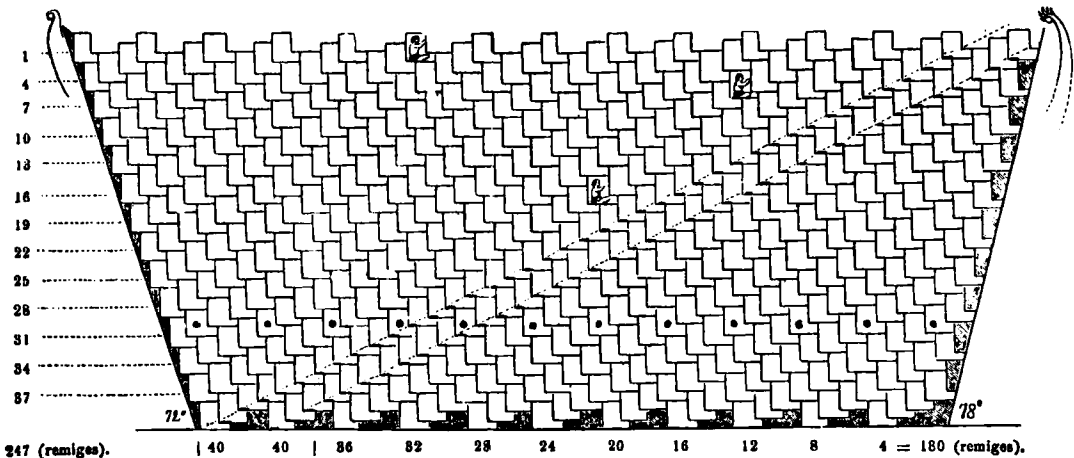


Figure 5. Schematic rendering of a tesserakontera or galley with 40 banks of oars, after Graser, B., 1864.

learned philologist, but to the inventor of the screw ship of the line and the iron clad, Dupuy de Lome, who took Jal as his adviser. Launched at Asnières on 9 March 1861, she manoeuvred in the Seine and then at Cherbourg, with disappointing results despite a crew of picked oarsmen.

Even if the results had been satisfactory, they would have proved nothing since the specifications of this ship differed considerably from what we know of the Greek *trieres*, or at least of the Greek *trieres* of the 4th century. For instance, along a length of 39.7 m at the waterline, which is a little excessive, only 130 rowers were installed where there should have been 170.

However, this attempt showed that as soon as attention was paid to the practical problems posed by the construction, more reasonable conclusions could be reached. The Asnières trireme, in spite of all, was much closer to reality than the models of Witsen and Graser.

In any case, the question of the actual structure could only be approached from the philological angle, and this aspect was far from negligible since 19th century authors, by their desire to make full use of the written sources, were compelled to analyse the structure of contemporary wooden ships, for the sole purpose of examining if the technical vocabulary of their period could correspond with the Greek and Latin terms. It was in this way, not without some hesitation, that the words, corresponding to the terms keel, keelson, false keel, floor-timber, frame, futtock, etc. were rediscovered.

The fact that each of these parts of the hull of a modern ship had apparently a Greek equivalent, resulted in the conviction that the structure of ancient ships was identical with that of modern ships, and Cartault could, in his *La trière athénienne*, 1881, Paris, illustrate his Greek technical vocabulary with a drawing of a modern ship taken from Jal's *Glossaire nautique*.

At the same period a German historian, E. Assmann, to illustrate a lexicon, produced a plausible hull diagram for an ancient ship, even though wholly based on texts. Although this reconstruction was theoretical it was this time far more reasonable (Fig. 6).

In 1885, for the first time, the excavations at Piraeus allowed the slipways for the *trieres* of the 4th century to be accurately measured. The length of these slipways (about 37 m) and their serviceable width, (about 5.5 m) gave at the same time, the maximum dimensions of the *trieres* of the period. From then on, definite limits were placed on the often unbridled imaginations of authors' reconstructions. These limits were not only applied to the dimensions of the *trieres*, but also to the possible ways of positioning the rowers, of which the number 170 was already known, within a given space.

Despite the impracticality of the 19th century philologists, their achievements in the purely philological field must never be underrated, and I cite in particular the works of Assmann (1889), Luebeck (1890-91), Cartault (1881) and Breusing (1886).

Torr's great work, *Ancient ships*, 1894, Cambridge, reprinted 1964, Chicago, de-

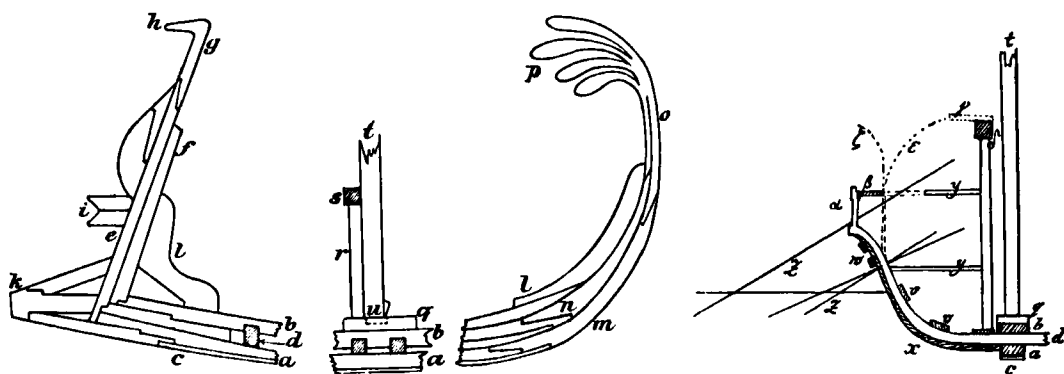


Figure 6. Structure of ancient Greek galley. (After Assman, 1889, fig. 1665.)

serves more specific mention. It contains in one small volume an almost exhaustive compendium of the writings of ancient authors on classical shipping, and is an essential instrument for the naval archaeologist.

From the pictorial point of view, Corazzini in *Atlante della Marina Militare Italiana*, 1885, is a virtually comprehensive collection of documents known up to that time.

The 20th century

By comparing Corazzini's collection with the vast synthesis prepared in 1929 by Moll in *Das schiff in der bildenden Kunst*, with its 100 folio plates and some 4000 illustrations from antiquity to the end of the Middle Ages, we can gauge the immense progress made in the still under explored sphere of iconography.

The outcome of this huge accumulation of material was the superimposition of 20th century syntheses on 19th century analyses.

The notions of "evolutionism" and "diffusionism" gave rise to numerous theories relating to places of origin and areas of distribution, as well as to discussions of ship-building techniques.

According to the diffusionist theory, techniques having reached a certain stage of evolution are diffused from a particular geographical area to other areas less evolved. The supporters of this theory are reluctant to admit that human groups can independently reach relatively advanced stages of technical evolution; they prefer to attribute all progress by the intervention of exterior influence, usually originating from a single source. In the nautical field, depending on private preferences seldom expressed, this unique source is very often Egyptian or Phoenician.

According to the evolutionist theory, on the other hand, cultures acquire evolved techniques independently—one might use the term polygenesis—and the fact that one or more similarities may be detected between the techniques of different cultural areas does not necessarily mean that those similarities have a common origin, or that one area has influenced another. Such resem-

blances are attributable to the so-called phenomenon of convergence^[6].

The evolutionist point of view is largely a minority, the principal experts on the subject being more or less diffusionist. Hence, this outline of naval archaeology would be incomplete without a brief description of the principal diffusionist theories relating to classical shipping. Though theories may differ widely, all are based on the same collections of evidence.

Among the "unique homes" of cultural diffusion, Egypt still retains the prestige it had in the days of Witsen. Hornell (1946: 252-3), at the end of his study of Ganges boats, concluded that their resemblance to the boats of Pharaonic Egypt was too close and too complete to be considered a coincidence or the result of parallel development. He was also willing to infer the influence of Scandinavian techniques of nautical construction upon the natives of the Solomon Islands in the South Pacific (*ibid.*, 212).

Another specialist in comparative ship building, Jean Poujade (1948: 41), in his study of models of Egyptian ships of the Old Kingdom, gives great weight to the similarities existing, in his view, between certain features of these models and the junks of the Yangtse Kiang, the sampans of the Bay of Along, Chinese sampans, Japanese vessels and ships of the Adriatic, notably the Venetian gondola.

But the most ardent advocate of Egypt in this domain was G. Elliot Smith, a doctor and authoritative writer on Egyptian embalming techniques, who saw the Nile Valley as the source of all nautical technology, whether of Bronze Age Scandinavia or of Lake Victoria in Africa (Smith, 1923, 1916: 63-102). The fascination exerted by Egypt as mother of the world's techniques of ship building is all the more curious in that, as several archaeologists have observed, although Egyptian methods, in part dictated by the lack of suitable timber, were admirably adapted for navigation on the Nile, boats so constructed were very little suited for navigation at sea. And hence, it is odd, to say the least, that other Mediterranean peoples should have imitated Egyptian methods in this respect.

This notwithstanding, Koester (1923: 48), a great pundit on ancient Mediterranean shipping, took the view that the Phoenicians had imitated Egyptian vessels in constructing their own. In 1947, Marx (1947: 157), tracing the evolution of Egyptian shipping, asserted that the galleys of Rameses III, figuring in the reliefs at Medinet Habu to celebrate his victory of 1194 BC over the Sea Peoples, show characteristics later to be developed by the Phoenicians, Greeks and Romans.

Since these Egyptian galleys themselves appear to be the end product of a long evolution going back at least to the Old Kingdom, if not to the Pre-dynastic period, this is the equivalent of saying that all types of Greek and Roman ship are distantly but directly descended from the earliest vessels of the Nile.

Parallel to egyptomania, another school of thought used to attribute considerable influence to Phoenicia. This trend developed at the end of the 19th century and as late as 1932, Charbonneaux (1932:246) held that the ships on the Dipylon vases (8th century) were based on Phoenician types diffused through Cyprus, Rhodes and Crete^[7].

On occasion, the Egyptian school does not exclude the Phoenician. So, Poujade (1946: 48), in a work full of original, though debateable views, only marred scientifically speaking by lack of references, thought it possible that Phoenician galleys had influenced the Senegalese dug-outs of today.

Marinatos (1933: 220-1) devised an elaborate theory in three stages:

1. Under the 18th Dynasty, Phoenician ships were completely dependent on Egyptian naval architecture.
2. Influence of Mycenaean Greece on the Near East at the time of the Sea Peoples (13th-12th century).
3. In the 9th and 8th centuries, the type "exported" by the Mycenaean Greeks and improved by the Phoenicians, is re-introduced by the Phoenicians to Greece proper.

Since the discovery of Minoan civilization, greater and greater importance is ascribed to Cretan and Mycenaean ships, and the idea dawns that Greek ships could, after all,

have been the fruit of local evolution, suitable to the coasts and islands of the Aegean.

This thesis is upheld especially by Cohen (1938) and Kirk (1949). In the same way, an essay devoted to the Etruscan navy, while at the same time accepting certain outside influences, postulates the existence of a particular local, continuously developing type (Paglieri, 1960: 134).

Finally, there is the revision of ideas on the size of ancient ships. Our fragmentary documentary sources leave room here for many and wide errors. The tendency to magnify in reconstructions the size of ancient ships is an old one; we have seen how Witsen exaggerated. But we could go back to the original author of Genesis and his preposterous dimension for the Ark. The same exaggeration is to be found in the otherwise very fine reconstructions by Albert Sébille in the "Histoire de la Marine" in *Illustration*, 1934. The reliefs from the Palace of Sennacherib at Kuyunjik representing the Tyrian galleys about 700 BC, inspired a remarkable composition from this marine painter; a Phoenician galley with high sides and a deck some 7-8 m above the sea. The whole appearance is completely nautical, the only question is that of scale.

Recently there has been a strong reaction. Thus Lethbridge sees in these same Tyrian ships only canoes and admits the possibility that each of the rowers operated two oars; this implies a width of about 1.5 m and a free board of less than 0.5 m (Lethbridge, 1952: 114, fig. 24). Similarly, Landström, (1961: 28-9), among his admirable reconstructions, has reproduced an Attic ship of the geometric period (9th-8th century), in which he sees only a very primitive pirogue, not even heightened and comparable to certain craft from the Bismarck Archipelago.

One may ask whence this reaction comes, when the state of basic sources has hardly changed. Without doubt it comes from our better knowledge of the comparative naval architecture of extra-European peoples.

In other words, ethnography has come to the rescue of archaeology by providing comparative terms.

Even so, I am convinced that the reaction, reasonable in itself, has gone too far in the

direction of reduction. The question of scale of reconstruction still remains open. Now, the depth and synthesis of knowledge due to the three great sources of naval archaeology, philology, iconography and archives, tend towards what should be the final aim, the production of an absolutely perfect model. It must be recognized that four centuries of research have only attained approximations, often misleading. It has become more and more apparent that if we wish to study ancient ships, the best solution is to find the ships themselves.

The following quotation from Georges G. Toudouze (1934: 40, 45), illustrates the disappointments born of four centuries of research, and above all, the great hopes placed in underwater archaeology⁽⁸⁾.

"... to excavate the battlefield of Salamis! There in the watery depths the victorious Greeks and vanquished Persians have slept for twenty-five centuries. Some of the wonderful divers we now have at our disposal, must be sent down ...

"For there is a cemetery at the bottom of the sea: of Phoenician vessels, Cypriot boats, Persian ships and above all, a complete collection of all the Greek galleys from all the great cities of Hellas.

"... the galleys of Salamis must be raised, brought to shore, and studied piece by piece. And when this task is wholly accomplished, then—and only then—shall we know.

"Texts and figures, archaeologists and sailors are in themselves insufficient. To solve the question one necessary object, so far lacking, is needed; a wreck. Without this invincible evidence there can only be half-truths and irreconcilable assertions, none of them verifiable by fact."

I shall now examine the degree to which the facts have realized these hopes.

Underwater excavations

Herodotus tells us, with a scepticism which does him credit, that during the Persian wars, a Macedonian named Scyllias swam eight stadia underwater, more than 1400 m (Herodotus, VIII, 8). Significantly, Scyllias

was reputedly "the best diver among men of his time", which shows that well trained, professional divers were not scarce in the 5th century BC.

From the days of Vegetius, who first mentions a diving-bell, in his *De Re Militari*, until the Renaissance underwater exploration seemed increasingly attractive and it is remarkable that one of the first, if not the first, applications made of it in 1535 marks the birth of underwater archaeology (Delpeuch, 1907).

Two great Roman ships sunk in lake Nemi, not far from Rome, had never been forgotten, and, in 1446 a first attempt to recover them was made. After a preliminary reconnaissance by Genoese divers, the architect Leon Battista Alberti built a barge from which he hoped, with the help of hooks and cables, to raise the wrecks. Except for the recovery of a statue, his efforts failed.

In 1535, Francesco Demarchi, equipped this time with diving apparatus, was able to measure one of the ships and bring back some pieces of wood. By a curious paradox, underwater archaeology was born exactly one year before the publication of the first work on marine archaeology.

Before being recovered owing to a partial draining of the lake in 1928 and 1931, the two galleys of Nemi were again excavated by a team of divers working in a bell, under the direction of the engineer Fusconi in 1827; and by a diver associated with a Roman antiquary, E. Borghi, in 1895. These two excavations brought to the surface many wooden parts of the ships. Those which came from Fusconi's excavation, especially two pieces of timber more than a metre long are in the Vatican Museum, and those from Borghi's are in the Roman National Museum. Unfortunately these two ships were only exhibited for 13 years in the fine, modern museum built for them. They were destroyed in 1944 by a fire, the cause of which is obscure (Cervin, 1955: 38-48). Fusconi's and Borghi's fragments are the only non-metallic ones that remain.

The first wreck of an ancient ship was discovered in 1864 during land excavations on the site of the ancient port of Marseilles. Of the keel of this ship, apparently late Roman,

which was traced in the excavations for more than 17 m, there remains only a section of 3.5 m^[9].

The rapid progress of underwater excavation is due principally to the perfecting of the aqualung in 1942 by Emile Gagnan and Jacques-Yves Cousteau. Nevertheless long before this date, underwater archaeology could boast substantial results.

Here is a short list of the principal excavations of Greek and Roman wrecks^[10].

1900. Sponge fishers from the Island of Syme (Dodecanese) accidentally found at some 40 m in depth, an ancient wreck off Antikythera. An expedition was at once organized by the Greek authorities in the hope of salvaging a rich cargo of works of art which were carried in this ship. In August 1901, part of the hull was raised. A little over a dozen planks, distorted through drying out of the wood, are preserved at the National Museum in Athens where they have only recently been studied.

Ever since this first important discovery archaeologists have been demonstrably less interested in ships than in their contents.

Commandant Cousteau's team explored the site again in 1953. The wreck, which dates probably to the second quarter of the 1st century BC, still lies under 0.40 m of sand. A new excavation, this time to study the ship, is essential (Karo, 1965: 35-9; Throckmorton, 1965: 40-7).

1907. Greek sponge divers discovered a cargo of works of art at a depth of 39 m three miles off Mahdia in Tunisia. The recovery of this cargo was the object of several excavations between 1908 and 1933, but the exploration of the ship itself was again neglected. Further underwater exploration took place in 1948, 1954 and 1955. The last exploration was directed particularly towards the wreck, of which little but the keel remained; a length of some 26 m was preserved. From an examination of the cargo, a date in the 1st century BC may be inferred for the sinking, probably in the time of Sulla (de Frondeville, 1965: 39-53).

1910. The wreck of an oak ship of the beginning of the 3rd century AD was found on the site of County Hall, London, and placed in the London Museum (Riley & Gomme, 1910). It has two special points of interest: Roman influence is shown in its typically Mediterranean construction; and, the col-

lapse of its upper parts into the interior of of the boat have conserved those areas which normally disappear first.

1928-31. Nemi. As already mentioned two ships, one 71.3 m and the other 73 m long, were brought to land. The hulls were sheathed in lead as a protection against teredo (ship) worms, although this was unnecessary on ships intended for use on fresh-water lakes, it showed that they were modelled on sea-going vessels. Despite the lack of superstructure a study of these wrecks might have provided valuable insights into the larger ships of Hellenistic times (Persson, 1935); but when G. Ucelli did his work, no other wrecks, except that of County Hall, had been subjected to serious study, so these important discoveries were treated as guinea pigs. Even now it is impossible to check the work against later material (Ucelli, 1950). It might, however, be worth examining and possibly publishing parts of the excavation notebooks kept by Fiorenzo Tassan now in the *Soprintendenza alle Antichità*, at Rome.

1930-31. During the course of the Nemi excavations there were found, on 15 July 1930 and 18 December 1931, a barge 5 m long and a small boat 9 m long. The second was in an excellent state of preservation (Ucelli, 1950: 233-5); both were of interest as being the only known examples, before 1957, of very small ancient boats.

1933. The Sulcis ship. At a later, but not precisely established, date the wreck of a merchant ship was found during dredging operations in the new port of Santantioco, at Sulcis (Sardinia). The only available information is contained in a few pages by Speziale (1939). The brevity of this account is regrettable, because despite damage by the dredge much of the ship, including the upper parts, remained intact and could have been preserved. This was the reverse of the situation at Mahdia: here the keel was much damaged but the ribs were in good condition. It is remarkable, and I think unique, that the main frame could be reconstructed (Fig. 7), and the dimensions of the ship precisely determined as 23 × 7 m.

There was little shrinkage of the wood, so that this remains the only known merchant ship which could have been reconstructed with small risk of error. A plan was published in *Le Navi de Nemi*, but it is too sketchy to be of value (Ucelli, 1950:

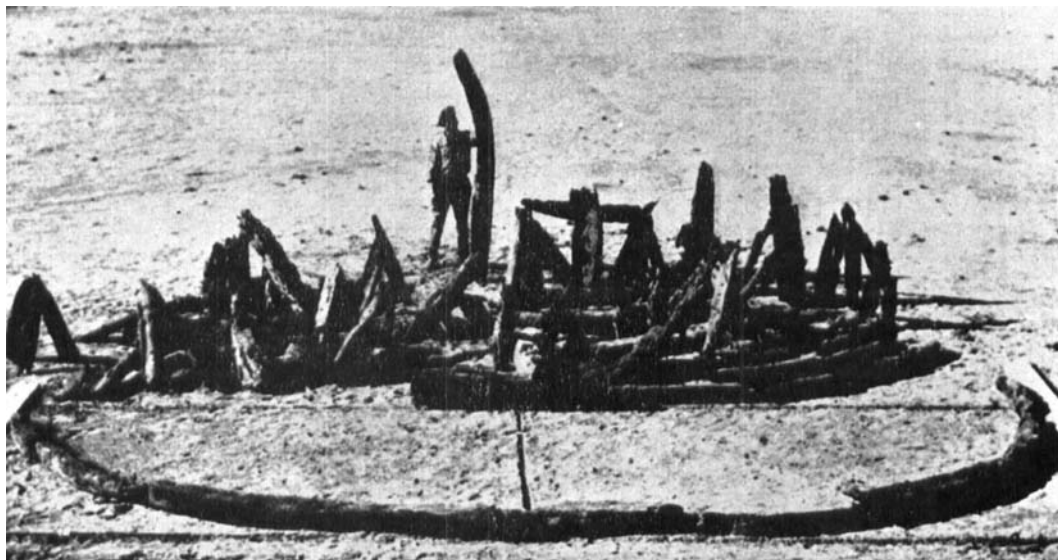


Figure 7. The Sulcis wreck: in the foreground the complete midships frame. It is exceptionally lucky to be able to obtain such a complete central section of an ancient ship. (After *Ingegere*, 17, 15 May 1939: 413, fig. 3.)

251, fig. 284). The existence of this plan, justifies the hope that Speziale has kept, and may eventually publish, his notes, drawings and photographs, even though the wreck itself has probably been destroyed. The affair of the Sulcis ship is one of the most deplorable in the history of naval archaeology.

1950. The Albenga wreck (Italy) was excavated by standard apparatus divers in 1950; they concentrated on the cargo which was dated to the beginning of the 1st century BC. Only a few fragments of wood and of lead sheathing were recovered and the wreck still lies 40 m down, under the silt of the river Centa (Lamboglia, 1952).

1952. A large merchant ship, of the 1st half of the 2nd, or, the end of the 3rd century BC was found off the reef of the Grand Congloué, Marseilles. Aqualungs were used, and the excavation was of great interest not only because of the date of the wreck but because it was the first underwater excavation to be published in detail (Benoit, 1961). The recovery of the Nemi ships was not an underwater excavation.

As a pioneer work it suffered certain disadvantages. The longitudinal axis was not accurately established, and it is even possible that there were two wrecks of

different periods in the area of excavation^[11].

1956. A wreck of the last 3rd of the 1st century BC was found at 35 m lying 1 km south of Cape Dramont, and excavated with limited resources. It was re-examined in 1959, after the site had been dynamited and robbed in 1957 (Santamaria, 1965).

1957. The hull of a boat of the middle of the 1st century BC, about 10 m long, was excavated at a depth of 29 m. It was named the "Titan" wreck after the lighthouse on the Ile du Levant near which it lay (Taillez, 1965).

1957-60. Work on the international airport of Fiumicino revealed the port of ancient Rome, the "Portus", and also seven boats, of from 5 to 19 m in length, probably of the late Empire. Their interest lies not only in their generally good state of preservation, but also in the fact that they can be firmly dated and attributed to a place of manufacture; being harbour boats they must have been built in or near the Portus. Only rarely can the exact origin of a wreck be established (see below).

