

## “KYRENIA II”: BUILDING A REPLICA OF AN ANCIENT GREEK MERCHANTMAN

The site of the Kyrenia ship was discovered by Andreas Cariolou off the north coast of Cyprus at a depth of 30 meters. Its excavation yielded the best preserved hull of the classical Greek period yet found. The ship's timbers were raised, preserved and reassembled for exhibition in the Crusader Castle at Kyrenia.

The merchantman carried a cargo of approximately 400 amphoras: Samian jars presumably filled with oil, and pitch-lined jars from Rhodes which probably contained wine. Part of the ballast consisted of hopper-type millstones, quarried on the island of Nisyros, weighing over 1.650 kilograms in total.

We believe that the ship was manned by a crew of four, since the excavations recovered 4 salt cellars, 4 oil jugs (*gutti*), 4 similar pitchers, 4 drinking cups (*kantharoi*), 4 casserole bowls, and fragments of 4 wooden spoons. Most of the crew's crockery was made on Rhodes, which suggests the ship's home port.

These remains were found about one kilometer off the coast in open water. The cause of sinking was not clear until eight iron spears were found underneath the hull, several still in contact with the ship's lead sheathing. On the basis of this data and for other reasons we believe that the ship was sunk by pirates. The numismatic evidence indicates that the sinking took place sometime between 310 and 300 B.C.

The hull was remarkably well preserved; about 60% of its area survived and more than 75% of its representative timbers were recovered. After the meticulous recording of the physical evidence *in situ* and following the laborious documenta-

tion of the fragments when lifted, J. Richard Steffy undertook the reconstruction of the hull, using both graphic and physical procedures. We can all agree that the results of his many years of work are a brilliant achievement.

In 1982 Harry E. Tzalas, President of the Hellenic Institute for the Preservation of Nautical Tradition, proposed to us to build a full-scale replica of the Kyrenia ship. The American Institute of Nautical Archaeology located at Texas A & M University decided to cooperate in such an example of experimental archaeology. The American Institute agreed to provide the necessary data and consultation while the Hellenic Institute committed its resources towards the logistics and funding of the project. Manolis Psaros volunteered his shipyard in Perama for building the replica and on November 1st of that year initiation of "Kyrenia II" was announced to the public.

In building "Kyrenia II" our primary objective has been to replicate the original lines of the ancient 14 meter merchantman as closely as possible. However, that fourth-century hull was assymetrical in configuration; the port side had approximately 5% more wetted surface than the starboard. This fact is not surprising in shell-first construction when the shipwright built by eye based upon generations of experience and apparently without plans. But in Psaros' shipyard the shipwrights would be working from plans and detailed drawings. Rather than seeking to duplicate exactly the assymetry of the ancient hull—a difficult, time consuming and more expensive endeavor—we compromised and decided to build a symmetrical hull following only the lines of the better preserved port side of the original ship. Even following the plans as accurately as possible, working in wood and using the shell-first method has yielded a replica which is very slightly assymetrical in shape.

Another priority of the project has been to use materials comparable to those in the ancient ship. Keel, planking, frames and interior scantlings were of *Pinus halepensis* Mill. This Aleppo pine is no longer readily available in Greece. Our pine (*Pinus brutia* Ten.) is very similar. It came from Samos and is the most commonly used shipbuilding timber in Greece today. Since logs of sufficient diameter or length were not always available, occasionally we had to alter slightly from the widths of the planking or relocate scarf joints. However, for the most part we have been faithful to the ancient hull. Wherever possible naturally curved timbers were used for the frames. As in the original, tenons and tenon pegs are Turkey oak (*Quercus cerris* L.). All the nails, fastening the frames, were hand-forged from rods of pure copper.

The construction of "Kyrenia II" was, of course, done in the shell-first method, a process probably not practiced in Greece for over 1,000 years. Initially, our shipwrights found it difficult to relearn the techniques for this old-fashion type of construction, and they were uncertain of their own ability to reproduce accurately the ancient design using the shell-first method. Also they were skeptical of the hull's ultimate strength and seaworthiness. Gradually though difficulties gave way to skill, uncertainty was replaced by confidence, and skepticism by

admiration for the labor-intensive shell-first process.

