

**THE WATER STREET SHIP:  
PRELIMINARY ANALYSIS OF AN EIGHTEENTH-CENTURY  
MERCHANT SHIP'S BOW**

**A Thesis**

**by**

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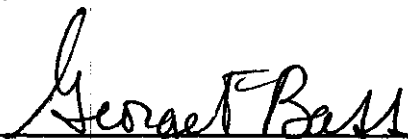
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JAY PAUL ROSLOFF

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## ABSTRACT

The Water Street Ship: Preliminary Analysis of an Eighteenth-Century Merchant Ship's Bow. (May 1986)

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Near the middle of the eighteenth century, a worn, 100-foot-long merchant ship was installed for pier cribbing off Manhattan Island's East River shore, in New York City. In 1982, the substantially intact ship was uncovered by archaeologists conducting a building site survey at 175 Water Street. The excavators removed approximately the first 8 feet of the vessel's bow and its associated structure, the knee of the head.

The recovered timbers demonstrate both the specifics of constructing a bow and the major structural features characteristic of the vessel as a whole. The ship's bow was built by first installing a stempost and apron (each consisting of two pieces) on a keel. The frames, pre-assembled from a floor timber and double rows of futtocks arranged to form a nearly solid structure, were erected both vertically and perpendicularly to the keel. They were reinforced longitudinally with a main wale belt, three strakes wide, inboard of which was a heavy deck clamp. Into the clamp were dovetailed the ends of the gently-arched

main deck beams. The beams were additionally secured with lodging knees, bolted to both the beams and the sides of the vessel. Large breast hooks bolted across the stem effectively tied the halves of the bow together. The hull planking was attached to the frames with a combination of iron and wooden fastenings, and protected from marine boring organisms with a sheathing of boards nailed over a layer of hair and pitch. The ship's thickest planking, the decking, was double-layered around structures piercing it, and attached to the deck supports with square-shafted iron nails.

The Water Street merchant ship is a rare example of the eighteenth-century shipwrights' art. As such, it aids us in interpreting the scant record of their construction techniques, and casts new light on one type of vessel that met our transoceanic requirements during the colonial period.

**DEDICATION**

**Venus Paradise  
and  
the emigrants**

## ACKNOWLEDGMENTS

I have been blessed with parents who know not only the differences between a pat on the back, a firm push in the right direction, and a swift kick in the can; but the appropriate applications for each. To them I owe it all.

I have also been fortunate in the kindness and quality of my teachers. If this thesis proves a contribution to our field of scholarship it is because of the examples they have set, and the encouragement they have offered. In this regard I wish to particularly express my gratitude to the chairman of my thesis committee, the remarkable, Professor John Richard "Dick" Steffy, as well as professors G.F. Bass, J.C. Bradford, E. Doran, D.L. Hamilton, C.T. Kimber, and F.H. van Doorninck, Jr.

I also wish to express my thanks to Warren Riess and Sheli Smith for their leadership of the Water Street ship excavation project, for their support of my research, and for their continuing friendship. Many thanks also must go to my other friends and co-workers on the project. In particular I want to thank Lisa Goldberg and Shelly R. Lang for their herculean efforts and years of friendship. Bob Adams, Kerri Horne, and Betty Siefert also share in the success of this project, as they did in its labors.

I hope there is a special place in heaven for Elizabeth Braznell, I certainly cannot reward her but for a fraction of what is her due.

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## GLOSSARY

- back--the top of a cambered timber.
- baulk--a portion of timber of great volume.
- belly--the underside of a cambered timber.
- bitts--posts for securing mooring or other heavy lines.
- board--broad wood stock less than 2 in. thick.
- breast hooks--horizontal timbers internally reinforcing the vessel's bow.
- breech--the part of a knee adjacent to its outside angle.
- butt joint--the flush meeting of two broad timber ends.
- cambered--having a slight upward arch.
- carlings--longitudinal deck supports spanning the space between two deck beams.
- ceiling--the internal planking of a vessel.
- cheek pieces--slender, horizontal knees providing lateral strength to the knee of the head.
- clamp--internal, longitudinal, thick, strenghtening member.
- cutwater--forward portion of a ship's head knee.
- dead works--in the early 18th-century, the portion of a vessel above the waterline.
- fay--closely fit wood-to-wood.
- floor timber--a thwartships framing member centered over the keel.
- frame--a grouping of transverse hull-strenghtening timbers.
- futtock--a framing member which extends a floor timber.

gammoning--lashings, particularly those between bowsprit and knee of the head.

gripe--fore part of a knee of the head, joining it to the keel.

ground futtocks--the first futtocks, usually attached to the floor.

hanging knee--a vertically-mounted knee, whose vertical arm is below its breech.

harpins--thickened portion of the wales at the bow.

hawse holes--the passages in the bow through which the mooring lines or anchor cable (hawser) passes.

hawse pieces--vertical timbers filling the space between the forwardmost frame and the stem.

head--structure lying forward of the stempost; including the railings, brackets, seats of ease, lace and lyon.

hooding ends--the ends of strakes which fit into rabbets.

hook--curved timber.

jeer capstan--auxiliary capstan, used for lifting, and assisting the main capstan in heaving up the anchor.

knee--angled timber, usually not acute.

knight head--hawse timbers carried up on either side of the stempost.

lines--a set of geometric projections demonstrating the contours of a hull.

lodging knee--knee mounted horizontally, usually to support a deck beam.

moulded dimension--the measure of a ship's component from inboard to outboard.

naval bolsters--reinforcement around hawse holes.

nib ends--narrowed ends of planks.

partners--timbers paired to support a vertical member.

plank--broad wood stock between 2 in. and 4 in. (10-20 cm.) thick.

quick works--in the early 18th century, the portion of a vessel below the waterline.

rabbet--a groove or notch cut into a timber, usually to receive a plank's edge.

rising timber--a floor timber whose arms angle upward.

scarph--overlapping of two timbers to make a single piece without increasing its thickness.

sheer--the sweeping line of a hull side or strake, as seen from the side.

sided dimension--the measure perpendicular to the moulded dimension.

standing knee--a vertically mounted knee, whose vertical arm is above its breech.

step--timber in which a mortise or socket is arranged to accomodate a vertical member.

strake--a line of planking.

throat--the inner curve of a knee or crotch.

treenail--a cylindrical wooden fastening.

wane--a lessening of timber from its full breadth or thickness.

wales--external, longitudinal, strengthening members.

waterway--boards filling the corner between the deck planking and the sides of the vessel.

whelps--vertical pieces on a capstan barrel to assist a cable's purchase.

## INTRODUCTION

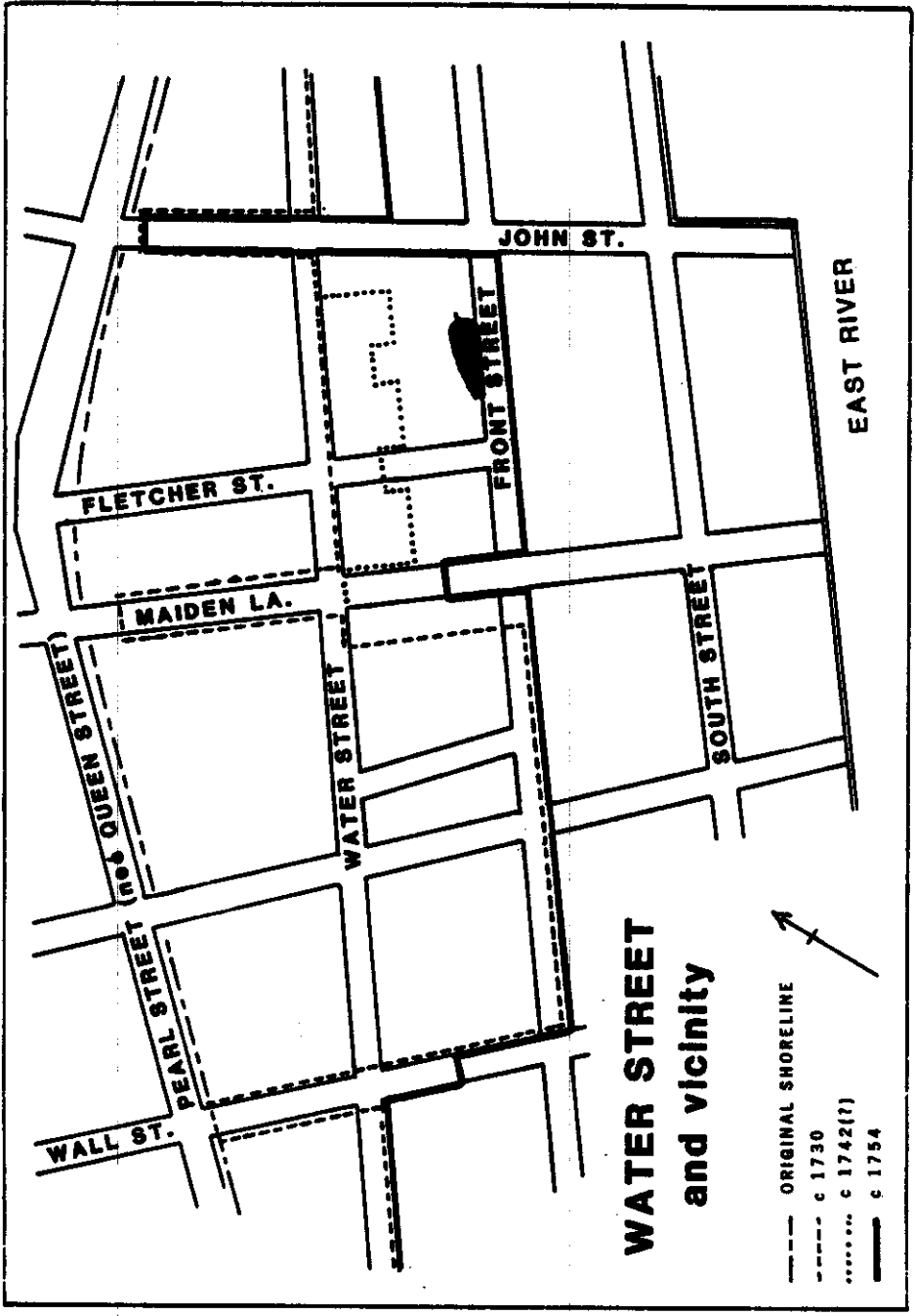
During the winter of 1981-82, archaeologists conducted a survey at 175 Water Street, a building lot on Manhattan's Lower East Side, in New York City.<sup>1</sup> The survey uncovered substantial remains of a bluff-bowed, 100 foot (30.5 m.)-long wooden vessel (ill. 1). Maps and other evidence indicate the vessel had been interred on the island's East River shore near the middle of the eighteenth century.<sup>2</sup>

The directors of the survey approached nautical archaeologists Warren Riess and Sheli Smith to assess the find. Riess, Smith, and other archaeologists convinced the property developers and city authorities that the ship was unique and of considerable educational and historical value.<sup>3</sup>

Although the developers were generous in their support, financial considerations determined the course of the excavation. Access to the site was limited to six weeks, and as curatorial and conservational costs estimates ranging into the millions of dollars were rejected by the principals involved, little of the hull could be saved for future study and display. After civil engineers determined that the stern and starboard portions of the vessel were thoroughly incorporated into the foundation of present-day Front Street and that to excavate those areas would require extensive

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This thesis follows the format of The American Journal of Archaeology (AJA).



Ill. 1. Water Street and vicinity. (Drawing author)

rebuilding of sub-surface electrical, telecommunication, and other service conduits, it was decided to take advantage of the fact that ships are, at least in broad terms, bilaterally symmetrical. Only portions of the vessel's port side and bow were exposed and recorded.

Excavation revealed a two-decked ship substantially intact from her bottom upward to a point corresponding approximately to the weather deck amidships. The deck beams had been chopped through, and the decks collapsed under tons of rubble fill. Although most of the surviving treenails were sound and holding fast, iron fastenings had deteriorated to black sludge or sludge-filled concretions with only occasional metallic fragments extant. Due to the loss of adequate internal support, the sides of the vessel were splayed outward and separated from the stempost.

The majority of the bow timbers were removed on the last day of the excavation. The decking and a few key components had previously been removed, but a 23-hour-long session was required before the last of the timbers, some weighing over one-half ton, were sawn, hammered, or torn free of the vessel, wrapped in burlap and plastic sheeting, and placed in a water-filled holding tank.

All of the wood salvaged from the Water Street ship is unstable. Timbers which lay above the water table are progressively more rotten, and correspondingly more fragile, the closer they were to the surface. The portions of the

hull from below the water table are in better condition, the wood being generally sound beneath a soft surface. The lower, external portions of the ship which had been in contact with seawater show moderate to severe damage caused by teredo spp. and other marine boring organisms.

Washed-out holes in apparently protected interior faces of the timbers may have resulted from the action of groundwater on areas previously damaged by dry rot or acid build-up caused by the deterioration of iron fittings or fasteners. Exposure to the extremes of winter during the excavation further damaged and eroded the wood, as did the abrasive action of excavators' boots and equipment.

In order to examine the salvaged timbers in a controlled environment, and to prepare the material for eventual reassembly and display, the excavators removed them to a conservation facility built for the project in Groton, Massachusetts. The catalog numbers referenced in this thesis are those assigned at the facility.<sup>4</sup>

The bow's component parts were recorded over the summer and autumn of 1982. The primary recording technique was that of preparing full-scale drawings by direct tracing on clear acetate. Black fine-tip felt pens were used to trace each component's outline, while constructional details, such as treenails, bolt holes, and tool marks were distinguished with colored fine-tip felt pens. The angles between surfaces were measured with a carpenter's bevel gauge and

directly transferred to the drawings.

Although the aforementioned techniques have been used with some success in recording wrecks around the world, several shortcomings became evident. The ship's timbers are stained to a rich brown-black. This, combined with the logistical problems previously mentioned, made the task of recording the timbers difficult. Photographs taken without benefit of strong lights reveal a featureless mass. Even close examination of a timber may fail to disclose the ends of treenails sliced flush with the surrounding surface, or the presence of sludge-filled nail holes. But the most serious recording errors were those introduced into the tracings by a failure to appreciate the distortions caused by parallax. If the recorder's eye is not exactly above the point being traced, it is impossible to align the tip of the pen with that point. This will either alter the apparent profile of a timber, causing it to appear wider or narrower than it really is, or, more seriously, alter the apparent curvature of the timber. Although most parallax errors can be mitigated by keeping the tracing materials close to the object, this is not feasible when tracing curved or beveled surfaces.

At the time the recording process began, it was planned to reduce manually the drawings to a 1:5 scale. In order to accomodate budget constraints, the drawings were reduced photographically in a two-stage process. This added to the

margin of error. Not only did some of the details marked in colored pen drop out of the final prints, but manual feeding of long drawings through a series of rollers introduced linear distortions and a slight inconsistency of scale. The method did, however, produce a workable set of reductions in just a few days.

During a visit to the laboratory facility in the winter of 1984, I examined the cleaned timbers and corrected some inaccuracies in the 1:5 scale prints. The reduced drawings, plus conservators' notes and photographs, enabled me to produce 1:5 scale replicas of the bow's major timbers.<sup>5</sup> By aligning fastener holes and otherwise manipulating these miniatures, I was able to interpret the original sketch maps and field photographs, model the vessel's bow as it looked prior to excavation, and produce the illustrations and plans appearing in this thesis.

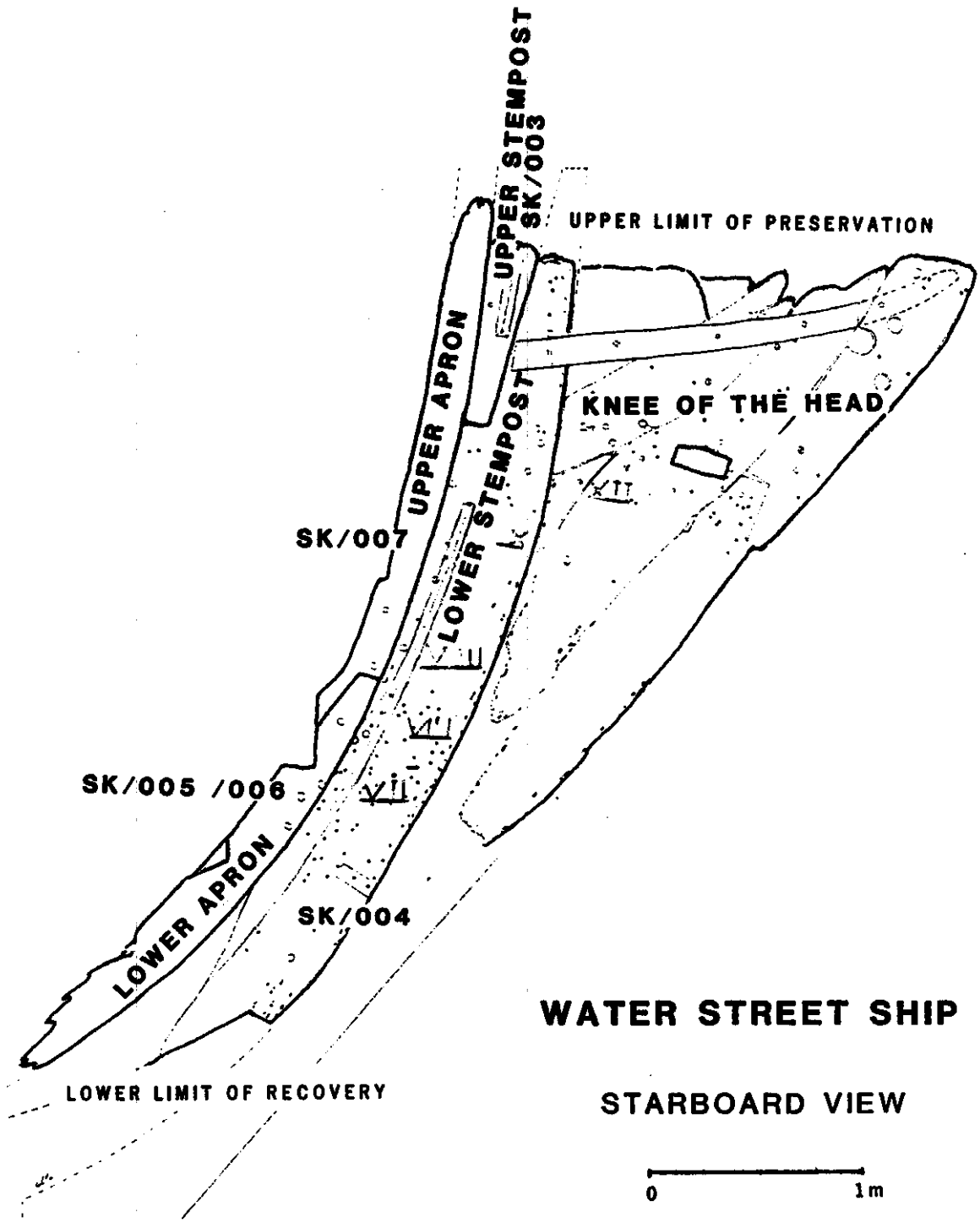
Currently, the timbers are in storage at The Mariners' Museum, Newport News, Virginia, where they await reassembly.