The shadow of Caligula's famous ship, which carried the Vatican obelisk from Egypt, now in front of the basilica of St Peter's, Rome, was also discovered at

- Fiumicino. It is known to have been filled with concrete and sunk, so as to make the foundation of the Portus lighthouse. The hull has completely disappeared but from its imprint in the concrete that has survived, it is possible to establish that the ship was 95 m long and 21 m wide (Scrinari, 1960; Testaguzza, 1964, 1970).
1958. A section of the keel of a late Roman Imperial ship was raised from the gravel in which it had lain at a depth of some 3 m, in the Condamine Harbour at Monaco. This, and other remains of the ship were brought ashore in 1965 (Benoit, 1961: 145–6; Mouchot, 1968–69).
1958. Parts of a river boat, from about 200 AD, were found on the site of New Guy's House, London. Some of the inner planking has been preserved (Marsden, 1965a).
- 1958–59. Excavation of a wreck off the isle of Spargi in the Maddalena archipelago north of Sardinia. Some details of the hull of which a dozen metres were excavated, have been published (Roghi, 1965). The cargo dates from 120 to 100 BC.
1960. Excavation by the University of Pennsylvania off Cape Gelidonya in south-east Turkey, at a depth of 26–28 m of a wreck and cargo of the Bronze Age, about 1200 BC. The cargo was of great interest but the ship, more or less contemporaneous with the Trojan War, was in a poor state of preservation (Bass, 1967).
- 1961–64. The same team excavated a Byzantine ship of the first half of the 7th century off the reef of Yassi Ada (Turkey) at a depth of about 36 m. Only the stern of the hull remained, but the improvements in underwater archaeological techniques permitted deductions that could not have been drawn some years earlier (van Doorninck, 1967a,b; Bass, 1966: 158–60, pl. 58, 60–1).
- 1961–62. In 1948 a wreck was found in 20 m, to the north-east of the beacon of La Chrétienne, off Anthéor. Pillage by amphora hunters occurred in the interim; it was not until 1961–62 that a scientific excavation was undertaken by Dumas (1964) who has described it in a masterly manner. The excavation demonstrated that results can be obtained by proper methods, even when resources are limited.
- The wreck, known as the “Chrétienne A”, to distinguish it from others in the area, is dated to the 1st century by its cargo, and by the discovery, in the cavity of the mast-step, of a coin minted between 217 BC and the 2nd half of the 1st century BC (*ibid.*, 122).
1962. A wreck of the 2nd century BC was found at Blackfriars, London. About 5 m of the forward area was fairly well preserved, and, as with the New County Hall ship, some of the upper works (Marsden, 1965b, 1967). Like all the ships already mentioned this was carvel and not clinker built, but in common with the New County Hall ship, the technique of construction differs from the Mediterranean tradition. Both vessels, however, merit inclusion in this list because they are ancestors of modern wooden ships. Dating as they do from Roman times, and being found within the Roman Empire, they rate comparison with Greek and Roman ships.
1963. The draining of a marsh in the south-east of Sicily, Pantano Longarini, revealed a wreck of a late empire or early Byzantine merchant vessel; the Carbon 14 date obtained is 500 ± 150 AD (Throckmorton & Kapitän, 1968). Unfortunately before archaeologists reached the site the greater part of the ship had been destroyed by bulldozers; only 10 m of the poop remained. This has been carefully studied and it is hoped that by deduction and extrapolation the complete ship may be reconstructed, at least in the form of a model. It must have been of considerable size, the total length being estimated as 40 m.
- 1967–68. A 4th century BC merchant ship was discovered in 1967 at a depth of 27 m, lying a mile outside the port of Kyrenia (Cyprus). It had a cargo of 403 amphoras and 22 millstones. The outstanding importance of the excavation lay in the wreck's excellent state of preservation. The length and width of the ship were determined as 11.4 m and 4.8 m. The sides of the ship, particularly the port side, could be traced exactly. The date of the wreck was precisely determined by a carbon dating which showed that the wood of the hull had been cut in 389 ± 44 BC; this was confirmed by coins of the reign of Demetrius Poliorcetes, struck between 306 and 294 BC.
- Further campaigns of the University of Pennsylvania expedition under the direction of M. L. Katzev followed in 1968 and 1969. The wreck was brought to land piece-by-piece; it is hoped to preserve and exhibit it in a museum at Kyrenia^[12].

The publication of this wreck should mark a major advance in the history of underwater archaeology. At long last a wreck will have been excavated with the intention of solving structural problems¹³¹.

Modes of naval construction

The analysis of wrecks has provided a mass of information about the varied types of wood used in construction and the methods of assembling the structure.

It remains to be seen whether general conclusions of any value can be drawn from these fragmentary new finds. Unfortunately it is impossible to answer this question without first examining some basic ideas relating to the construction of wooden ships. I say "unfortunately" because space precludes full consideration of these techniques and it is practically impossible to treat them briefly without gross over-simplification which gives rise to errors. The basic distinction, accepted for centuries, and now regarded as classic, contrasts clinker building (where the planks partially cover each other like tiles on a roof), with carvel building (in which the planks are placed edge to edge). It has always been known, from representations, that Mediterranean ships of all periods were carvel built; this has been confirmed by excavations.

The classification, however, applies only to the external appearance of a ship; it is not particularly illuminating with regard to its underlying construction. A more fundamental criterion for classification is the way the parts of the hull have been assembled. The following points should therefore be observed:

1. First, the positioning of the keel; second, the erection of the framework upon it. Next, how the planking is fixed on the framework in the manner of a skeleton being covered with its skin. This last comparison is so obvious that it has been recognized for some centuries. A French 17th century manuscript states: "several people compare it (the keel) with the chine, backbone or spine of an animal, in view of the similar effect to that of a skeleton that the crotches produce when they are joined to it"¹⁴¹ and in Falconer (1830: 209): "By comparing the carcase of a ship to the skeleton of

a human body, the keel appears as the backbone and the timbers as the ribs."

In constructions to which the term "skeleton" technique applies, the planking is, by definition, joined to the framework but nothing prevents the planks from also being joined to each other. Being a useless luxury, this latter form of construction is rare, but it does exist (see *infra*), which proves that it is not a technical impossibility.

2. When the planking has been assembled first, in such a way as to produce a shell (Hasslöf, 1957-58), this shell could not stand up to the sea were it not subsequently strengthened by an inner framework, i.e. by timbers inserted *afterwards*. Although in the first mentioned system it is the frames which decide the shape of the ship, in the second, their function is much more modest: they are mere supports. The important element in "shell construction" is the joining together of the planks; the frames only come later.

In the second type of construction, henceforth referred to as "shell" technique the planks can be joined by one or other of two distinct methods:

- either by the overlapping of their outside edges: clinker building (Scandinavia, and occasionally in Portugal, East Pakistan, China, and Japan);

- or by joining them edge to edge.

In the latter case the planking seen from the outside gives the impression of carvel building, so it is obviously not a sure guide to the underlying construction.

Further, the actual edge to edge joining of the planks can be effected in several different ways:

- by clamps, e.g. in India and in China;
- by nails driven diagonally, notably in present day Egypt, in China and in Japan;
- by tying, notably in Arabia;
- by tenons, mortises and dovetails, e.g. in ancient Egypt.

When relating this to methods of ship-construction, it must be stressed that these diverse processes are, functionally, interchangeable. For this reason Hornell has justifiably observed that modern, Upper Nile boats are reproductions of the boats of the pharaonic era, except that slanting nails have replaced tenons (Hornell, 1946: 217). This

difference has, obviously, very little bearing on the structure of the hull.

The timbers of the framework are at first glance a common factor to both methods of construction. In reality, their function is very different. In the “shell” technique the form of the planking determines that of the framework, for which reason I shall call it “passive”. In the “skeleton” technique, the shape of the framework dictates the shape of the outer planking, so I will call it “active”. The common factor of these two types of framework is that both of them consolidate the planking, but although the “passive” framework is merely a reinforcement, the “active” framework is a guide *and* a reinforcement.

The result is that these differences are materially manifest when the planking is bent on to “active” frames, the latter offer strong resistance, consequently the planks have to be massive. In a “passive” framework, e.g. the Scandinavian clinker method, the planks are, on the contrary, relatively thin in

section. Furthermore, “passive” frames can be independent of the keel, whereas “active” frames are necessarily fixed to the keel.

Geographically speaking, the distribution of the “shell” technique is universal, stretching from Scandinavia to the Solomon Islands. In my opinion one must see this as a convergent effect: after all, the insertion of transverse supports is the most simple and logical method of strengthening a hull and it is not surprising that different peoples spontaneously adopted the same solution to solve the same problem.

An early application of this method of reinforcement can be seen on a dugout found in Paris, near the foundations for the Iena bridge, in 1806^[15]. Although it was hollowed from a single trunk of oak, there was an inherent weakness in its sloping sides. This explains the presence of six half-frames fixed with pine pegs (Fig. 8).

By contrast, the “skeleton” technique was invented solely in Europe^[16] whence the process was universally diffused. The time and

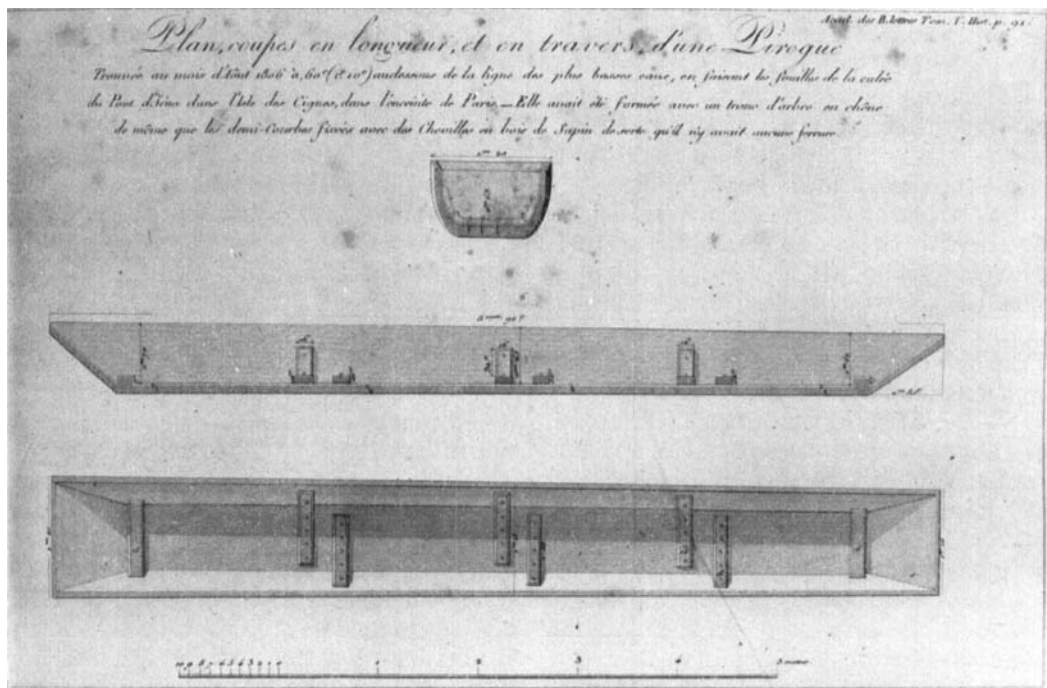


Figure 8. Dugout canoe found in Paris in 1806. The junction of the sides to the bottom is reinforced by half-frames; evidently these have no place in determining the shape of the canoe. (After *Mém. de l'Académie des Inscriptions*, V, 1821, pl. opp. 91.)

place of this invention cannot be determined, though it is tempting to try to resolve the problem because this invention revolutionized naval architecture.

We must, however, bear in mind that "shell" technique and "skeleton" technique are not so opposed as to be mutually exclusive in any one geographical area. As long as the construction of wooden boats lasted, the two techniques co-existed (in Scandinavia, in the Low Countries, in Portugal, in China, in East Pakistan).

Though the basic distinction between "shell" technique and "skeleton" technique has the merit of simplicity, it presents two serious disadvantages: the first is the omission of a series of intermediary methods of construction, to which we will return. The second disadvantage lies in the danger of arriving at conclusions amounting to axioms, such as the following:

1. Clinker building *necessarily* means "shell" technique.
2. Carvel building, with planking joined-edge-to-edge (for example, by tenons as in Mediterranean wrecks) *necessarily* implies "shell" technique.
3. Carvel building, without the edges of the planks being fixed to each other, *necessarily* signifies "skeleton" technique.

The first statement is only true for Europe, where the upper strakes generally jut out over the lower ones^[17].

But in China, where the opposite method is employed, the clinker planking is fixed to transverse bulkheads, set in position beforehand and playing the part of frames. For construction: Audemard (1959: 11ff), Worcester (1966:8).

The second statement is contradicted by the technique still used recently in India, on the coast of Gujarat which stretches from Bombay to Combay. This was described by Hornell (1930:309-12). His comprehensive knowledge of Indian naval construction is undisputed, so that his description has great value.

The construction of the boat *began* by setting up the framework. The edge of each piece of planking—around 0.025 m thick—was notched the whole way along to form a groove followed by a small tongue, both

triangular in section. It was then placed provisionally on the framework. After trying it in place in order to adjust it, the subsequent plank was grooved along the edge in the opposite direction from the preceding one so that the tongues and the grooves corresponded reciprocally. Since several planks were needed to make a complete strake in the longitudinal plan, the ends of these planks were joined vertically by the same process.

The strakes were moreover made firm in the vertical plane, by nails driven diagonally into a notch in the strake above (Fig. 9).



Figure 9. Assembly of strakes in boats from the Gujarat coast. (After Hornell, 1930, fig. 1, and Paris, F., 1841, pl. 10, fig. 4.)

It was only after the strakes were put together that the planking was firmly nailed to the framework.

As for the third statement, it is only true, or rather it only makes sense for boats with keels. In the "shell" technique—"skeleton" technique classification the element of a keel has been assumed, but it must not be forgotten that a long tradition of boats with flat bottoms and without keels, exists among clinker built as well as among carvel built boats. The very form of these ships imposes a peculiar method of construction, at least in the early stages. It derives neither from the "shell" nor the "skeleton" technique.

Let us take a few examples of these boats, far apart in time and space: a Dutch *bomschuit*, clinker built (Petrejus, 1954: 28ff), a Chinese junk, carvel built (see Audemard and Worcester above), and a *quantel battella* from

the Indus (Greenhill, 1963). Initially, the method of construction is common to all three: the bottom planks are placed horizontally, side by side, then they are held together by means of transverse beams fixed at right angles to the direction of the planking. One hesitates to describe these cross beams which make up the lower part of the framework as "floor timbers": clearly they do not answer to this description, a large number of boats with flat bottoms being without true frames. Variations of the cross beams can occur, e.g. in China, they are made up of vertical bulkheads that can be described as simple frames on which the planking is fixed. The system is akin to "skeleton" technique.

On the *bomschuit* the transverse timbers are simple beams. After the floor planking has been assembled, the next step is the erection of the side planking, then finally the frames are inserted. Although the initial stage is exactly the same as that for the Chinese junk, the succeeding stages conform to the orthodox "shell" technique.

On the *quantel batella* the cross beams are made up of right-angled timbers joining the flat bottom and the side planking. The same occurs in the Amatovo boat from Macedonia (Fig. 10) (Traeger, 1904: 35): the base of right-angled timbers served as cross beams for the assembling of the floor-planking, then

the side-planking is fixed to their upright ends. Such construction, *sui generis*, is difficult to classify as either "shell" or as "skeleton" technique. It would be wrong to assume that flat-bottomed boats, without keels are of negligible importance in Europe. On the contrary, one finds them in the North (Vistula: the *szkuta*, which can reach as much as 35 m in length) (Boczar, 1969: 262, pl. 12), in the South (Adriatic: the *rascona*) (Fig. 11C) (Paris, F. E., 1882, II, pl. 86), in the West (Portugal: *saveiro*, *moliceiro*, *meia lua*) (Guthrie, 1949) and in the Centre (Danube: lighters of Degendorf)^[18].

It must be stressed that the initial stage of construction common to all these boats viz. the assembling of the floor-planking is common of necessity, but this sameness of technique has no connection with the origin of the flatness of the actual bottoms. Three reasons for the flatness can be distinguished:

1. A flat bottom recalls the origin of the ship. In the case of the Chinese junk, the flat bottom is inherited from rafts which were its forerunners (Hornell, 1946, chap. V; Worcester, 1966: 1-4).

2. Flat-bottoms also result from the deliberate adaptation of boats to suit the conditions prevailing in the area where they are used: this is the case with the Portuguese ships, with the Dutch *bomschuit*, or yet again

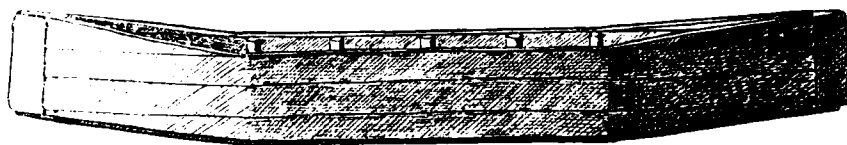


Fig. 20. Boot auf dem Amatovo-See.



Fig. 21.

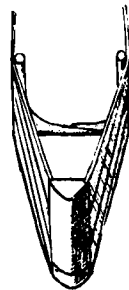
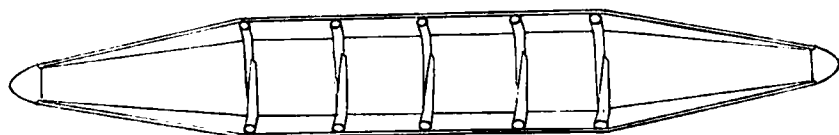


Figure 10. Flat-bottomed boat from Lake Amatovo, Macedonia. (After Traeger, 1904: 35, figs. 20-23.) The frame is made up of right-angled timbers which have the joint function of floor timbers and frames.

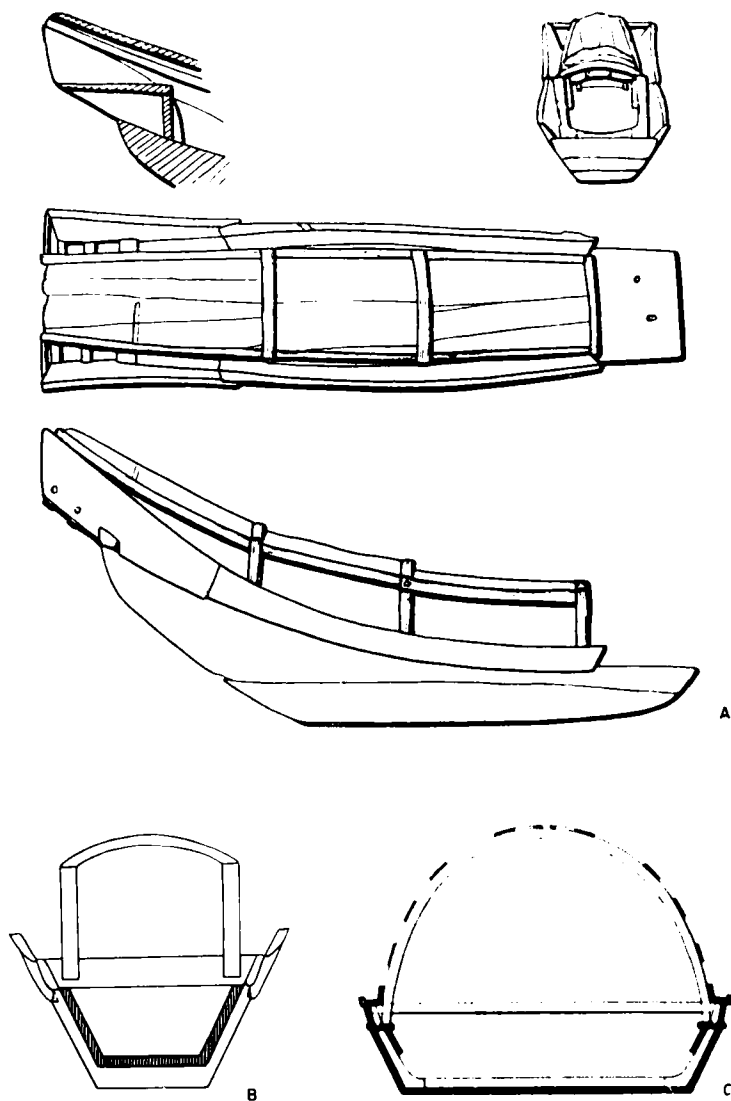


Figure 11. A. Model of an Egyptian ship of the VIth Dynasty. (After Jéquier, G., 1933, *Les Pyramides des reines Neit et Apout*, 37, fig. 20. Cairo.)

B. The hatched part shows the reconstruction of the floor-timber which must have strengthened the bottom.

C. For comparison, the section of a ship built on identical principles: an Adriatic *rascona* of the 19th century. (After Paris, F. E., 1882, pl. 86.)

with the surf boats of Durban (Clissold, 1932: 320).

3. A flat bottom is imposed by the builder's limited level of technology or by the limited means at their disposal. Such could well be the case with the Amatovo boat which appears to be merely a copy, made with very poor means, of either a dug-out or possibly a modern boat.

Egyptian construction

There is only one justification for broaching such an immense subject in a few lines: the

impossibility of avoiding it. The construction of Egyptian ships is the prime example of the problem of synthesizing knowledge drawn from such diverse sources as the following:

Texts. Herodotus tells us that Egyptian boats were constructed of planks little more than 1 m long, placed like bricks in a wall and put together with pegs. He adds that they had keels (*τρόπις*), but not a framework of ribs. The keel was pierced to allow the rudder to go through (Herodotus, II: 96).

Iconography. The paintings of the tomb of Khnumhotep at Beni Hasan (XIIth Dynasty)

(Lepsius, 1849–59, II; Newberry, 1893, I, pl. XXIX; Boreux, 1924–25: 238, fig. 72; Vandier, 1969, V: 115, fig. 69) confirm the aptness of the comparison between assembling planks and bricks in a wall, but they give no certain clue as to the existence of a framework.

Archaeology. The discovery at Dahshur in 1893, of six boats contemporary with the paintings of Beni Hasan (de Morgan, 1893, pls. XXIX–XXXI) demonstrate the absence of any framework. The construction was altogether more complex than that described by Herodotus: the fixing of the planking by pegs, or more exactly by tenons and mortises, was by no means the only method of joinery. The planking was, in addition, held together by dovetails and by ligatures of leather or metal (Reisner, 1913: 83–6). Further, these boats showed that Herodotus' *τρόμις* was no true keel, but a central plank (rather than a beam) which explains how the "keel" allowed the rudder to pass through it.

This satisfactory measure of agreement between three sources, some 14 centuries apart, tempts us to deduce a single unchanging Egyptian technique which, considering its great antiquity, was the source of all subsequent naval construction in the Mediterranean.

Such a theory, based on excessive generalizations, is certainly untrue. Boreux and Hornell adduced that the boats from Dahshur could not be considered as representative of Egyptian construction in general and they were right: they concluded that frames and half-frames must have existed. The argument is virtually philological (except insofar as hieroglyphics can be considered iconographic) being based almost solely on the shapes of certain hieroglyphs (Boreux, 1924–25: 286–94; Jéquier, 1911: 62–4). Moreover, they rely on the fact that certain contemporary nilotic boats, that have numerous similarities with pharaonic boats, have interior supports for their planking (Boreux, 1924–25, 239; Hornell, 1946: 224).

A most eagerly awaited publication is the report that will give the results of the study of Cheops' boat which was discovered in 1954 to the south of his pyramid. It should throw new light on the methods of construction used in the Old Kingdom (Nour, 1960). This boat,

43.4 m long and 5.53 m wide^[19], must have presented very different resistance problems in the boats of either Herodotus or Dahshur. A thorough examination of the photographs published in the first volume of the excavation report did not permit me to detect the existence of any framework, but it would be surprising if a boat of this size had neither ribbing (or at least floor timbers) nor even cross beams, the existence of which is manifest on other Egyptian ships^[20].