At various stages of the building the workmen did experiment with hand tools. Saws cut planks. Mallet and chisel opened mortises. Adzes trimmed surfaces. However, considerations of time and money rapidly caused these hand tools to be replaced by the band saw, an electric mortiser (beginning with strake 4), and various powered planers.

The keel of the Kyrenia ship was 9.3 meters in length; its average height was 20.3 centimeters, and its average width was 12.2 centimeters. This keel was rockered over its length, and the heartwood followed this curve through its entirety. It had been hewn from a single log which came presumably from a naturally curved trunk. To duplicate these specifications was Psaros' first task, and this challenge proved to be a difficult problem to solve. Samian shipbuilding timber today is usually cut to shorter lengths, and modern shipwrights prefer these logs to be of straight-grained wood. After cutting the first log, it was decided that the heartwood did not curve sufficiently through the length of the rockered keel to give it adequate strength, and the piece was scrapped. The second log when cut revealed nests of tiny woodworms, and it was discarded. A third log was cut down, but when its bottom sided dimension ended up being 2 centimeters too thin we agreed to abandon it too. A fourth log was found; perfectly curved and of proper size, it was cut down to meet our exact specifications; and finally, after more than six months of part-time labor by two or more men, the keel was ready to be joined by stem and sternposts and set up.

The ancient shipwright had made the stempost of two timbers. Inner and outer planks were joined together by mortise-and-tenon joints and with nails. It is doubtful that he lacked properly curved or sized wood since no where else in the original hull did we find such a similar economic use of timber. Furthermore, joining of two planks would not seem to add strength to the stem, and such joinery would require considerable additional labor. Why it was done, we do not know. This procedure remains an enigma. Since Psaros had a naturally curved timber of the correct size in the yard, he and Steffy decided to make the stempost of "Kyrenia II" of one plank. It was connected to the keel by a simple hook scarf locked by keys.

The forward most part of the stempost of the Kyrenia ship did not survive. The bow configuration of "Kyrenia II" is therefore conjectural, but based on ancient representations, sailing tests and common sense. A near vertical cutwater was dove-tailed into the end of the stempost and reinforced by a substantial knee.

Fortunately a portion of the aft end of the keel of the Kyrenia ship had survived giving us the initial angle of attachment of the sternpost. A small fragment of the sternpost itself was identified but contributed little evidence to our knowledge of its configuration. A major part of the stern knee was found, permitting us to install a massive knee in "Kyrenia II". The curvature of the sternpost of "Kyrenia II" is somewhat hypothetical, but we are confident that it is reasonably correct considering extension of planking lines as well as illustrations

of merchantmen from antiquity.

After the rabbets were cut along the upper edges of the keel of "Kyrenia II", mortises were opened along its lower bevel, or shoulder, using mallet and chisel. These mortises were centered in the slope of the shoulder and spaced about 12 centimeters from center-to-center; each mortise was between 4.5 and 5 centimeters wide, about 6 millimeters thick, and their depths averaged approximately 8 centimeters. These dimensions for mortises remained more or less consistent while they were being cut by hand. Moreover, in the case of the keel-to garboard strake seam, as well as the garboard to strake 2 seam, the angle of entry of the mortises had also to be carefully judged in respect to the considerable curvature of these planks and the possibility of the planks splitting when secured upon tenons.

The planks for the garboard strakes were then cut, or in light of their cross-sectional curvature it might be more appropriate to say that they were carved. The edges were shaped to fit the configuration in the keel's rabbet. This was an unfamiliar task for the workmen, and as a result of their inexperience the result was not a snug fit between the surfaces of the lower edge and inner face of the garboard with the shoulder and beard face of the rabbet. However, the exterior seam appeared tight enough to be waterproof. So the planks, temporarily held in position by clamps, were marked by pencil for the placement of mortises on their lower edges. These mortises were opened, as were the mortises on the upper edges of the garboards. Tenons were prepared of almost the same width and thickness as the mortises, but of course twice as long as the mortises' depths. These tenons were also slightly tapered in their thickness towards the ends, and their corners were rounded. They were then set into the mortises of the keel.