## THE CATALOG

### Stempost

The gently curving stempost (ill. 2) is composed of two parts: the upper (SK/003) and lower (SK/004) stemposts, flat scarphed and nailed together. The lower post (SK/004) is slightly eroded at its upper end; its lower portion, where it was originally scarphed and bolted to the keel's fore-foot, was torn away during its 1982 salvage, leaving a timber 4.45 m. in length. The upper post has largely disappeared. It is preserved only as a 93 cm.-long fragment of the after lip of the scarph between the upper and lower stemposts. The stempost's moulded dimension tapers from a maximum of 79.5 cm. above the lower scarph to 65 cm. below the upper scarph. Its maximum sided dimension is 29 cm. The forward half of the stempost is slightly beveled, the leading face narrowing to 25 cm.

Planking rabbets are found on both sides of the stem, except for a  $77.5 \pm 1.0$  cm. gap where the rabbet line crosses the scarph between the upper and lower posts. The gap in the port rabbet is centered about 9 cm. higher than the corresponding gap on the starboard side. The rabbets are 4 to 5 cm. deep and 6.5 to 7.0 cm. broad at their upper ends, but their after faces are cut progressively lower, widening the rabbets as they descend, in order to accommodate the lower hull planking where it sweeps aft in the hollows



Ill. 2. The Water Street ship. The stempost, apron, and knee of the head. (Drawing author)

of the bow.

At least ten 2.8 cm. dia. holes pass fore and aft through the post, while an additional eight holes of similar size penetrate only the forward or after faces. The former held iron bolts securing the stempost, apron, and frame assemblies to one another (and to the keel in the case of the lowermost fasteners), while the latter represent the path of drift pins or bolts which attached the knee of the head or the breast hooks to the stempost.

Five transverse holes, varying in diameter from 3.2 to 3.9 cm., are located in the forward half of the post. These holes (and similar holes in the knee of the head) provide evidence for the placement of the cheek pieces (knees) which provided lateral support to the knee of the head. The purpose of a similar hole near the stempost/keel scarp is unknown.

Square shaft holes left by disintegrated iron nails are found on many of the stem's surfaces. Those on the inboard face of the stempost resulted from the shipwright's preliminary assembly of the upper and lower posts and aprons. The dozens of 1.9- to 2.4-cm. square holes found in the rabbets remain from nails used to attach the hull planking. There are also 0.9- to 1.5-cm. square holes found forward of the rabbets. These, along with traces of hair and a yellowish mastic material, provide evidence that the stem was sheathed (see: Sheathing, below). Carved into the

starboard face of the stempost is a series of Roman numerals (see: Lading Marks, below).

Shallow, 7.5 cm. wide iron-stained notches are found on the lower starboard and upper port faces of the stem. Two or more square nail holes are located within the notches.

#### Apron

Fayed to the inboard face of the stempost, and running its entire length and breadth, is an apron (ill. 2, p. 8). Like the stempost, it is composed of two curved timbers: an upper apron piece (SK/007) and a lower apron piece (SK/005/006), which were scarphed and nailed together. The 2.36-m.-long upper apron piece is rectangular in section throughout most of its length, and is sided 30.5 cm. and moulded 20 cm. Its lower end terminates in a 34 cm.-long scarph table, and is offset in an aftwards direction to lap over the upper end of the lower apron piece, to which it is nailed. A notch, cut across the after face of the piece, lies about 1.92 m. from the apron's upper end. The nails which secured the ceiling planking to the upper apron piece have left ten or twenty square nail shaft holes in its after side. Round holes 2.7 to 3.7 cm. in diameter (the larger holes may have been enlarged by erosion), running fore-and-aft, held the bolts which secured the breast hooks to the stem. The timber is heavily eroded at its upper end.

The lower apron piece is 2.63 m. long and moulded approximately 27.5 cm. It is trapezoidal in section; the

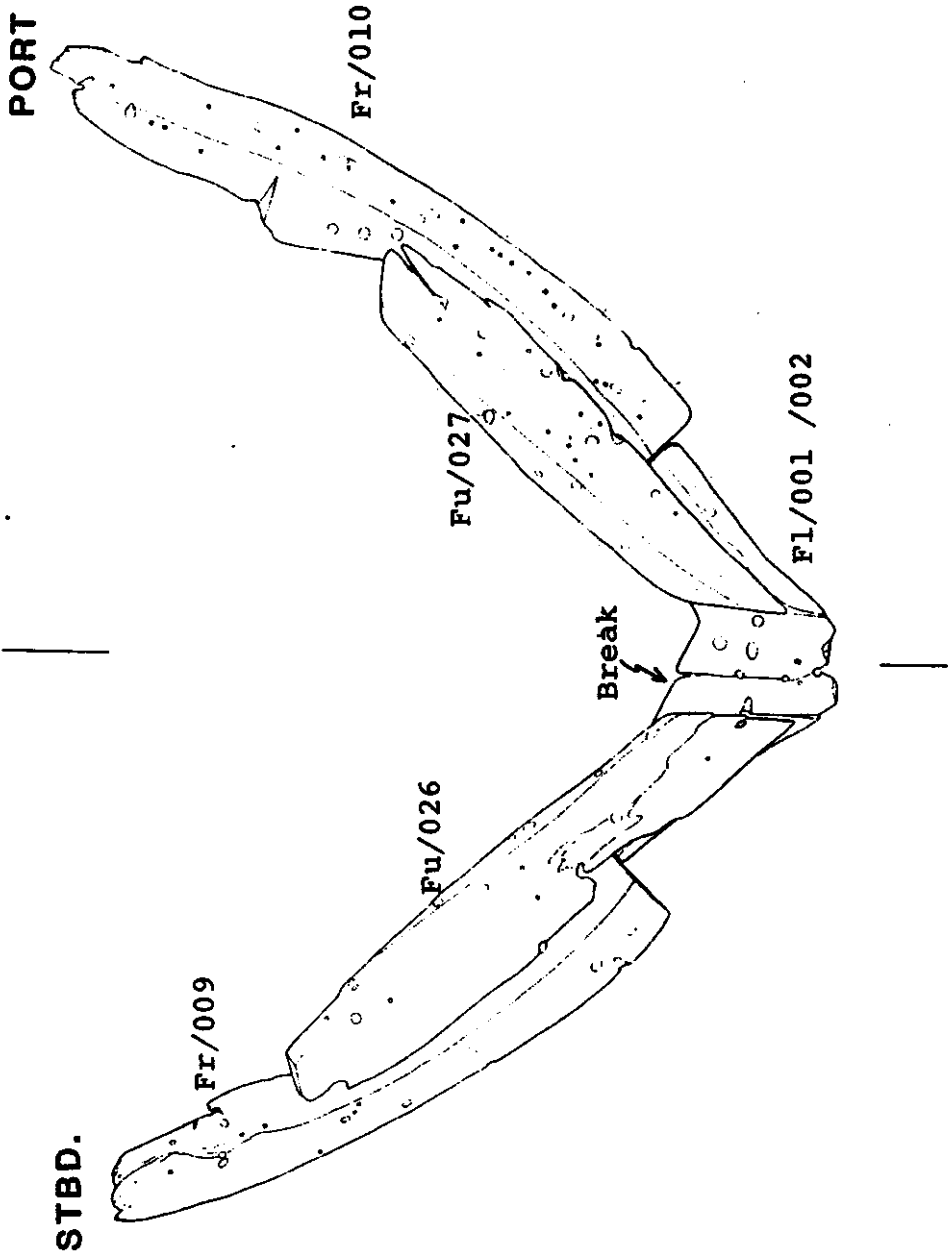
forward face, sided 23 cm., is 6 cm. narrower than its after face measurement of 29 cm. The timber's lower end is torn where it was pulled free of the ship during removal.

There are three steps cut into the inboard side of the lower apron. Each is arranged so that its forward face is approximately vertical while its lower face extends about 17 cm. aft. The uppermost step is a single notch extending the entire width of the piece. The second and third steps are in the form of a pair of notches 11.5 cm. apart. The third step, found in the broken and torn area near the bottom of the apron, is largely destroyed. Round holes, 2.5 to 2.9 cm. in diameter, run fore-and-aft through the lower apron piece. These contained the bolts which held the apron to the stempost or the floors of the frames to the stem. Square nail shaft holes found on the aft face of the lower apron piece are from nails toed in to support the floors of the frames. The holes on the sides of the apron held the outer hull planking fastenings (see: Fastenings, below).

#### Frames

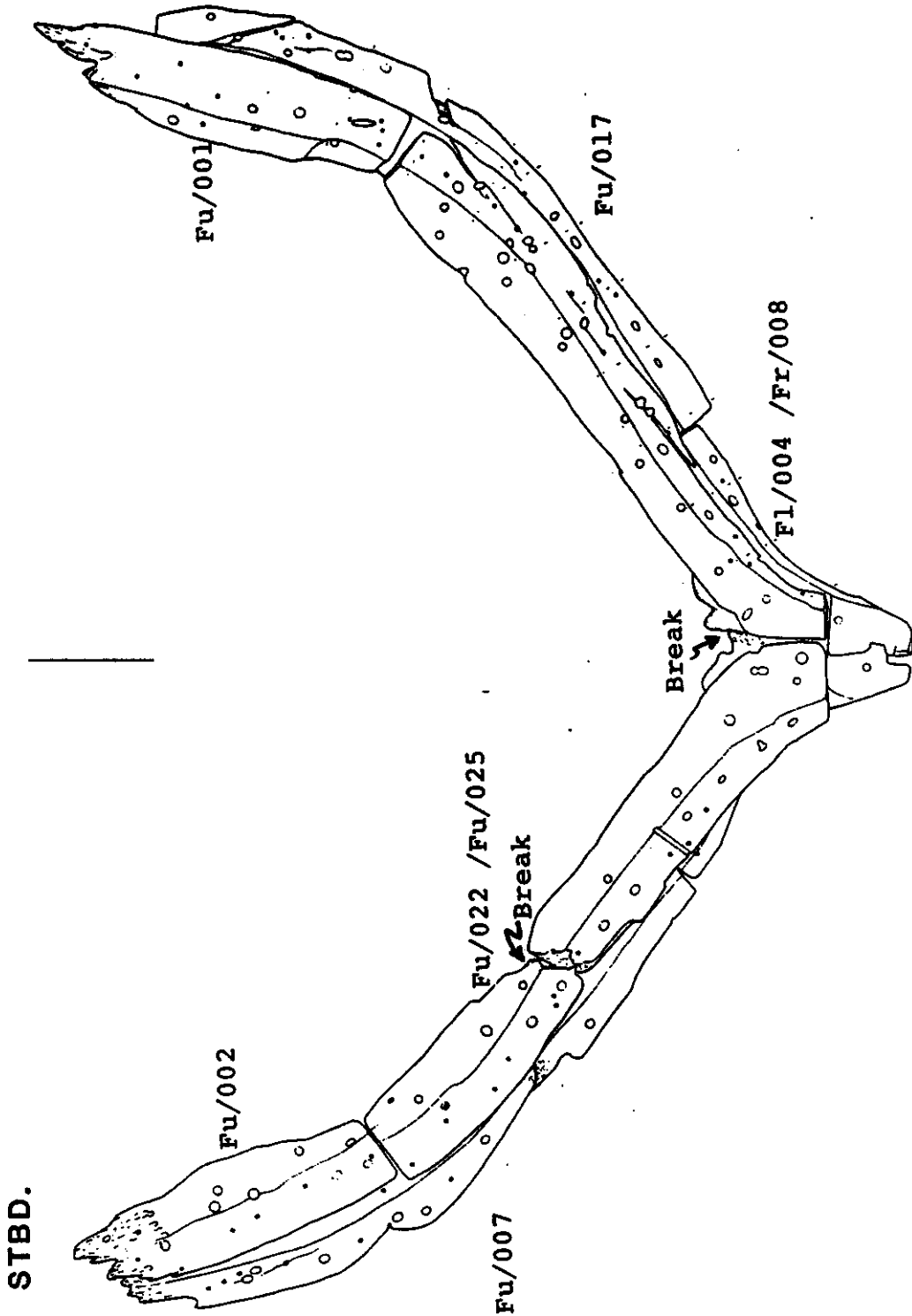
The forwardmost three frames and the port futtocks of the fourth frame were salvaged and documented in the laboratory (ills. 3, 4, 5, 6, and ill. p. 47).

The Water Street ship's frames were installed nearly vertically and perpendicularly to the ship's longitudinal axis. Their room-and-space interval is approximately 38 cm.

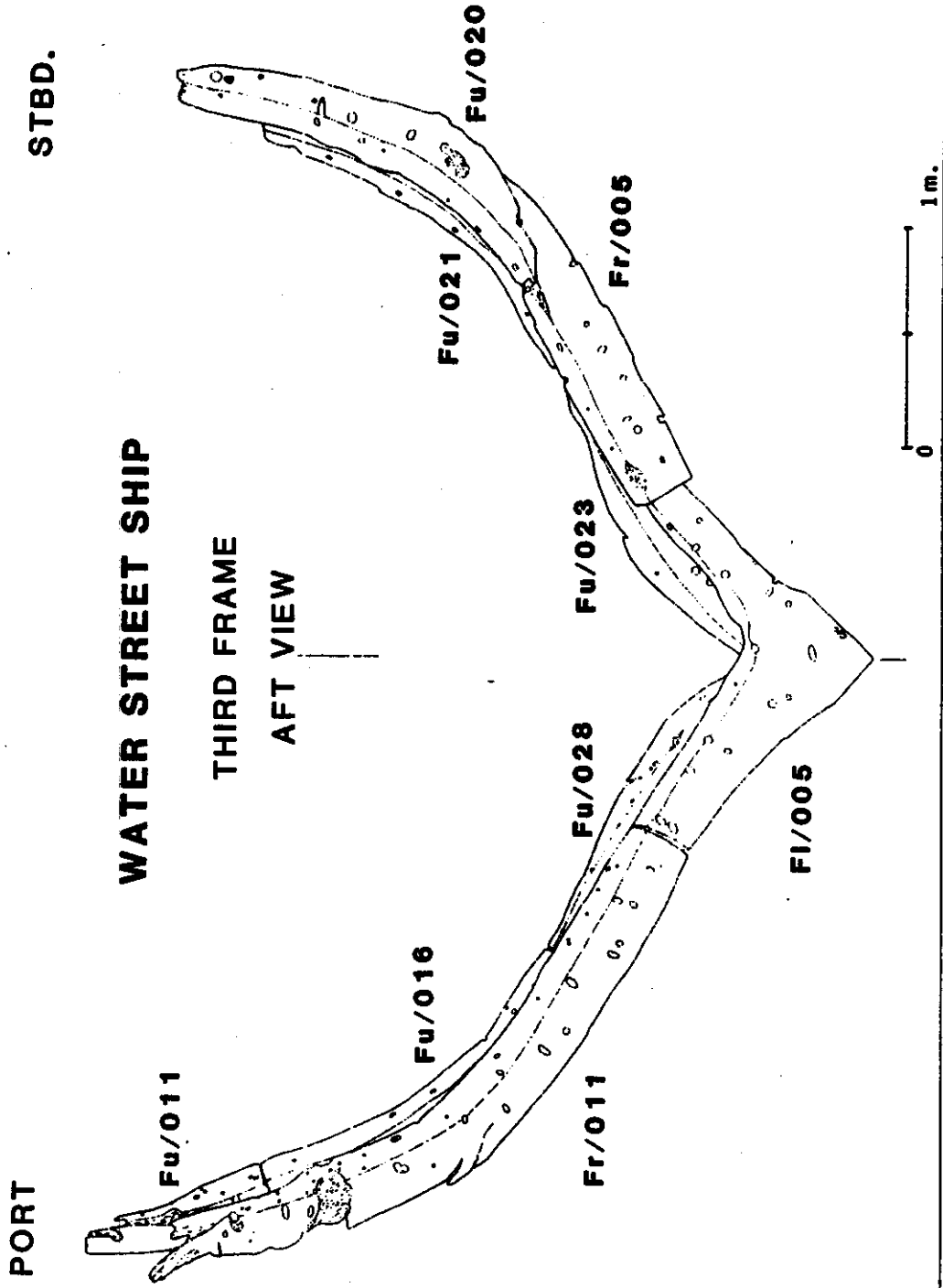


Ill. 3. Water Street ship. The first frame, forward view. (Drawing author)

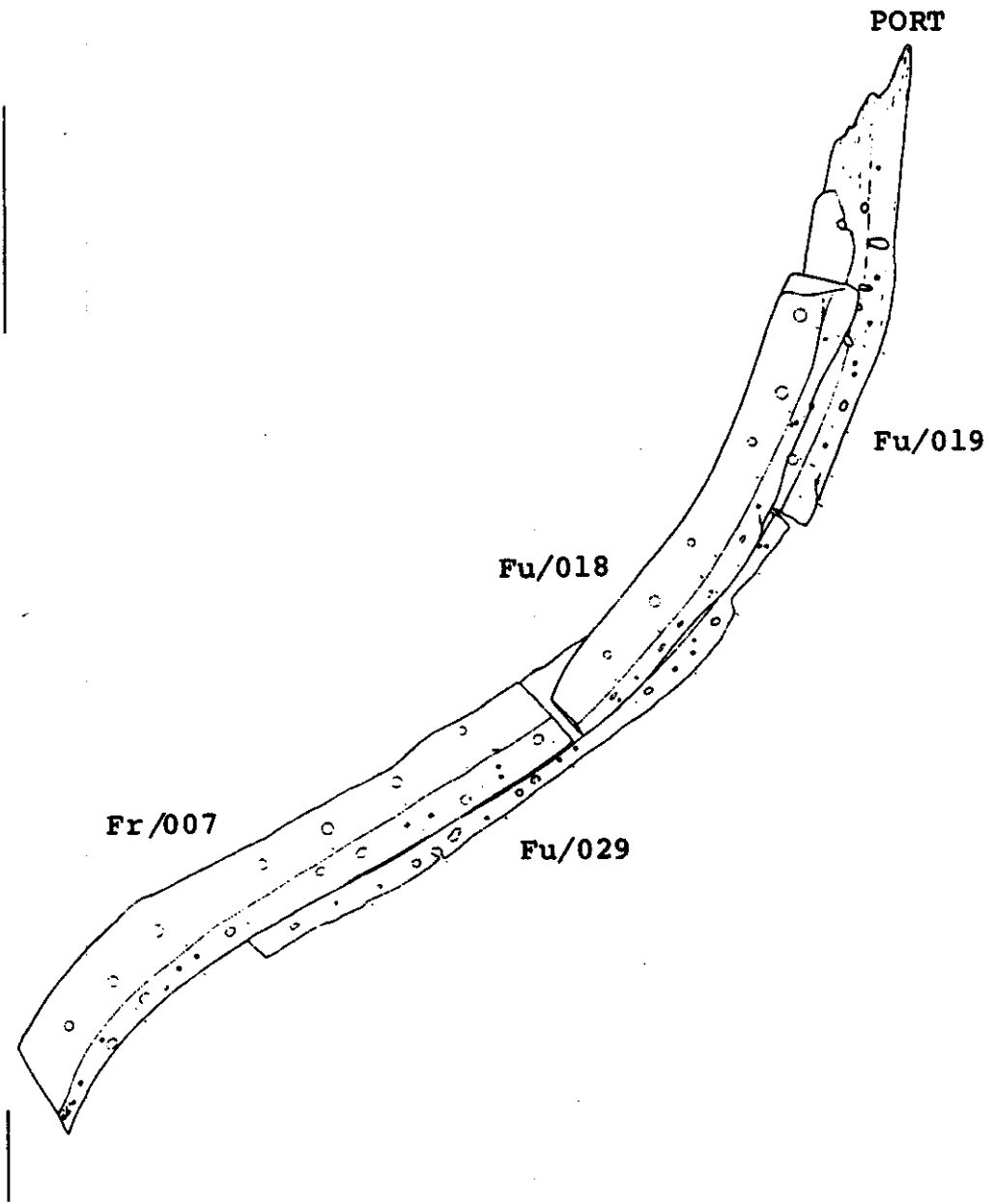
PORT



ILL. 4. Water Street ship. The second frame, forward view. (Drawing author)



Ill. 5. Water Street ship. The third frame, forward view. (Drawing author)



Ill. 6. Water Street ship. The fourth frame, forward view, port futtocks only. (Drawing author)

Each frame is composed of a floor timber and six curving futtocks arranged to form a nearly solid double row of timbers, with the sharply-angled floor timber located on the after side of the frame.