We know, thanks to an exceptionally rich source of information, miniature models, that at least during the Old Kingdom, flat bottomed hulls existed alongside round bottomed hulls (Reisner, 1913, no. 4882–6; Poujade, 1948, pls. II–VI). Considering on the one hand the estimatable width of the bottoms, and on the other, the lack of large sized timbers for ship construction in Egypt, it is obvious that such bottoms could not consist of a single large plank, but rather of a patchwork of smaller planking possibly interconnected by means of tenons; also without doubt held together by cross-beams in the manner described above (Fig. 11A).

Functionally, boats that are rounded in section and boats with flat bottoms present different resistance problems. The shape of the former, according to the principle of the inverted arch allows the pressure of the water to insure the cohesion of the separate parts, providing that the main beam keeps the ends of the arch apart (Marx, 1947: 140, fig. 2; Bell, 1933: 101). Due to this principle, a framework within these small vessels was superfluous.

The principle of the arch does not obviously apply to flat-bottomed boats wherein the sides could not be joined to the bottoms without recourse to internal supports. Consequently, a boat such as the model illustrated in Fig. 11A, as already explained, needed to have floor timbers, these in turn had to be extended in order to hold together bottom and sides: the result is a form of construction similar to the *quantel battella* (cf. Greenhill, 1963: 273–5) (Fig. 11B). It might be objected that this is conjectural, but luckily confirmation is available in the form of material representations that are almost contemporary with the model.

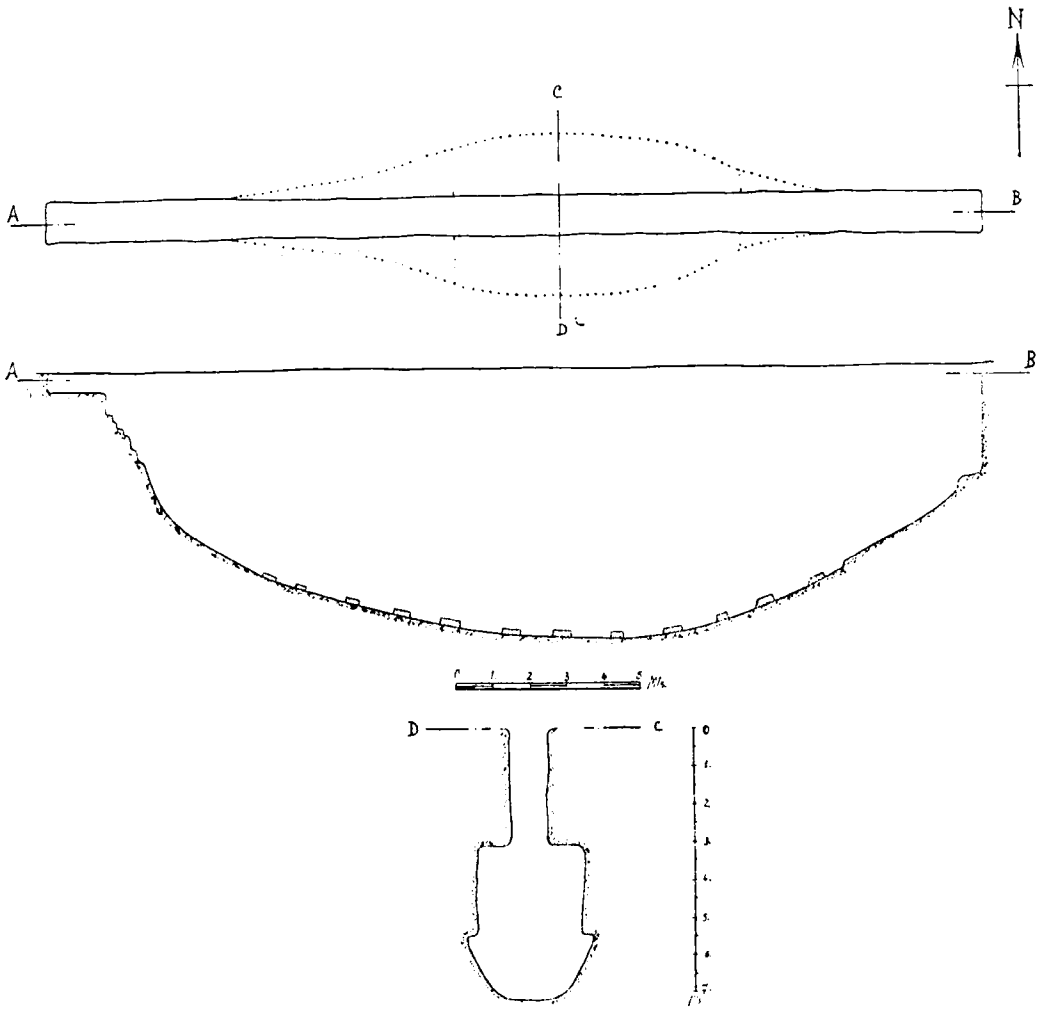


Figure 12. Plan of a solar ship (southern night boat) of Chephren, cut in the rock near his pyramid. The floor-timbers are shown in the longitudinal section. (After Hassan, 1946, 61, fig. 21.)

Excavations at Gizeh revealed “sun-ships” cut into the bedrock near the pyramids (Hassan, 1946: 57ff). The best preserved example is one of the four that surround the pyramid of Chephren. Carved in the rock, it measures 25 m in length and 5.7 m in width; it has been identified as the “southern night-boat” (Fig. 12). The proportions of this boat, a *flat-bottomed one*, demonstrate the architect’s intention to depict a real ship of actual size (which agrees with our knowledge of the Egyptian mentality). Further, elements that have been sculpted should be recognized as

faithful reproductions of the parts of a real ship. Now these sculptured parts are exactly the same as the framework which a reasoned study of the boat in Fig. 11A lead us to postulate (Fig. 13).

It follows that some Egyptian boats, from the Old Kingdom onwards, were certain to have had at least floor-timbers. It seems to me unlikely that, subsequently, this kind of technical accomplishment should have been lost. Probably Herodotus went too far in his generalization and, in fact, ships both with and without framework co-existed.

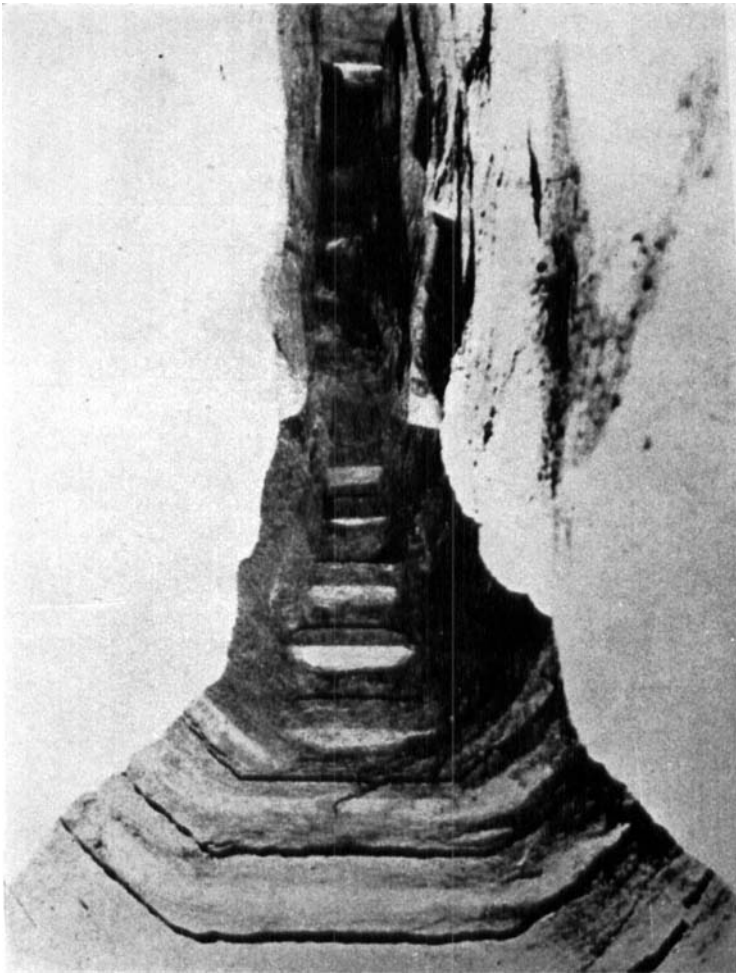


Figure 13. Sculptured floor timbers of the solar ship of Chephren. (After Hassan, 1946, pl. I.)

The Egyptologist Montet, wrote (1925: 236): "At the present time the boats of the fellahs possess a strong framework. The planks of the hull are nailed to the upright sides, but nothing indicates that such a framework existed in boats built under the Old Kingdom. It must therefore be concluded that the Egyptians did without it." And Bell wrote (1933: 101): "The Ancient Egyptian shipbuilder built his ship without any framing. This is a fact beyond any doubt. No framing of any kind, other than cross beams, is indicated in any drawing, nor is there any in the boats which have survived; further Herodotus (ii, 96) makes a special note of this feature." Here is an example of these hasty generalizations that it would be best to avoid in the future.

Greek and Roman construction

It has been observed how easy it is to confuse carvel edge-to-edge construction with "skeleton" technique, and that all representations of ancient ships, including those known in the 16th century, show carvel built ships. On the other hand, from the 16th century the "skeleton" technique has become the norm in the construction of large ships in Europe. Finally, between the Renaissance humanists and the 19th century *Savants*, it is rare indeed to find anyone equally interested in ancient ships and general problems of naval construction (in any event it was the arrangement of oars on a trireme that absorbed most of their energies). Those who did possess this dual interest, relied on contemporary works which

described only the "skeleton" technique; Cartault for instance took Jal as his mentor.

How could it be then that the "skeleton" technique should not, implicitly, have been accepted as universal in antiquity?^[21] One well known Greek text expressly relating to construction did, however, furnish precise information in which Homer describes how Ulysses constructed his craft by first joining the planks by means of tenons, then continued his work by positioning the frames^[22].

It was a sailor who, before any of the philologists, was the first to realize that Ulysses had joined his planks with treenails. This is what Folkard (1870), the author of a treatise on ships, wrote "It is mentioned by Homer that the boat built by Ulysses was put together with wooden pegs instead of bolts", and was followed in 1876 by commentators of the *Odyssey*^[23].

Brewster (1926, quoted by Casson, 1964a) established a comparison between the technique Ulysses used and another that is still practised in certain parts of Egypt.

It was not until 1896 that a lesson was drawn from the observation of a wreck: Vars proposed a new translation for Ovid's "*iamque labant cunei*" (*Metamorphoses*, XI: 514-5) by suggesting that *cunei* meant tenons. He wrote (1896: 386-7): "A ship of Roman construction found in the mud of the Vieux Port of Marseilles has precisely these tenons" (referring to the wreck that had been found in 1864).

In fact, when one considers that the "skeleton" technique is only typical of one part of Europe, while the "shell" technique is universal, it is *a priori* improbable that the latter should have been unknown in the ancient Mediterranean. Technical considerations also preclude the belief that the ancients knew only the "skeleton" technique. In 1891, Admiral Serre in the light of his knowledge of naval carpentry, wrote that between the construction methods used for large and small ships, a host of intermediary techniques must have existed (Serre, 1891, II).

In 1963, Casson drew attention to a fact of major importance: all that the wrecks already cited, excepting the New Guy's Hospital and Blackfriars, have in common is that the planking is always assembled with tenon and

mortise (Casson, 1963: 28-33; 1964b: 81-94). The tenons are usually held by dowels, themselves transfixed by nails which hold the planks to the ribs.

Having explained the links between this method of construction and the "shell" technique, Casson further maintains, in several articles, that the Greeks and Romans used nothing but the shell technique (Casson, 1967). He argues as follows:

1. In the Chrétienne-A wreck Dumas had noticed on the inner surface of the hull a mark made with a blunt point which might well be a guide line for the placing of a frame^[24]. Similar marks have been found in the Yassi Ada wreck (van Doorninck, 1967a: 93) but, as may be seen, the meaning of these marks is not as obvious as at first appears.

2. In many cases the nail which attaches the side-planking to the frames impales the tenon which joins the strakes of the planking. This certainly proves that the nail was driven in after the joining of the planks by the tenons. But Casson goes further, considering that the placing of the nails necessarily implies the subsequent insertion of the frames. He writes: "if the planks... had been set on pre-erected frames, why would the shipwright have bothered to put mortises directly in front of the frames?"^[25] Casson is not alone in his belief. Hasslöf writes (1963: 162-77, more particularly, 163), in a very interesting study of the methods of constructing wooden ships, that the frames of the Nemi ships were "obviously" inserted in the finished shell.

Hasslöf in a private letter has kindly supplied his reasons for this assertion: "In my opinion (the ship builders in classical times) used not "skeleton" but "shell" construction; in the Nemi galleys it is also apparent, 1, in the joining of the planks by close-set mortises and tenons transfixed by dowels and, 2, that some ribs are placed over such dowels. I mean that this neither was done nor could have been done had the ribs been pre-erected, though it might well have been so had they been inserted afterwards."

Mortise and tenon construction

The absolute incompatibility of tenon construction with "skeleton" technique is

assumed, so that a belief in "shell" technique has become orthodox doctrine among most recent writers on underwater archaeology^[26]. This dogma is summarized by Throckmorton (1964: 205): "Ships of the Roman period have in common the tenon construction, *that is* (my italics) that they were built 'from the planks in', rather as clinker ships are constructed today".

Again, in a recent article, Casson (1967: 286) write: "The information we now possess . . . reveals that, in the construction of boats and merchant ships (we know nothing new about warships), until at least the early Middle Ages, no inner skeleton of keel and frames was used. The standard practice was to build up a shell of planks, edge-joining each plank to its neighbours; what frames were needed—the number varied with the purpose of the vessel and the tradition of the locale—were inserted in the finished hull."

These set theories need stringent scrutiny: accepted as gospel they would stifle research, by imposing an oversimplified view. It is natural to question the reasons which led to the adoption in Greece and Italy of a method as complicated as that of tenons; wood being abundant in these countries, there was not the same need for this method as there had been in Egypt, where wood was scarce (Throckmorton, 1964: 207ff). To answer this question would lead to a long digression, but it would be wrong to suppose that the technique was exclusively applied by ship-builders. The attachment to tenon and mortise joinery was almost manic: one finds it in the fixing of the rudder to its main-piece (Ucelli, 1950: 168, fig. 179) and, equally, in the fitting of the deck planking. In either case, but particularly in the second, the strength that it gave was luxuriantly excessive; the explanation lies in the low cost of labour, but there must also have been an element of inertia in the face of minor mechanical problems. Whatever the explanation, the outcome was that the Greek and Roman workmen must have been much more familiar with this technique of assembly than we are, so that they used it expertly and at high speed. To forget this is to misunderstand the real implications of the method.

Reverting to ship's planking, Ucelli gives the plan of a floor adjoining the hull, on

each side of the *apostis*: i.e. the *parodos* (Fig. 14; Ucelli, 1950: 172, fig. 185). It is clear that the timbers marked A were put in when the hull was in a fairly advanced state of construction. It is just as clear that the narrow planking was only assembled and fixed to the beams A after these beams had been set in place. These narrow planks were then joined to each other by tenons (T).

Because the part of the deck from the Nemi ship is, to the best of my knowledge, the only one to have been recovered on an ancient ship, we cannot infer that it was technically exceptional. The fact that the same technique was used for assembling the deck, floor and side planking, is shown by the term *τό γομφώμα* (from *γόμφος*) that is common to them all. It is applied equally to the floor planking of the "Sambuca" used by Marcellus during the siege of Syracuse (Plutarch, *Marcellus*: 15), and the side planking of a ship (Longus, II: 26).

It is apparent from this example that, given the necessary skill, a plank with mortise slots along its side can easily be slid into position against another plank already held by a tenon, and so on. A construction of extreme solidity has thus been achieved, but the addition of tenons appears superfluous. It would have been enough to have nailed the strakes of the planking to the timber extensions without joining them together by tenons. Now turn Fig. 14 on its side and pretend that A in the two lower sketches represents ribs (instead of the extensions of timbers), and that B represents strakes of side planking (rather than floor boards), and you will have the diagram of a "skeleton" construction combined with assembly by tenons. The result is a peculiar kind of construction, for as already mentioned, planking joined edge to edge is usually the hall mark of "shell" technique. Such a hybrid construction—I hasten to say—is no figment of the brain, it exists and indeed provides a useful basis for comparison. I refer to the already mentioned technique used along the Gujarat Coast.

As already noted in connection with the Nile boats, basic structure is in no way affected by the fact that metal nails rather than treenails join one plank to the next. Nor is there a fundamental difference between

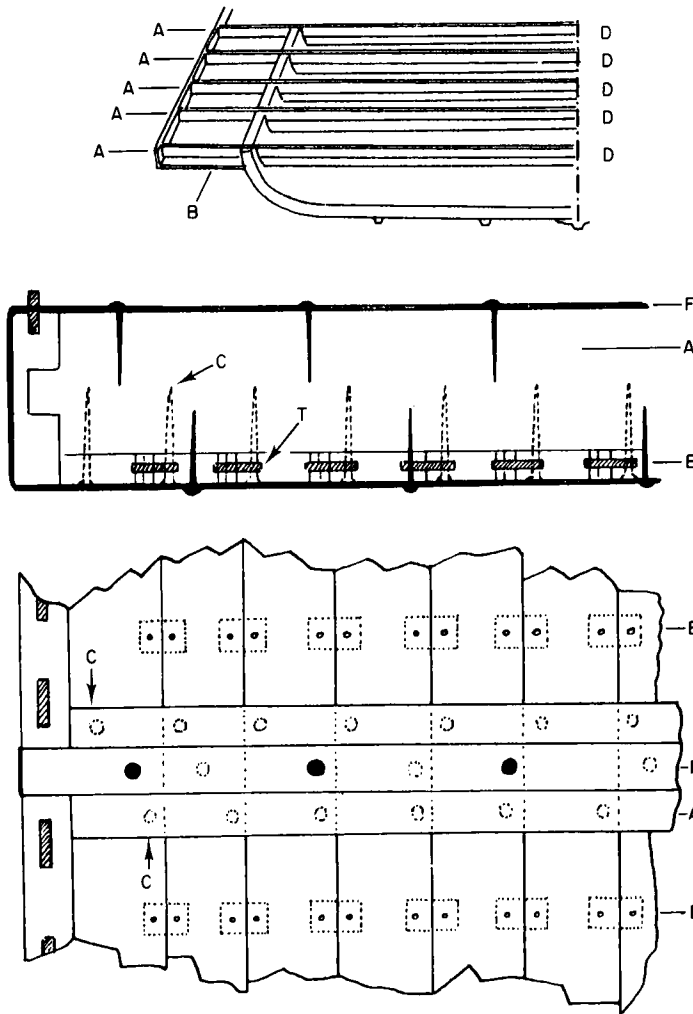


Figure 14. The second Nemi ship. Diagram of *apostis*. (After Ucelli, 1950, figs. 184-5.)

Above: top view of one section. The horizontal timbers, A, are the prolongation of the beams, D, and support the floor of the *apostis* B. So as not to overload the drawing the knees supporting the beams are omitted.

Centre: section of the end of beam A. The floor, B, is assembled with tenons, T. A strip of iron, F, securing the whole is fixed by nails shown in black.

Below: plan of the floor. The nails, C, hold the floor to the beam; they do not pierce the tenons.

tenon-and-mortise and groove-and-tongue assembly. The techniques are similar; the latter is not even a simplified version of the former, since the accurate slotting of tongues into grooves along the entire length of two planks, both curved, must have been at least as difficult to achieve as the regular spacing of mortises along two corresponding planks. Hornell describes the cutting of grooves along planking as being carried out both quickly and by rule of thumb, no preliminary guide lines having been marked out on the wood. There is no reason to suppose that Greek and Roman builders were any less skilful than their Indian counterparts. Construction on pre-erected frames of a ship fitted by tenons is

technically feasible; Fig. 15 shows how such a process could be applied, but after such a boat was finished, it would be impossible to tell whether the frames had been pre-erected or inserted during the final stage of construction.

Casson's second argument: the apparent incongruity of a mortise placed opposite a timber, has only a limited significance. In Casson's opinion the builder would not have troubled to cut such a mortise had he known that a frame was going to be placed opposite, but this is doubtful for two reasons. Firstly, because the mortise was not completely unfunctional. Each tenon contributed, albeit in a small way, to the strength of the whole.

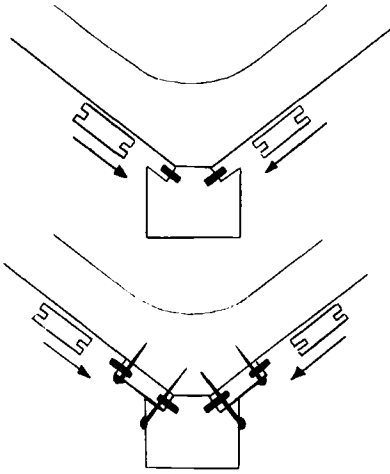


Figure 15. In this technical diagram, it is not impossible to assemble the strakes piece by piece against a frame already in place, as is shown by Hornell's description of the Gujarat coastal boats. The assembly by tenon and mortise would be no more difficult than with oblique nails (cf. Fig. 9). The hull section shown is imaginary.

The argument would be still weaker if, as seems probable, mortises were hollowed out in each side plank before its assembly^[27].

Examination of wrecks shows that the spacing of tenons was regular; the patterns vary in accordance both with a ship's date and its place of manufacture. For example there is less than 0.05 m between the tenons of the wreck of the *Grand Congloué* and 0.05 m on the *Albenga* wreck. Probably carpenters worked mechanically, so that even if frames had already been erected, it would have been a waste of their time to calculate whether or not a mortise was going to face a timber; it was simpler to cut the slots regardless (Figs 16, 17 and 18).

Casson's argument does not apply at all to wrecks where there was only a very small space between the frames, for instance: 0.08–0.10 m on the *Titan* and *Dramont* wrecks. The intervals between both frames and tenon were decreased to such an extent that they repeatedly overlapped, thus the

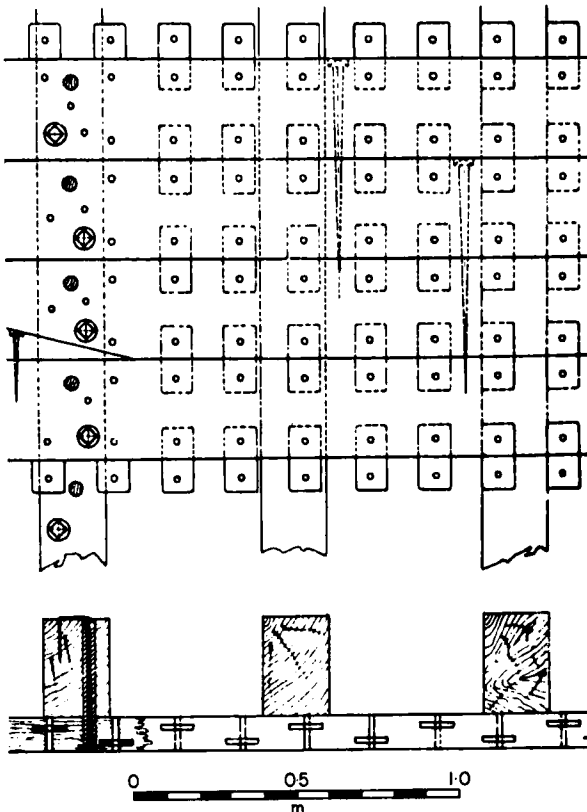


Figure 16. Typical example of a Graeco-Roman assemblage by tenon and mortise. (After Ucelli, 1950, fig. 153.)