Setting a mortised plank onto more than 50 tenons is not easy, especially when the plank must be twisted in several directions over its length. Slowly from one end to the other the plank is fitted over each tenon and gradually driven down—an application of animal (pig) fat over the exposed portion of the tenon eases the process—until the plank is completely in place and the seam light tight. After several days in position—during which the wood has settled in place, dried and shrunk, the plank is again pounded down to tighten the seam. Holes are drilled into the wood through each half of a tenon, and tapered tenon pegs are driven home to lock the joint in place. Again, after a few days, the tenon pegs are re-hit to be absolutely certain that they are dead tight. Later, the protruding ends of the pegs are adzed flush to the surfaces of the hull's shell. In the case of the keel-garboard seam, tenon pegs were driven in from the outside. However, in virtually all other cases (the exceptions being near the stem and sternposts, where there was not enough hammering space) tenon pegs were driven in from the interior of the hull, as the ancients had done.

The garboard strakes of "Kyrenia II" were finished during October of 1983, almost one year after the beginning of construction. With this experience of mortise-and-tenon joinery successfully completed the shipwrights became more confident in their capability to handle the method of shell-first construction. But,

they found work on the second strake still to be difficult, since it was almost as radically curved as the garboard. However, with chocks temporarily placed on the garboards to serve as a guide for obtaining the correct curvature, they did proceed more assuredly and certainly more quickly. The second strakes were done by two men working part-time within the period of two months.

Now totally persuaded that a ship could be built in the shell-first method, the builders considered the almost flat third strakes to be relatively easy. But due to the severity of the winter of 1984, these strakes were not finished until March.

Alas, due to a lack of financial resources work on "Kyrenia II" came to a virtual halt during the spring and early summer of last year.

Then in July, 1984, two members of the Hellenic Institute volunteered their labor for work on "Kyrenia II": Michalis Oikonomou, a 56 year old master shipwright, and Sokrates Kavalieratos, a young apprentice naval architect. Devoting their full time to the building, progress on the hull rapidly accelerated, not least because with the fourth strakes an electric mortiser began to be used.

Strake 4 of the Kyrenia ship made the most extreme curve over its length; from an almost vertical alignment at the sternpost, it turned to about a 30 degree above horizontal position at amidships. Duplicating this almost 60 degree turn in the planking of "Kyrenia II" was not easy, but we want to emphasize that absolutely no steaming of planks was ever employed in the building of the replica. Wet pine, that is to say wood still heavy with resin, can be twisted without too much difficulty. However, once in place, as the wood progressively dries and shrinks, more and more space opens in the seam between planks. Using dry, seasoned timber minimizes this phenomenon, but wood too dry cannot be twisted into position without cracking. Therefore, timber of just the right temper, not too wet with resin or too dry to have become brittle, had to be selected. Because of Michalis Oikonomou's 40 years of experience in wooden boatbuilding, he immediately appreciated the situation and selected perfectly the appropriate log to meet satisfactorily the requirements of this 4th strake.

Strakes 5 through 7 of the ship represent the turn of the bilge. Here we might pause for a few general observations. The thickness of the planks, except for the wales, of "Kyrenia II" ranges from 3.5 to 4 centimeters. Plank widths vary from 18 to 28 centimeters at amidships and average about 23 centimeters. Lengths of the main plank in each strake run from over 7 meters to close to 10 meters. With the exception of the wales, the planks of each strake are joined by a simple diagonal scarf having on the average three mortise-and-tenon joints.

Michalis and Sokrates quickly became comfortable with the method of mortise-and-tenon joinery in shell-first construction. By the end of August they had finished the seventh strakes and were remarkably impressed by the extreme stiffness of the shell. Nevertheless, they wondered whether it would not be prudent to add some temporary frames as braces to make certain that the shape of the hull remained fixed.

By the time work began on the eighth strakes Oikonomou was so familiar

with the design and construction of the Kyrenia ship that he virtually had become the *alter ego* of the ancient shipwright. One example of this kinship was the way he faultlessly replicated the widening of port strake 8 towards the stern. In turn port strake 9 narrowed to join this scarf-like configuration short of the sternpost. We believe that the original shipwright made this modification thinking that it would balance the sheers of both port and starboard sides in anticipation of his setting the first wales. However, such an alteration was not deemed necessary on the starboard, and Michalis identically as the ancient shipwright gradually narrowed the starboard strakes 8 and 9 towards the sternpost.