The timbers were each cut from the crotch of a tree, with one arm heavier than the other. Beginning with the forwardmost frame, the heavier arm is alternated from port to starboard. The forwardmost two frames have separated along the grain with some material lost to erosion.

The futtocks are generally diamond-shaped in section, their forward and after faces hewn to planes approximately parallel to each other. The frames have a fairly regular sided dimension of about 34 cm., the floor timbers and futtocks each being sided at approximately 17.0 cm.  $\pm$  1.0 cm. The complex shape of the ship's bow requires that the inner and outer faces of the frames not be strictly parallel to one another, but carved to appropriate curves. The frames' moulded dimensions therefore vary from a maximum of about 25 cm. near the floors to under 20 cm. near their preserved upper margins.

The ground futtocks meet their counterparts along the vessel's mid-line, except in the case of the forwardmost frame, where the heels of the ground futtocks straddle the apron. There is a rabbet cut into the heels of the third frame's ground futtocks that allows it to fit in the step on

the after side of the apron. The butt joints between the heads and heels of the component parts are staggered to meet near the middle of the adjacent timber. The frames were assembled with iron fastenings 2.5 to 2.8 cm. in diameter running fore-and-aft, which were spaced at 30 to 60 cm. intervals.

Not every frame component made contact with every hull plank that crossed its inboard or outboard faces. A moderate amount of wane was allowed in each component and no chocks were substituted for adequate timber at the futtocks' ends.

The upper portions of the frames are heavily eroded, and most of the futtocks exhibit splitting along the grain, especially in the vicinity of the treenails. The starboard ground futtock in Frame II (Fu/025, Fu/022) was discovered with a washed out break running across the grain, while its after companion, Futtock 2, (Fu/007) was nearly split in two. Starboard Futtock 2, on Frame III (Fr/005, Fu/020), is also split in two along the grain.

The inboard and outboard faces of the floor timbers and futtocks show square holes, 1.0 to 1.5 cm. across and up to 20 cm. deep, left by the iron nails used to affix the hull planking. Round holes, 3.1 to 3.8 cm. in diameter, deeply penetrate or completely pierce the timbers. These held the treenails which also secured the hull planking. Somewhat narrower (2.3 to 2.8 cm. in diameter) athwartships holes are

found in some of the upper futtocks. These holes marked the site of bolts which held the deck knees and clamps to the sides of the vessel.

#### Half-Timbers

A set of half-timbers, moulded to approximately 22 cm. and sided at 12 to 13 cm., fill the room between the second and third frames aft. They are similar in function and design to a frame, but there is no floor timber and only a single, not a double, row of timber. The lower ends of the half timbers straddle the apron.

There are no fastenings primarily dedicated to attaching the half-timbers to the keel or the adjacent frames, although the lower timbers were pinned to the third frame aft by several hull planking treenails which passed through the half-timbers.

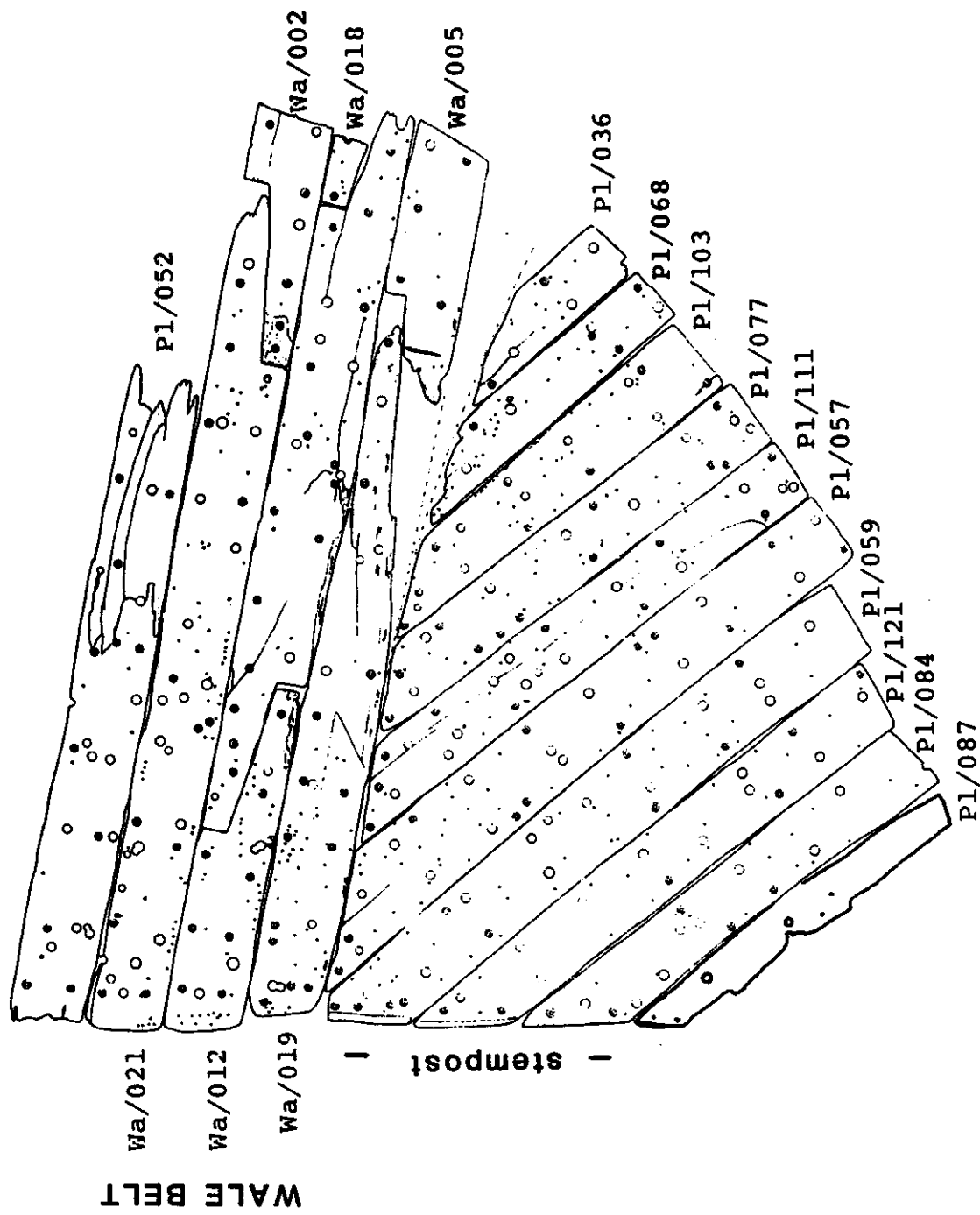
#### Hawse Pieces

The Water Street ship was built with six hawse pieces lying on either side of the stem. Their lower ends rested upon, but were not attached to, the upper surface of the forwardmost frame. The moulded dimensions of the hawse pieces average about 18 to 20 cm., similar to those of the frames at the same height, but their breadths vary from one another by as much as 50%, with the knight heads, sided at 22 cm., being the narrowest of the hawse timbers. The knight heads were fastened together through the stempost by means of at least two transverse iron fastenings of 2.3 cm.

diameter. Each of the outer pieces was attached to its inner neighbor by means of a similar iron fastener. The hawse pieces are pierced fore-and-aft with fasteners for the wales, clamps, breast hooks, and cheek pieces. They are also pierced by treenails and contain square nail-shaft holes from the fastenings that secured the hull planking. The hawse pieces are heavily eroded; the outermost portside hawse piece was not recovered during the excavation. The port knight head is partially chopped through near its lower end.

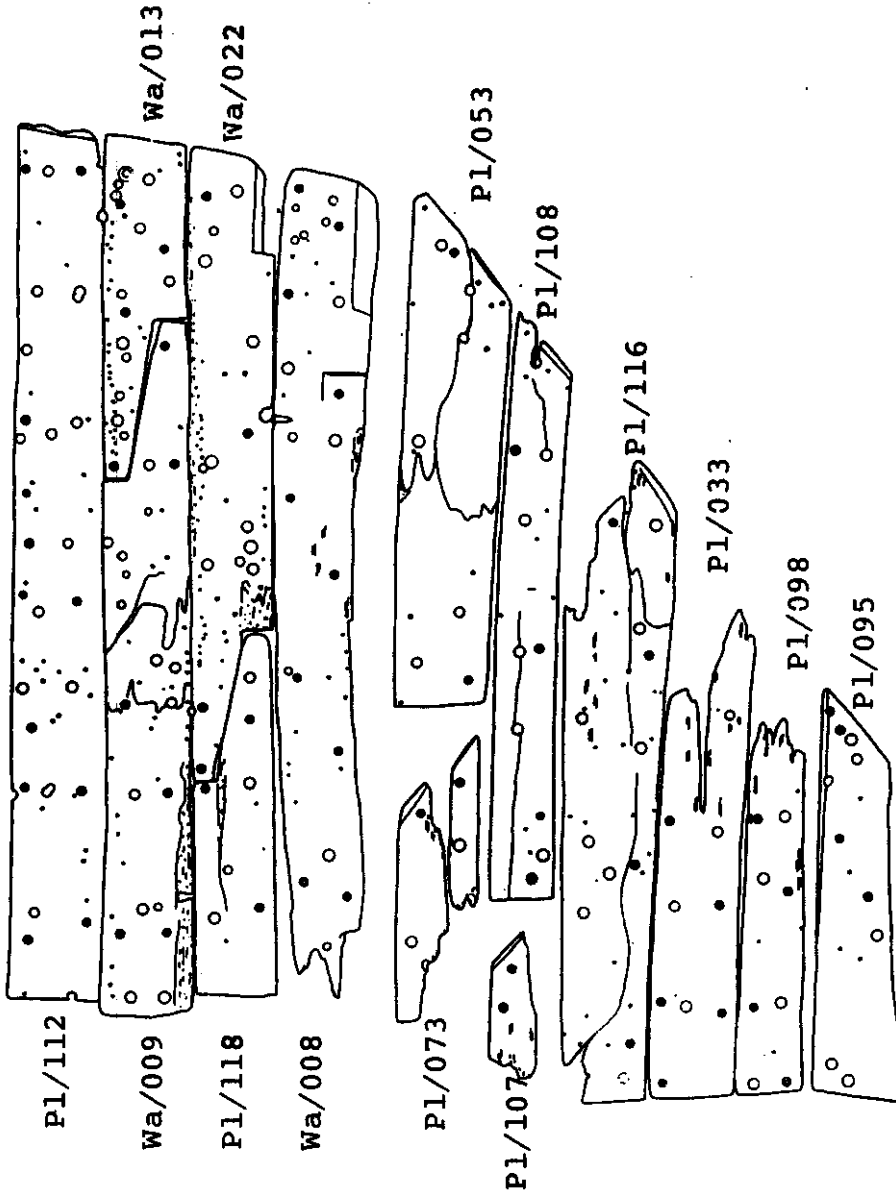
#### Wales

The bow of the Water Street ship includes the lower, or main, wale belt (ills. 7, 8). The 78 cm.-wide belt is comprised of three parallel, contiguous strakes of planking, each is approximately 26 cm. broad and 10.9 cm. thick. The wales spring from the stempost at only a slight angle aft and downward. They were not directly attached to the stempost, but were fastened to the hawse pieces and frames of the vessel with treenails 2.9 to 3.6 cm. in diameter, and iron nails 1.8- to 2.7 cm.-square which had heads 2.5 to 4.2 cm. in diameter. The individual segments used to make up each strake are hewn from curved timbers, their arcs more acute than the natural curve of the grain. The segments of each strake are not fastened to one another, but linked indirectly with long flat-scarphs spanning two or more frames.



Ill. 7. Water Street ship. Port side wales and hull planking. (Drawing author)

### WALE BELT



Ill. 8. Water Street ship. Starboard wales and hull planking. (Drawing author)

On the forward portions of the wales are holes, 2.3 cm. in diameter, which held bolts attaching the cheek pieces to the ship. Similar iron fastenings linked the wales to the deck clamp and lodging knees found within the vessel. The outer surface of the wales are riddled with small, square holes left by disintegrated iron nails.

Erosion and loss of wood due largely to marine borer damage are found throughout the wale belt. The damage increases in severity towards the lower margin, especially along the edges of the wale segments. The after ends of the wale belts were sawn through during the ship's excavation.

#### Lower Hull Planking

Ten planks were removed from the better-preserved port side of the vessel's quick works while only portions of eight or nine starboard strakes have been identified. The strakes of the quick works broaden as they approach the juncture of the wales and stempost, ranging in breadth from 24 to 28 cm. The strakes average 5 to 6 cm. thick, although individual points may exceed this range by more than half a centimeter. The planks below the wales have their hooding ends cut at rather sharp angles. These lower planks may be divided into two groups: those which have their ends rabbeted into the stempost and those whose ends terminate at the wale. The two groups are differentiated mainly by the direction of their nib ends; also the stempost-rabbeted planks have a caulking bevel cut into the outer face of the

nib end while the wale-abutting strake ends are beveled on their interior faces. The excavation did not expose or recover the lowermost strakes, including the garboards.

Without exception, the interior face of each of the quick works' strakes are charred. The outer faces of the planks are riddled with small square iron nail holes. Their outer faces preserve traces of a layer of hair or hair felting and yellowish mastic, with the occasional fragment of sheathing board still attached at the time of excavation (see: Sheathing, below).

#### Upper Hull Planking

Only two or three outer hull strakes remain from either side of the Water Street ship's dead works (ills. 7, 8, pp. 20, 21). While the breadths of the dead works' planks are similar to those of the lower hull, they average about a centimeter thinner. The strake immediately above the main wale belt is tapered from a maximum thickness of 6.5 cm. where it meets the wale to under 5 cm. at its upper edge. The strakes of the dead works all sweep into the stempost rabbet nearly perpendicularly, and therefore have fairly square-cut hooding ends. Although the upper hull was sheathed with planks (see: Sheathing, below), no traces of hair and mastic were found on them.

#### Ceiling Planking

The internal hull planking, like the outer planking, may be divided into two general areas: the strakes above

the main deck, and those which cover the frames in the lower hull. Although the strakes in both areas were well fitted, there was no evidence of caulking.

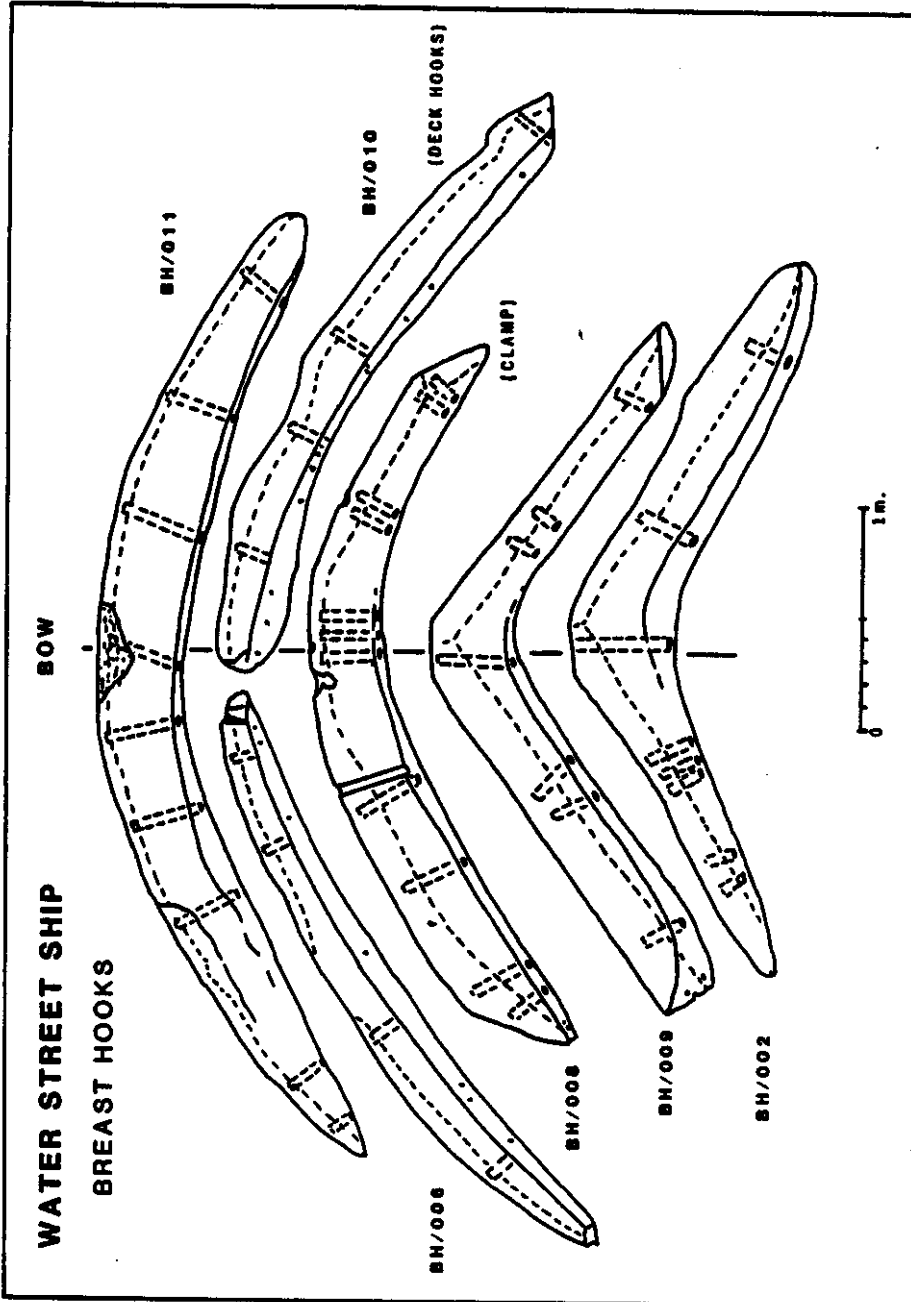
The planks of the lower ceiling narrow as the floor rises and the hold narrows towards the bow. They average 15 to 25 cm. wide, and 3.5 to 5.0 cm. thick. The forward ends of the lower ceiling planks were eroded when found. The salvage techniques employed resulted in extensive damage to most of the lower ceiling planks.