1. The tenons are fixed by a dowel to each of two adjoining planks (cf. Figs 17 and 18).

2. The mortises are arranged in a regular pattern and the space between the ribs is likewise governed by a regular design; it can be seen that the two arrangements do not coincide, indicating that the maker of the mortises was not concerned with the position of the ribs.

3. The regularity of the design is seen also in the thickness of the plank.

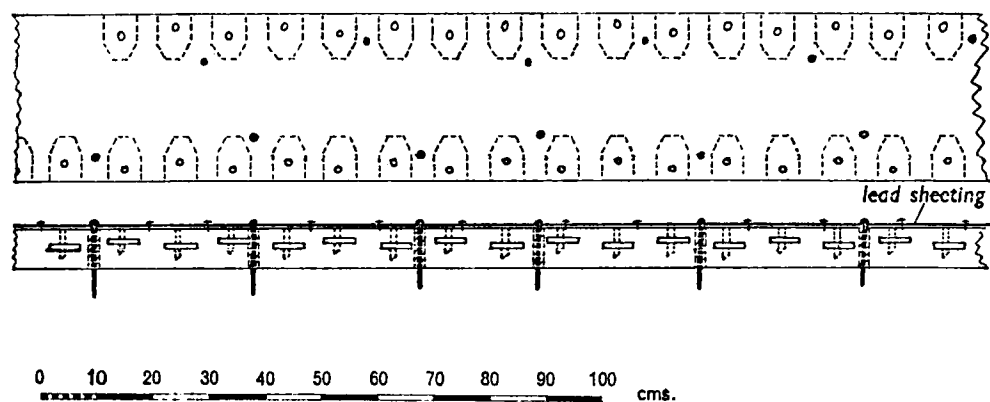


Figure 17. Mortises cut on a regular pattern. Planking of Grand Congloué wreck. (After Frost, H. 1963, fig. 48, 3.)

nails inevitably crossed a large number of tenons. This type of wreck shows very clearly that the mortises were dowelled irrespective of their position opposite a frame. Casson and Hasslöf's arguments neither prove nor disprove the existence of "shell" construction.

Hasslöf's second point regarding the presence of pegs under the frames of the Nemi

ships is particularly significant. It seems that he was referring to Ucelli's fig. 153 (Fig. 16) which does in fact show tenons opposite a frame but the diagram itself is hardly conclusive. Either the peg has been driven in from the outside of the hull, in which case the construction could be either "shell" or "skeleton", or, it has been driven in from

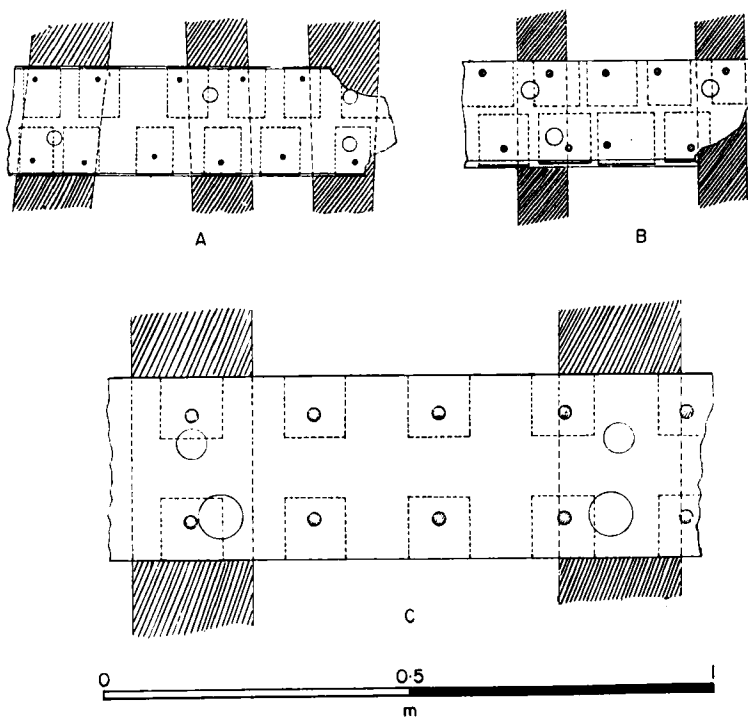


Figure 18. Regular patterns of tenons compared: A, Titan wreck; B, Antikythera wreck; C, Nemi ship. The hatched parts represent the frames. (After Throckmorton, 1965: 45.)

inside the hull, in which case it is absolute proof that the assembly by tenons took place before the frame was introduced, consequently that the construction was by "shell" technique. The direction of insertion becomes crucial, but it could only be ascertained if the pegs were more conical than cylindrical. With a truncated cone, the thinnest end will obviously face outwards if the peg has been hammered in from the inside. Unfortunately the importance of this feature seems to have escaped attention, and my study of pegs has to rely on published diagrams. They appeared to be definitely truncated and turned outwards on the Grand Congloué (Benoit, 1961: 136, pl. XXIV) and Titan wrecks (ibid., 139, pl. XXVI; 140, pl. XXVII), but cylindrical on the Antikythera¹²⁸, Dramont (Benoit, 1961: 143, pl. XXVIII) and Monaco wrecks (ibid., 146, fig. 29) as in the Nemi galleys (Ucelli, 1950: 153, fig. 153) and boat (ibid., 233, fig. 263). However, I find it hard to believe that all pegs are rigorously cylindrical, to

such a degree that it is impossible to see from which direction they had been inserted; I fear therefore that the drawings we have may be schematic and their draftsmen guilty of certain geometric oversimplifications.

From now on, closer examination of these pegs might prove rewarding. Nor is it essential to examine a peg next to a frame because common sense dictates that carpenters must have hammered all the pegs along a plank from one, but never both, sides. Consequently the discovery of a single peg showing the direction of its insertion, would be sufficient guide to the direction of the rest, irrespective of whether or not they correspond with a frame.

Driving in the pegs from outside the hull would not, as already observed, preclude "shell" construction, though it would be more logical that they should have been inserted from the inside. Working from inside the hull is well illustrated by a miniature from a 1460 German Bible, now at Gotha, in which



Figure 19. Boat built by "shell" technique in the 15th century. The planks are probably fixed to one another by clamps; the dowels fixing the floor-timbers are driven in with mallets. (After Moll, 1929, G 1, c 13.)

a carpenter is shown in the act of fixing a frame to the inside of a hull clearly built according to the "shell" technique (Fig. 19).

Some intermediary techniques

The preceding passage has shown that tenons and mortises do not necessarily connote "shell" technique. This kind of construction, though common to all the hulls found hitherto, is only one of the many neglected problems relating to ancient shipbuilding.

Initially, when wood was the medium, tenons afforded a very satisfactory solution to the problem of building up a hull by uniting irregular and always curved planks, without using frames at all. This is, again, the *initial* connection with "shell" technique. Only at a later stage of evolution, did builders consolidate the shell by introducing into it a "passive" form of frame or half-frame.

The relation of frames to planking can be modified without entailing any corresponding modification to the way the hull planks are assembled. In other words: "passive" frames can become "active" without altering the autonomous joinery of the "shell". Proof of this is again found along the Gujarat coastline.

It can be assumed that groove-and-tongue—so similar to tenon-and-mortise joinery—had its origins in a form of "shell" construction to which, technically, it would have been better suited than to the procedures adopted by 1930. Happily, this is no mere presumption. A century before Hornell, Admiral Paris witnessed the building of a *pattamar* on the Malabar coast. Though his description of the method of assembly by grooves, tongues and oblique nails is identical to Hornell's, he definitely states that the frames were not pre-erected, but inserted after the construction of the "shell". Only the keel, stempost, sternpost and midship frame had been set up beforehand (Paris, F. E., 1841: 17, pl. 10, fig. 4).

The initial erection of the midship frame prevents—in the strictest sense—the use of the term "shell" technique. Yet "skeleton" technique is equally inapplicable, since all the frames bar one were inserted into the "shell".

The method is a mixture of one "active" frame to a majority of "passive". A century later, according to Hornell, *all* the frames had become "active" *though the method of assembling the hull planking had not changed*; which implies that at some earlier stage all the frames must have been put in last. The importance of the following observation cannot be overlooked: the wreck of an 1829 *pattamar* would be no different from the wreck of a 1930 *pattamar* although we happen to know that each had been constructed in a different way.

Tenons, though important, are but one of many indications of the method by which a hull has been built. The direction of their insertion is another. Whether or not frames are joined to the keel is a third.

How the keel is joined

In the "skeleton" technique the bottoms of the frames had, *ipso facto*, to be attached to the keel. This, of course, pre-supposes the existence of real frames, i.e. frames that stretched, uninterrupted, across the hull (floor timbers, futtocks, top timbers).

On such wrecks as the Grand Congloué and the Chrétienne A, it is clear that the frames are unattached to the keel; the half-frames are cut short before reaching it while the floor timbers (if indeed those on the Congloué merit this name) are not in contact with the keel. Further, the half frames are not in alignment with the floor timbers, which are consequently unconnected. At this stage it becomes obvious that, for these two wrecks at least, any techniques other than the "shell" is inconceivable. On the Dramont wreck, which differs from the preceding in that frames in one long piece alternate with half-frames, it appears that not even the floor timbers are fixed to the keel (Benoit, 1961: 143, pl. XXVIII), so that, once again, the "skeleton" technique is excluded.

On the Titan wreck, at least, two treenails pegged the keelson^[29] to the keel (Benoit, 1961: 139, pl. XXVI). These pegs do not, however, traverse the keel through and through, their function might only have been to hold the keelson in position, rather than the frames over which the keelson had been placed.

Why such a crucial point has, hitherto, been neglected, is incomprehensible. From reading what Ucelli has to say on the subject, no clear picture of the relationship between the keel and floor-timbers of the Nemi ships emerges (Ucelli, 1950; cf. 157, figs 158–9, and pl. II–VIII). The same ambiguity applies to the Marseille and Mahdia wrecks. In contrast, the authors of the report on the County Hall ship carefully noted the lack of connection between its keel and floor-timbers.

To sum up: most ancient wrecks were demonstrably built by “shell” technique, but for reasons (of which tenon joinery is but one), that are more in the nature of an assumption than that of a complete proof.

Scantling

Too little attention has been paid to the scantling of timber as a criterion for evaluating the respective functions of frames and planking in the construction of a ship. The conclusions drawn hitherto have, by their empiricism, led to contradictory appraisals. While Throckmorton (1964: 208) writes “most of the Roman ships to date seem to have had keel and frames comparable to those of modern ships”, Dumas (1964: 156) observes (apropos of the *Chrétienne A*) “... the scantling of this hull seems very weak by modern standards”.

None better brought out the importance of scantling than Admiral Serre, in 1891, not only in relation to the structure of a ship, but also as a clue to the method of building. He is worth quoting on this point (1891: 138–9): “... all ancient ships were, like modern ones, made up mainly of frames, spaced more or less closely, which dictated the vessel’s shape after these timbers had been covered with planking. The planking insured the strength and water-tightness of the vessel. It does not, however, follow that the purpose of the two layers is always the same, or that their relative importance never changes. On a ship-of-the-line, the frames are made up of numerous pieces of exact contours being achieved by altering the natural form of the tree trunks. The side planks are laid unbent on to this matrix, the outlines being delineated by the frames. The “bent” timbers (the frames)

account for more in weight and size than those of the side-planking.

“In a clinker built boat, by contrast, the frames are mere pliable battens whose function is to keep the side-planking in position. The outside layer is all important, the frames are, as it were, an accessory.

“A host of variations exist between a ship-of-the-line and a clinker built boat. In analysing structure one finds that the lower one goes down the ladder, the less important is the relationship between the inner and outer layer. At the bottom of the scale, however, it is apparent that the side planking of small craft is made of thin planks. This planking, instead of being modelled on a definite curve, is forced into the required shape by pressure and torsion. As a result it is impossible on boats of small size to begin by erecting frames that are not heavy enough to resist the tension of the planking; one solution is to stretch the planks over moulds that are subsequently withdrawn and replaced by frames, once the side planking is set. One can see the advantage that this has for the builder: it allows him ultimately to insert bent frames, which are lighter, stronger and less expensive. The use of bent frames is further limited by the size of the ship, by its shape, by the degree of flexibility of a given wood or by the artificial means of increasing flexibility at the builders disposal.”

The above makes it easy to appreciate how scientific analyses of the scantling of the timbers from wrecks would enhance the understanding of structural problems.

Structural differences

Structural differences have, unfortunately, received less attention than the joinery of the superficial planking. The *Chrétienne A* and *Grand Congloué* wrecks have half-frames, whereas in the Nemi ships and *Titan* wreck the frames are in one piece. In the *Dramont* wreck, frames alternate with half-frames, and the *Kyrenia* ship is distinguished by frames of unequal lengths (*Bull. Corr. Hell.* 94 (1970): 294).

Lastly, it should be noted that *Chrétienne A* frames were laid out in pairs (Dumas, 1964: 111). From this evidence Benoit (1961:

141–2) attempted to deduce two distinct forms of construction: first, Hellenic, with half-frames, keelson, and angular bottom covered with lead sheathing (Grand Congloué, Mahdia). Second, Roman, with one-piece frames and a flat, unsheathed bottom (Titan, Monaco, Marseille).

The basis for this hypothesis is fragile indeed! The Nemi ships fit into the second category—except for their lead sheathing. The very existence of a keelson is hypothetical on both the Titan and the Dramont wrecks. According to Dumas' (1964: 154–6) observations at the Chrétienne A, the so-called keelsons were probably parts of the mast-steps. Indisputable keelsons do, however, exist on the Nemi, Marseille and Portus wrecks.

Finally, the Chrétienne A falls into the first category but for its lack of lead sheathing (*ibid.*, 111), while as Benoit himself admits, the Dramont has to be classed as an intermediary type.

Further, there has to be agreement on the definition of a ship with an "angular bottom". A flat bottomed vessel can be angular at its extremities. Now, on many wreck sites there is considerable doubt as to which part, along the length of the hull, is represented by the surviving wood, or indeed by the part of it that has been published.

From these brief comparisons it emerges that any attempt at stylistic classification is premature. In the circumstances, Benoit's attempt to connect the "Greek tradition" (which he qualifies as the "primitive technique") with Egyptian Middle Kingdom naval constructions, when so much obscurity still shrouds the latter, is nothing more than conjectural (Benoit, 1961: 132). Even if the half-frames which Boreux suggested were proved to have existed on Egyptian ships, nothing proves the connection between them and the half-frames on the Congloué and the Chrétienne A; the same technique is used in South Vietnam (Paris, P., 1956, figs 66, 74). Benoit's conjectures must be seen as the "Egyptian mirage" which haunts the history of ship construction.

The universal use of tenons within the Mediterranean might well have been invented independently of Egypt, since the technique

crops up in India (Paris, F. E., 1841: 20, "manche" of Calcutta) and Madagascar (Hornell, 1944: 12, fig. 6B) as well as Vietnam (Paris, P., 1955: 20; Pietri, 1949: 17–19).

A more rewarding method of understanding ancient wrecks, than Benoit's vast and premature theorizing, would be structural comparisons (based on the correct analyses of wrecks) set alongside analogous structures drawn from existing and well known material. Few analogies are, to my knowledge, more striking than the comparison of the Chrétienne A wreck with certain Vietnamese ships, particularly from South Vietnam. In either region, floor timbers, separated half-frames (cf. Paris, P., 1955, figs 66, 74) and tenons pierced through by treenails are identical to those found on Mediterranean wrecks (Fig. 20).

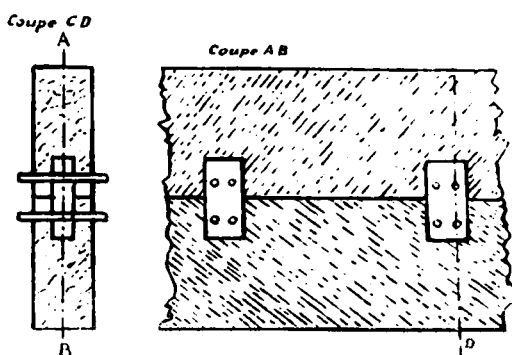


Figure 20. Actual assembly of Vietnamese tenon and mortise. (After Pietri, 1949, pl. XXVI, fig. 65.) There is only one difference from the ancient tenons: the Vietnamese are fitted with two dowels instead of one. cf. Figs 16, 17, 18.

The descriptions of these ships by P. Paris and J. B. Pietri are in complete accord: all the planking had been assembled, edge-to-edge, before the insertion of the frames (cf. Paris, Pietri, above). Despite this, a series of photographs in the Musée de l'Homme in Paris demonstrates that, as is the case with the Indian *pattamar*, the same elements could be assembled in a quite different order. The ship photographed under construction, has thin planks which are assembled, not by real tenons (as in Fig. 20), because these were reserved for thick planks, but rather by long

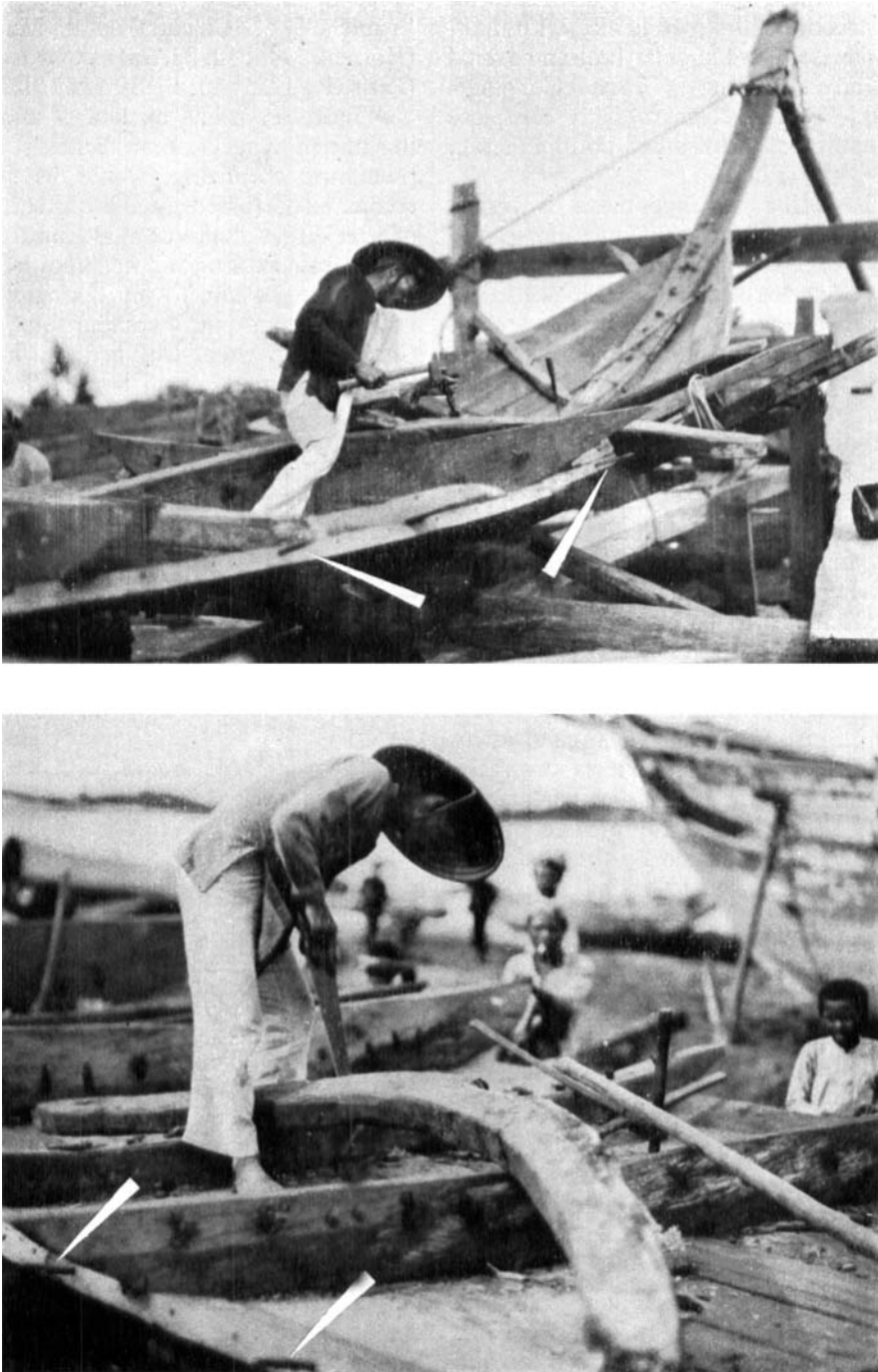


Figure 21. South Vietnam. The floor-timbers are assembled on the bottom planks of the hull. Long dowels can be seen (white arrows) already in place on the edge of the planks; these play the part of tenons in antiquity to penetrate the adjoining plank. Below, a carpenter is finishing a floor-timber for one of the ends (see Fig. 22). Photo: Musée de l'Homme, Paris.

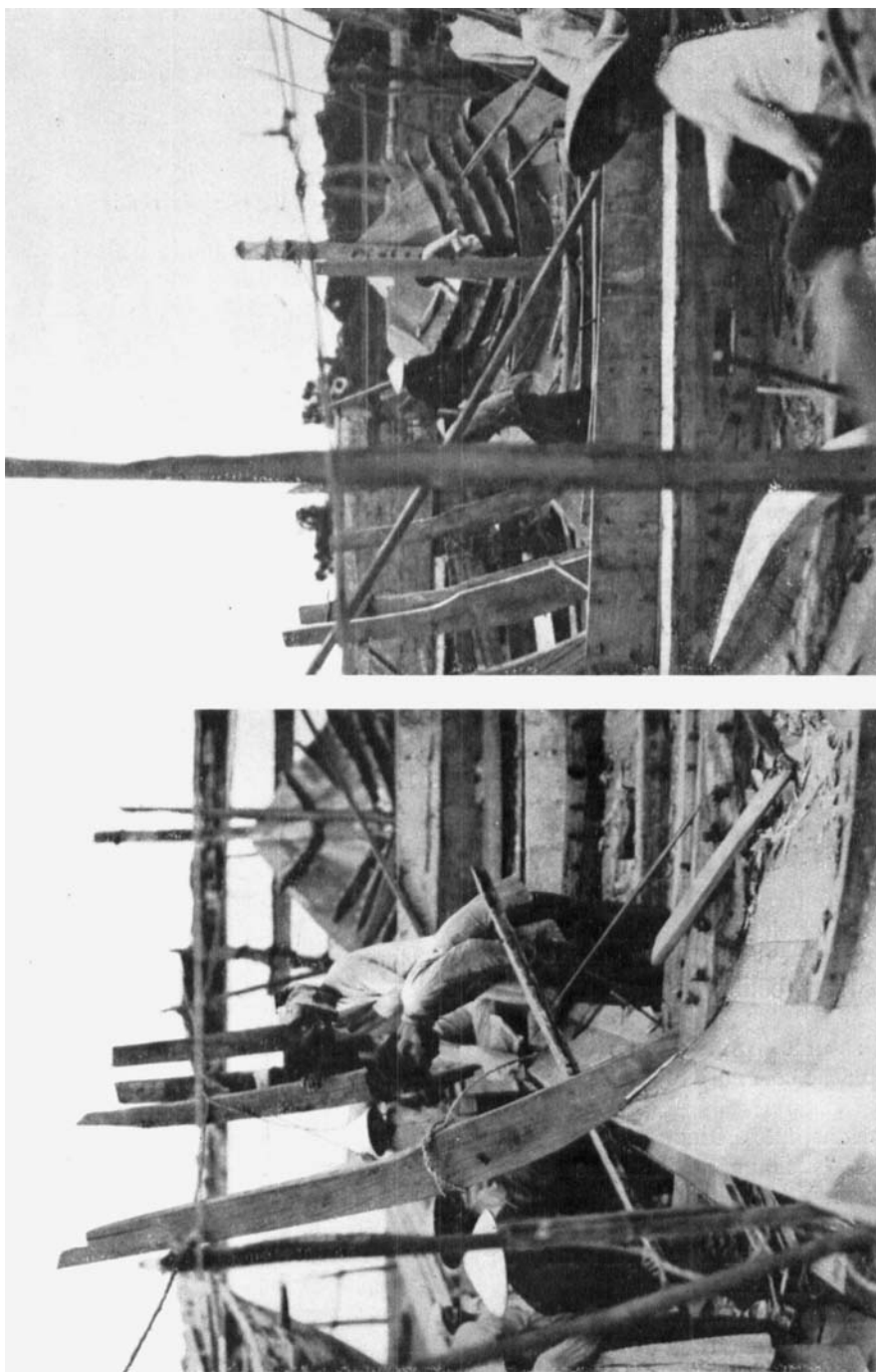


Figure 22. South Vietnam. After assembly of the bottom of the hull, the half-frames are erected. The difference may be noted between the centre floor-timbers which are flat-topped, and those at the ends. Photo: Musée de l'Homme, Paris.

thin treenails that fulfilled the same function (Paris, P., 1955: 21; Pietri, 1949: 17). The photos clearly show that the hull was built in two stages: in phase one, the bottom, i.e. some five strakes each side of the keel are joined edge-to-edge, then consolidated by floor-timbers (Fig. 21).