The first wales, the tenth strakes, are planks 8 centimeters thick, at least twice that of the lower planking. This increased thickness, doubling the weight of the planks, made working with them all the more difficult. A third workman, Spyros Exarchos an apprentice shipwright, was assigned to the crew to ease the burden. These planks were joined one-to-another by more complex, Z-shaped scarfs. The greater length of the scarfs and increased thickness of planks provided more space so that additional mortise-and-tenon fasteners could be staggered in two rows to yield stronger scarf joints. Indeed, the wales acting as girdles added such extraordinary strength to the shell that the workmen no longer felt the need of internal framing in order to maintain the rigid shape of the hull. These main wales were completed by the end of November, 1984.

Port strake 11 in the Kyrenia ship was the widest found in the hull's excavation, almost 29 centimeters wide at amidships. Logs of that great a dimension were not available in Psaros' shipyard. Therefore, for "Kyrenia II" it was decided to make the eleventh strakes of narrower boards, let us call them lower strakes 11 and upper strakes 11 to remain consistent with the strake numbering of the original ship. In the replica each of these strakes was made up of two planks joined by a single diagonal scarf, and these planks are notable in "Kyrenia II", since in each strake there is a plank 9.7 meters in length — the longest planks to be found in the replica.

We believe that the Kyrenia ship had only the two wales we found. In "Kyrenia II" the upper wales, strake 12, are almost 7 centimeters thick. Each strake is composed of three planks joined like the main wales by three-planed Z-scarfs, there being two such scarfs in each strake 12. It should be noted that in the wales the tenon pegs were also driven from the inside, but because of the greater thickness of these planks the pegs did not extend to the outside surfaces. However, in the scarfs the outside staggered row of tenons was pegged from the exterior of the hull, and similarly these pegs did not penetrate to the inner surfaces of the wales. The upper wales acted like a second band of girders, belting tight the hull at this level and adding even more intrinsic strength to the shell. On February 20, 1985, by which time the twelfth strakes were finished, we had the great pleasure to welcome to Psaros' shipyard Melina Mercouri, Greece's Minister of Culture. Indeed, may we take this opportunity to express personally how grateful we are to Mrs. Mercouri and her administration for their considerable interest and generous

financial contributions towards the successful completion of "Kyrenia II".

When Mrs. Mercouri saw the ship it stood 12 strakes high, without a single frame. It was now time to begin the framing of the replica. The Kyrenia ship had a system of framing which we now know to have been commonly employed in antiquity: floors alternating with half-frames, futtocks continuing the arms of the floors, and what we call top timbers extending beyond the ends of the half-frames. Chocks fill the cavity within the keel, garboards and second strakes. The floor timbers are secured to these chocks by two to four mortise-and-tenon joints, pegs locking the tenons in place. But at no point do the chocks actually touch the keel. Rather, that potential area of contact has been cut, forming limber holes for bilge water to flow through.

All frames are virtually square in cross-section over most of their lengths: floors 9 to 8 centimeters on a side, half-frames an average of 8 centimeters, futtocks about 7 centimeters, and top timbers 7 to 6 centimeters. The lengths of the frame timbers are, for the most part, comparable to their counterparts in the original hull, although there are occasional variances due to the different availability of sized and curved logs in Psaros' shipyard compared with that of his ancient predecessor. The distance between floor and half-frame timbers (center-to-center measurements) averages 25 centimeters.

In the replica floor timbers alternate consistently with half-frames as in the Kyrenia ship. But there is one exception to this rule. In the stern are two adjoining half-frame pairs. The ancient prototypes of this peculiarity were labeled frames 6 and 7 during the hull's excavation. Also, port frame 6 was found to have 6 regularly spaced mortises with broken tenons in its upper surface. Later we will return to this situation in more detail.