The upper ceiling planks are virtually parallel-sided. Their breadths range between 20 and 30 cm., but are about 0.5 cm. thinner than the lower ceiling strakes.

Each ceiling plank is fastened to the framing with an iron nail and a treenail driven into most of the frame components it crosses. However, many of the treenails intersect the seams between the ceiling planks.

#### Breast Hooks

Five large breast hooks were preserved in the ship (ill. 9). The uppermost hook (EK/001, not shown) corresponded with the approximate upper margin of the preserved portion of the vessel and exhibits heavy deterioration and loss of wood. The second hook (BH/010) is a gently curving timber 4.27 m. long. Below that, another curved breast hook (BH/008) bridged the gap between, and secured the ends of, the port and starboard lower deck clamps. The lowest two hooks (BH/002, BH/009) are angular,



Ill. 9. Water Street ship. The breast and deck hooks. The uppermost hook (Ek/001) is not shown. (Drawing author)

exhibit a reverse curve where they fit into the hollows of the lower bow.

There are two additional differences between the lower two hooks and their upper counterparts. While the three upper breast hooks were installed horizontally, the lower two had their arms canted upwards to some extent. Also, the lower two hooks were not installed until after the hull planking had been attached, resulting in each hook lying across several runs of ceiling planking.

With the possible exception of the eroded and fragmentary EK/001, each hook was attached to the stem with a single iron fastener, 2.5 to 3.7 cm. in diameter, and to the sides of the vessel with two additional iron bolts and a pair of treenails in each arm. Additionally, a few square iron nail shaft holes are found in the feathered tips of the hooks' arms. Treenails fastening the hull planks penetrated the outboard faces of the three upper hooks.

#### Mast Steps

Two steps were removed from the forward area of the vessel. Both were fished out of the mud from an area slightly aft of the balance of the recovered material; therefore their original positions can only be estimated.

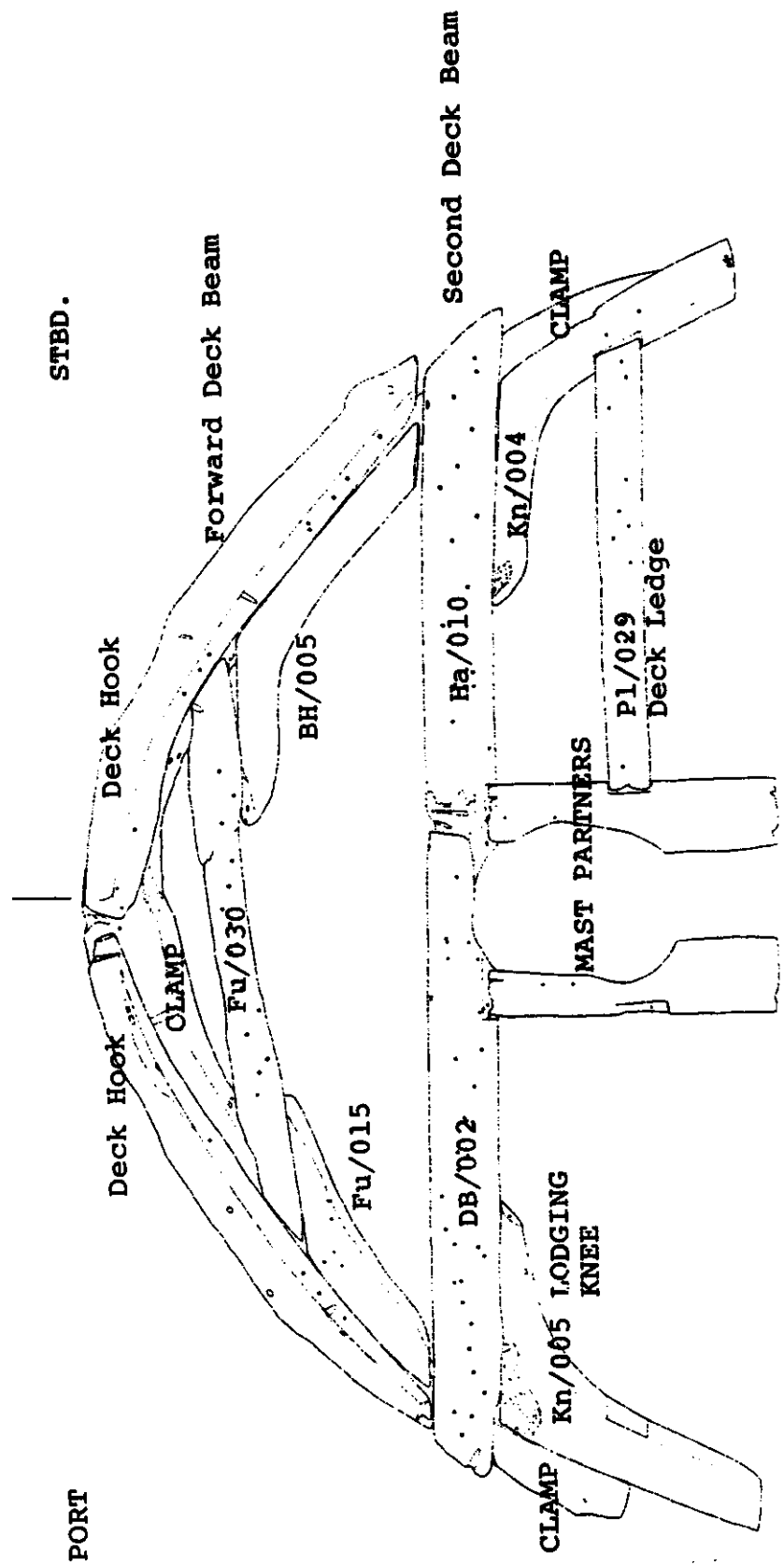
The first (MS/001) probably rested on the the other as would a saddle, with its long axis lying approximately athwartships. It is 1.95 m. long, 40 cm. wide, and up to 35 cm. thick. Its most noticeable feature is a large, square

mortise, 19 cm. x 22.5 cm., cut into its center to a depth of 11.5 cm. The step was fixed in place by an assortment of iron fastenings.

The lower step (SK/002 /006) extended aftward into the baulk wall separating the bow excavation area from the balance of the vessel. To facilitate the step's removal, the after end of the timber was sawn off at the baulk wall, producing a fragment about 1.45 m. long and 22 cm. thick. The step is approximately 30 cm. wide at its forward end, but broadens to about 68 cm. towards its after end, where it is apparent that it was beginning to bifurcate. The step has a rectangular mortise, 18.5 cm. x 35 cm., cut lengthwise in its upper surface to a depth of 18 cm. at its forward end and 13 cm. at the mortise's after end. A longitudinal split in the step is washed out, with a loss of material.

#### Deck Clamps

Broad, thick timbers which both supported the deck beams and acted as internal wales were laid up aft to fore throughout the length of the vessel (ill. 10). Their forward ends were overlapped by, and secured to, a breast hook (BH/008). The clamps (port: WW/001; stbd.: BH/007) are sided at 37 cm., and their moulded dimensions average 20 to 22 cm. They were secured by means of iron bolts, 2.5 cm. in diameter, which passed through the frames and corresponding wales on the outside of the ship. Each clamp is notched 8-15 cm. deep along its upper margin to receive the



Ill. 10. Water Street ship. Deck supports. (Drawing author)

dove-tailed ends of the major deck beams. Additional iron-stained holes are found where the deck beam lodging knees were attached to the vessel with long bolts.

#### Deck Hooks

A pair of long, curved timbers met near the stem (ill. 9, p. 25). The port timber (BH/006), which lost some wood to erosion at its inboard end, is now approximately 2.91 m. long, moulded at 25 cm., and sided at 22 cm. The starboard timber (BH/010) is slightly shorter (2.85 m.), but somewhat heavier, being moulded at approximately 30 cm. and sided at 26 cm. Each timber is attached to the vessel with three iron bolts, 2.5 cm. in diameter, one of which secured each end of the first deck beam and its associated knee. At least 15 treenails, used to affix the hull planking, also penetrate the timbers.

The foremost ends of the deck planks are supported by, and nailed into, an approximately 8 cm. square rabbet cut into the upper inboard edge of these deck hooks. A yellowish, mastic material was found in the rabbet and the upper surfaces of the timbers. This same substance was found along the seams of the deck planks.

#### Deck Beams

Two deck beams were recovered (ill. 10 and ill. p. 18). The forwardmost one (FU/030) is 3.15 m. long and was originally 22.5 cm. broad and 23 cm. deep, but the now bowed timber is severely eroded. Square iron nail holes are still

present in its upper surface. Each of its ends abutted a deck hook (see: Deck Hooks, infra), to which they were attached by means of a lodging knee (see: Deck Knees, infra) affixed to the beam's after side.

The second beam (DB/001, HA/010) is more typical of those recovered from the balance of the vessel in that the undersides of its ends were fashioned into dovetails which fit into the deck clamp notches. The beam was chopped in two when the vessel was interred, but was originally 5.28 m. long. The beam is 33 cm. broad and 28 cm. deep near its starboard end and tapers to 26.5 cm. broad and 23.5 cm. deep at the other. The taper represents the natural shape of the log from which the beam was hewn. The grain of the timber largely follows the arch (camber) of the beam.

In the beam's middle, where it was chopped, there is a shallow curve cut into the after side of the beam. Approximately 65 cm. across and 10 cm. deep, it lay above the presumed position of the foremast step. On either side of the shallow curve, sloping notches, at least 25 to 30 cm. wide and 6 to 7 cm. fore-and-aft, are let 5 cm. into the after edge of the second deck beam's upper surface. These notches held the foremast partners (see: Mast Partners, below) in place. Two pairs of 2.4 to 2.8 cm. dia. holes are drilled fore-and-aft through the beam at approximately the same location as the mast partners. These marked the

position of vertical bitts attached to the front of the beam. Similarly oriented iron-stained holes found near the ends of both beams held the bolts securing the beams' lodging knees.

#### Lodging Knees

Horizontal knees are found aft of either end of the deck beams (ill. 10, p. 28). In all cases the baulk arm of each knee was fastened to the side of the vessel with iron bolts while the lighter branch arm was fastened to its deck beam with similar bolts.

The knees of the forward beam are quite different in length, but both are approximately 18 cm. thick across the breech. Only the port knee (Fu/015) had one bolt attaching it to the forward deck beam; the starboard knee (BH/005), like the others in the ship, was fastened to its deck beam with a pair of bolts.

The second pair of lodging knees is about 21.5 cm. thick across the breech, but the port knee's (Kn/005) baulk arm is much stouter than that of the starboard (Kn/004). Square-cut notches 21 cm. wide are found about half way along the upper, inboard margin of their baulk arms. These 7 cm.-deep notches held deck ledges (see: Deck Ledges, infra) which spanned the gap between the knees and the mast partners or carlings.

### Mast Partners/Carlings

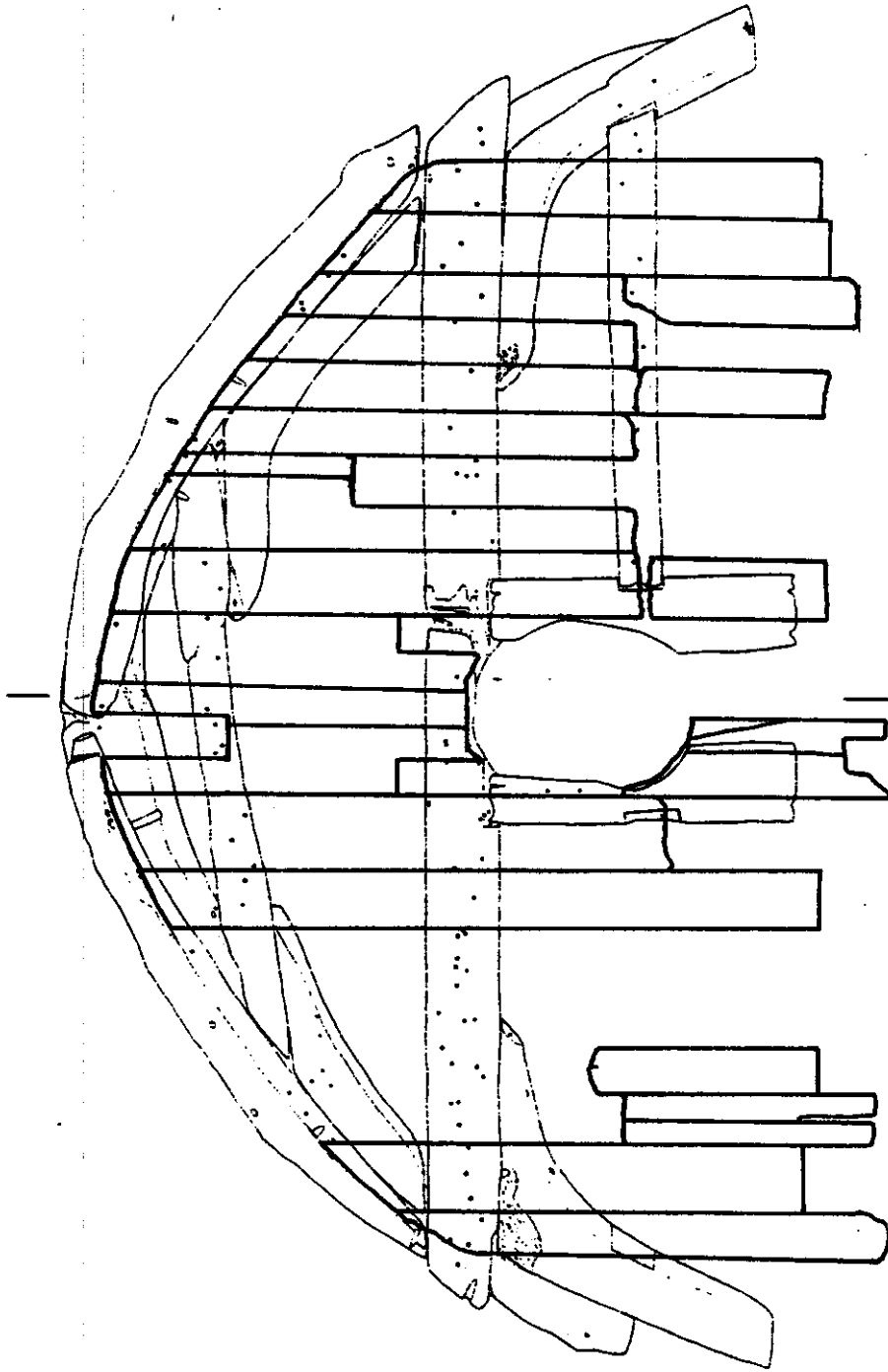
Two planks (port: DB/001; stbd.: PL/038), each 1.3 m. long, 55 cm. wide, and 5.5 to 7.0 cm. thick were nailed into sloping notches cut into the aftermost portion of the top margin of the main deck beam (ill. 10, p. 28). The last 5 cm. of the undersides of their ends are beveled. The partners are separated from one another by a gap that had become enlarged and rounded due to damage incurred prior to their excavation. The deck ledges (see: Deck Ledges, below) sat in sloping notches cut near the center of the partners' outer margins.

### Deck Ledges

One ledge (Pl/029) was recovered (ill. 10, p. 28). It is 2.05 m. long, 20 cm. broad and 5.0 to 7.0 cm. thick. The ledge's outboard end is cut vertically, but angles inboard to the fore, while its inboard end is cut squarely fore-and-aft but beveled under for a distance of 5 cm. Its upper face is marked by the square holes left by the decking's nails.