In the technique described by Paris and Pietri (true "shell" technique) the building proceeded with the insertion of all the other strakes, then with the insertion of the half-frames. In this case some half-frames are fixed on to the bottom of the hull to serve as guides for the positioning of the next strakes (Fig. 22). In this respect, the construction belongs to the "skeleton" technique.

Unfortunately the series of photos from the Musée de l'Homme, being incomplete, does not show the last stages of the construction, but as there are few pre-erected half-frames some additional half-frames were probably added after the side planks had been placed. The photos show that despite the pre-erection of part of the framework, the long pegs were still used to join the strakes of the second stage of the construction (Fig. 21)^[30].

Was the wreck of the *Chrétienne A* built according to the Paris-Pietri diagram (pure "shell" technique) or according to the photos in the Musée de l'Homme? It is impossible to say. Even the guideline showing where the half-frames were to go, that was scratched on to the inside of the side-planking^[24] is not absolute proof of the first solution, because according to the second solution, *part* of the framework was probably inserted at a late stage.

We can assume from the evolution of techniques on the coast of Gujerat and South Vietnam:

1. That an absolute distinction between the "shell" and "skeleton" techniques is as convenient as it is artificial^[31].

2. In both cases the planks are joined edge-to-edge, though the component parts may be assembled in a different order.

3. That in both cases the evolution is similar: a part of the framework (midship frame for the Indian ship, some of the half-frames for the Vietnamese) serves as a guide for laying the strakes, instead of only reinforcing the hull.

4. That a similar evolution *might* have occurred in the ancient Mediterranean, but this alternative is not proven. None of the wrecks that have been examined could disprove it, so it is quite legitimate to put the question.

The problem of the use of moulds

In "skeleton" technique it is the framework that dictates the shape of the hull, but how can a preconceived shape be obtained by the "shell" technique? The quick answer is: by eye (Hasslöf, 1957-58: 50), but further consideration is required.

P. Paris makes some penetrating remarks on this subject (1948: 27): '... the differentiation, from the moment the *definitive* frames are introduced, is equivocal. The real point of discrimination should be: are these frames (or provisional moulds) there to give shape to the planking, or is it the planking which has dictated the shape of all the frames?'

What can be the shape of the planking if not the shape of the hull itself? Therefore, this is a fundamental question.

Pure "shell" technique means that it is the shape of the assembled strakes that dictate the shapes of *all* the frames. It implies that no mould has been used; in terms of comparative construction, this has become rare. Some examples are known from the Far East and from Egypt. Similarly, the shape of the Dahshur boats suggest that they were constructed without moulds.

In European clinker building, always by "shell" techniques, the use of moulds has been specifically denied by Hasslöf, who writes (1957-58: 50): "Old clinker builders questioned on this point, claim never to have used drawings or moulds. In connection with inspection of their workshops and equipment of various tools and auxiliary means, nothing has been found. Nor have any appeared when watching their building activities."

In respect of the use of plans, this statement cannot be doubted, but it does need to be reconsidered in relation to moulds.

It does not seem improbable that, originally, clinker built ships were made without a mould. This must have been the case with the

Nydam ship (Timmerman, 1941). But in relation to current clinker building Hasslöf's assertion is very exaggerated.

Hornell (1946: 195), in his description of a (clinker-built) Rye lugger, compares it with the Gokstad ship: "Neither plans *nor* moulds are made by Sussex shipwrights", but he immediately adds "apart from a half-mould used amidship as a guide to curves and to the distances from the axial line at which the strakes are to be fitted".

Likewise, Petrejus (1954: 18), describing the Dutch *bomschuit*, another clinker-built boat, writes: "it was built by eye... even moulds were hardly used".

The author immediately informs us, however, that some have been used, indeed five, one for the central section, two fore and aft, one for the stem-post and one for the stern-post (*ibid.*).

On the other hand Atle Thowsen, director of Bergen's Maritime Museum, in a personal communication, for which I am deeply grateful, tells me that the clinker construction on moulds is current in certain Norwegian shipyards. He has kindly authorized me to reproduce a photograph in which a mould is still in place in the final stage of construction so that it plays the role of an "active" frame (Fig. 23)^[32]. No overall study of the use of moulds has yet been undertaken.

It appears from my personal research that moulds have a double role:

1. *A theoretical role.* They determine either directly (as in Thowsen's photo), or indirectly (by determining the shape of one of several frames), the shape of the side planking and therefore of the hull. In this instance the mould is the instrument which permits the production of a successful type, which permits competitive copying or the bettering of an existing type. In this theoretical function, it is unnecessary for a mould placed on the keel to support the side planking. The planking may not even be in contact with it. It serves only as a guide to the builder.

2. *A material role.* A mould may be used in the shipyard to force the side-planks into a preconceived curve. More frequently this function is served by several frames whose shape is decided by a mould used in the first, theoretical, manner. The question of bending



Figure 23. Clinker-built boat under construction, western Norway. The mould of which only the upper part is visible, is still in place at the last stage of building. This type of mould is in the form of an arc of which the extremities are joined by a cross-piece. (Photo by courtesy of A. Thowsen, Director, Bergens Sjøfartsmuseum.)

the side planks is very important: a ship whose side planks have not been "strained" can hardly take anything but spoon-like shapes, so the use of "active" frames is, in this case, therefore, highly improbable. Inversely, "strained" side-planks suggest that some device such as a mould might have been used in order to get such an artificial shape^[33].

Moulds can be used in a dual role: either, side-planks are shaped on to a mould which is then withdrawn, before the insertion of frames, in such a way that no trace of the mould will be visible in the finished hull—as was the case in the Rye lugger (mould of type 1); or, the midship frame, shaped in accordance with a mould, is positioned on the keel as is frequently done in the Mediterranean area where midship frames do the job of a mould in its second function (in another sense, being incorporated into the final construction it is a mould of type 2).

This distinction has a more than a theoretical interest: the first type of construction is in complete accord with the definition of the "shell" technique and the second is not,

though the two techniques are closely associated and the same forms can be achieved with a mould of either type. This shows, once again, how oversimplified is the usual direct comparison between shell and skeleton techniques.

In Mediterranean countries the practice of using moulds appears to be as ancient as it is widespread. One description is of particular interest; it refers to Djerba which, if not the legendary land of the Lotophages, is certainly a land of unbroken traditions. Capitaine de Frégate Hennique wrote (1888: 6): "... a builder will own sets of frame-templates, one for each kind of ship. When, for instance, he wants to build a *chabek*, he will set up *chabek* templates, joining them by interior ribbands to achieve a firm overall shape. Pine planks (which will be the final side planking) are nailed on to the outside.

Contrasting woods, usually battens of olive wood, are nailed to the inside to make the frames. The wood is usually taken from broken ships; when no such supply is available the parts are hewn (rather than bent) into the desired shape. Just before the inside of the ship is completed, the guiding templates are withdrawn." They are therefore moulds of the first type. Hennique (*ibid.*) goes on to pose some interesting questions which, unfortunately, are still unanswered: "How many generations of builders used the same templates? ... their shapes were probably the result of long experience. It would therefore be interesting to know how much they varied from one builder to another. ..."

Such observations are regrettably rare. The tradition of Mediterranean shipbuilding being almost extinct, there is an urgent need to record those that still persist (Throckmorton,



Figure 24. Templates used in a Syra boat shed (Syros). These moulds contrary to those shown in Figs 23 and 26 are not intended for erection on the keel, but to establish the shape of the more important structures of the ship, the frames as well as the stem and sternposts. (Author's photo, June 1969.)

1964, indicates the direction to follow). In 1969 and 1970 when I visited Syra, the capital of Syros, I examined the impressive collection of templates on the walls of a hangar (Fig. 24); as at Djerba, they were for a variety of ships.

These moulds are called *χνάρι*, *ιχνάριον* or *ἰχνάρι*^[34] or "modela".

In 1969 at Marathokampos in the island of Samos I witnessed a boat being constructed on moulds identical to those of Syra. From the explanations I collected it appears that initially only the two central frames were set in place. As these frames, which determined the shape of the boat, have been based on a mould they may in consequence be classed as moulds of type 2.

Temporary battens link the central frames to the stem and sternpost. It is the builder's skill that determines the curve of these battens, and it is at this point that he has to use his eye. Once the battens have been given a shape, this in turn determines the shapes of the frames. The latter are drawn by means of a pliable metal rod; as the metal serves as a template its curve need only be transferred to wood to give the exact shape of a frame.

Figure 25 A, B, C shows the majority of the frames in place before the removal of the battens. In this type of construction, the importance of the temporary battens cannot be overstressed. They dictate the shape of the hull as much as the central moulds. The latter determine only the central portion of the hull, but in theory, the variations that the battens can give to either extremity are limitless.

The temporary battens therefore perform the same function as side planks in the "shell" technique: they determine the shape of all but one of the frames. Similarly, when the ship is finished, it is only in appearance that the shape of the side planking depends on the frames; even when this planking covers pre-erected frames because the shape of the frames themselves had previously been taken from a "pre-side-planking".

This method cannot be exclusively Samian; it has long been known in Provence as the "St Joseph's mould". A characteristic common to both the Provençale and the Greek method is that the mould is used only in a primary function, as a "plan". It is never used on a



Figure 25. Shipyard at Marathokampos, Samos, June 1969. The form of the central frame has been established by a mould. The provisional battens serve, so far as the shape of the intermediate frames is concerned, exactly the same purpose as the planking in "shell" technique. (Author's photo.)

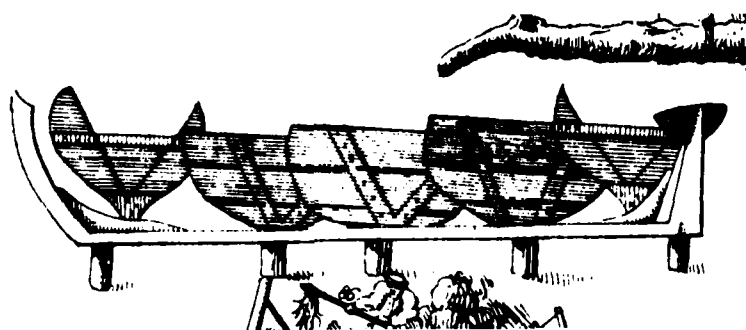


Figure 26. Moulds in position on the keel. Sweden, 17th century. (After Raland, Åke, 1691, *Skeps Byggerij eller Adelig Öfnings Tionde Tom.* Stockholm.)

keel (contrary to the method illustrated on Fig. 26 for example).

P. Paris' account of the technique (1948: 27) (according to Vence)^[35] is virtually the same as the above description; but instead of two central frames, four tenths of the central part of the hull was pre-erected from moulds while the remaining six tenths were inserted afterwards from the temporary battens. Because of the larger number of pre-erected frames the Provençale method is rather more like "skeleton" technique but one realizes that, in such cases, the terms "shell"-and-"skeleton" technique are beginning to lose their meaning.

It would be wrong to assume that this method was limited to the building of small craft, as is shown by Jean de la Varende's abridged description of the building of French ships in the 17th century (1952: 81-2).

"Once the purpose of the ship had been established, four elements were immediately mounted on the blocks of the hold: the keel, the stempost, the sternpost and the midship frame. The midship frame was set aft of the foremost third, which gave a good idea of the ship's character: one third of the total length for a cargo boat; one quarter for light, fast ships; one eighth for galleys. For big merchantmen, the frame was U-shaped (squarish at the base and narrowing towards the top for the heavy freighters); V-shaped for the speedier vessels.

"There followed the abstruse but predominant operation of the positioning of the frames by trial and error. Between the extremities and the midship frame, the next two frames had to be fitted over the keel by means of cranes and blocks. In order to find the right place for these intermediary frames,

there had to be some groping around. They would be moved back and forth, because it was precisely these frames that were going to determine the ultimate character of the ship. The more they were pushed forward the heavier she became, and the nearer they were to the central frame, the lighter she was. The master shipwrights' rule of thumb was the sole arbiter.

"Finally, ribbands or very long lathes, were fixed on to these five 'fish-bones'. The lathes gave the ship its line. They were afterwards replaced by the side planks, but, in the interim, it was from them, by a process of fitting and measuring that the builders arrived at the shapes of the intermediary frames which completed and held together the entire skeleton." I had witnessed the same process at Samos, except for one improvement: the addition of two supplementary "active" frames.

The method described by La Varende is a masterpiece of empiricism never to be surpassed. The next evolutionary stage that he describes illuminates the history of naval architecture (*ibid.*, 82): "as early as 1675 Colbert had obtained some standard moulds, said with some overstatement to be definitive, which could by proportional variations serve for each class of ship. There were fourteen moulds in all: six for the fore part (including the midship frame) and eight for the after-part." Thus, from 1675, vessels are constructed on 14 pre-erected frames, instead of five: the real "skeleton" technique is beginning to emerge. The satisfactory results obtained empirically, also began to be standardized in Italy during the 16th century (Anderson, 1925; Lane, 1934). Real "skeleton" technique

(i.e. when frames are designed, carved and positioned in advance) was not born until naval architecture leaving empiricism behind, became a science, and notably in England at the end of the 16th century^[36]. In practice, this meant the conception of the first plans and the determining of the frames on a drawing board, rather than in a shipyard, where the only guide to their shapes were the temporary ribbands^[37].

Recapitulation

At this juncture the factual evidence can usefully be tabulated. The definitions of an

How? Hornell's comment (1964: 194) on this point is:

"How and when inserted framing came to be replaced by pre-erected frames is an insoluble problem; no gradual evolution is conceivable even in respect of the pre-erection of keel, stem and stern posts, which is a feature common to both the clinker and the carvel system. The pre-erection of the transverse frames is clearly an act of invention, a thought-out mutation, the logical outcome of a train of reasoning in the brain of an inventive shipwright having an abundance of metal nails at his command for the construction of his vessels."

		Moulds or plans	Active frames	Passive frames
I	The Dahshur Boat	—	none	none
II	"Primitive" clinker construction (the Nydam boat)	—	none	all
III	"Developed" clinker construction (a Rye Lugger)	1 mould	none	all
IV	"Developed" clinker construction (the <i>bomschuit</i>)	5 moulds	none	all
V	Pattamar from the Gujarat coast 1829	moulds: ?	1	all—1
VI	Boat described by J. Vence (Mediterranean, 19th century)	moulds	4/10	6/10
VII	French vessel c. 1650	moulds: 5	5	all less 5
VIII	French vessel 1675	moulds: 14	14	all less 14
IX	Boat from Marathokampos 1969	mould: 1	2	all less 2
X	Big, 19th century wooden ship	from drawings	all	none

If the definition of "shell" – and "skeleton" – technique are rigidly applied it becomes apparent that, of the foregoing examples, only nos. 1, 2 and 10 fit at all: nos. 1 and 2 being in the first category and no. 10 in the second. For the remainder, such classification could lead to sterile and interminable debates. It would be more rational to classify according to the type of the frames. First because it is based on realities. Second because it is a guide to the evolution of naval architecture. Indeed, in the course of time, the shape of the hull appears to have been taken less and less from the side planking (or the provisional battens) and more and more from the frames.

"active" frame, as one which determines the shape of the side planking, and of a "passive" frame, as one that takes its own shape from either the side planking or the provisional battens, should be kept in mind.

"Active" frames in the Ancient Mediterranean

The idea of determining the shape of a hull by one or more pre-erected frames was born in Europe; but how, when and where?

Hasslöff (1963: 166) had already shown from northern European examples that Hornell was exaggerating the difficulty; the foregoing table confirms this in terms of time and space. The first "active" frame clearly stems from the mutation of a "passive" one probably because the latter had become a "standard".

When? The earliest testimony that I know of a construction on pre-erected frames, is a painting of Paolo Veneziano (1290 (?))



Figure 27. Shipyard in Italy (Venice?); first half of 14th century. Painting by Paolo Veneziano in a private collection. (After Pallucchini, 1964, with the author's kind permission.)

1358/62) (Fig. 27)^[38]. Thirteen frames are evidently in place as well as two wales and the upper rail. On the lower part of the hull, five or six strakes have been fixed to the frames. A carpenter is in the act of drilling a hole through the principal wale, probably in order to insert a peg attaching the wale to a frame. It should also be noted that the two carpenters working inside the ship have their legs hidden, though one would have expected them to be visible through the skeleton. Technically this might be explained by the

presence of inner planking, though it is more likely that the artist was making a conventional use of opacity in order to avoid some difficult drawing.

It might be suggested that the lower strakes were set up before the frames, as in certain Vietnamese and 17th century Dutch forms of construction (Hasslöf, 1963: pl. 11, fig. 11). Equally, the shape of the frames might have come from the ribbands or temporary battens. These hypotheses neither can, nor need be refuted, because it is quite clear that most of

the strakes were fixed on to a pre-erected frame and that the process is a far cry from "shell" technique.

Where? Since Scandinavia and Germany practised clinker building from the outset, neither can be credited with the invention of "active" frames, even if moulds had been known. The method itself precludes the transformation of type 1, or true mould, into type 2, or the midship frame that had been carved as a copy of a mould.

Can the naval tradition of the Venetii, which differed from both the northern and the Mediterranean tradition, fill this gap? Since all that is known about it is contained in a few brief references made by Julius Caesar (*De Bello Gallico*, III: 13), the "tradition" had best be set aside until such time as a Venetic or Celtic wreck be discovered.

It has been suggested that the Blackfriars ship might have been the product of a Celtic tradition that persisted in Roman Britain (Marsden, 1967a: 35). Peter Marsden, the author of this suggestion also maintains that the Blackfriars ship proves that a form of

"skeleton" technique was current in Great Britain from the 1st century AD (*ibid.*, 22-3). The construction of this boat, so well analysed by Marsden himself, must therefore be examined.

First, the bottom planking (it will be remembered that the Blackfriars ship had no keel) was set out in the shipyard. Next, it was assembled by means of the floor-timbers (better called cross beams, since they are not extended by futtocks and top timbers so as to form frames). An exceptional floor-timber, it should be noted, was inserted after the ship had been finished (*ibid.*, 33). Bilge-planking was then affixed to the underside of the curved cross beam. Some half frames were joined to this bilge-planking, but not to the cross beams. The rest of the side planking was attached to the half-frames⁽³⁹⁾ (Fig. 28).

I have already analysed this kind of construction: it is typical of keel-less, flat bottomed boats that are neither "skeleton" nor "shell" technique.

The local origin of the Blackfriars ship seems incontestable to me; its descent is easy to trace. Considering the ship from its bottom

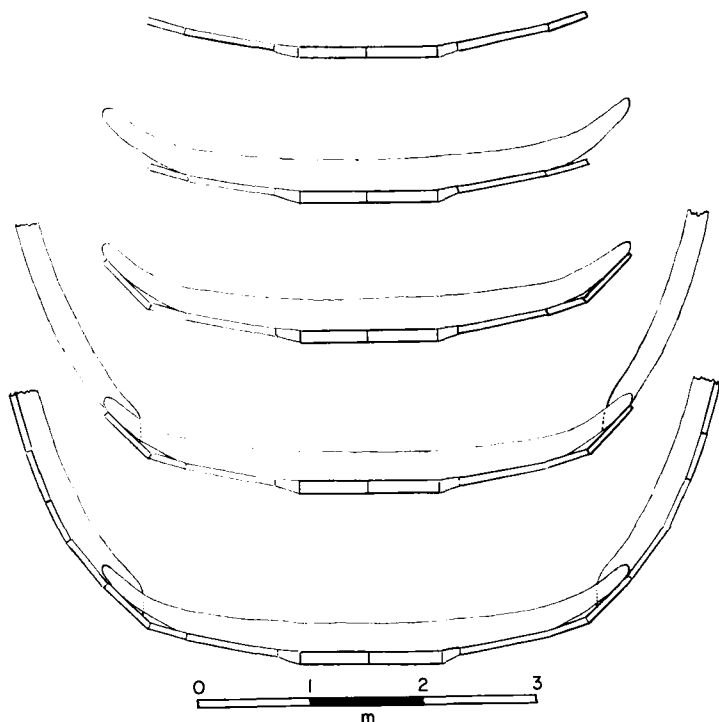


Figure 28. Schematic reconstruction of the probable order of assembly of the parts of the hull of the Blackfriars ship. Modifications in detail are possible; but it is certain that the first stage was the placing of the floor; this may have had fewer planks than the eight which I have shown. This type of assembly is analogous to the South Vietnamese method in Fig. 22.

planking, cross-beams and bilge, side planking, the resemblance to the Brigg "raft"^[40] (Fig. 29) (Wright, 1947: 251, fig. 15) is very striking, though the latter was built several centuries earlier^[41]. The essential difference between the two boats, lies in the use of metal, which is present in the first mentioned. In the second, the cross beams that hold down the bottom planking are slotted into perforated cleats cut into the planks themselves. Another instance of metal being substituted for wood in assembling, while leaving the structure of the ship unchanged, has already been mentioned in this paper (p. 15).

The main interest of the Blackfriars ship is that it is the first example, within the framework of European naval history, of side-planks being fixed to pre-erected frames. We have already seen, from the photographs

in the Musée de l'Homme^[42], that this technique is used in South Vietnam. The improvement, by comparison with the Brigg "raft", lies in the addition of the extra, side-planks. Probably this progress was due to the introduction of metal; certainly the "rafts" mode of assembly would have precluded it.