Work on the framing proceeded relatively rapidly, in part because of the use of the band saw and power planers, in part due to Michalis' eye to hand dexterity, and because a fourth man was put on the team: Michalis' older brother, Kostas Oikonomou — he too being an experienced and skilled wooden boatbuilder. In fact, aside from sawing and chiseling to open the watercourses, the only by-hand work on the frames was adzing their lower surfaces to fit them tight against the inner face of the shell.

It is now appropriate to cite a few statistics. Four men working 8-hour days for 13 days made 18 floor timbers and 16 pairs of half-frames. This averages about 8 man hours per frame. After one month of beginning the framing all the 23 floor timbers (plus 5 futtocks), and 25 pairs of half-frames for "Kyrenia II" were in place. However, since the copper nails were not yet made, these frames were temporarily held in position by lag bolts.

After a month's interruption of progress on the replica, the nailing began in earnest. Holes 2 centimeters in diameter were drilled from inside the hull through frames and planks. Each successive hole through a frame was started alternately slightly forward or aft from the center-line of the frame and angled back in the opposite direction to minimize the chance of the frame's splitting. When

effectively done, the holes on the exterior of the hull lined up in vertical rows. Depending on the width of the strake, either two or three holes were drilled through the frame into a given plank. Pieces of pine for treenails were cut square in section with straight grain running down through their lengths. Each piece 16 centimeters in length was then turned round on a lathe so that its diameter tapered. A hole was drilled down through the center. These treenails were inserted, of course narrower end first, from the exterior of the hull through planks and frames. The center holes guided our modern nails through true. We believe that the ancients had no need of such holes and that they simply whittled their treenails to shape.

Most of the nails were made from 10 millimeter round rods of pure copper. Lengths ranged from 20 to 25 centimeters. Rose heads were hand-forged and varied in diameter from 2 to 2.5 centimeters. The pointed ends were tapered over a length of about 4 centimeters. After the nails were driven home, the excess portions of treenails protruding above the inner surface of the frames was chiselled or adzed away. About 2 centimeters of a nail's tip was turned down. Then the remaining end of the nail was clenched down with a hammer. Clenching was done downward in the direction of the keel, and each successive clench was slightly angled in an opposite direction in order to avoid splitting the frame. This method of nailing created a herringbone pattern and made a staple-like fastener the strength and tightness of which cannot be overstated.

Meanwhile, the 13th strakes were being worked on spasmodically. Only a small portion of port strake 13 survived from the ancient hull. Therefore, in the replica we were now building in an area where sizes had to be based more on conjecture than the physical evidence from the Kyrenia ship. Since we were now presumably above the level of the load waterline, we decided to make the planks thinner — about 3.5 centimeters thick, and 25 centimeters wide. Each strake 13 of "Kyrenia II" is made up of two planks joined by a simple diagonal scarf.

At this stage, everyone connected with the project agreed that it would be a useful learning experience to give "Kyrenia II" a trial launching. Up until now the wood had been periodically coated with a mixture of 50% linseed oil and 50% turpentine. But, since no evidence of caulking was found in the seams of the ancient hull, no caulking material had yet been used in the replica. However, because the keel-to-garboard joint was not that snug a fit, it was thought prudent to caulk this seam with a combination of hemp and cotton, which was continued up the stem and sternposts as far as the first wale.

On May 9th, 1985, at 12:43 p.m., "Kyrenia II" floated into the sea for the first time. Wood which had been drying and shrinking for over two years provided openings in the strakes' seams of one to two millimeters for water to rush through. After one hour so much water had filled the hull that the ship's main wale was almost submerged; after two hours she was down to the upper wale. But, after 24 hours the water was pumped out, and except for a few minor leaks, "Kyrenia II" remained high and dry. Within that short a period of time the wood had swelled

sufficiently to close those opened seams. The hull seemed very solid, and sat evenly in the sea. Estimates were made as to the level of the sheer strake.

"Kyrenia II" was hauled out, and during the next six weeks building proceeded at a considerably accelerated pace. As many as ten men were working on the replica at once, and some even on Saturdays and Sundays. We planned to have the ship ready for official launching in conjunction with the inaugural ceremonies of "Athens Cultural Capital of Europe 1985".