### Deck Planks

The majority of the deck planking is of fir or similar softwood (ill. 11). The planks average 25 to 30 cm. broad and 4.5 to 7 cm. thick. Most of the long planks were sawn free of the ship during excavation. In general, the planks ran parallel to the keel, their forward lengths "nibbed" where the vessel narrowed towards the fore. A single



Ill. 11. Water Street ship. Deck planking. (Drawing author)

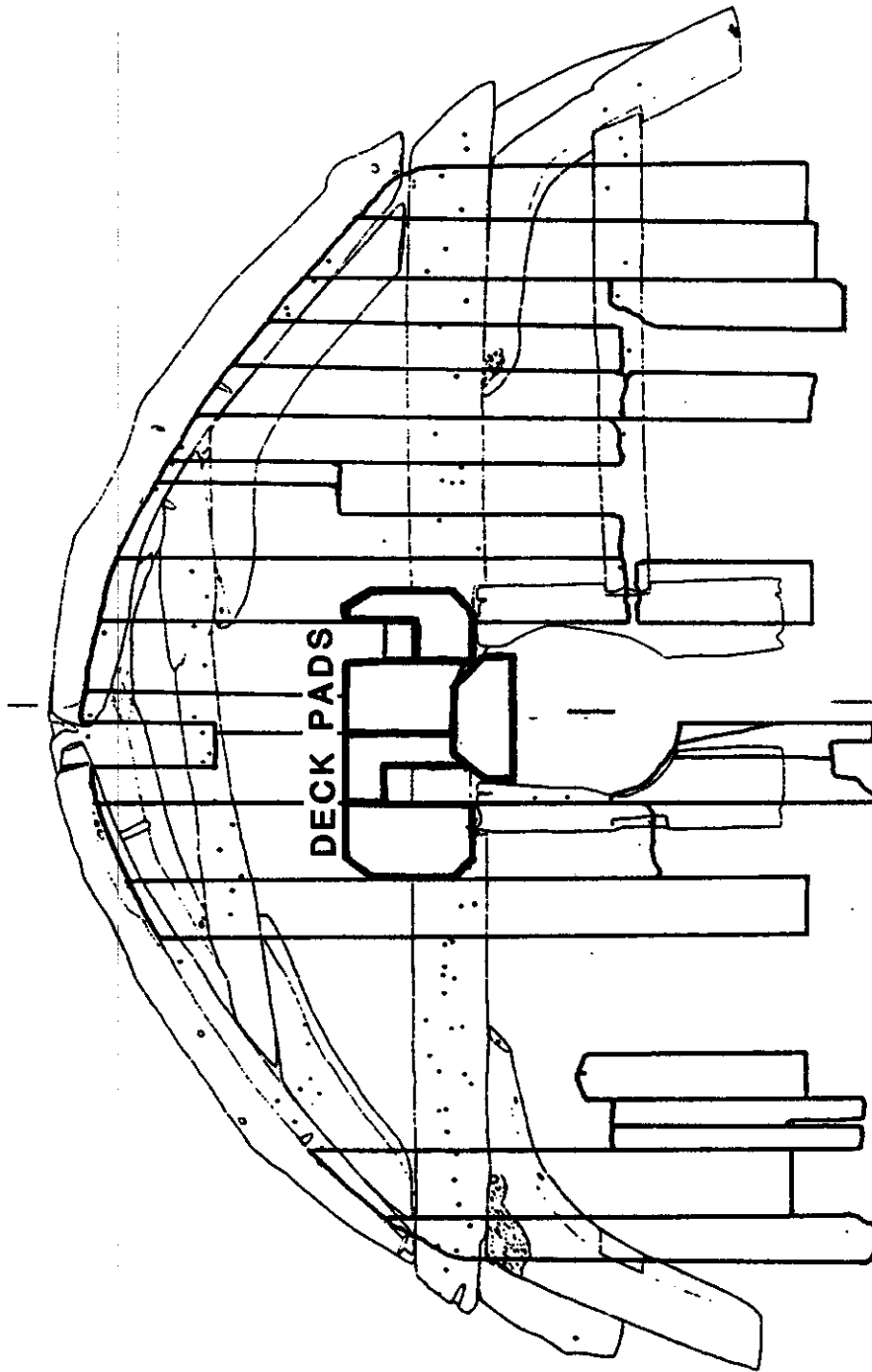
caulking bevel is located along the upper one-third to one-half of each plank's outboard edge, and traces of yellowish mastic material were found in and around many of the seams. Two, or occasionally three, square iron nails affixed each plank to each support it crossed. The nails' heads were recessed below the surface of the planks in square mortises cut 1 cm. deep and about 2.5 to 3.0 cm. across.

Because the decking was crushed against the inside of the vessel's hull by tons of filling material, the planks are curved and cracked where they bent over the supporting structures. The planks' upper surfaces are smoothed, but their lower surfaces still show irregular marks of large, hand-powered saws. The edges of the planks also show sawing marks except where the above-mentioned caulking bevel has been cut.

No waterway has been identified among the salvaged bow timbers.

#### Deck Pads

Where the deck was pierced by mast, bits, or other structures, the decking within a distance of 15 to 20 cm. of the members was covered with a second layer of planking of equal thickness (ill. 12). The edges and corners of the doubling planks are rounded. This second layer was fastened with iron nails in a manner identical to that of the deck.



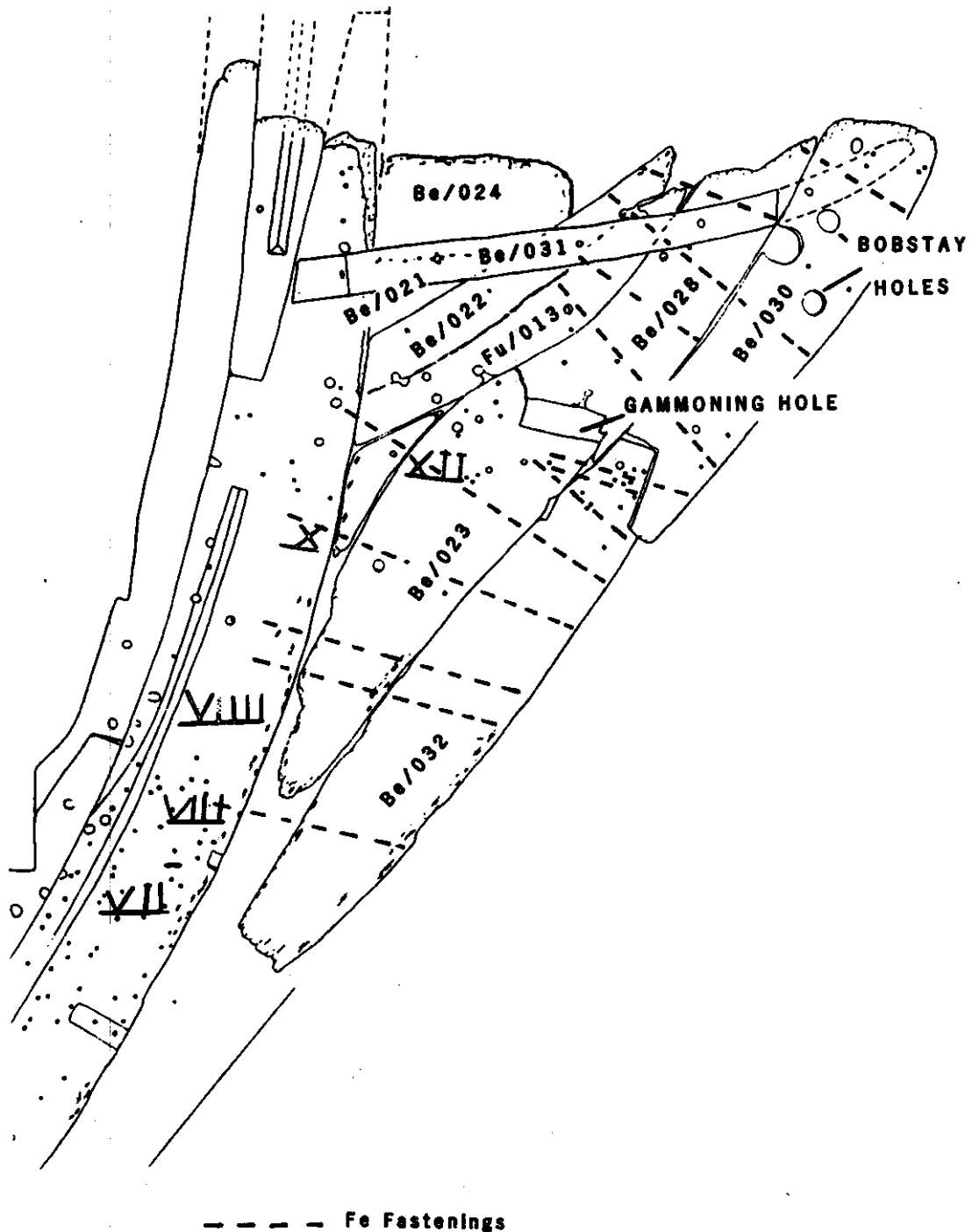
Ill. 12. Water Street ship. Deck pads around bitts and mast. (Drawing author)

### The Knee of the Head

The knee of the head originally was comprised of five or six large timbers fastened edge-to-edge with a series of through- or drift-bolts 2.5 cm. in diameter (ill. 13). Spaces between the large timbers and the stem were filled with smaller chocks of wood. The structure narrows forward from a sided dimension of 25 cm. where it meets the stempost to 17.5 cm. across at its forward edge. The lowermost portion of the structure was not extracted during the excavation. If the heavy marine-borer activity found in the surviving timbers is any evidence, much was probably lost in the eighteenth century. Much of the upper portion of the knee is eroded, only a fragment of the knee's standard remains.

An irregular, transverse hole, 12.5 cm. in diameter and two companion holes, each 7.5 cm. across, are located near the upper forward end of the cutwater. About 2/3 of the way down the surviving structure is the large, rectangular gammoning hole, 27.5 cm. long by 10 cm. high. Aft of and slightly below the gammoning hole, on the knee's starboard face, is carved the Roman numeral XII (see: Lading Marks, *infra*).

Two fastening systems held the knee to the stem. The first was a series of iron fasteners, 2.5 cm. in diameter, driven through the assembled knee structure and into the stem. The second system provided lateral support through



Ill. 13. Water Street ship. The knee of the head.  
 (Drawing author)

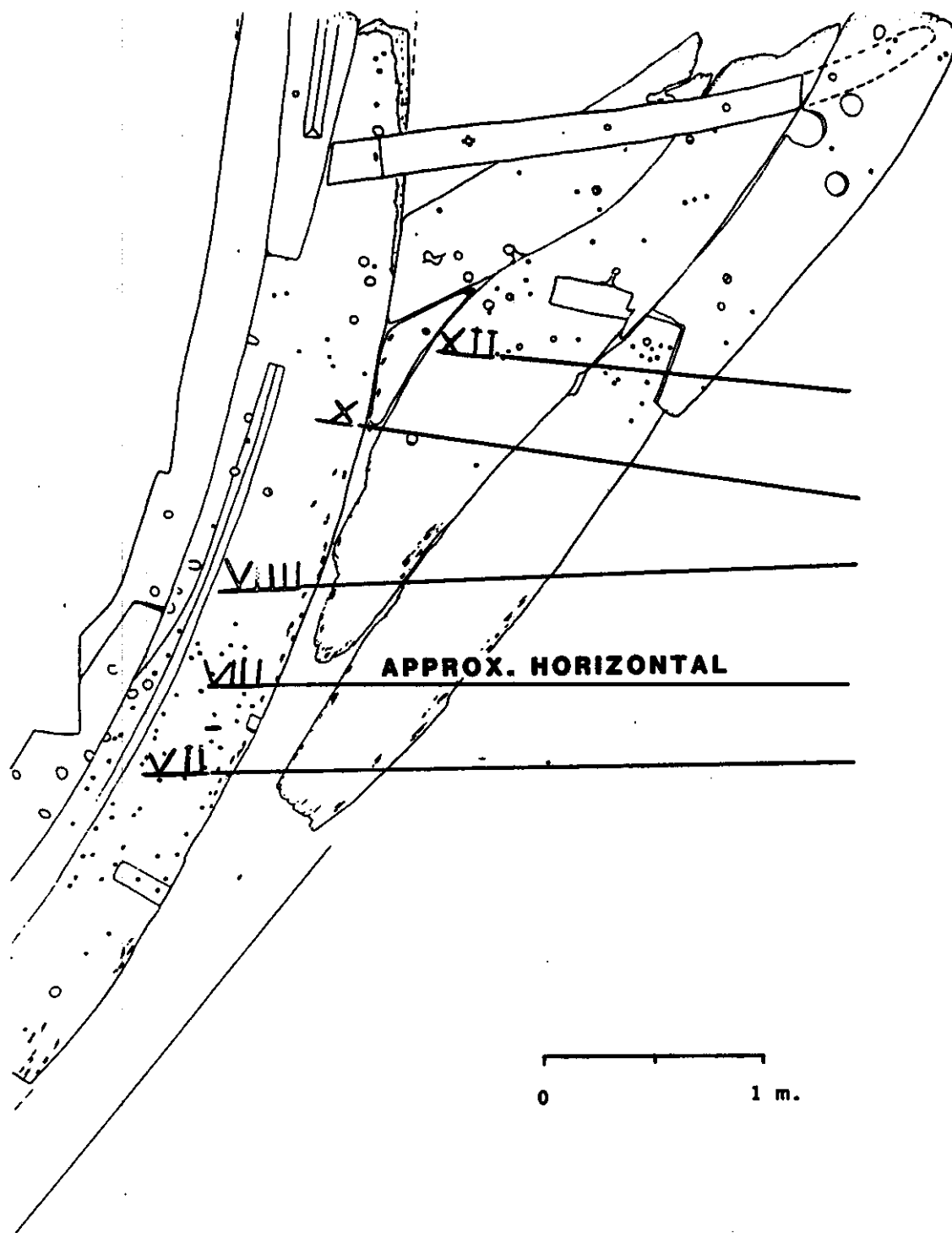
pairs of slim, horizontal knees, called "cheek pieces." At least three iron bolts secured one arm of each cheek piece to the knee, while a similar number secured the other to the hull.

Additional lateral holes, about 3.2 cm. in diameter, were found plugged with treenails. The gammoning piece is broken in two along the grain near the gammoning hole, and the split is washed out. Numerous lateral iron nail holes are found in the region surrounding the gammoning hole.

The entire port and starboard faces of both the knee and stempost were sheathed with 7.5 cm. thick planks, nailed over a layer of hair bound with a yellowish, mastic substance (see: Sheathing, infra). The sheathing planks were fitted around the cheek pieces and pierced by three large, round holes mentioned previously. No sheathing boards were recovered below the second pair of cheek pieces, although nail holes and traces of yellowish mastic remain. Many nail holes are also present in the forward edge of the knee.

#### Lading Marks

A series of Roman numerals are incised into the starboard face of the stem and knee of the head; they occupy the middle 1/3 of the preserved height of the vessel (ill. 14). The numerals are sequentially arranged in ascending order from VII to XII, with the numeral nine carved as "VIII." Each numeral is nearly vertical, and aligned



**BOTTOM OF THE KEEL BASED ON AVERAGED LADING MARKS**

**Ill. 14. Water Street ship. Lading marks. (Drawing author)**

slightly forward of the one below it. Approximately half-way between VII and VIII is found a 5 cm.-long horizontal line. The numerals range in height from 8.5 cm. to 11.5 cm. and are composed of rudely gouged V-shaped channels approximately 1 cm. wide and 0.5 cm. deep. The marks lie in wood which is heavily eroded, the I in XI is lacking and the entire numeral X is obliterated. The placement and orientation of numeral XII is based upon my reconstruction for the knee of the head.

#### Sheathing

The preserved portion of the vessel's outer hull was sheathed with boards held in place with square iron nails averaging 1.0 to 1.5 cm. across the shaft, with heads as much as 2.5 cm. in diameter. Severe erosion precludes an accurate description of the boards sheathing the hull planking from the wales downward. The laboratory drawings of the lower hull planking indicate a maximum nail pattern density of 10 to 20 nails per square meter. From the wales downward, the hull maintains traces of a thin, irregular layer of hair or felt, bonded with some yellowish or brown mastic substance.

The boards covering the dead works range in breadth from 14 to 29 cm. and 3.1 to 4.1 cm. in thickness, except for one which I believe came from immediately above the wale. That board (Un/022) tapers from a maximum of 4.7 cm. just above the wale to only 1.6 cm. along its upper edge.

Iron nails 0.9 to 1.9 cm. square were spaced near the edges of the boards at 20 to 40 cm. intervals. Broadaxe cuts running perpendicularly to the grain (kerfing) are found on the interior faces of some of the boards. No traces of hair or mastic are found on the upper sheathing boards.

The 5.0 to 7.5 cm.-thick planks sheathing the sides of the stempost and knee of the head were nailed over a layer of hair felting and yellowish mastic in a manner similar to that of the hull's sheathing. The uppermost pair of planks from either side ranged up to 34.5 cm. in breadth and were fitted around the cheek pieces and rigging holes.

#### Fastenings

The Water Street ship was held together by three types of fastenings: iron bolts, iron nails, and treenails.

For the most part, when the vessel was uncovered, the wooden treenails were found sound and quite effective in holding components together. The fragments remaining in the components after the bow's initial disassembly were removed, often with great difficulty, by the personnel of the Groton, Massachusetts, conservation laboratory. The iron fastenings, on the other hand, with the exception of one bolt and two or three additional fragments, had disintegrated prior to the excavation. Some rust- and carbon sludge-filled concretions were found, but proved fragile and did not survive the excavation. Therefore, the specifications of the iron fastenings from the Water Street ship have been determined

through measurement of empty shaft holes and head impressions.

Major structural components, that is, components such as the keel, stempost, apron, floor timbers and futtocks, deck supports, wales, and so on, were attached to one another by means of bolts.

All of the iron bolts seem to have been between 2.3 cm. and 2.9 cm. in diameter, and exhibit little detectable taper. Where head impressions remain, it would appear that 2 cm. more than the shaft diameter was the common head size, although the extremes of range may exceed that by as much as  $\pm 0.2$  cm. Sometimes, just below the bolt head impression, the shaft hole is square in section. It is not known if this is due to the bolt's having been beaten from square stock or a result of the head-fashioning process.

The deck planks and the sheathing boards were fastened exclusively with iron nails.

The iron nails used throughout the vessel were forged between 1.9 and 2.5 cm. square in section just below the head. The head impressions are 2.9 to 3.6 cm. in diameter, are generally of a shape somewhat between square and round, and are often quite irregular. A few centimeters below their heads the nails begin to taper, keeping their square sections. The lengths of the nails have not been determined with any precision, but most seem to fall between 20 and 30 cm.