It may be that the improvement was due to Mediterranean influence, of which the Blackfriars wreck affords further evidence: the piercing through of the floor timber by a dowel (Marsden, 1967: 29, fig. 1e) (as in the New County Hall, Nemi, Dramont and Titan wrecks), the hammering back of the ends of the nails (ibid.) (as in the Nemi wrecks), and the placing of a coin in the mast-step (ibid., 36-7) as in the Port-Vendres^[43], (Dumas, 1964: 121) and Chrétienne A wrecks (ibid.,

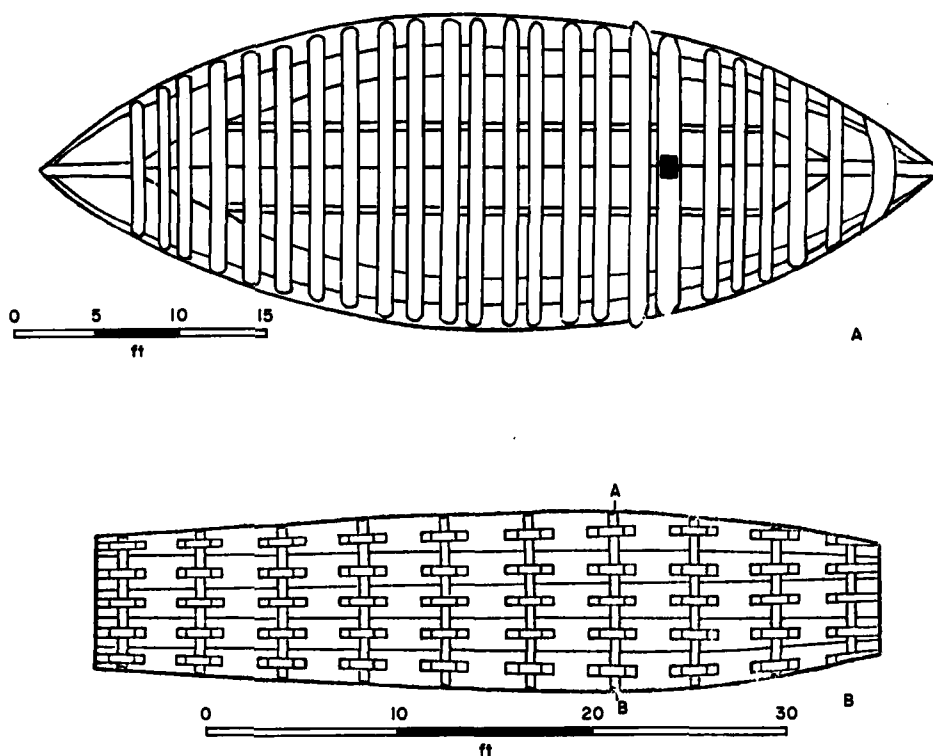


Figure 29. A. The Blackfriars ship. (After Marsden, 1967: 25.) B. The Brigg raft. (After Wright, 1947: 251 by permission of the author.)

Given that the Brigg "raft" was not a raft, but a flat-bottomed boat, the Blackfriars ship could have been the result of local evolution, starting from the Brigg boat. The principal difference lies in the assembly of the cross beams to the planks: a complicated and fragile assembly in wood on the Brigg boat, but simple and strong with iron nails, in the Blackfriars ship.

123). The use of half-frames is also a Mediterranean technique (Grand Congloué and Chrétienne A): because it has been possible to draw up a list of Mediterranean characteristics, I am prepared to consider the Blackfriars ship as an example of diffusion rather than convergence. Considered as a whole, it can be classed as indigenous construction marked by some foreign influence.

The ship should not be interpreted as a stage in the development of "skeleton" technique, but rather as a special form of construction which, because of its lineage, has great importance in northern Europe: the framework of certain 17th, 18th and 19th century wrecks from the Zuider Zee (to judge from published photographs) was identical with the framework of the Blackfriars ship^[44].

This same type of construction characterized by frames independent of the floor timbers, and which do not touch the keel, also occurs between the Middle Ages and the 16th century, in boats called "eels" from the River Gironde (see Bernard, 1962: 445). Doubtless further examples could be found in Europe.

The possibility of a Mediterranean origin, in antiquity, for active frames needs examining. Though absolute certainty is out of the question, this does not preclude consideration of a working hypothesis, namely, that evolution could have occurred along the following lines:

1. A ship without frames.
2. A ship with side-planking strengthened by "passive" frames.
3. The introduction of moulds.
4. The real mould (of type 1) transferred to make an "active" frame.
5. Increased numbers of "active" frames.

The arguments are as follows:

1. Large military fleets, such as the Athenian of 5th and 4th century, often had to be built in a hurry so that a high degree of standardization was required. This is demonstrated by Philon's *skeuotheque* (Piraeus). What could be more logical—and even necessary—than to base an entire series of ships on moulds?

Furthermore, it so happened that a particularly efficient ship had to be copied. It is known that the 100 quinqueremes which, in 260 BC, constituted Rome's first fleet, were copied from a captured Carthaginian quinquereme. Probably the copy was not absolutely faithful and Roman quinqueremes were rough adaptations (this in view of Roman technology and tactics) (Thiel, 1954: 177). Since neither Rome nor her allies had ever built a quinquereme, the Carthaginian must have served more as an example (Polybius, I: 20, 13).

By 242 BC, the construction of a new Roman fleet of quinqueremes was a very different matter. Roman builders had learned all about quinqueremes, what they now needed was a fast, seaworthy ship. During the siege of Lilybaeum (250–249) they had captured a Carthaginian quinquereme noted for these very qualities (ibid., 47, 10); it was this ship that served as prototype for the fleet they built in 242 (ibid., 59, 8).

Was there a new arrangement of oars on this ship? Possibly, but the quality of its build is so emphasized as to imply that it was the particularly efficient shape of the hull that decided the Roman choice.

The 200 copies made from this hull must of necessity have been identical, else the operation would have been pointless. It seems to me inconceivable that this could have been carried out without moulds—even without several moulds for each ship. The operation was on such a scale (several shipyards must have been working simultaneously) that it denotes, with certainty, a longstanding familiarity with the use of moulds^[45].

2. It would seem hardly credible that an entire fleet could have been built in such a short space of time were it not attested by several writers: in 260 BC Rome built a fleet of 100 quinqueremes and triremes in 60 days^[46]; in 254 she built 220 ships in three months (Polybius, I: 38, 5); a fleet of 220 units (to be used against Hiero of Syracuse) was equipped in as many days (Pliny, *N.H.*, 16: 192).

Such speed was not the norm for ships that were not standardized. For Hiero's *Syracusia* which must have been comparable with the Nemi ships, the hull alone

took six months and its completion another six (Athenaeus, V: 207a).

This speedy construction of Roman fleets has intrigued several commentators. As far back as 1889 Assman (1889: 1600) conjectures that such Roman ships might have been nearer to river barges (he points out that an Oder barge took four weeks to build) than seagoing ships. More recently, Casson (1963: 33, n. 19) postulated that some such technique as used on the Blackfriars ship might have solved the problem.

Close scrutiny of the iconography of Roman warships, from the "prows" on the first Republican coins, leads to the rejection of these hypotheses.

In fact, careful consideration should be given to the terms used by Polybius: ἐκ δρυόρων (Polybius, I: 38.5) should in my opinion be translated as "starting from the setting up in the shipyard (on the stocks?)". The times that are mentioned therefore refer to the assembling rather than the construction, since many parts such as frames, strakes, etc. could have been prefabricated.

Even more astonishing construction times were recorded in France during the 17th century. In 1678, during a competition between ports, Rochefort succeeded in building a frigate in 30 hours, Brest in 22 and Marseille in 7! In 1679, Seignelay, Colbert's son, and Maréchal de Vivonne, embarked for the Chateau d'If at 5 p.m. on a galley that had been laid down in a Marseille shipyard at 6.30 in the morning of the same day. These examples are too well attested to be doubted (La Roncière, 1934, V: 335e, refs. quoted ns. 1-2), but obviously they refer to the assembly time of prefabricated parts. During the Second World War the construction time for a Liberty ship, from the moment of laying its keel, up to its delivery, was 33 to 42 days. A Liberty ship was, however, a vessel of some 4000 tons displacement (Washington), 135 m long and 17 m wide. The record was held by the firm of Kaiser in Richmond, California, who constructed or rather assembled the *Robert E. Peary* in 4 days, 15 hours and 26 minutes (Windeling, 1946: 250-2). It was a triumph of prefabrication.

Mass prefabrication of identical parts being the obvious solution to the problem of

mass producing a series of identical ships, I can see no reason to doubt the figures given in the sources I have quoted.

It goes without saying that such prefabrication implies the use of moulds or plans.

Were ancient moulds used on the inside or the outside of a hull? To my knowledge, external moulds are only recorded in the Arab sphere (Johnstone & Muir, 1962: 60). In the Mediterranean, in antiquity as at the present time, the moulds must have been internal^[47].

3. Moulds have so far only been considered in their primary function, as a means of reproduction. Their other use is to *constrain* the planking to a certain curve. Consequently, the shape of a hull betrays, to some extent, the way it was built.

A spoon-shape, that is to say, a hull of which each section is the arc of a circle, demonstrates that the planks were bent in accordance with a natural curve, in consequence the use of moulds is virtually excluded. The Dahshur boats are a perfect example of this kind of hull, but they were river boats; no wreck of a seagoing ship of this kind has yet been found. Such ships must, however, have existed in the Mediterranean at an early date: one need look for them no further than the wall paintings of Dra Abu'l-Neggah, showing Phoenician ships of the New Kingdom (Daressy, 1895: 286).

In the absence of wrecks, carefully made models give a good idea of hull shapes. There is no better antique model than the bronze lamp from the Erechtheion, now in the National Museum, Athens; it is dated, by the style of the inscription on it, to the 4th century BC (Morrison-Williams, 1968: 179, pl. 27b). The lines are, however, those of a 6th century ship, so that the lamp may either have been reproduced, two centuries later, from an archaic pattern, or the model represented some still surviving type of archaic ship; alternatively, the inscription may have been added two centuries after the lamp had been made.

The plan of this model, taken from a plaster cast (at the level of the water line), (Fig. 30) is, like the section (taken amidships), not without interest. The section shows a very pointed hull with slightly convex sides.

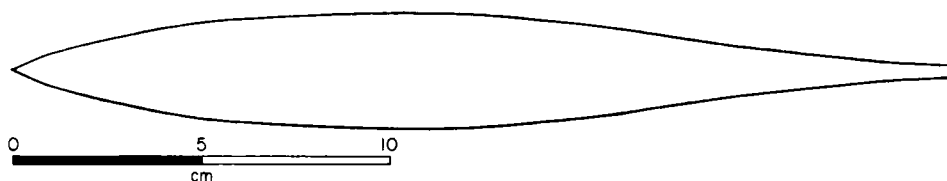


Figure 30. Plan, at probable waterline, of boat-shaped lamp from the Erechtheion, now in the National Museum, Athens. The plan is made from a cast; note the hollow bows.

This convexity appears farther aft and continues to the extremity of the stern. Forward it stops at the prow shelter, giving place to a V-shaped section with rectilinear sides. The front of the model is distorted by the burner of the lamp; without this, the section would have been slightly concave. This concavity is clearly visible towards the prow on the plan. This curve which necessitated the bending of the planks against their natural curvature, was very probably obtained from one or other of the two types of moulds (used in their secondary function)

Until the excavation of the Kyrenia ship, all the other wrecks that had been found (with the exception of the Nemi ships) were too fragmentary to allow more than an approximate study of hull shapes. The shape of the framework in the Chrétienne A wreck does, however, merit some attention. Dumas (1964: 134, fig. 17) was able to measure one element to a height of 2.6 m: the bottom was slightly concave, but the upper part was convex. This double curve again argues the use of moulds in their *secondary* function, as forms over which the planks are *constrained* to adopt a given shape.

4. The next stage in the evolution is of primary importance: it is the transition from the guide-mould to the "active" mould. Had it been achieved? Recourse to philology is indicated: the importance of the word *νομεύς* needs to be considered. *Νομεύς* means "he who makes animals graze": shepherd, grazier, cow—or swine herd. In this meaning the word is ancient, occurring frequently in Homer, it is used in the same sense in classical times (Plato, *Theaetetus*, 174d, Rep. 370d).

In terms of naval architecture, however, *νομεύς* also has a technical meaning. Hesychius, in the 6th century AD, defined the *νομεῖς* as the *ἐγκοίλια* or frames. Similarly for

Photius in the 9th century *νομῆς*: *ἐγκοίλια*. *Νομεῖς* also occurs in Procopius' 6th century description of Aeneas' boat, preserved in Rome, where *νομεῖς* clearly means frames.

The oldest references to *νομεῖς* in the naval sense are found in Herodotus, where they occur twice. This is the only instance of this use in classical times.

How to explain the transition, if transition there be, from "shepherd" to "frame"? Even a writer addicted to metaphors could find no justification for calling frames "shepherds"! Dewing's (Loeb, 1928) rendering of *νομεῖς* as "shepherds" in his translation of Procopius is indefensible, "shepherds" having no meaning at all in English maritime vocabulary.

The solution must be sought in the origin of *νομεῖς*; the root *νεμ-* gave rise, notably, to *νέμω*, the primary meaning of which is: divide, distribute, share out. For visual reasons alone, there might be some justification for saying that frames *divide* a hull into sections. This interpretation must, however, be rejected because the function of frames is the direct opposite; they always assemble, support and consolidate. Semantically and keeping to the sense *νέμω*: divide, Laroche (1949: 119) writes in his remarkable thesis on the root *νεμ-*: "*νομεῖς*, the dividers must be understood as an allusion to the shape of a long boat that cleaves the water".

Here the distinguished linguist's hypothesis becomes so far fetched that it need hardly be refuted: nothing is cleft or divided by a frame, certainly not water. *Νέμω* is also used in the sense of to govern, administer, be master of, etc. Laroche, in the study in question, convincingly shows how from *νεμ-*, the root's original meaning of "distribute or share out" had been derived, after various intermediary stages, on the one hand *νομός* "pastureland" (whence *νομεύς* shepherd), and on the other

hand νόμος, "equitable share". From this last meaning are derived: "order, rule, norm, law based on precedent"—all of which concepts are common to politics, music and religion. "In a general sense," Laroche wrote, "νόμος applies to the rule of action, to the principle on which all non-empirical action is exercised" (ibid., 178). "This explains the complementary existence to νόμος or order, rule, of νομείς or the dispenser, qualifying βασιλεύς, of τύραννος, or more generally of νομοθέτης" (ibid., 119).

Here at last is a possible naval meaning for νομείς: the function of an "active" frame

deriving from a mould being to guide, according to well established custom, the shape of the planking. This is the ordinary use of a frame in which it becomes the νομοθέτης of construction. It is striking that the only classical reference to a pre-erected frame comes in one of the two references made by Herodotus to νομείς; the one in which he describes the method of building a Mesopotamian *quffa* (Herodotus, I: 294). The craft were made by covering a carcas (νομείς) with hides. There could be no more illuminating example of construction on "active" frames.

Another word for frame is εγκοιλία (*costa* in

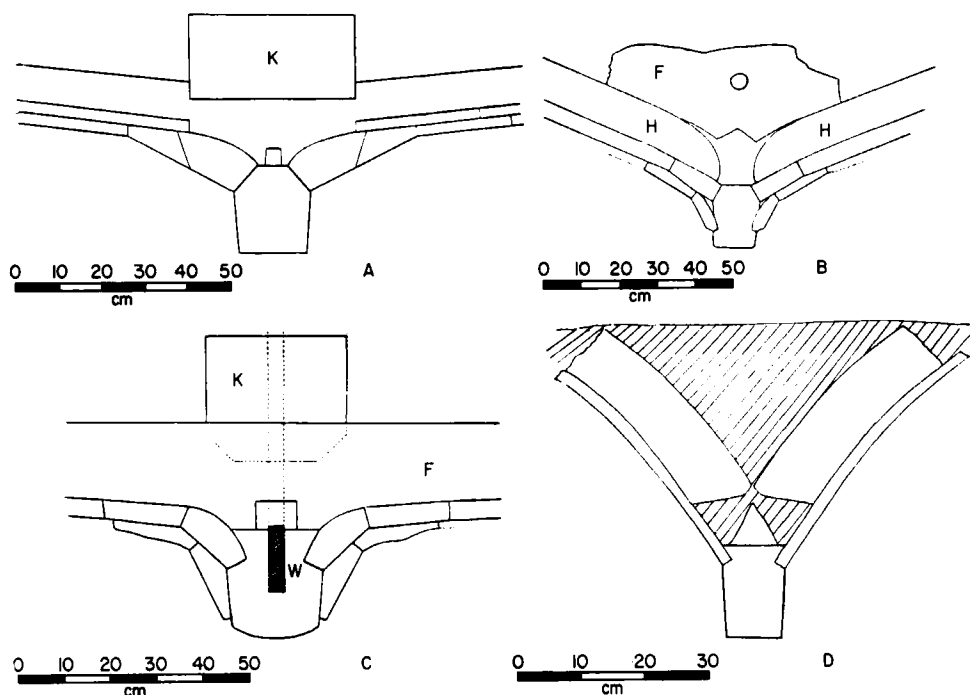


Figure 31. Sections of wrecks from the coast of Provence. (In order to simplify the drawings, all nails and tenons have been omitted.)

A. Dramont. (After Benoit, 1961, pl. 28.) The timber K was identified by Benoit as a keelson, but it is, more probably, a mast-step.

B. Grand Congloué. (After Benoit, 1961, pl. 23.) F, Floor-timber; H, half-frame. It may be noted that in the arrangement of the half-frames they do not reach the keel, a common practice in comparative naval architecture; but in this case neither does the floor-timber, which is unique. To me the reconstruction should be accepted with reservations.

C. Titan. (After Benoit, 1961, pl. 26.) Timber K was again identified by Benoit as a keelson, but is more probably a mast-step. The function of the wooden dowel W is probably not for fitting floor-timber F to the keel, but to fix the mast-step.

D. Chrétienne A. (After sundry diagrams and photos in Dumas, 1964.) The reconstruction of the keel is entirely imaginary. Hatched area: triangular floor-timber which partly touches the keel to which it is not fixed. In fact one may wonder if the structure of the Grand Congloué was not similar.

Latin). It is in no way descriptive of function; it is completely neutral and it must have been the usual term, since lexicographers use it to define the *νομεῖς*. This in addition to the term's rarity would confirm that it had a particular and not a general meaning. It does not follow that the meaning which I accept for *νομεῖς*, signifies that the Greeks had knowledge of "skeleton" technique, but rather it suggests that they were conversant with the use of "active" frames. Finally, it should be noted that *νομεῖς* or "director frame" has a very close parallel in the French "maître-couple".

5. The absence of any connection between keel and frames is a decisive refutation of the argument that construction started with the setting up of frames.

There are several ways of uniting keel and frames, the simplest being the slotting of the keel into a notch expressly cut for it on the underside of each floor timber. Such notches are found in most modern ships built according to the "skeleton" technique. Similar notches, significantly, are never found in old Scandinavian clinker-building in which the floor timbers, when they rest on the keel, are

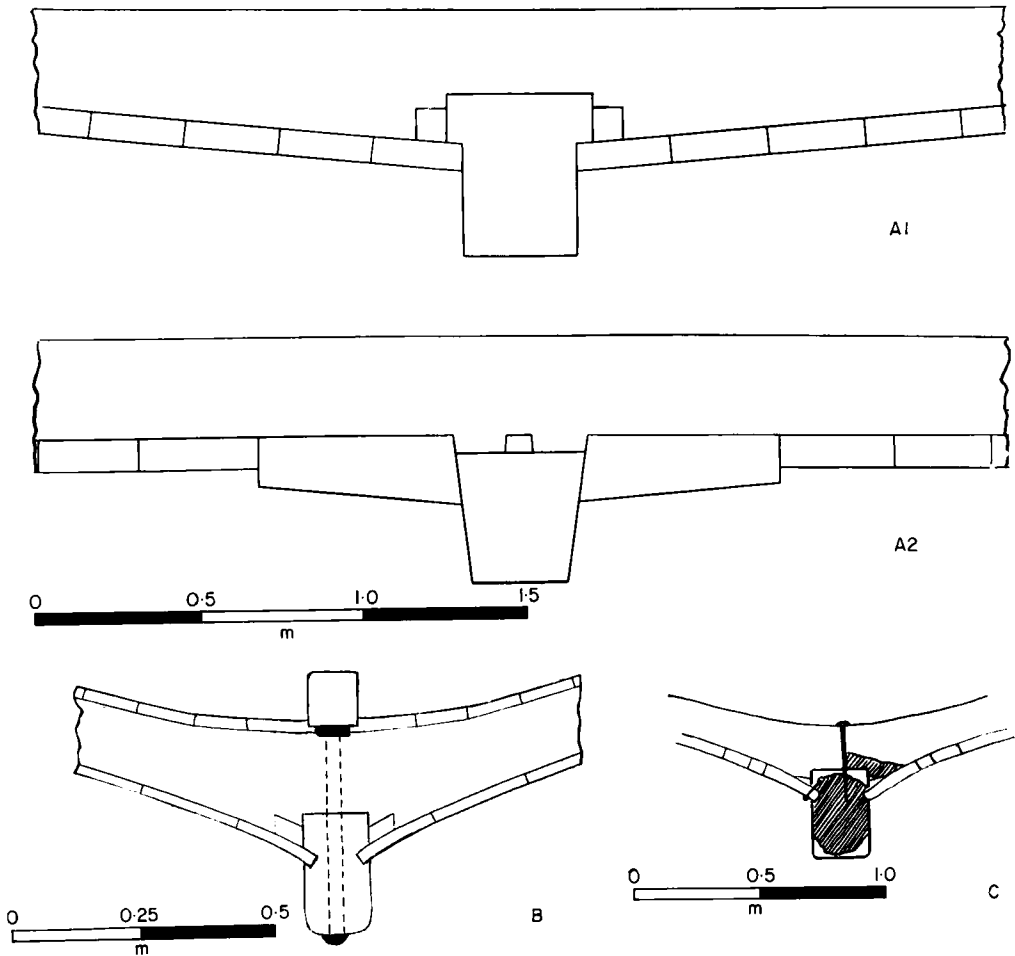


Figure 32. Fitting of keel to floor-timbers. (Again for simplification the nails and floor timbers have been omitted.)

A. Nemi ship. Section of keel fitting. 1. Notch in the floor timber (After Ucelli, 1950, fig. 158.)

2. Floor timber without notch (After Ucelli, 1950, fig. 155.)

B. Monaco wreck. (After Benoit, 1961, fig. 79.) C. Yassi Ada wreck. (After van Doorninck, 1967, fig. 14.)

adapted to its upper surface without ever having true notches in them⁽⁴⁸⁾.

A more solid joint was obtained, by means of bolts, in the great vessels built by "skeleton" technique (Longridge, 1955: 18 is a good description of such an assemblage). On the following wrecks (to judge from published records): Dramont (Fig. 31A), Titan (Fig. 31C), *Chrétienne A* (Fig. 31D) and the Marseille ship there were apparently no notches in the floor timbers, hence no slotting. On the Grand Congloué wreck (Fig. 31B) the floor timbers did not even touch the keel, if credence can be given to Ch. Lagrand's reconstruction (Benoit, 1961: 135, pl XXIII).

With regard to the Nemi ships Ucelli's incomplete documentation must, once again, be deplored: most of the diagrams show no hollowings, but there is a single exception (compare Fig. 32 A1 and A2). They are not necessarily in contradiction: on the Blackfriars ship there was no such problem of slotting because there was no keel (Fig. 29), though this did not prevent a floor timber from one extremity from being hollowed out where it fitted over a central beam (Fig. 33B). This example shows that only some floor timbers may be notched. Ucelli's publication does not, unfortunately, show the proportion

of notched to un-notched timbers. On the County Hall ship, which, in many respects, is better recorded than the Nemi ships, some of the floor timbers have central notches (Fig. 33A), but the cuttings are so shallow that they hardly justify the description of joints. The hollowings in the floor timbers do not seem to derive from any wish to join the two elements, indeed they only demonstrate the fact that the beam representing the keel is, in certain parts, slightly higher than the surrounding planks. It is no more than an adaptation, in the same way as the grooved floor timber on the Blackfriars Roman ship.

There is, by contrast, one clear case of a slotted joint on one of the small boats from Lake Nemi (Fig. 33C). But for this single exception, it would appear that the absence of true jointing was the rule.

The same applies to the Titan wreck, but for the ambiguous treenail previously mentioned.