Having decided that about 30 more centimeters had to be added to the heights of the sides to prevent the vessel from shipping too much water in heavier seas, the 14th and final strakes were installed, being the same size as the 13th. Later, a five-centimeter-high cap rail was made and completed the shell. And the rest of the futtocks were nailed in place, as were some of the top timbers; but not all of the latter were in place by launch time.

As in the Kyrenia ship, shelf clamps were placed inside the hull at the level of the 10th strakes, reinforcing these main wales and providing some longitudinal strength. Each clamp consists of three planks, the ends of which are diagonal scarfs nailed to frames. Limber ledges support rectangular boards simply laid in place athwarts and easily removable to gain access to the bilge. Between shelf clamps and limber ledges are ceiling planks lightly nailed onto frames. In the ancient hull these planks ran from frame 6 to frame 40, defining the limits of the hold, and protecting frames from the wear and tear of ballast and cargo.

Now let us return to the oddity of the two adjoining half-frames, frames 6 and 7, and recall that frame 6 had remnants of tenons in its inner face. Considering this evidence, and also that the ceiling planks, limber ledges and boards ended atop this frame, as well as the fact that the distribution of millstone ballast and amphora cargo stopped abruptly here, we believe that a bulkhead once extended athwarts at this point. Because of the high probability of the existence of this bulkhead and the type of objects found behind it, we also presume that a deck ran from frame 6 aft, enclosing a stern locker and providing a platform for the ship's helmsman.

The builders of "Kyrenia II" closely copied our hypotheses, while also relying considerably on their own boatbuilding experience. In the stern a deck 3.8 meters in length was constructed with a hatch opening cut in its forward starboard quarter, giving access to the locker below. However, in the rush to finish the replica a minor error in the placement of the bulkhead was made. Rather than being placed atop Frame 6, it was built against its forward face.

The Kyrenia ship's excavation did not yield any substantial evidence for locating a bulkhead forward of the hold. Perhaps there never was one. However, common sense dictates that a deck must have existed in the bow to serve as a platform for lowering anchors and handling the sail. After lengthy discussions during which Michalis contributed his expertise, we all agreed that for "Kyrenia II" a bow deck should run aft to above floor frame 44. As built, the length of this bow deck is 3.3 meters. There is no bulkhead at its aft end, leaving easy access to

the space below this deck.

The pine mast step of the Kyrenia ship was found relatively well-preserved, and the stanchion steps just forward and to each side of it were also in good condition. These have been exactly replicated in every detail for "Kyrenia II". The mast step sits upon floor timbers 33, 35 and 37, rabbets having been cut in the upper surfaces of these frames to fit the notches in the bottom of the step. The mast step is secured by nails driven through it into each of the frames, two nails per frame. The cuttings around the mast box are somewhat of an enigma, but in time "Kyrenia II" should better explain their function. Portions of two cross beams were found to the port of the Kyrenia ship's mast step complex. Their ends were nailed to the top of the shelf clamp. Steffy has identified them as mast partner beams and ingeniously interpreted their use in supporting the mast. Following his plans and drawings the builders of "Kyrenia II" have restored his concepts in three-dimensions. The aft partner beam spans the hull and is supported at its center by rectangular stanchions tenoned into the after cuttings of the mast step. Partner shelves run parallel to each side of the mast step; at their stern ends they are nailed to and supported by the aft partner beam; at their bow ends they are supported by round stanchions tenoned into the stanchion steps. The forward partner beam does not span the hull; rather, its center is cut away to leave room for the foot of the mast to swing out when the mast is being lowered aft. The inner ends of the forward partner beam are rigidly held up by being nailed to the bottom of the partner shelves. Atop these shelves should be removable pieces of a collar helping to support the mast. Forward of the collar a removable brace would add rigidity to the entire complex.

Part of a third cross beam was found just aft amidships in the Kyrenia ship. Although substantial in size (cross-section: 10 cm high and 12 cm, wide), it was not nailed at its port end but simply rested in a notch in the top of the shelf clamp. Therefore, it does not seem that it could have provided much athwart strength. What its purpose was is a mystery. Perhaps "Kyrenia II" will give us an explanation.