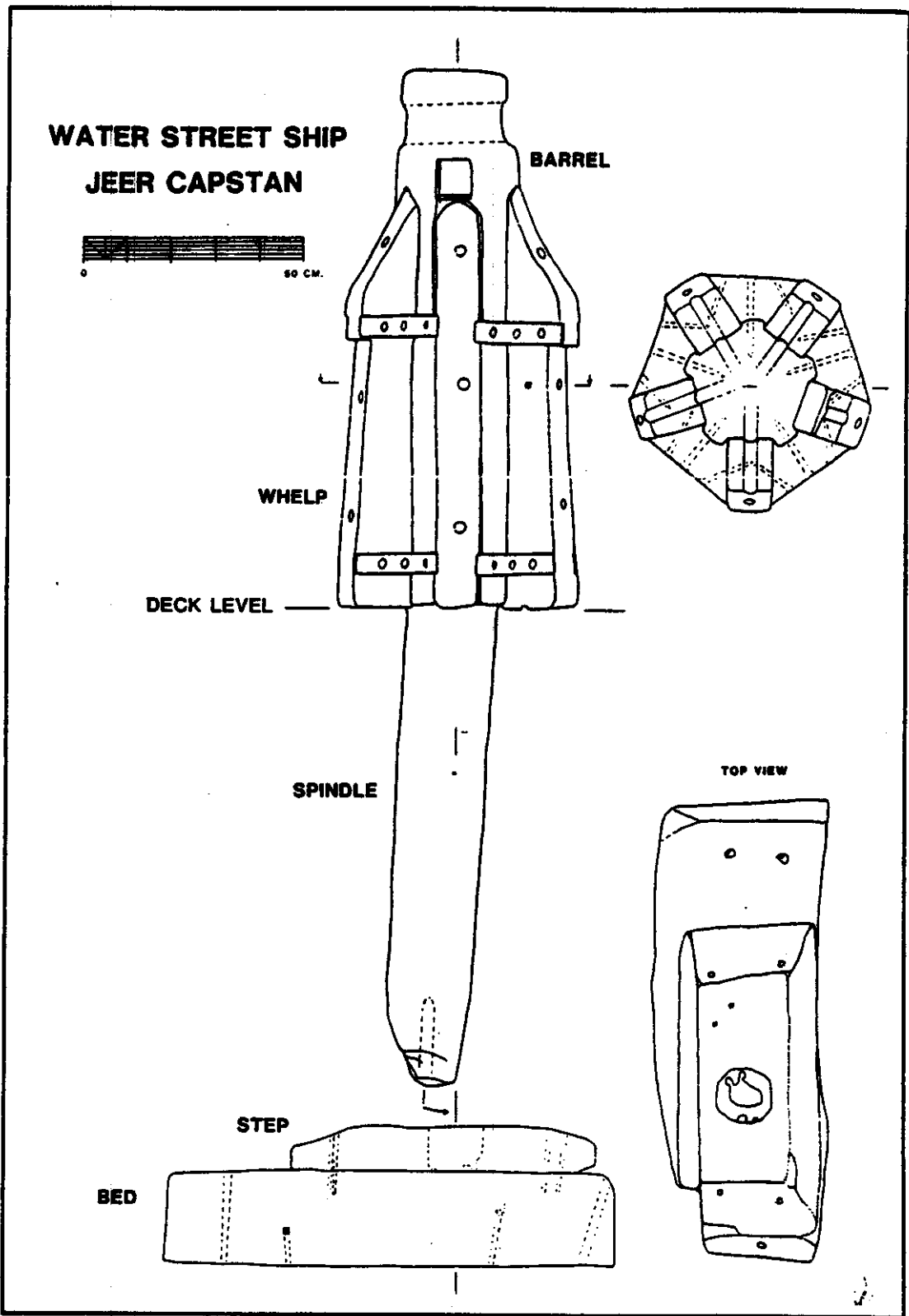
A 55:45 ratio of wooden to iron nails was used to attach the hull and ceiling planks to the frames. The treenails were shaved to a faceted surface from a variety of woods. They averaged close to 3.3 cm.  $\pm$  0.2 cm. in diameter. Some special-purpose treenails exceed this range by as much as 0.5 cm., an example being the treenails holding the breast hooks to the bow. Most pierced both the inner and outer hull planks, for an average length of 25 to 30 cm.

Occasionally, a wedge or two of caulking material or, more rarely, a small wooden wedge was forced into a treenail's end. Caulking was often found forced in around the outboard ends of the treenails (see: Sheathing, supra, for a description of the caulking material).

#### The Jeer Capstan and Step

A capstan was found collapsed in the forward area of the vessel (ill. 15). Although, like the pump and mast fragments described below, it lies outside the strict confines of this thesis, its rarity makes it significant and worthy of examination.

The capstan's overall length is 2.31 m. divided approximately in half between the barrel and the spindle, all of which is cut from a single length of fir or other softwood. Radiating from the barrel are five vertical whelps, braced by two rows of chocks. The capstan is relatively intact, with the exceptions that the barrel and



Ill. 15. Water Street ship. Jeer capstan. (Drawing author)

spindle are bent about  $5^{\circ}$  out of line, seven of the chocks are missing, and the lower end of the spindle is eroded.

The 71.5 cm.-long barrel is 21.5 cm. wide at the head and broadens to a maximum of 30 cm. at the bottom. Centered at 12 and 25 cm. from the top of the barrel are two 8.6 cm. square holes cut through the head of the barrel at right angles to each other; the lower hole cuts through the tops of three of the whelps. The whelps and chocks seat in corresponding rabbets cut about 1 cm. into the barrel.

The whelps are less than 95 cm. long, and 10.0 to 12.25 cm. thick. They have a profile similar to half of an arrow, and reach a maximum depth of 15 cm. at their bottoms and just above a narrow throat, called a stop, located about  $\frac{2}{3}$  of the way up the piece. The five whelps are attached to the barrel both directly and indirectly; treenails, 2.7 cm. in diameter, pierce the whelps at approximately  $\frac{1}{4}$  and half-way up each whelp, while a square iron nail held the upper  $\frac{1}{4}$  of the whelp. The lower row of chocks is centered 10 cm. from the bottom of the barrel, the upper row at the height of the stop of the whelps. Each 5-cm.-thick chock had a single iron nail driven directly into the barrel, as well as an iron nail toed into each adjacent whelp.

Where it begins just below the barrel, the spindle is 25 cm. wide. It tapers to less than 17 cm. across at its lower extremity, but the end is badly eroded. Centrally located in the bottom of the spindle is a longitudinal hole,

3 cm. square and at least 18 cm. deep.

Except for a vertical rabbet cut into one corner, the capstan step is rectangular, 71.5 cm. long, 32.5 cm. wide, 10 cm. thick, its edges beveled to about half that thickness. The flat upper surface is approximately 47.5 cm. by 20 cm. In the middle of the flat area is a vertical hole, 13 cm. in diameter, penetrating most of the way through. As recovered, the hole was filled with iron concretion. What may be the positions of three or more fastenings was revealed after the mass was cleaned away.

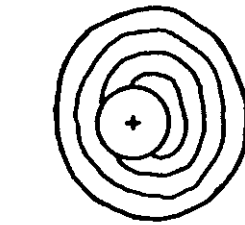
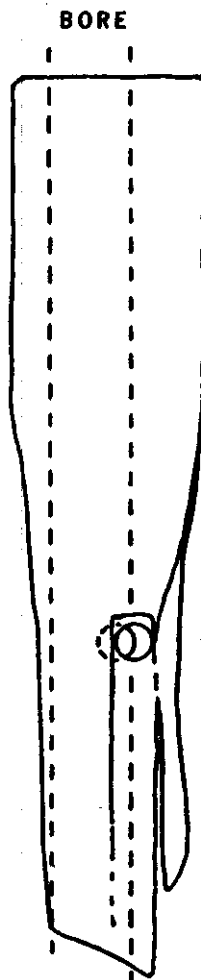
Four iron fastenings secured the step to a heavy bed. The bed is rectangular, and much larger than the step, being 1.02 m. long, 40 cm. wide, and 22 cm. thick. Cuttings in one corner of the bed correspond to a similar cut in the step. In addition to the four fastenings which pass through it from the capstan step, the bed is pierced by a single vertical treenail at one end and two bolts at its opposite end. Single iron nails were toed in on each of the long sides of the bed; they emerged through the bed's bottom.

#### Pump Stock Fragment

The head of a ship's pump was recovered from the hold of the vessel (ill. 16, fig. 1). It is not certain if the fragment belongs to this vessel or if it is contemporaneous trash dumped from near-by shipyards.

The fragment is 1.52 m. long, broken and chopped at its lower end. Octagonal in section, but slightly flattened, it

Fig. 1



BP/004

OUTFLOW

0 0.5m.

MM/001

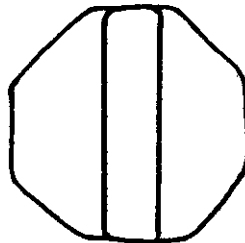
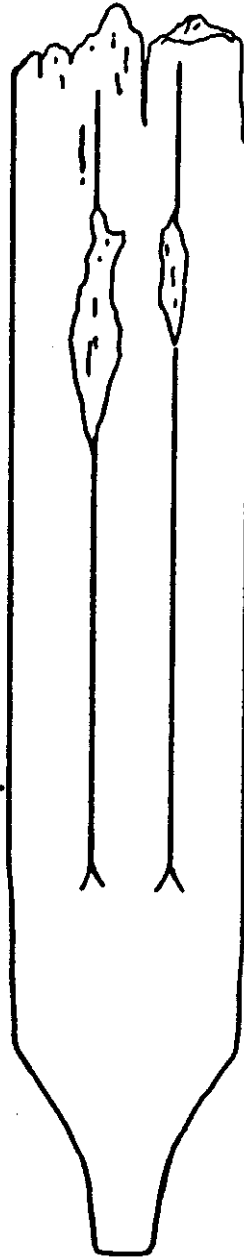


Fig. 2



Ill. 16. Water Street ship. Pump and mast fragments.  
(Drawing author)

has a maximum width of 37.5 cm. with a bore hole 12.5 to 13 cm. in diameter. An outflow hole, 5.8 cm. in diameter, is located at the bottom of a mortice 7.5 cm.-square, which is in turn centered 97.5 cm. from the top of the pump fragment. The pump stock was cut from fir or some other fine-grained softwood and is still bouyant.

The most notable detail of the fragment is the extent to which the bore hole is off-center, causing the wall of the tube to vary between 8.0 and 16 cm. thick at the stock's upper edge.

#### Mizzen Mast Fragment

A 2.26 meter-long fragment comprising the lower end of a mast was recovered from the rubble filling the vessel near the hold's after end (ill. 16, fig. 2, p. 47).

The octagonally-sectioned stub was chopped and broken short at its upper end, but is otherwise well preserved. The stub's maximum diameter is approximately 40 cm., but it is only 36 cm. across the flats.

The lower 36 cm. of the mast is hewn down, terminating at the heel in an 11.5 cm. wide tenon running the entire width between two opposite flats. The tenon broadens to 15 cm. at a point 17.5 cm. from its end, then smoothly broadens to the full diameter of the mast over the following 18 cm.

The mast was cut from a log of fir or some other softwood, and maintains its ability to float.

## CONSTRUCTION ANALYSIS

## The Stem

The stempost of the Water Street ship is composed of two pieces, flat-scarphed together. Although a stempost made from smaller timbers was recognized as inferior to one cut from a single timber, the practice was accepted.<sup>6</sup> William Sutherland's further caution: "... it ought not to be piec'd, especially in the Wake of the Rabbits: ...,"<sup>7</sup> is followed, and the scarph was placed across the rabbetless flats from which the wales spring.

It will be noted that the stempost's moulded dimension diminishes from bottom to top, making it difficult to compare its scantlings with those in the literature of the day. Sutherland, in 1717, provided the information that a stempost for a vessel of 250 Tuns should measure 11 in. x 11 in. (28 cm. x 28 cm.).<sup>8</sup> Mungo Murray's work of 1765 states that a vessel of 200 Tuns should have a stempost moulded below at 11.5 in. (29 cm.) and moulded above at 15 in. (38 cm.), and that a vessel of 300 Tuns should have its stempost moulded at 12 in. (30.5 cm.) below and 16 in. (40.5 cm.) above.<sup>9</sup> Although the table of scantlings presented by Murray isn't specific on the matter, I must suppose the sided dimension of the stempost is equal to the keel's.<sup>10</sup>

The scarph attaching the stempost to the keel was damaged during salvage. The remainder of the scarph is too

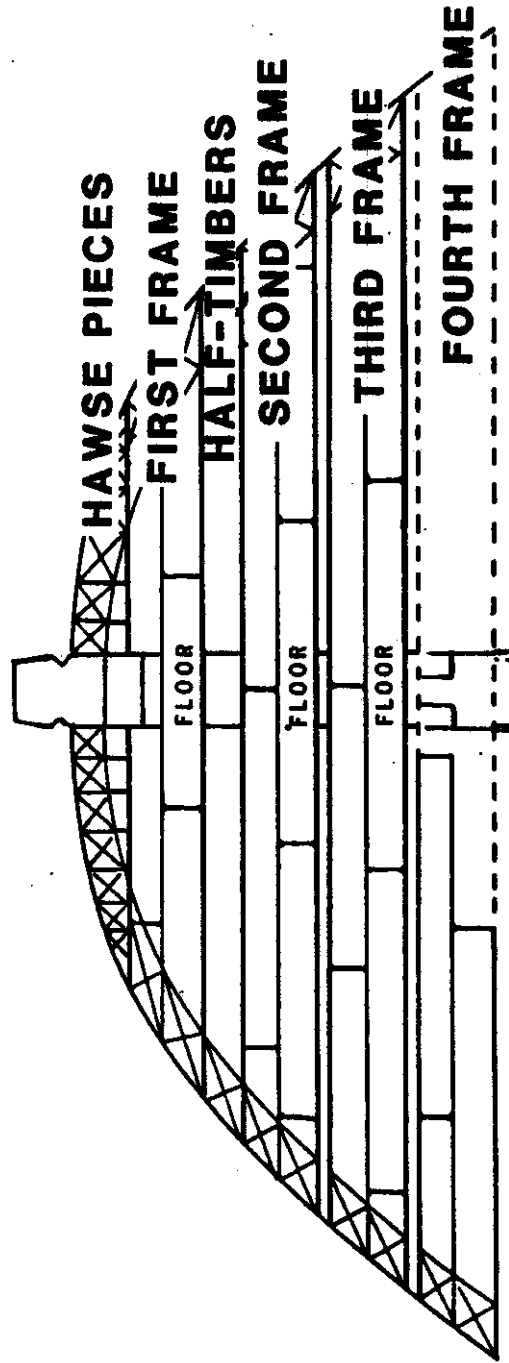
small to allow one to authoritatively state if it is either a flat- or hook-scarph, although the scarph between the upper and lower stemposts is flat.

The aproning of the stem is as wide as the stempost. Although I have found no exact parallel for this type of aproning, it seems to be contrary to the English tradition throughout the eighteenth century. In 1717, Sutherland noted that a ship was "... to have a false Stem or Apron of the inside on the main Stem, half the thickness of the main Stem, and twice the breadth...",<sup>11</sup> while YO88, the small vessel lost with Cornwallis's fleet at Yorktown in 1783, features a shallow apron twice the width of its stempost.<sup>12</sup>

#### The Framing

The frames of the Water Street ship are solidly built from a double row of timbers overlapped and fastened fore-and-aft (ills. 3-6, pp. 12-15, and ill. 17). The space between the frames is less than half the frame's room; in other words, much less than the sided dimension of the floors or futtocks. The fastenings of the frame components must therefore be more than twice as long as the space between the frames, requiring the ship's frames either to have been assembled prior to installation or constructed sequentially from the master couple to the ends of the vessel.

The frames are built up by overlapping individual futtocks and the floors. Mungo Murray was the first English



Ill. 17. Water Street ship. Overhead schematic of frames. (Drawing author)

author to publish a description of frames built solidly with double rows of timber:

...they [the frames] are in several pieces; the head of the lower piece being cut square to join the heel of the next above it: And in order to support these joinings, another sett [sic] of pieces are cut, and joined together in such a manner, that... the joinings in one sett, would be nearly against the middle of the pieces in the other sett.<sup>13</sup>

Previously, authors published works indicating a large gap between the butt ends of the ground futtocks or between the heads of the floors and the second futtocks.<sup>14</sup>

Recommendations made in 1719 for improving ventilation and passage of water in the bilges include the separation of the first futtocks from one another, suggesting the common practice was otherwise.<sup>15</sup>

That the frames of the bow are installed nearly vertically rather than canted forward may be significant. The narrowing of the bow resulted in the frames having a thin, diamond-shaped section, a source of structural weakness. This weakness is reflected in the broken futtocks found on the Water Street ship.<sup>16</sup> English military shipyard practice from at least 1719 had been to cant the forward frames, but the practice, according to J.R. Stevens, never gained popularity among merchant ship-builders.<sup>17</sup>

#### The Hawse Pieces

The timbers which fill in the space between the forwardmost frame and the stem begin at approximately the

same height as the main wales. As they were preserved to about the level of the weather deck, their original heights can only be assumed. It is also impossible to determine the height of the hawse holes other than to say that they must have been somewhere above the level of the weather deck.

The six hawse pieces on the Water Street ship are contiguous, but irregular in their widths. This may be at variance with the English practice. A schematic drawing appearing in van Yk (ill. 18) presents a front view of the skeletal members of an English ship's bow.<sup>18</sup> On either side of the stempost lie four hawse pieces, the same number as provided by Sutherland in 1717, where he calls for pieces 6 4/10 in. (16 cm.) broad.<sup>19</sup>

#### The Wales

The main wale of the Water Street ship is a broad belt, three strakes wide. This follows a shipbuilding technique of obscure origin, which gradually grew in popularity until, by the second half of the eighteenth century, it was nearly universal.