In view of all this evidence, the extraordinary character of the connection between keel and floor timber on the Monaco wreck is most striking. It is in fact threefold (Fig. 32B) (Benoit, 1961: 146, fig. 79):

1. Slotting: the hollowing of the floor timber is pronounced.

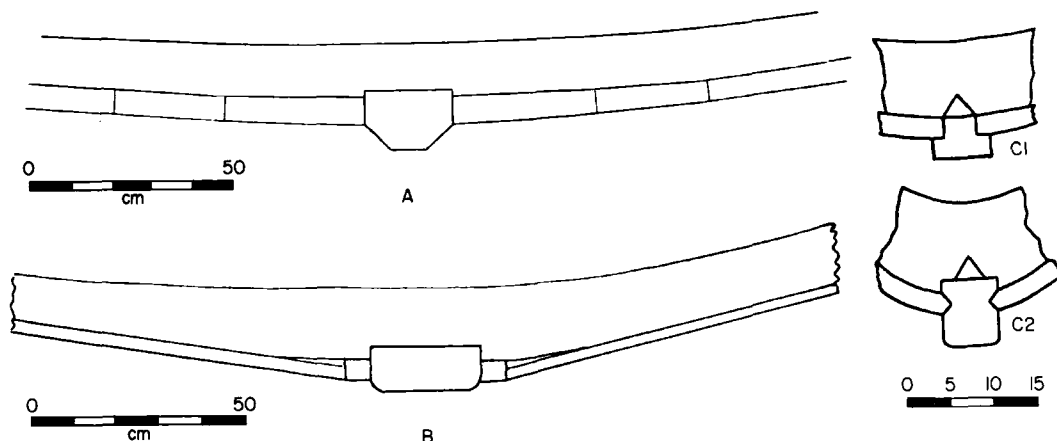


Figure 33. Fitting of keel to floor-timbers, ctd.

A. New County Hall boat. (After Riley & Gomme, 10.) Note that the floor timbers of this boat are slotted in, cf. *ibid*.

B. Blackfriars ship. (After Marsden, 1967, fig. 4, upper.) Note that fitting is the exception on this ship: cf. fig. 29 which shows the majority of the floor-timbers.

C. Two sections of the Nemi boat found in 1930. (After Ucelli, 1950, fig. 263.) 1, Without slots in the floor timber; 2, the keel is slotted in.

2. Large bronze nail runs right through both keel and floor timber.
3. There is riveting with a bolt under the keelson.

The Monaco wreck (late Imperial) is not unique; the Yassi Ada, Byzantine wreck (7th century) has the same nailed slottings (Fig. 32C)^[49], but whereas we know little of the Monaco wreck, the publication of the Yassi Ada ship, by van Doorninck, is excellent. It shows a singular feature: only about one floor timber in four is nailed on to the keel (van Doorninck, 1967a: 104).

Technically and theoretically, this method of assembly does not *preclude* the introduction of frames during the final stages of construction. In practice, this careful joinery not only connoted superabundant strength, but it departed from the previous practice shown on other wrecks, to such an extent that the rupture deserves an explanation.

Now, far from being a luxury, as it would have been in the "shell" technique, this kind of joinery was a necessity in a form of construction which started with the setting up of the frames.

It might be objected that, on the Yassi Ada wreck, the pre-erection of the side planking is indisputably marked by the guide lines scored inside the planks; scoring that can only be explained by the subsequent introduction of frames (ibid., 93). Judgment should be withheld until the definitive report is published, nevertheless some observations are already justified.

van Doorninck in his reconstruction of the building technique draws on a Scandinavian practice, described by Hassl f, which is an intermediary compromise between the "shell" and "skeleton" techniques. He extracts three stages:

1. The first 16 planks (from the keel outwards) are assembled by "shell" technique.
2. The introduction of the frames higher than the highest strake (no. 16) (ibid., 86–106).
3. The fixing to the frames of the higher side planks (no. 17 onwards). Now this otherwise plausible explanation makes the presence of the guide lines difficult to understand: guide lines are in fact present on the *inside of planks nos. 18 and 20* (ibid., 93, n. 8).

van Doorninck's hypothesis does not explain them, since he assumes that the planks were to be fixed on to pre-erected frames. Further, it is impossible that the planks that came after 16 could have been assembled by "shell" technique, because there was no tenon joinery between them (ibid., 98, n. 17). (Planks 1–16 were joined by very widely spaced tenons, at intervals of up to 0.9 m (ibid., 90).)

It would be out of place to dwell on the significance of these guide lines, what must be concluded is that they do not decisively disprove an alternative hypothesis, namely: *that some, or all, of the frames attached to the keel might have been pre-erected.*

The Yassi Ada tenons are peculiar: they are no longer fixed to the planking by dowels and being much smaller than the mortises they fit them loosely (ibid., 90–1).

Such tenons cannot have been much use in the assembling, so that van Doorninck's conclusion seems to me to be most judicious when he writes: "These joints, then, were designed to facilitate as much as possible the task of fitting the strakes together and *shaping the hull*" (ibid., 92) (the italics are mine). This is not in contradiction with the pre-erection of *some* frames, round which some planks could have been loosely assembled, like the provisional battens at Marathokampos.

In my working hypothesis the stages would be the following:

1. The erection on the keel of either some widely spaced frames, or perhaps only of one.
2. The positioning of the first side planks.
3. The insertion of the remaining frames.
4. The riveting of two wales to the frames^[50].
5. The fixing of the remaining strakes.

If this sequence be right, the resemblance between stage 4 of the Yassi Ada ship and Paolo Veneziano's painting (Fig. 27) becomes most striking.

6. The examples from the Gujarat coast and South Vietnam (Fig. 21) have shown that edge to edge assembly is not technically incompatible with the fixing of side planks to a frame. It can be assumed that if "active" frames were sometimes used in antiquity, this method would not have been lightly

abandoned, first because a great number of frames were always put in at the end, second because of the conservatism of ship-building techniques.

This inertia, stemming from centennial or even millennial practices, has not escaped Throckmorton who, in questioning the use of tenon assembly outside Egypt (where it is easily explained by shortage of wood), writes (1964: 208): "another explanation for the survival of tenoning as a technique could be the traditional conservatism of shipwrights and seamen. Tenoning lasted long after the development of strong keel and frame structures made it unnecessary".

It is nevertheless reasonable to suppose that as "active" frames increased in number tenoning must be seen as, proportionally, a dispensable luxury; thus its disappearance became, sooner or later, inevitable.

A progressive disappearance is indeed attested after the Late Empire when the spaces between the tenons become ever wider. Compare, for instance, the 0.01–0.05 m spaces on the Congloué, the 0.1 m spaces on the Portus wreck and as much as 0.90 m at Yassi Ada. The intervals on the Pantano Longarini ship must have been considerable, as it was said that "these tenons served no structural function" (Throckmorton & Kapitän, 1964: 187); the distance appears to have been around one metre (van Doorninck, 1967a: 102, n. 24).

Moreover tenoning only existed below the water line (*ibid.*). It is more than a coincidence that the linking of floor timbers with keels should appear just as tenons were being placed, progressively, farther apart^[51].

Limitations of underwater archaeology

If submarine archaeology, despite its successes, is disappointing in some respects, it is because few conclusions could be drawn from an enormous mass of sure, but fragmentary, findings. The new discipline has certain inherent limitations.

The most important, in my opinion, is the virtual impossibility of deducing the shipyard where a vessel was built.

Superficially the Nemi ships appear to be an exception. Obviously they had been built near the lake, but equally obvious the shipwrights were foreigners to the region. Did they come from Italy, Alexandria or—why not—Tyre?

A cargo can date the loss of a ship, but the cargo's place of origin (which is usually easy to deduce) gives no clue to the place where the ship was built. A ship wrecked off Corsica might have been built at Thasos, have belonged to an Alexandrian owner, have carried a cargo from Naples and been bound for Marseilles. It would be of the highest interest, in terms of the history of naval construction, to find out what characterized a ship from Thasos, yet it is precisely this that may prove to be an impossibility. That the Mahdia wreck had been carrying towards Italy the loot which Sulla took from Athens in 88 BC is a seductive suggestion, but it does not resolve the question as to whether the ship itself was Roman or whether it was a captured or a requisitioned Greek bottom.

River boats are the exception. In their case the region—if not the shipyard itself—is likely to be the same as the find spot; thus the Blackfriars boat was probably built somewhere along the Thames or the Medway.

How different it is at sea; consider for instance the flotillas of small Greco-Levantine sailing boats of some 15 m which, during the 19th century fished sponges on the shoals at Kerkennah and Djerba along the Tunisian coast. Their home ports were Syme or Kalymnos in the Dodecanese. Though they journeyed farthest they were by no means the only visitors, for Arab *sandales*, Maltese *speronares*, Italian *balancellas* and Sicilian *tartanes* met them along the Tunisian coast (Hennique, 1888). Similarly, up to the beginning of this century, Norwegian *jakts* delivered cargoes of fish to Spain and Portugal and even as far afield as Rio de Janeiro and Chicago (Thowsen, 1968: 70). How could archaeologists, 1000 years hence, deduce the place of origin of one of these ships from only the bottom of its hull?

There is no reason to believe that there was less diversity of style in antiquity. Though Torr could write (1904, IV: 1, 24): "The great nations of antiquity thought alike when

designing their ships. Doubtless there were differences in detail, but in all the important points a Roman or Etruscan ship of any period would be approximately the same as a Phoenician or Greek vessel of the corresponding period," but all the evidence—from excavated hulls to iconography—points to a different conclusion. The generic term "trireme" in a Greek context will, for instance, designate a different ship than when used in a Phoenician or Roman context.

Uniformity was doubtless more pronounced at some periods than at others. If the ship carved on the Sidonian arcophagus published by Contenau (1920, pl. VI, 2nd–3rd century AD) is indeed Phoenician, then it shows the extent of Roman influence in the Levant—just as western influence is apparent in the ships built in the Island of Ruad during the first half of this century (Vercoe, 1947). Ships were never, of course, built to a uniform pattern, even when the *mare nostrum* was a reality, as the very different shapes of the ships shown on the mosaic of the Corporation portico at Ostia (Becatti, 1961) convincingly demonstrate.

Wood analysis cannot be expected to produce a definite provenance. Usually the most that emerges from a satisfactory diagnosis, is that the tree in question flourishes in many Mediterranean lands.

Some rare species are diagnostic, as for instance the pistachio tenons of the Pantano Longarini wreck. Because this tree is grown in Aegina and the Cyclades, the excavators suggest a Greek origin for this wreck (Throckmorton & Kapitän, 1964: 187). Even supposing the geographical distribution of the tree to have been the same 1500 years ago, the argument is far from profound because shipyards always used imported foreign woods. The most significant example of this is the use made in Egypt of Lebanese cedarwood. When Hiero built the *Syracusia* he brought wood from afar not only for the framework, but also for the dowels (partly from Sicily and partly from Italy) (Athenaeus, V: 206 ff).

In a personal communication, for which I am most grateful, M. Jean Bouis, engineer of Marseilles, tells me that while studying the wreck found in that town in 1864, it was

established by analysis that the wood of the framework was *Pinus leucodermis*. The tree now grows only in the Carpathian mountains, but M. Bouis says that there is evidence that, in antiquity, it flourished in Illyria and Boeotia. Despite M. Bouis' scientific achievement, uncertainty persists: was the ship built with Illyrian or Boeotian wood? Illyria is some distance from Boeotia!

By an exceptional stroke of luck the plate bearing the ship's name was found at Pantano Longarini. It was subsequently lost and though the inscription is not exactly known, it is known that it was in Greek.

Despite this precious clue the ship need not necessarily have been built in a Hellenized part of the Mediterranean, let alone in Greece, as the case of the battleship *Sphinx* demonstrates. Built in Bordeaux in 1864, it was bought by Denmark; it was renamed *Staerkodder*, then *Olinde* before being sold to the Confederate States. Having become the *Stonewall*, it was sold to Japan after the war of Secession, where it continued its long career under the successive names of *Kotetsukan*, *Adzumakan* and *Adzuma* (Stern, 1962: 222–3).

Finally, Bass used another method for determining a wreck's origin. On the assumption that a ship's origin is related to the origin of its crew, he concluded from personal belongings (as distinct from cargo) that the crew came from North Syria, hence the ship must have been built there (Bass, 1967: 164).

The objects in question, notably a cylinder seal and a lamp are indisputably North Syrian, but as Miss Honor Frost has rightly observed, there is no proof that they belonged to members of the crew; similar objects are indeed common throughout the Near East and in Cyprus^[52].

Even supposing that it was possible to prove that the cylinder seal belonged to a member of the crew, for instance the captain, the validity of the assumption that this identified the ship would still have to be verified. In this particular case, and even though a Mycenaean origin cannot be ruled out^[53], there are other reasons which, in my view, favour an oriental origin but it would seem impossible to go further and name a

place, though Cyprus and Cilicia cannot be excluded.

I have not dwelt on this wreck without reason: its origin is a matter of extreme importance in connection with pan-semitist theories, such as those of Michael C. Astour and Cyrus H. Gordon, claiming a high date for the semitic penetration of the eastern Mediterranean. The "Phoenician" origin of the Gelidonya wreck is on the way to becoming the "official" theory (Katzev, 1970: 345) though it is in fact far from being proven.

Thus, a quantity of very precise and chronologically easily classifiable information has been amassed, though it remains virtually impossible to attribute any of it to a specific provenance.

Should there never be any certitude about this, it might at least be possible to deduce more or less satisfactory probabilities from comparisons of sea wrecks with the remains of coastal vessels found near their place of origin. The *Portus* ships, for instance, were probably built in the vicinity (this is, of course, no more than a reasonable hypothesis); herein lies their interest.

Fortunately there is another more promising method of finding the origin of ships that plied a particular sea lane: the identifiable nature of their anchors. H. Frost has demonstrated that anchors (particularly Bronze Age stone anchors) are frequently excavated on land in dateable contexts (Frost, H., 1969*b*, *c*; 1970*a*, *b*). In respect of trade routes, this discovery opens the door to deductions which are, as yet, far from complete; in respect of wrecks, another consequence of the discovery might be that their provenance should be deducible from the identifiable anchors.

The second limitation of submarine archaeology stems from the fact that only commercial vessels have been found.

It should be remembered that if parts of hulls have survived, it is usually because they have been protected by some cargo of a less perishable nature than the wood that it covered. This is the apparent explanation for, up to now, the discovery of exclusively commercial ships. An unloaded ship leaves little trace on the surface of the seabed: the presence of a buried hull is marked by cargo that protrudes above the sand. Consequently,

a warship being a cargoless vessel, the chances that submarine excavation will produce one are slim. Hope should not, however, be abandoned, since a warship might come to light in silted conditions like those at Pantano Longarini.

Such a discovery is the more desirable because there may prove to be technical differences between war and merchant ships, for reasons I have already stated: quickness of construction, mass production, standardization.

Conclusion

Throughout this study I have too often called for caution in reaching general conclusions, not to formulate some myself. Instead, some points can usefully be emphasized:

1. To the historian of naval architecture, what matters most is the evolution of structural method and the shapes of vessels. In this respect a knowledge of whether planking was fixed on to a frame, or whether the frames were erected before the planking, is only one of the many elements in the enquiry.
2. The conception and the construction of a ship are so complex that their intellectual, technological and social import, in antiquity, are still not fully appreciated. This is why wreck excavation can never be too meticulous or publication too exhaustive: the significance of some detail may not be clear today, but a new discovery may clarify it tomorrow. The loss of the Nemi and Sulcis wrecks is a disaster, but it could have been minimized had complete reports on them been made.
3. In order to make use of submarine excavations the results must constantly be cross-referred to the other sources of naval archaeology: iconography and philology. Can any one archaeologist master these two disciplines and also the specialized techniques required by underwater archaeology? It is doubtful; teamwork would appear more rewarding.
4. In addition to philology and visual representations, it will have been noted how many times in the course of this study

comparisons have been evoked from non-European construction techniques.

The study of these techniques is of capital importance in the interpretation of the often very fragmentary remains that are excavated. G. S. Laird Clowes, one of the most competent historians of naval architecture, wrote (1933: 345): "... as the study of the many curious types of boats which survive in remote corners of the world advances, it becomes more and more apparent that there is hardly any boat-building usage of the ancient world which cannot be matched by some practice still in use, although possibly in some totally different part of the world".

These lines written in 1933 were prophetic: the revelations of underwater archaeology go on confirming them. The comparative study of naval architecture, which is but a branch of naval ethnography, is still in its infancy. It must be admitted, I think, that those of us who are interested in the history of the ship, are insufficiently informed on the technicalities of ship building. The resulting problems are numerous and their solutions, amassed in the course of centuries, differ widely while being sometimes, paradoxically, very similar. The similarities are often interpreted by diffusionism, whereas they amount to no more than the discovery of the same solution to the same problem in different places where the level of technology was the same.

Let me end with a specific example of the usefulness of the comparative approach; at what stage in ancient ship building were mortises cut and by what criteria were they placed, spaced and their shape determined? When the extraordinary similarities of antique and Vietnamese tenons are considered, it becomes clear that a searching enquiry into the reasoning of Vietnamese ship builders

would have contributed a great deal towards the solution of the problem^[54].

With regard to research methods, it is essential to consider ship archaeology as one of the branches of comparative naval architecture.

Postscript

1. *The Cheops boat*

It is regrettable that there is still no official publication of this vessel, but the attention of those avid for information may be drawn to B. Landström's new book, *Ships of the Pharaoh's*, Allen & Unwin, 1970, wherein the ship's structure is analysed in a drawing (29: fig. 86) that clearly shows frames. This drawing is completely different from the one in Landström's previous book, *Sailing Ships*.

2. *The Monaco wreck*

Mouchot's article (1968-9) came into my possession after I had written the foregoing. The Monaco excavation was finished in 1965. In 1958 a sample of the keel had been lifted; it is this fragment that was drawn by J. C. Roux and published in Benoit's *Grand Congloué* (146: fig. 79, whence my Fig. 32B, above). The remainder of this keel, two fragments of 4 and 4.4 m were lifted in 1965; Mouchot (178) observes that these sections bear no trace of nails, unlike the fragment of the same keel which Benoit published. Roux's drawing is, nevertheless, categorical. The two statements need not conflict: on the Byzantine Yassi Ada wreck only some frames were nailed to the keel. It is therefore possible that very few frames—perhaps only one—were nailed to the keel of the Monaco wreck.

References

- Anderson, R. C., 1923, Italian naval architecture about 1445. *MM*, 11:135-63.
 Assman, E., 1889, Seewesen in *Denkmäler der klassischen Altertums*, III: 1593-1639.
 Audemad, L., 1959, *Les jonques chinoise II*. Rotterdam.
 Bass, G. F., 1966, *Archaeology under water*. 158-60. London.
 Bass, G. F., 1967, Cape Gelidonya. A Bronze Age shipwreck. *Trans. American Philosophical Society (N.S.)*, 57: 8.
 Becatti, G., 1961, Mosaici e Pavimenti Marmorei. *Scavi di Ostia*, IV. Rome.
 Bell, C. D. Jarrett, 1933, Ancient Egyptian ship design. *Ancient Egypt and the East*.
 Benoit, F. 1961, *Fouilles sous-marines. L'épave du Grand Congloué à Marseille*. (Gallia XIV supp.) Paris.

- Bernard, J. 1962, Remarks at the 4e Colloque international d'histoire maritime, Paris 20–23 May 1959. *Actes du 4e Colloque*: 445. Paris.
- Blackman, D. J., Schäfer, J. and Schläger, H. 1967, Un port englouti de la basse époque romaine en Grèce centrale. *Archaeologia*, 17, 12–17.
- Blackman, D. J., 1968, Der Hafen von Anthedon. *Archäologische Anzeiger*: 21–77.
- Boczar, M. L., 1969, Early craft on the Vistula. *MM*, 55: 262–88.
- Boreux, C., 1924–5, *Études de nautique égyptienne*, V.
- Breusing, A., 1886, *Die Nautik der Alten*. Bremen.
- Brewster, F., 1926, The raft of Odysseus. *Harvard Studies in Classical Philology*, XXXVII: 49–55.
- Cartault, A., 1881, *La trière athénienne*. Paris.
- Casson, L., 1963, Ancient shipbuilding: new light on an old source. *Trans. American Philological Association*, 94: 28–33.
- Casson, L., 1964a, Odysseus' boat. *American Journal of Philology*: 61–4.
- Casson, L., 1964b, New light on ancient rigging and shipbuilding. *American Neptune*, XXIV: 81–94.
- Casson, L., 1967, The river boats of Mesopotamia. *MM*, 53: 286.
- Charbonneaux, J., 1932, Deux grandes fibules géométriques du Musée du Louvre. *Préhistoire*, I: 191–259.
- Cervin, G. Rubin de, 1955, Mysteries and nemesis of the Nemi ships. *MM*, 41: 38–42.
- Clissold, P., 1932, Durban surf-boats. *MM*, 18.
- Clowes, G. Laird, 1933, Boats at Trebizond. *Antiquity*, 7: 345.
- Cohen, L., 1938, Evidence for the ram in the Minoan period. *Am. J. Arch.*, 42: 486–94.
- Contenau, G., 1920, Mission Archéologique à Sidon. *Syria I*.
- Crous, Jan W., 1940, Ein antiker Fries bei Sebastiano del Piombo. *Mitt. Deutsch. Arch. Inst., Röm. Abt.*, 55: 65–7.
- Dareasy, G., 1895, Une flotille phénicienne d'après une peinture égyptienne. *Revue archéologique*, 27.
- de Frondeville, G., 1965, Mahdia in J. Plat Taylor (Ed.), *Marine archaeology*: 39–53.
- Delpeuch, M., 1907, *Les sous-marins à travers les siècles*. Paris, particularly 13–42, on the beginnings of diving.
- de Morgan, J., 1893, *Dahchour*.
- Dumas, F., 1964, *Épaves antiques*. Paris.
- Fabretti, R., 1683, *De Columna Trajana Syntagma*. Rome.
- Falconer, W., 1830 (Ed.), *A new and universal dictionary of the Marine*. London.
- Flemming, N., 1959, Underwater adventure in Apollonia. *Geographical Magazine*, 31: 497 ff.
- Flemming, N., 1961, Apollonia revisited. *ibid.*, 33: 522 ff.
- Folkhard, H. C., 1870, *The sailing boat*, 4th ed.
- Frost, F. J., 1968, Explorations dans le Péloponnèse. *Archéologia*, 25: 40–3.
- Frost, H., 1963, *Under the Mediterranean*. London.
- Frost, H., 1964, Rouad, ses récifs et ses mouillages. *Annales archéologiques de Syrie*, 14: 67–74.
- Frost, H., 1966, The Arwad plans 1964. *ibid.*, 16: 13–28.
- Frost, H., 1969a, On the plotting of vast and partly submerged harbour works from aerial and underwater photographs. Chap. III in Throckmorton *et al.*, *Surveying in archaeology underwater*. London.
- Frost, H., 1969b, The stone anchors of Ugarit. *Ugaritica*, VI: 235–45.
- Frost, H., 1969c, The stone anchors of Byblos. *Mél. Université St. Joseph*, XLV: 425–42.
- Frost, H., 1970a, Some stone anchors from land sites and from the sea. *Report of the Dept. of Antiquities, Cyprus*: 14–24.
- Frost, H., 1970b, Bronze Age stone anchors from the Eastern Mediterranean. Dating and identification *MM*, 56: 377–94.
- Graser, B., 1864, *De Veterum Re Navali*.
- Greenhill, B., 1963, A boat of the Indus. *MM*, 49: 273–5.
- Guthrie, J., 1949, Bizarre craft of Portugal. *MM*, 35: 166–88.
- Hall, John E., 1967, Une prospection préliminaire du site archéologique de Pheia en Grèce. *Archéologia*, 18: 25–7.
- Harding, A., Cadogan, G. & Howell, R., 1969, Pavlopetri. An underwater Bronze Age town in Laconia. *Ann. Brit. School, Athens*, 64: 113–42.
- Harding, A. F., 1970, Pavlopetri: a Mycenaean town underwater. *Archaeology*, 23: 242–50.
- Hassan, S., 1946, *Excavations at Giza 1934–35*. Cairo.
- Hasslöf, C., 1957–8, Carvel construction and technique. Nature and origin. *Folkliv*, 49–60 contains excellent illustrations.
- Hasslöf, C., 1963, Wrecks, archives and living tradition. *MM*, 49: 162–77.
- Hennique, P. A., 1888, *Les caboteurs et pêcheurs de la côte de Tunisie*. Paris.
- Hornell, J., 1930, *The tongue and groove seam of Gujarati boatbuilders*. *MM*, 16: 309–12.
- Hornell, J., 1944, The outrigger canoes of Madagascar, East Africa and the Comore Islands. *MM*, 30.
- Hornell, J., 1946, *Water transport*. Cambridge.
- Jal, A., 1840, *Archéologie navale*, I.
- Jéquier, G., 1911, Essai sur la nomenclature des parties du bateau. *Bull. Institut française d'Arch. Orientale*, IX: 37–82.