The false keel on the ancient hull was Turkey oak. But searching high and low we could not find this wood available in Greece except in lengths less than about 50 centimeters. So in the replica we have used another hard wood: beech. But, like her ancestor, the false keel on "Kyrenia II" is held in place by tapered square pegs driven into round holes.

Professor Steffy has already spoken to you about his restoration of the steering assembly and quarter rudders for "Kyrenia II" based in part on the one surviving steering oar blade from the Kyrenia ship. We will only add that the looms of beech are probably about 35 centimeters too short, because longer lengths of beech were not available. This will be corrected. Also, a satisfactory method of lashing the steering oars secure has not yet been implemented but should evolve after future sea-trials of "Kyrenia II".

Aside from the replication of a few items of block and tackle found in the

Kyrenia ship, the remainder of "Kyrenia II" has been built based on conjecture following our interpretations of ancient representations of ships, literary testimonia, and the experience of our shipwrights, rigger and sailmaker. Therefore, our verbal descriptions will not be so detailed, and the subjects may be more effectively conveyed through visual presentation.

As has been said, the strake seams of the hull have not been caulked, but they have been covered with a mixture of fat from around the kidneys of oxen, pine pitch, and fine saw dust, to make the seams more water-proof.

The hull from the keel to the top edge of the main wale has been coated with a mixture of pig fat, pine pitch and soot, giving the effect of Homer's black-hulled ships, and providing some protection against bacterial growth.

The end of the stempost and the finial of the sternpost were finished in the simplest yet graceful way. One concession for decorating "Kyrenia II" was made. I asked my wife to design and paint apotropaic eyes on the ship's bows. Stanchions and railings also consistent with those depicted on vase paintings were built around the stern and bow decks for safety.

Channels for belaying pins have been placed slightly aft the mast for securing the shrouds. The stern bits are for lashing a variety of lines: backstay, braces, sheets and brailing lines.

No fragments of the mast or yard were found in the Kyrenia ship's excavation. Following Theophrastus' advice we decided to make them of silver fir for "Kyrenia II". The mast is 10.5 meters high and tapers upwards from 25 centimeters to 10 centimeters. The yard is a single piece 10 meters long, 18 centimeters at its center, tapering to 12 centimeters near its ends. A more flexible three-piece yard will be tried next.

The sail should have been made of linen, but this material was not available in Greece. It should have been made up of horizontal strips. For a preliminary experimental sail we decided to use cotton canvas which is readily available here. But the sailmaker, Kostas Kafetzidakis, has a mind of his own and made this sail of vertical strips. It is wide and low in configuration, measuring 9.6 by 4.9 meters, or 47 square meters. Our early sailing tests have suggested that this sail is too small. For the proper linen one we are considering a sail as large as 11 by 6 meters (66 square meters) made up horizontal strips, in no. 7 linen canvas.

We advised that the sail should have 10 brailing lines, each line having perhaps as many as 10 lead guide rings (176 were found in the excavation), these rings being sewn to the leeward side of the sail. But the rigger, Yiorgios Kasanis, also has a mind of his own, and used fewer rings sewn to the windward side of the sail. After a couple of sailings the mistake was appreciated, and the rings transferred to the lee side.

The standing rigging of "Kyrenia II" consists of a forestay, backstay, and two shrouds to both port and starboard. The running rigging, in addition to the brailing lines, consists of a halyard, two topping lifts, braces and sheets. Manila line, roughly comparable to fragments of rope found in the excavation, has been

used. Wherever possible pully blocks and heart thimbles, like those found in the Kyrenia ship, have been used in the rigging. The function of the toggles resembling yo-yos that were found in the ancient hull is still uncertain, but future sail tests of "Kyrenia II" will experiment with their use.

"Kyrenia II" was christened by Mrs. Melina Mercouri and Susan Womer Katzev the morning of June 22, 1985, and officially launched. Since that date I have learned that five sea-trials have been performed. From brief reports received on the earlier trials, I understand that "Kyrenia II" in a following wind of 5 to 6 Beaufort moves at over 4 knots. She has also sailed as close as 70 degrees off the wind.