William Abell's assessment as to the origin of the wide wale belt is nonspecific: "Between [1711] and 1750 the wales had become a belt of timber worked in four layers of planks, thus in effect filling the space between the two wales with the same thickness of thick stuff...."<sup>20</sup> Brian Lavery's research presents an English Admiralty reference to the practice in 1715, "'The main wales and strakes between them wrought in narrower strakes, all of a thickness,' so



**HOEDANIG DE ENGELSCHER HAARE INHOUTEN  
VOORWAARDS GEREED MAKEN.**

making a single thick portion along the ship's side."<sup>21</sup> Frank Howard, however, states that the first record of it on a new ship dates from 1717, but that it is likely that the practice began in the previous century.<sup>22</sup>

Only the weakest of cases can be made for a seventeenth-century origin for the technique. I have found only two possible representations from that time which might show the feature. One is a crude sketch of a ship in careen found in Ake Raalamb's illustration of a shipyard ca. 1690.<sup>23</sup> The other, even less certainly shown, is a draught of the Danish 110-gun Fredericus Quartus (né Store Christianus Quintus).<sup>24</sup> A seventeenth-century origin for the wide wale belt is also contraindicated by the dearth of evidence for the practice in the early eighteenth century. In 1705, Carol Allard provided us with the Dutch term "Vullingen" for the space between two wales,<sup>25</sup> while Sutherland makes no mention of a belt of adjoining wales in either of the original editions of his works. The earliest unambiguous representation of a multi-strake wale belt is the draught of The Grafton & The Kent, dating from 1721 - 1722.<sup>26</sup> In substance, research into the practice has agreed with R.C. Anderson's 1921 assessment.<sup>27</sup>

Fabrication techniques for the wales are less thoroughly documented. Fincham relates the practice of bending wales to form,<sup>28</sup> but hewing the wale to shape, as is the case of the Water Street ship's wales, is noted in

Sutherland, where he states:

The Wales will require as much Time to work as three Strakes, altho' no thicker than two Strakes in some Ships, and has generally been allowed as two Strakes, but considering that they must be nicely trimmed with the Adze, so that it may be term'd twice wrought....<sup>29</sup>

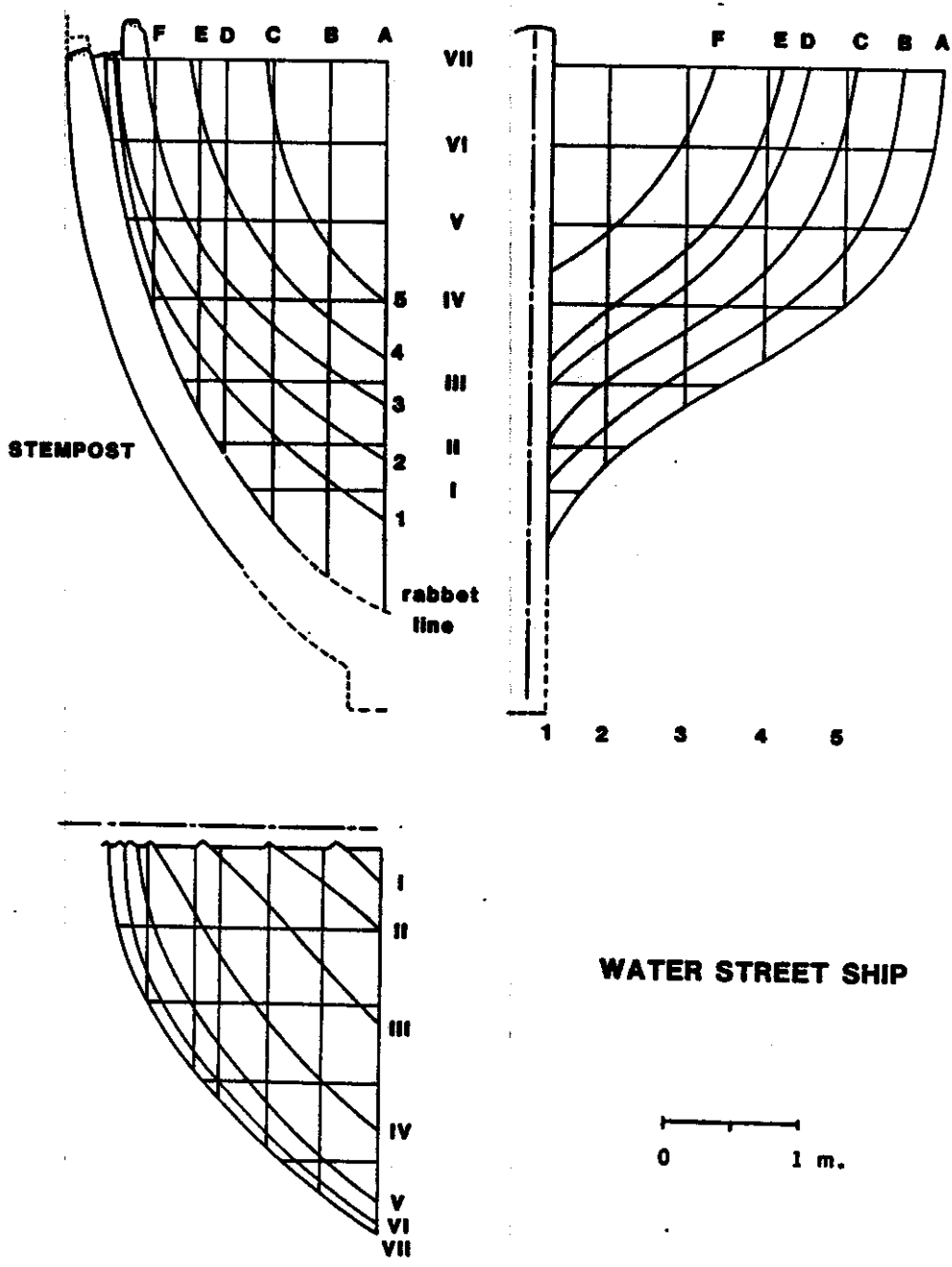
According to Falconer's dictionary of 1780, "harpins" are the thickened portions of the wales at the bows. The Water Street ship's recovered wales are only twice the thickness of the hull planking and, at 4 in. (10 cm.), probably are not thickened at all from their mid-ship's scantlings. They are, in fact, somewhat lighter than the 6 1/2 in. and 6 in. (16.5 cm. and 15 cm.) specifications given for ships of 330 and 220 Tuns by Murray in 1765. The same source recommends the main wale belt to be 30 in. and 26 in. (76 and 66 cm.) broad, respectively.<sup>30</sup>

The shipwright's general disregard for strict symmetry of construction in building the Water Street vessel is amply demonstrated by the construction of the wales. The port belt is 9 cm. higher on the stempost than the starboard, the scarphing of the wales follows no discernable pattern, and the scantlings of the wales vary as much as 2 cm.

#### Planking the Hull

The hull's outboard planking may be divided into two areas: those above and those below the main wale belt.

An examination of the Water Street ship's lower waterlines (ill. 19) shows that portion of the vessel's



Ill. 19. Water Street ship. Lines drawings, port side. (Drawing author)

bows to be hollowed.<sup>31</sup> The difficulty in bending planks to match these complex curves was somewhat mitigated by running the sweep of the planking as a series of parallel diagonals. The planks originating at the stempost continue aft and underneath the turn of the bilge while the higher strakes, the ones which terminate in the wale belt, sweep aft to cover the sides of the hull.

This diagonal plan reduced the actual shape of these lower planks to a single, inward bend, with a slight twist, rather than a sharp "S", or reverse curve. The suitability of this technique for planking full-bowed vessels may be seen in Frederik af Chapman's 1768 draught of a large Cat (ill. 20).<sup>32</sup> Even so, the shipwright employed fire and water as an aid to his efforts.

The carbonized inner surfaces of the lower hull strakes are evidence of a plank-bending process called, logically enough, "charring." The technique is clearly illustrated in Raalamb and in a print by Reinier Nooms (pl. 1, left).<sup>33</sup> Sutherland described the process well:

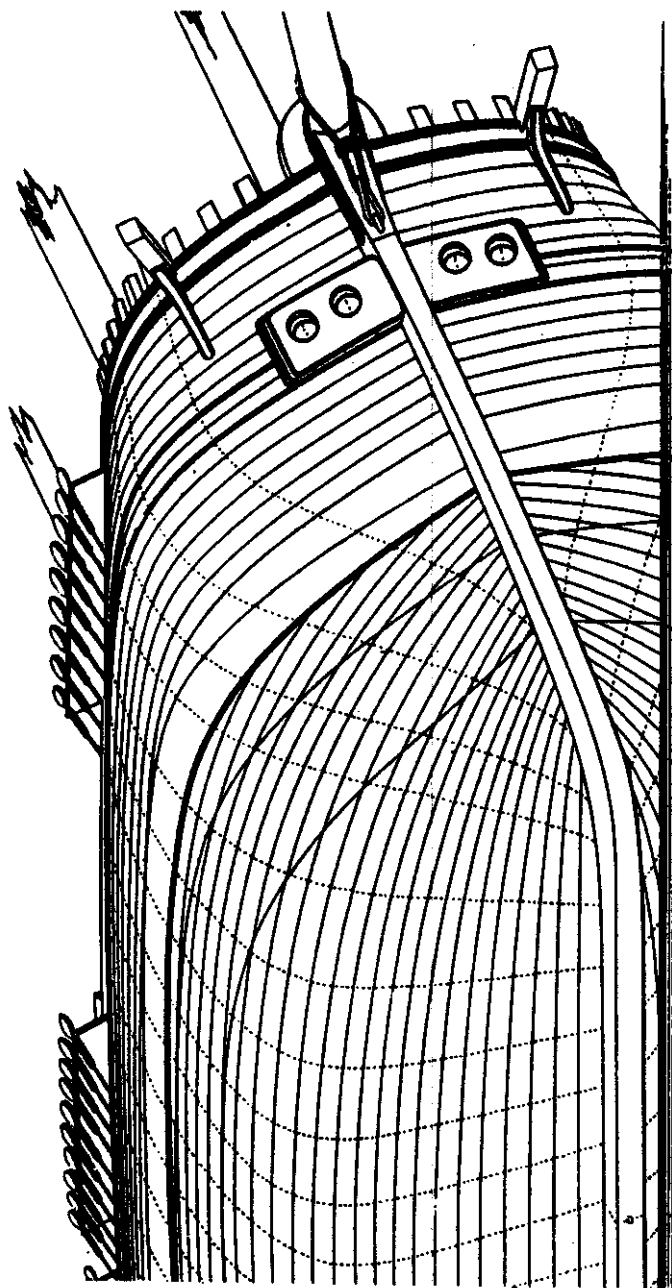
All our fore-most and after-most parts of Shipping in general is very Round, and will require the Plank to be very Round that covers such parts; however such Crookeding is generally forced with Fire and Water: . . . .

First, To choose a Plank that has no Knots or Defects.

Secondly, Let it be an outside Plank, and the ground-end, or butt, put to the greatest Bending.

Thirdly, In Bending, if it be possible, lay the outside of the Plank next to the Fire, that the Water may be applied to that side which is next to the heart of the Tree.

Fourthly, Let the Plank be very even and smooth,



Ill. 20. Lower hull planking as drawn by Chapman (1768).

and well tended with a quick Fire, and Water as hot as can well be made.<sup>34</sup>

The origin of this technique is unknown. Abell states the practice began in 1690,<sup>35</sup> but I believe he mistakenly assumed that the illustration of the process in Raalamb's work of 1691 commemorates its initiation. The practice of charring was superceded in English naval yards beginning in 1720, after trials on the Falkland showed the superiority of "stoving" timbers in hot, wet, salt sand; this process was itself made obsolescent with the adoption of steaming, beginning in 1736.<sup>36</sup>

The Water Street ship's hull planking averages between 5 and 6 cm. thick. This is appropriate for a vessel of its size. According to the formula commonly employed from at least the sixteenth century, the ratio of hull planking thickness to the vessel's tonnage was 1 in.:100 tons with a minimum thickness of 2 in. (5 cm.)<sup>37</sup> The ship's average planking thickness is appropriate for the eighteenth century also. Sutherland's Britain's Glory recommends hull plank thicknesses of 2 4/10 in. and 2 1/4 in., while Murray also recommends 2 4/10 in.<sup>38</sup>

Sutherland also recommends that the hull strakes below the wale be 12 in. and 14 in. (30.5 and 35.5 cm.) broad.<sup>39</sup> While this is wider than those of the Water Street ship, he later notes that 2 in. (5 cm.)-thick planks should be between 9 9/10 in. and 11 1/4 in. (25 and 28.5 cm.) broad.<sup>40</sup>

### The Ceiling Planking

Above the main deck the runs of the ceiling strakes are parallel to the deck, while the lower ceiling planks are reduced or eliminated as the vessel narrows towards the stem. The lower ceiling planking terminated just aft of the second frame, while the upper ceiling planks were carried over the apron.

Like the outer hull planking, the ceiling planks were attached to the ship with approximately equal numbers of square iron nails and round treenails. Although each iron nail passed through the planks and terminated within the underlying frame component, most of the treenails ran completely through the hull, piercing both the exterior and interior planks. However, many of the treenails emerge from the seams between the ceiling planks, a good indication that the holes for the treenails were bored from outside the vessel (see: Fastenings, *infra*).

### The Breast Hooks

The transversely-mounted timbers are of two types: the hooks above the main deck are gently curving timbers, while the two hooks below the main deck are angular and more akin to knees. The two types also differ in that the upper hooks were attached to the frames prior to the planking of the hull, while the lower hooks were installed over the ceiling planking in a manner akin to hull riders.<sup>41</sup>

Each hook's heavier arm is fastened to the opposite

side of the vessel from the one above or below it.

Contemporary representations of breast hooks are symmetrical and give little hint that timbers may follow their natural shapes to any extent.<sup>42</sup> The variations of the breast hooks' cross sections will show the difficulty in ascertaining the shipwright's intention. Did the shipwright intend that the narrowest portion of the lesser arm meet the specifications for his vessel, or did he consider only the timber's maximum dimensions? Are we to measure the point of the hook where it crossed the stempost, or were the differences averaged in the same manner as a timber merchant averaged the yield of the piece? Currently, the records provide no answers.

#### The Foremast Steps

The Water Street ship's keelson terminated within the baulk wall separating the bow excavation area from the balance of the ship's hold, about 3 m. aft of the stempost. Instead of a keelson above the forwardmost frames, the position was occupied by a bifurcated timber. Perhaps, like a similar timber found on the Revolutionary War privateer Defence, the primary purpose of the timber was to strengthen the hollows of the bow, but a longitudinal mortise cut in its upper face indicates another duty.<sup>43</sup> It is reasonable to assume the mortise, lying along the vessel's mid-line, was a fore-mast step. The timber's position within the vessel is undocumented, but if we accept

the aforementioned premise, the mortise should be positioned below and slightly aft of the mast partners (see: Decking Structures, below). This would place the forward end of the timber over the third frame aft.

The athwartships step removed from about the same area had a square mortise carved in its back. Despite the difference between the shape of the mortises, I believe the athwartships timber to be also a foremast step, serving as a later replacement for the original mast step, located in the longitudinally-split bifucated timber.<sup>44</sup>

#### The Main Deck

A clamp, is located adjacent to the wale belt, on the inner frame faces. In addition to providing longitudinal strength to the vessel, it supports the ends of the Water Street ship's lower, or main, deck beams. It is, therefore defined as a lower, or main, deck clamp. Figures given in 1765 indicate the common sided dimension for lower deck clamps was 4 to 4 1/2 in. (10 to 11.5 cm.),<sup>45</sup> or half that of the Water Street ship.

The larger of the two recovered main deck beams is similar to those found aft of it. It is slightly cambered and tapers from one end to the other, following the natural taper of the tree trunk from which it was hewn. Its center line was set directly athwartships. The beam was secured to the sides of the vessel in two ways: the beam's ends were dovetailed and partially set into the main deck clamp, and

lodging knees were bolted between the beam ends and the clamps.

I cannot say when the practice of dovetailing beam ends began, but it is documented by Raalamb as early as 1691.<sup>46</sup>

Lodging knees appear in sixteenth-century works and are also archaeologically documented as early as the sixteenth century.<sup>47</sup> The Murray recommendations of 6.5 - 7 in. (16.5 to 18 cm.) thick<sup>48</sup> are lighter than those found on the Water Street ship, but the variance between the thicknesses of the branch and baulk arms indicate, as they did for the breast hooks (see: Breast Hooks, above), that the shipwright had an opportunity to build as he saw fit. This is nowhere more apparent than the assembly comprising the forwardmost deck beam and its lodging knees.

The forwardmost deck beam is slightly different from its companions. Probably because it spans a relatively short distance, it is considerably lighter and its ends abutt the deck hooks instead of being dovetailed into the deck clamp. What is remarkable about the beam is its orientation. It is rotated about 5° counter-clockwise from athwartships. The reason for this is uncertain, but I believe it can be attributed to the shipwright's desire to make use of available materials.

The deck planks run parallel to the mid-line of the vessel, and are therefore unremarkable. Also within the

common weal of western shipbuilding was the practice of doubling the deck with pads around deck-piercing structures and members. The thickness of the deck planking is slightly less than that recommended by Sutherland.<sup>49</sup>

#### The Knee of the Head

The structure projecting forward of the stempost was the support for the ship's head, but its primary purpose was to provide an anchor for the bowsprit. Evidence from the seventeenth and eighteenth centuries indicates that the head and its knee were optional appointments, installed after the construction of the balance of the hull.<sup>50</sup> As such, it may be best to regard the structure as part of the ship's rigging.

The origin and evolution of ship's heads is currently a matter of research, with the form of a ship's head and cutwater generally regarded as being diagnostic as to date and national origin of a vessel.<sup>51</sup> Unfortunately, a diagnostic analysis of the Water Street ship's head is impossible because the railings and decorations lay above the preserved portion of the knee. The erosion and loss of the cutwater's lower and forward margins makes it difficult to determine its original configuration, but in general the head appears similar to those built prior to the first half of the eighteenth century.<sup>52</sup>

In most respects, the knee is unremarkable. It has the same breadth as the stempost where the structures meet, and

it tapers forward. It is a made knee; that is, a knee built up from smaller pieces, with appropriate chocks filling the gaps left between the major components and the stempost.<sup>53</sup>

When discovered, the knee was detached from the stempost due to the loss of its iron fastenings. Its height and orientation have been reestablished mainly by the realignment of holes left by disintegrated longitudinal bolts and the bolts which secured the cheek knees. An additional clue to the knee's position and orientation, the 13-foot lading mark (XIII), proved to be of only limited value as the irregular nature of the lading marks could provide us with only a general orientation and position for the piece in which it was cut (see: The Lading Marks, below).

The most interesting feature of the Water Street ship's knee of the head is the orientation of the gammoning hole. It is apparently unique in that it angles 30° downward in a forward direction rather than 30° upward (approximately parallel to the bowsprit). Could this have been intentional? Is there something intrinsic to the dynamics of the gammoning that would be better served by cutting the hole in such a manner? I think not. Rather, I believe, the gammoning hole was incorrectly cut. It is not hard to imagine a shipwright's helper approaching either the loose gammoning piece, or the pre-assembled knee, lying in the yard awaiting installation, and laying out the marks for the

hole at an angle exactly opposite that intended. Nor is it difficult to imagine the shipwright accepting the consequences and making an adjustment in price in lieu of the expenses necessary to correct the error. The evidence for this angle being the result of a shortcoming in construction rather than design is found not only in the absence of similarly inclined gammoning holes in contemporaneous records, but also in the subsequent failure of the gammoning piece.

Originally, BE/023 and BE/028 were a single timber. Sometime during the life of the vessel, the gammoning piece split at the gammoning hole. If the hole had been cut at an upward angle of  $30^{\circ}$  or so, as one would expect, the gammoning piece would have had twice as much oak forward of the hole as was the case, and the strength of the piece would have been much greater. Sometime after the piece failed, the cheek knees were reset and the beak sheathed with planks. The sheathing covered not only the lading mark on the starboard side of the knee, but the lading marks on the stempost as well.

I am at a loss to explain the fact that there are three holes forward of and above the gammoning hole. As the bobstays would occupy two of the holes, my assumption is that they were in the pair of similar size, leaving the central and largest of the three for some other use. It may be relevant that the large hole is nearly circular where it

pierces the sheathing, but its after side is flattened where it follows the seam between the gammoning piece and the cutwater, perhaps indicating the hole was cut after the sheathing was installed. Perhaps additional lashings for the bowsprit were placed there to relieve some of the strain on the damaged gammoning piece.

#### The Lading Marks

The Roman numerals carved into the starboard face of the stempost and the knee of the head are meant to indicate the vertical distance to the bottom of the keel's forward end. These marks and, presumably, a similar set on the sternpost, aided the master in lading his vessel to the proper trim, hence the term "lading mark." The marking of maximum-safe-draught load lines on European ships dates from at least the twelfth century.<sup>54</sup> It is unknown when the practice of calibrating stem and stern posts on a foot-by-foot basis began, although it was common from the seventeenth century onward.