- Johnstone, T. M. & Muir, J., 1962, Portuguese influence in shipbuilding in the Persian Gulf. *MM*, **48**.
- Jones, H. Stuart (Ed.), 1912, *The sculptures of the Museo Capitolino*. British School at Rome. Oxford.
- Karo, G., 1948, Art salvaged from the sea. *Archaeology*, **1**: 179–85.
- Katzev, M., 1970, Resurrecting the oldest known Greek ship. *National Geographic Magazine*, **137**: 841–57.
- Kirk, G. S., 1949, Ships on geometric vases. *Ann. Brit. School, Athens*, **44**.
- Koester, A., 1923, *Das antike Seewesen*. Berlin.
- Lamboglia, N., 1952, La nave romana di Albenga. *Rivista di Studi Liguri*, **18**: 166 ff.
- Landström, B., 1961, *The ship*. London.
- Landström, B., 1969, *Sailing ships*. London.
- Lane, F. C., 1934, Venetian naval architecture about 1150. *MM*, **20**: 24–49.
- Laroche, E., 1949, *Histoire de la racine NEM—en grec ancien*. Paris.
- La Roncière, Ch. B. de, 1934, *Histoire de la Marine française*, **V**, Paris.
- Lepsius, K. R., 1849–1859, *Denkmäler aus Aegypten und Aethiopen*. Berlin.
- Lethbridge, T. C., 1952, *Boats and boatmen*.
- Linder, E., 1967, La ville phénicienne d'Athlit a-t-elle été l'un des plus anciens ports artificiels de la Méditerranée. *Archéologia*, **17**: 25–9.
- Longridge, C. Nepean, 1955, *The anatomy of Nelson's ships*. London.
- Luebeck, E., 1890–1, *Das Seewesen der Griechen and Römer*, **I–II**. Hamburg.
- Marinatos, S., 1933, La marine créto-mycénienne. *Bull. Corr. Hell.*, **220–1**.
- Marsden, P., 1965a, A boat of the Roman period discovered on the site of New Guy's House, Bermondsey, 1958. *Trans. London and Middlesex Arch. Society*, **21(2)**: 118–31.
- Marsden, P., 1965b, The Blackfriars ship. *MM*, **51**: 59–62.
- Marsden, P., 1967, *A Roman ship from Blackfriars*. London: Guildhall Museum Publ.
- Marstrand, V., 1922, *Arsenalet i Pireus og Oldtidens Byggeregler*, Copenhagen, contains a good bibliography. arranged in chronological order.
- Marx, E., 1947, Egyptian shipping. *MM*, **33**.
- McCann, A. M. & Lewis, J. D., 1970, The ancient port of Cosa. *Archaeology*, **23**: 200–11.
- Moll, F., 1929, *Das schiff in der bildende Kunst*. Bonn.
- Mongez, A., 1821, Mémoire sur la manière de naviguer des Normands et sur un bateau déterré à Paris près du Champ de Mars en 1806. *Mémoires de l'Académie des Inscriptions*, **V**: 91–3.
- Montfaucon, 1719–1724, *Antiquité expliquée*, **IV**.
- Montet, P., 1925, *Les scènes de la vie privée dans les tombes égyptiennes de l'Ancien Empire*. Strasbourg.
- Morrison, J. S. & Williams, R. T., 1968, *Greek oared ships, 900–322 BC*. Cambridge.
- Mouchot, D., 1968–9, Épave romaine A du Port de Monaco. *Bull. du Musée d'Anthrop. préhistorique de Monaco*, **15**: 159–201.
- Newberry, P. E., 1893, *Beni Hasan*, **I**. London.
- Nour, Mohammed Zaky, Iskander, Zaky, Osman, Mohammed Saleh, Mustafa, Ahmed Youssef, 1960, *The Cheops Boat*, **I**. Cairo.
- Paglieri, S., 1960, Origine e diffusione delle nave etrusco-italiche. *Studi Etruschi*.
- Paris, Amiral F. E., 1841, *Essai sur la construction navale des peuples extra-européens*. Paris.
- Paris, Amiral F. E., 1882, *Souvenirs de Marine*, **II**. Paris.
- Paris, P., 1948, Discussions et données complémentaires à propos de l'ouvrage de M. J. Hornell: Water Transport, origins and early evolution. *Mededelingen van het Rijksmuseum voor Volkenkunde*. No. 3. Leiden.
- Paris, P., 1955, *Esquisse d'une ethnographie navale des peuples annamites*. Rotterdam.
- Persson, Axel. W., 1935, Die Hellenistische schiffbaukunst und die Nemi schiffe. *Opuscula Archaeologica*, **I(2)**. (Acta Instituti Romani Regni Sueciae **IV**.)
- Petereus, E. W., 1954, *De Bomschuit, een verdwenen Scheepstype*. Rotterdam: Prins Hendrikmuseum.
- Pietri, J. B., 1949, *Voiliers d'Indochine*. Saigon.
- Pi Joan-Soteras, J., 1949–67, *Summa Artis*. Madrid.
- Poidebard, A., 1939, *Un grand port disparu: Tyr. Recherches aériennes et sous-marines*, 1934–1936. Paris.
- Poidebard, A. & Lauffray, G., 1951, *Sidon. Aménagements antiques du port de Saida. Études au sol, aériennes et sous-marines*, 1946–1950. Beyrouth.
- Poujade, J., 1948, *Trois flotilles de la VI^e dynastie des Pharaons*. Paris.
- Price, Derek J. de Solla, 1959, An ancient Greek computer. *Scientific American*, June.
- Reisner, G. A., 1913, Models of ships and boats. *Catalogue général des antiquités égyptiennes du Musée du Caire*.
- Roghi, G., 1965, Spargi in J. du Plat Taylor (Ed.), *Marine archaeology*: 103–18.
- Riley, W. E. & Gomme, L., 1910, *A ship of the Roman period discovered on the site of New County Hall*. London.
- Santamaria, C. et al., Dramont, A., 1965, in J. du Plat Taylor (Ed.), *Marine archaeology*: 93–103.
- Scrinari, V., 1960, Strutture portuali di relative al porto messo in luce durante i lavori dell'Aeroporto intercontinentale di Fiumicino (Roma). *Rassegna dei Lavori Pubblici*, 3 marzo.
- Serre, Amiral, 1891, *Les marines de guerre de l'antiquité et du moyen age*, **II**. Paris.
- Speziale, G. C., 1939, La nave di Sulcis. *L'Ingegnere*, May 15, 412–14.
- Smith, G. Elliot, 1923, *The ancient Egyptians and the origins of civilization*. London.

- Smith, G. Elliot, 1916, Ships as evidence of the migration of cultures. *Journal of the Manchester Egyptian and Oriental Society*: 63–102.
- Stern, Phillip van Doren, 1962, *The Confederate Navy*. New York.
- Traeger, P., 1904, Schiffsfahrzeuge in Albanien und Macedonien. *Correspondenzblatt der deutschen Gesellschaft für Anthropologie, Ethnologie und Urgeschichte*, XXXV.
- Taillez, Ph., 1965, Titan in J. du Plat Taylor (Ed.), *Marine archaeology*: 76–93.
- Tarn, W. W., 1905, The Greek warship. *J. Hell. Soc.*, 25.
- Testaguzza, O., 1964, The port of Rome. *Archaeology*: 173–9.
- Testaguzza, O., 1970, *Portus*. Rome.
- Thiel, 1954, *A history of Roman sea power before the second Punic War*. Amsterdam.
- Thowsen, A., 1968, En studie i Vestnorsk trebåt-og treskipsbygging. *Sjøfartshistorisk Arbok*. Bergen Maritime Museum.
- Throckmorton, P., 1964, Roman shipwrecks and modern Aegean ships. *MM*, 50: 205.
- Throckmorton, P., 1965, in The Antikythera ship reconsidered. *Trans. American Philosophical Society* (N.S.), 55(3): 40–7.
- Throckmorton, P. & Kapitän, G., 1968, An ancient shipwreck at Pantano Longarini. *Archaeology*, 21: 182–7.
- Timmerman, G., 1941, Wie das Nydamschiff gebaut wurde. *Mannus*.
- Torr, C., 1894, *Ancient ships*. Cambridge.
- Torr, C., 1904, in Daremberg, Saglio and Pottier, *Dictionnaire des Antiquités grecques et romaines*, IV.
- Toudouze, Georges G., 1934, *Histoire de la Marine*. Paris.
- Ucelli, G., 1950, *Le navi di Nemi*. Rome.
- Vandier, G., 1969, *Manuel d'archéologie égyptienne*, V.
- van Doorninck, F. H. 1967a, *The seventh century Byzantine ship at Yassi Ada. Some contributions to the history of naval architecture*. Doctoral dissertation, University of Pennsylvania.
- van Doorninck, F. H. 1967b, Reconstruction d'un navire byzantin du VIIe siècle. *Archéologia*, 17.
- Varende, J. de la, 1952, *Le Maréchal de Tourville et son temps*. Paris.
- Vars, J. 1896, *Comptes rendus à L'Académie des Inscriptions et des Belles Lettres*.
- Vence, J. 1897, *Construction et manoeuvre des embarcations à voile latine*. Paris.
- Vercoe, A. G. 1947, Wartime shipbuilding at Ruad Island. *MM*, 33: 54–5.
- Windeling, 1946, Liberty ships—Wandelaar. *Sur l'eau* no. 216, March, 250–2. Ghent.
- Worcester, G. R. G., 1966, *Sail and sweep in China*. London.
- Wright, E. V. & C. W., 1947, The North Ferriby boats. *MM*, 33.
- Wright, E. V., 1964, The North Ferriby boats—a reappraisal. *MM*, 50.
- Yorke, R. A., 1967, Les ports engloutis de Tripolitaine et de Tunisie. *Archéologia*, 17: 18–24.

Notes

- [1] Only one well preserved wreck, from Hjortspring, remains as physical evidence of Scandinavian naval architecture of the Bronze Age, which is elsewhere represented by hundreds of ship engravings. The Hjortspring ship is dated to the early Iron Age, but reproduces an older type.
- [2] B.N., Paris, Ms. Lat. 1 (La Roërie, Guilleux. 1938. L'histoire du gouvernail. *Revue Maritime*: 495, fig. 17).
- [3] A Basle edition of 1537 has slightly different illustrations to that of 1536.
- [4] The latest tentative reconstruction of a Greek trireme is by Gille, P., 1965, Les navires à rames de l'Antiquité. *Journal des Savants*, No. du tricentenaire: 36–72. See the careful criticism of this study by Anderson, R. C., 1968. *MM*, 54: 21; and Casson, *ibid.*: 279.
- [5] It is remarkable that nearly three centuries later, J. Poujade, 1946, 241–2, should resume the argument on “natural structures” by comparing the forms of Roman ships to those of . . . ducks.
- [6] On the state of the problem of naval construction by primitive peoples, the communications should be read of H. H. Brindley, A. C. Haddon, J. Hornell and G. S. Laird Clowes at the Meeting of the Society of Nautical Research on 24 February 1932 when the theme was “Primitive craft—evolution and diffusion”. 1932, *MM*, 18: 303–17.
- [7] Torr (1894: 3); Leroy, J., 1777, in *La Marine des anciens Peuples expliquée* had already attributed the origins of navigation to the Phoenicians.
- [8] It was mistaken to consider that this enthusiasm was outmoded for in 1970, M. Robert de la Croix wrote “south of the Dardanelles, it is hoped to discover the remains of Trojan ships”. *Atlas*, May 1970, 68.
- [9] Benoit (1961: 145, fig. 78). The remains of the wreck are in Roman Docks Museum at Marseilles. Their condition has continued to deteriorate since the photographs published by Benoit were taken.
- [10] The following list of wrecks, includes some which were the subject of land excavations; it is not exclusively concerned with underwater excavation. A list of some twenty-seven ancient wrecks between the Gulfs of Lions and Genoa will be found in Taillez, Ph., 1960, *Nouvelles plongées sans cables*: 161–71, Paris. The majority of these wrecks have not been excavated, at least as regards the hull. A list of wreck sites may also be found in:

- Benoit, F., 1956, Épaves de Provence. *Gallia*, 14: 23.
- Benoit, F., 1958, Nouvelles épaves de Provence, *ibid.*, 16: 5–39.
- Benoit, F., 1962, Nouvelles épaves de Provence III, *ibid.*, 20: 147–76.
- Tchernia, A., 1969, Informations archéologiques: recherches sous-marines, *ibid.*, 27: 465–99.
- More and more wrecks are reported, but publications are slow and few. In addition to several wrecks in Cyprus, we may note those mentioned by Casson, 1968, in *Archaeology*, 21: 219–20: Torre Sgarata near Taranto, the Lipari Islands, Cosa and Elba. Communications were presented at the IV International Congress of Underwater Archaeology (Nice, 11–16 October 1970) on the subject of a 4th century BC wreck from Palma in Majorca and a Roman wreck from Cartagena.
- [11] For a discussion on the possibility of these two wrecks being entangled see Frost, H., 1963, 252–3. The author adds interesting details to the official report of Benoit (1961).
- [12] The Kyrenia wreck is only known from brief reports: see *Bull. Corr. Hell.*, (1969) 93: 562–4; (1970) 94: 291–5. Katsev, 1970.
- [13] If the Nemi ships had been examined by the methods employed by F. Dumas, who was faced with only a mediocre hull, we would know far more. Kyrenia represents an unrivalled opportunity.
- [14] “Explication des noms des pièces servant à la construction des vaisseaux”, quoted by Jal, A., 1848, *Glossaire nautique*, V° Quille, II: 1248. Paris.
- [15] Mongez (1821: 91–3). This canoe is foreign to “Norman” construction, which is of Scandinavian origin; it could be gallo-roman.
- [16] With reservations on what will be said later on the subject of Chinese construction; but this form does not use frames.
- [17] Audemard, L., 1959, *Les jonques chinoise*, II: 16. Rotterdam. The lower strake projecting over the upper is a method which has been used on the Hanseatic cogs; P. Heinsius believed he could distinguish in this the proof of the existence and invention of “skeleton” technique in the Hanse period. Heinsius, P., 1956, *Das schiff der hansischen Frühzeit. Quellen und Darstellungen zur hansischen Geschichte*, N.F. Bd. XII. Weimar. Heinsius developed the same thesis in *Le navire et l’économie maritime du nord de l’Europe du Moyen Age au XVIIe siècle. Travaux du 3e colloque internationale d’histoire maritime*, 30–31 May 1958, 1960, 16, Paris. In my opinion this theory was convincingly refuted by Crumlin-Pedersen, O., 1965, Cog-Cogge-Kaag: Troek af ein Frisisk Skibstypes Historie. *Handels-og Søfartsmuseet pa Kronborg Arborg*.
- [18] Types called Fischerzille, Bauzille, Plette, Canalzille, Fahrm. *Correspondenzblatt der deutschen Gesellschaft für Anthropologie, Ethnographie und Urgeschichte*, XXXIV: 6–8, 1903.
It is evident that there are numerous other European examples of analogous construction. Folin, Marquis de, 1892, *Bateaux et Navires*, 61. Paris.
- [19] According to Nour *et al.*, 1960. But after restoration, the length appears to have been amended to 36 m. See Frost, H., 1969c: 435. n. 1.
- [20] This drawing represents a section of the Cheops boat; but it is wiser, before criticizing it, to await the official publication of the excavation.
- [21] Picturesque evidence of this manner of viewing is supplied by a print of J. Saedeleer representing the building of Noah’s ark; the keel and frames being already in place before the planking is added. But the print only reproduces in reverse, an engraving by de Bry representing the building of a small 16th century vessel. Laing, A., 1961, *American sail; a pictorial history*: 230–1.
- [22] Casson (1964a). In this article the author discusses the critical doubts on the exact nature of Ulysses’ boat: raft or ship. He believes the facts that Ulysses split the tree trunks into planks and that the craft had a deck, favours it being a ship. Strictly, it is true that a raft has no deck; but it is probable that Ulysses’ ship was a flat-bottomed craft without a true keel; in consequence it can be classed neither in the “shell” nor in the “skeleton” technique. In my opinion the Amatovo bark in miniature, corresponds the most closely to Ulysses’ boat, provided a half-deck is added at either end of an enlarged version.
- [23] Merry & Riddel, *Homer’s Odyssey* I, note to line 248 and 538 (quoted by Casson, 1964a).
- [24] Dumas (1964: 159). Frost, H. (1963: 266). Moreover, Chrétienne A was certainly built in “shell” technique but this certainty rests on other grounds which will be explained later.
- [25] Casson (1964b: 88). Casson’s third argument in favour of “shell” construction, is a very plausible interpretation of the stela of P. Longidenius (end of 2nd—beginning of 3rd century AD) in the National Museum of Antiquities, Ravenna. At any rate, if Casson’s interpretation of this relief is correct, it proves that the subsequent insertion of frames was practised in the 3rd century AD, which I believe is true. But it does not prove that *all* frames were *always* and *everywhere* subsequently inserted at this time.
- [26] Frost, H. (1963: 225 ff); Throckmorton (1965: 42); Marsden (1967a: 34). In the end, only one writer, van Doorninck (1967a: 102) admits, “it has now become necessary to reopen the entire question of how and when the most practised method of wooden hull construction in the world today originated”.
- [27] A drawing by W. H. Bond in the *National Geographic Magazine*, June 1970: 854, appears to give a plausible idea of the work.
- [28] Throckmorton (1965: 42, fig. 7). The author writes (41): “the fact that nails were driven through tenon assemblies indicated that the frames were put into the hull after the planking was assembled”. This would only be correct if the nails were driven from inside.

- [29] Benoit (1958: 12, fig. 10). The carline is pierced by two widely spaced, square holes (ibid., 1961: 139, pl. 26).
- [30] The Musée de l'Homme has not been able to give me exact information on the date of these photographs, which must be earlier than 1934, the date of their acquisition by the Museum.
- [31] Hasslöf, 1957-8 and 1963, had given some other examples relating to western Europe.
- [32] According to Thowsen the use of moulds was introduced in Norway at the same time as the carvel building technique, probably at the end of the 15th or the beginning of the 16th century (pers. comm.). If this opinion is well founded, it would be interesting, as it gives some indication that the use of moulds is allied to a typically Mediterranean technique at a very early date.
- [33] I do not pretend that the mould is the *only* means of straining the planks. See the curious post leaning against the roof of the shed covering the yard in Thowsen (1968: 46).
- [34] These words are modern Greek and do not exist in ancient Greek. Evidently they derive from ἵχνιον or ἵχνος, footprint, impression.
- [35] Vence (1897). A drawing, in a manuscript bearing the arms of Colbert, representing a dockyard at Toulon shows, at the back, a longboat being built in this fashion. (Farrère, C., 1956, *Histoire de la marine française*: 122. Paris).
- [36] See a representation of naval architects at work on a design of the end of the 16th century 1942, *Svenska Flottans Historia*, I: 79; Phillips-Birt, D., 1966, *Ships and boats, the nature of their design*: 32. London. (Fragments of ancient English shipwrighty, Pepysian Library, Magdalene College, Cambridge.)
- [37] For the passing from empiricism to theoretical calculation for frames, at Venice, see Lane, F. C., 1965, *Navires et constructeurs à Venise pendant la Renaissance*: 81 ff. Paris.
- [38] Palluchini, R., 1964, *La pittura Veneziana del Trecento*, fig. 44. The attitude of the person in the foreground is intriguing: he leans with a ruler over a white rectangle. A plan?
- [39] If it is a fact that, at this stage, certain planks are fixed to the ribs as Marsden writes, it is a form of "skeleton" technique, as would be the case with numerous pirogues from Mannar Gulf, India. After being widened, these log canoes are provided with frames which extend over the side. Planking is then attached to the rib; this is the same principle observed in the Blackfriars wreck. (See Hornell, J., 1948, *The making and spreading of dugout canoes*. *MM*, 34: 48-9.)
- [40] Wright (1947: 251, fig. 15). The Brigg "raft" is in fact the bottom of a flat boat; it had at least one strake (ibid., 249).
- [41] It is impossible to be precise; the canoes from Brigg are dated by C¹⁴ to the period 920-720 BC, but the "raft" is later. Wright (1964: 91, note).
- [42] With this difference that the Vietnamese ships are keeled.
- [43] For the wreck at Port Vendres, see *Gallia*, 22: 475-6, 1964, and 24: 450, 1966.
- [44] Van der Heide, G. D., 1955, Archaeological investigations on New Land. The excavation of wrecked ships in the Zuyder Zee territory. *Antiquity and survival*, Wreck R 43, lost in the 17th century, 249, fig. 37; Wreck B 6, lost in 1788 or 1789, 250, fig. 38; Wreck of tjalk, lost about 1815, 243, fig. 31.
- [45] The importance of the fact of building in large numbers and the particular problems which it poses, has not escaped van Doorninck who writes (1967a: 106): "Complete carvel building . . . may have been practised at any time after the seventh century or thereabouts in Mediterranean shipyards where large numbers of ships of the same design were simultaneously built. Certainly there can be little doubt that many ships were being built in this way during the time of the Crusades." But the example of thirty ships ordered in Genoa, quoted by the author, is less convincing than the numbers for building in ancient times, beginning with those for the Athenian fleet of 480.
- [46] Pliny, N. H. (16: 192). The expression "ab arbore" could well be a mistranslation of ἐκ δρυόων of Polybius.
- [47] Internal moulds are nevertheless well known in Arabia. Nougarede, 1964, *Qualités nautiques des navires arabes*. *Travaux du 60 colloque d'Histoire maritime*, 13-18 aout, 1962: 99, Paris, and Bowen, R. Le Baron, J., 1949, Arab dhows of Eastern Arabia, *American Neptune*, 9: 109. The method described in the last article is that of the French 17th century described above, with certain "active" ribs.
- [48] See examples of semi-circular adaptation to the base of the frames in Olsen, O. & Crumlin-Pedersen, O., 1967, The Skuldelev ships, *Acta Archaeologica*, 38: 58, fig. 69 and 59, fig. 70.
- [49] van Doorninck (1967a: 49, Fig. 14). The joint does not seem to have been so strongly made as on the Monaco wreck. The nail, particularly, does not seem to have passed through the keel from side to side. One cannot rely on the sketch given by Bass (1966: 159, fig. 47) which contradicts the drawings published by the excavator, van Doorninck.
- [50] ibid.: 104. "It would appear more likely than not that only the two wales below deck were . . . bolted to these frames".
- [51] It is possible that the deteriorated economic circumstances of the later Empire contributed to the disuse of the very close tenon technique.
- [52] Review of Bass, Cape Gelidonya . . . 1968, *MM*, 54: 423-4; scepticism as to the origin of the ship was also manifested by McCann, A. M., 1970, *Am. J. Arch.*, 74: 105-6.
- [53] Cadogan, G., Review of Bass. Cape Gelidonya . . . in 1969. *J. Hell. Studies*, 89: 187.
- [54] I say "contribute to the solution" not "solve the problem".