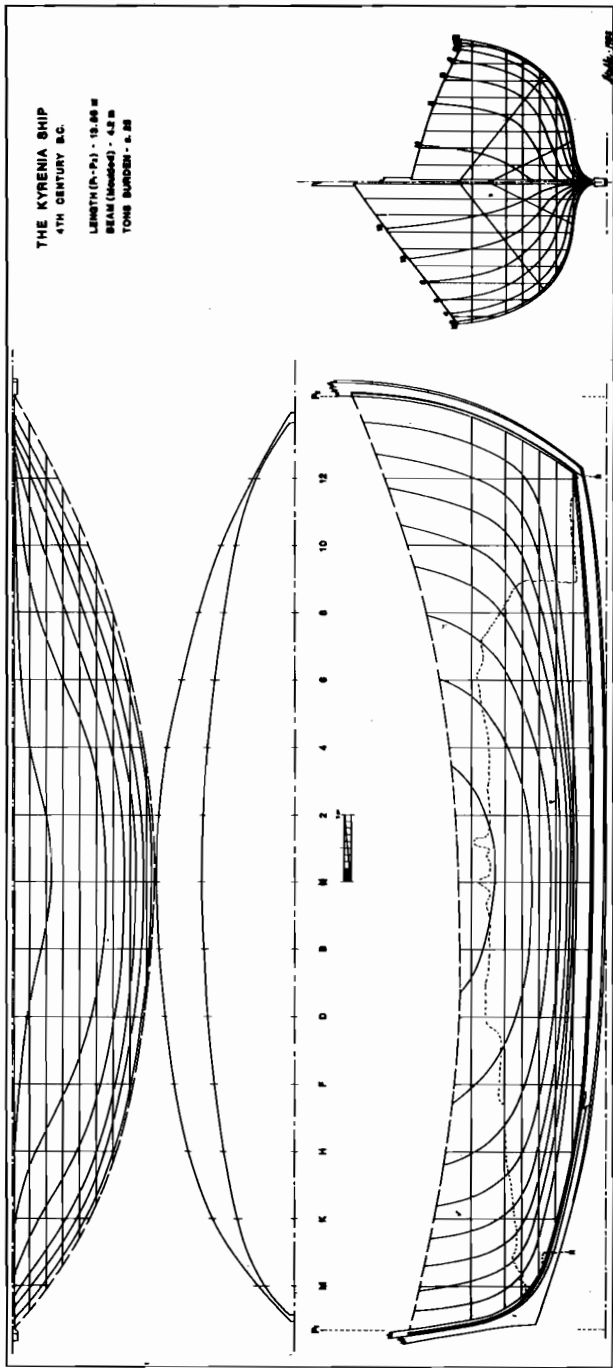
Mr. Harry Tzalas informs me that, to date, the Hellenic Institute for the preservation of Nautical Tradition has spent 8 million drachmas, or a little over sixty thousand U.S. dollars, at current exchange rate, for building and testing "Kyrenia II".

The project of building a replica of the ancient Kyrenia ship has taught us much. We have learned that modern shipwrights can readapt to the method of shell-first construction and relearn the mortise-and-tenon joinery method last used by their ancestors almost a thousand years ago. We have shown that the shell of a hull can be built up to its load waterline by mortise-and-tenon alone, without virtually any internal bracing. And we have proven that Steffy's lines drawings of the Kyrenia ship can be precisely duplicated. Professor Steffy calculated the distance between the rabbets in the stem and stern posts of the Kyrenia ship to be 13.86 meters. In "Kyrenia II" it is 13.76 meters - a difference of 10 centimeters. He calculated the moulded beam to be 4.2 meters. In "Kyrenia II" this distance is 4.20 meters!

We have also learned that "Kyrenia II" floats and can be sailed. Gradually we are learning the performance characteristics of this replica. But, changes are already dictated, and many more sea-trials must be undertaken before we can properly analyze the accumulated data.

"Kyrenia II" is an authentic replica of a Greek merchant ship dating to the 4th century before Christ. I hope that at the 2nd Symposium on Ship Construction in Antiquity we will be able to report to you about her seaworthiness, sailing capabilities; and success in carrying bulk cargoes through the eastern Mediterranean.

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NAUTICAL ARCHAEOLOGY

1st INTERNATIONAL SYMPOSIUM  
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