The practice of indicating lading marks with Roman numerals was nearly universal by the eighteenth century. Those on the Water Street ship exhibit the additional stylistic quirk of the numeral for nine carved with four "I's," rather than the more common "IX." This is apparently rare; I have found only three other early eighteenth-century examples of "IIII" having been employed in a lading numeral. The earliest example, "XVIIII," is found on a model of a

Dutch warship of 1725.<sup>55</sup> Another "IIII" is carved into the sternpost of a grain-laden merchantman sunk at Huvudskar, Sweden, in the 1730s.<sup>56</sup> The third example is the French-built Machault, lost in 1760, into whose recovered stempost are incised the numerals "VIIII" and "XIIII." <sup>57</sup>

It is certain that the unit of measure indicated on the Water Street ship is that of a foot. What is uncertain, and possibly undeterminable, is the nationality of that foot measure. The spacing between each of the marks is irregular, but averages 31.9 cm., or about 12 1/2 English inches.<sup>58</sup> The result is a fully-laden vessel actually drawing about six English inches more water than indicated.<sup>59</sup> Table 1 provides a sampling of national and municipal foot measures in use during the first half of the eighteenth century. Two of the measures exceeding the English foot in length were the Paris and Rhineland foot, the latter used in several towns, including Rotterdam.

The reason for the variation in the incline of the numerals on the Water Street ship is a mystery. One possibility, that the incline compensates for an increase in the stern-down attitude of the vessel as it is progressively laden, is unlikely, as even a one foot increase in stern-down would alter the pitch of the vessel by only two or three degrees.<sup>60</sup> A better explanation is that a workman simply laid out the numerals by eye and inadvertently skewed his work. This reasoning, supported by the crude quality of

TABLE 1

Conversion Chart of Eighteenth-Century  
Linear Measurements

<u>Nationality</u>	<u>Eng. "</u>	<u>Meters</u>
Amsterdam foot	11.15	0.2831
Antwerp foot	11.29	0.2868
Bossche foot	11.09	0.2816
Bremen foot	11.35	0.2883
Lubeksche foot	11.32	0.2876
Dantzick foot	11.33	0.2878
London foot	12.00	0.3048
Luiksche (St. Hubert) foot	11.59	0.2946
Maastrichtsche foot	11.04	0.2805
Mechelsche foot	10.80	0.2745
Paris foot	12.79	0.3248
Rhineland foot	12.36	0.3139
" (mid 18th)	11.32	0.2876
Spanish foot	10.96	0.2784
Toledo foot	10.79	0.2741
La vara de Avila	32.91	0.8359
1 codo real de Astillero	22.63	0.5747
1 pulgada de id	9.41	0.0239
Swedish foot	11.65	0.296

the carving itself, would also account for the variations in the spacing of the lading marks.

### Sheathing the Hull

In all but the coldest or most brackish waters it is necessary to protect the wetted areas of a wooden hull from the destructive action of marine wood-boring organisms. Although coverings of lead,<sup>61</sup> and even copper,<sup>62</sup> sheeting had been tried by the early part of the eighteenth century, the predominant technique was that of applying a layer of hair and a mastic substance to the hull and holding it in place with a layer of boards nailed to the hull.<sup>63</sup> Once again the process was described by Sutherland:

The laying the Hair to a true Gauge, smooth and even, I presume will be highly objected against as a vast Hinderance in Time, and therefore it will be rather allowed that this Part in the Sheathing shall be continued according to the ancient Custom, which is for two or three Men, or as many as are upon one Length of Board, to Tar the Board, and then dab on the Hair so very confused, that in some Places it shall be half an Inch thick, and in other Places never a Hair; ... when the Hair is put upon the Board, in raising the Board upon the Edge, and clapping it on the Ship, half the Hair is scatter'd, and so becomes of no Service, except to the Bottom of the Dock.<sup>64</sup>

The few fragments of the sheathing recovered from below the Water Street ship's waterline, as well as the hull planks themselves, bear evidence of this common practice. The hair was mixed with a mastic substance of yellowish and brown colors. The likely components of this substance include wood tar and sulfur.

The extant boards were attached to the hull by means of square iron nails spaced at 20 to 40 cm. intervals, mostly near the edges of the boards. This interval, when combined with an average breadth of 20 cm. for the sheathing boards, results in a nail pattern density of approximately 25 to 30 nails per square meter (4 - 6 nails/sq. foot), or close to twice what we were able to record on the actual hull. This discrepancy indicates a lapse in the recording technique, and that many more nail holes remain undiscovered. However, the magnitude of the discrepancy makes it unlikely that there could have been more than one or two sheathings applied to the hull during the course of its lifetime, and a certainty that the technique of heavily studding the sheathing with nails was never employed.<sup>65</sup>

There was no fixed term for the life of wooden hull sheathing. A few months in tropical waters can result in more teredo damage than centuries of immersion in the Baltic. Eroded sheathing was stripped from the hull and replaced as often as necessary or as economics warranted. Sutherland observes that if he " ... must cobble up such a Ship for the West-Indies, or some other foreign Voyage, ... I will apply a Sheathing, ...which Sheathing well laid on, may last half seven Years....," although he later states that, "I shall observe that this Sheathing may continue 3 years....."<sup>66</sup>

### The Fastenings

Throughout the Water Street ship, similar fastenings seem to be fabricated to slightly different diameters or with varying tapers. This may be due to inaccuracies in the recording.<sup>67</sup> Regardless, alternative measurements of the same feature can exceed 0.3 cm., greater than the difference between historically-known fastening specifications.<sup>68</sup>

Iron bolts and treenails were forced into pre-bored holes. Sutherland has told us that, "...the common Difference or Excess, between Treenel and the Augre, is 1/4 of an Inch; ... but the Difference between the Bolt and the Augre is but 1/8 of an Inch...."<sup>69</sup> We may assume pilot holes were used for starting iron nails, but these would have been obliterated.

All of the iron bolts and drift pins appear to be between 1.9 cm. and 2.9 cm. (3/4 and 1 1/8 in.) in diameter, which is in keeping with specifications for vessels of this size.<sup>70</sup> It is impossible to be sure how the bolts were prevented from starting out, but contemporary records indicate that forelock bolts may have been used where timbers might have needed to be reset, while the others were hammered over roves.<sup>71</sup>

The square-shafted iron nails which secured the deck and hull planks seem to be tapered. Where Sutherland provides us with specifications for iron nails, the given size of the cross-section is that at its center of gravity.

His requirement for planks of 2 in. (5 cm.) is a nail 5 4/10 in. (13.7 cm.) long and 30/100 in. (0.76 cm.) square, while a 2 1/2 in.-thick plank needs a nail 6 1/2 in. (16.5 cm.) long and 36/100 in. (0.91 cm.) square. While the lengths of the Water Street ship's nails fall within that range, the Sutherland specifications are nearly 50% narrower.

Although, as is the case of Water Street ship, Sutherland specifies two iron nails in each deck plank where it crosses each deck beam or other support, I am at a loss to explain what he means by "heads forked over."<sup>72</sup>

In addition to two or three iron nails, approximately the same number of treenails secured each hull plank to almost every frame component crossed, a technique known from the sixteenth century onward.<sup>73</sup> The treenails pass through the frame and the ceiling planking. Because they were so carefully arranged as not to be near the edges of the outer hull planks, and several pass through the seams between the ceiling planks, it is obvious that the holes were bored from the outboard.<sup>74</sup>

This raises the question of how the treenails were set. Apparently, "...the Custom is to drive all the Trenels that fastens the Out-board Plank out again, by reason of having all Trenels drove through both Planks and the Timber"<sup>75</sup> .  
"...excepting one Trenel left cross in every 3rd or 4th Timber, which shall not be drove out again."<sup>76</sup>

The outboard rims of the treenails were packed with a yellowish substance similar to the sheathing mastic. In addition, some of the treenails had a wedge of this material rammed into their outboard ends. This well-documented technique<sup>77</sup> also is similar to what was found on the Dartmouth, a British frigate lost in 1690.<sup>78</sup>

The diameters of the Water Street ship's treenails are approximately the same as those recommended by Murray in 1775,<sup>79</sup> but slightly larger than Sutherland's specification of 1717 where the treenails are to be equal to the cube root of the breadth of the planking.<sup>80</sup>

#### The Jeer Capstan

Although the capstan is one of the vessel's machines, and not part of the bow construction, the discovery of a barrel-headed capstan on the Water Street ship is significant and deserves consideration. A barrel-headed capstan is one in which long turning bars are inserted through holes cut through the capstan's barrel. The origins of the capstan are ancient, although it is likely that vertical whelps were a sixteenth-century invention.<sup>81</sup>

In any event, throughout much of the seventeenth century the typical capstan consisted of an axle with its upper portion set with vertical whelps, while its lower portion was reduced in diameter and fitted with a bearing at the bottom. The closest parallel to the jeer capstan found on the Water Street ship was an example drawn by Raalamb.<sup>82</sup>

The major shortcoming of the barrel-headed capstan was that any attempt to install more than two or three bars in staggered rows caused some of the men to push at levels too high or too low for efficient effort. The invention of the drum-headed capstan in the 1660s-1680s allowed many bars to be inserted in a row of "pigeon holes," all of which were placed at an optimum height.<sup>83</sup> The success of the invention was immediate and overwhelming. Other than the example from the Water Street ship, I have found no indications of barrel-headed capstans in shipboard use after the seventeenth century, although I am sure the Water Street was not unique in this respect.

## RECONSTRUCTION OF THE BOW

The Water Street ship's reconstruction is an ongoing project. The plans offered in this thesis are based upon evidence provided for the most part by direct documentation of the remaining fragments of the vessel, and extrapolation of those data. To a lesser extent the reconstruction relies on comparison with contemporary documentation, including plans, texts, and illustrations. No records specific to the vessel are known.

Naturally the most reliable evidence is based upon the materials documented in the laboratory. The recovered portion of the ship was relatively intact and contiguous prior to the excavation, with the exception of the upper portion of the vessel, removed in antiquity, and the decks' collapse. The surviving timbers of the knee of the head were salvaged, as were the first three meters of the lower deck. The first two to three meters of the hull were removed to a point slightly above the keel.

The plans of the reassembled timbers appearing in this thesis are my interpretation based on the alignment of the fastenings between adjacent timbers. This technique produced convincing results for the major assemblies of the Water Street ship's bow including the stem, framing, main wale belt, port side outer hull planking, breast hooks, deck supports and planking, and the knee of the head.

Ambiguities, however, remain. The most notable of these are the positions of the starboard outer hull planks and the ceiling planking. There is also some question as to the placement of the half timbers and the specifics of the hull sheathing.

For the most part these ambiguities are the result of lapses in the recording technique. For example, it is probable that 50% of the hull's sheathing nail holes are unrecorded, as are the contours of the futtocks' moulded faces. No doubt reexamination of the conserved components prior to and during their reassembly will provide information leading to additional refinements of placement.

Establishing a viable reconstruction for the missing portions of the bow requires more subjective judgement than the physical reassembly. As demonstrated in the Analysis of Construction, there are virtually no contemporaneous data pertaining to merchant shipbuilding other than Sutherland, Murray, and Chapman, and even these sources do not provide close parallels.

Likewise, there are no archaeological parallels to the Water Street ship. Contemporaneous merchant vessels, the Brown's Ferry vessel, and the Amsterdam, are of different orders of magnitude, and in the latter case, the excavation is in its preliminary stages and largely unpublished.<sup>84</sup>

The following reconstruction of the missing portions of the bow is therefore based on an extrapolation of documented

timbers, and such limited information as is available from existing sources.

### The Keel

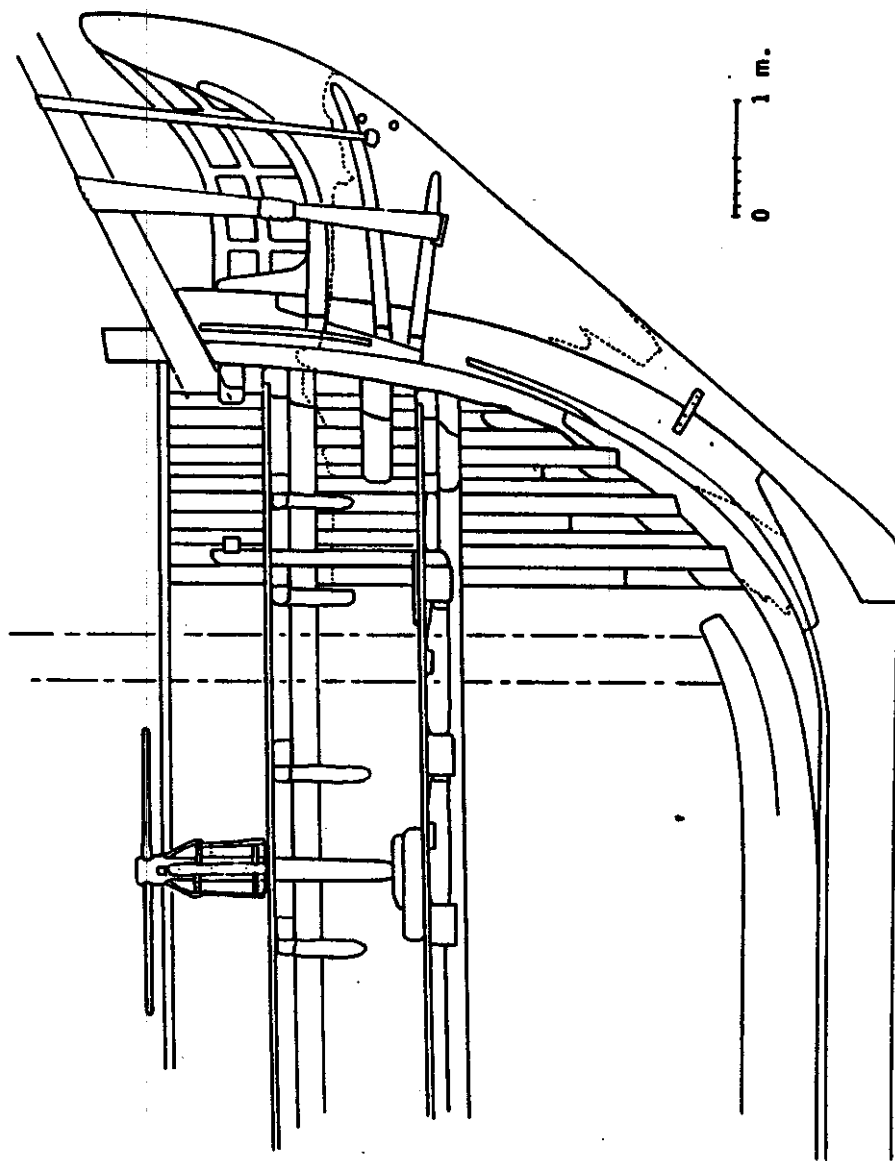
The absence of a keel presents a series of problems ranging from the vertical height and orientation of the stempost and frames (in effect, the entire bow), to the configuration of the keel itself.

The evidence needed to reconstruct the keel is found in the shapes of the stempost's keel scarp and the lower apron piece, as well as within the lading marks.

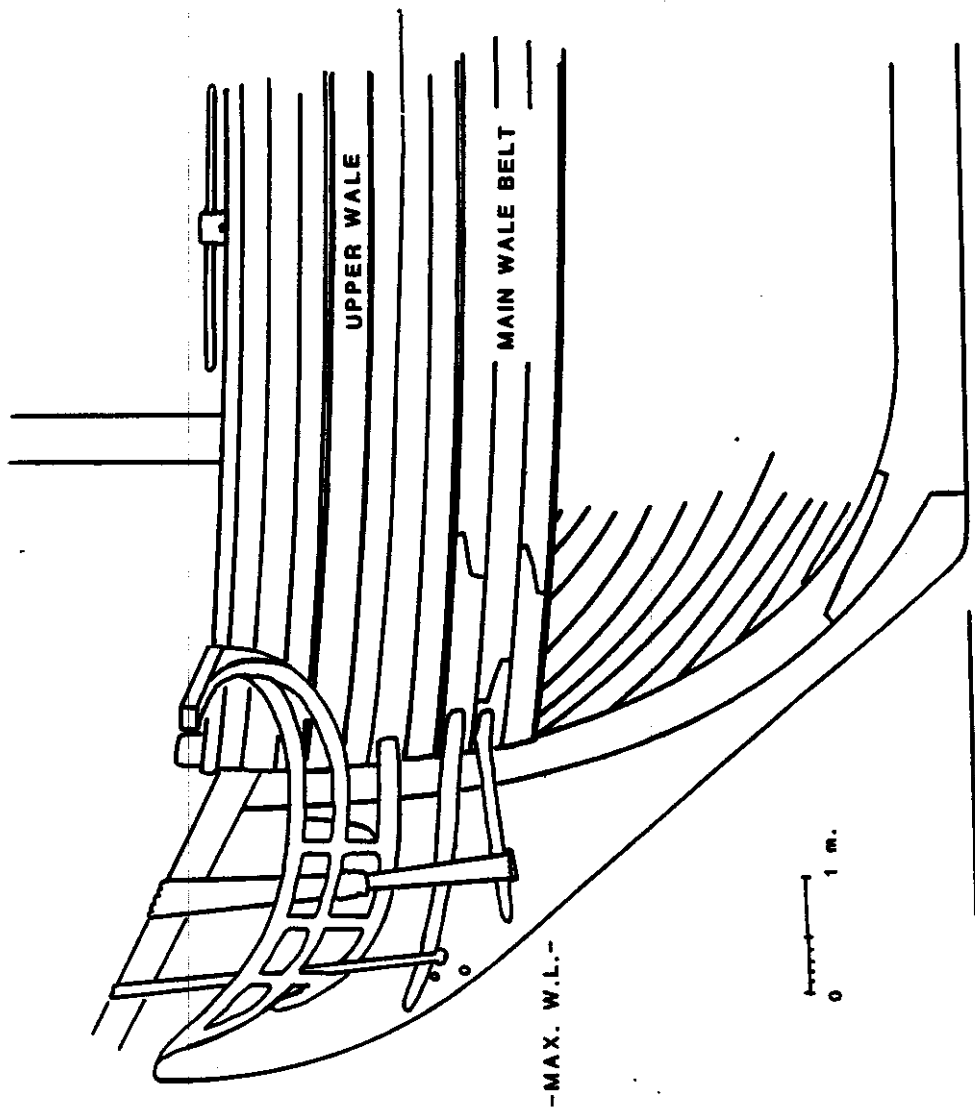
Illustrations 21 to 23 present my reconstruction for the missing lower portion of the bow. It minimizes the differences between the variations of the lading marks' indicated foot-measure and orientations while allowing a reasonable space for the scarp between the keel and the stempost. I have not found any exact parallels to this extrapolated configuration, but I am confident that its moulded dimension was approximately 50 to 60 cm., while its sided dimension was probably the same as that of the stempost (29 cm.), appropriate for a vessel of this size.<sup>85</sup>

### The Stempost

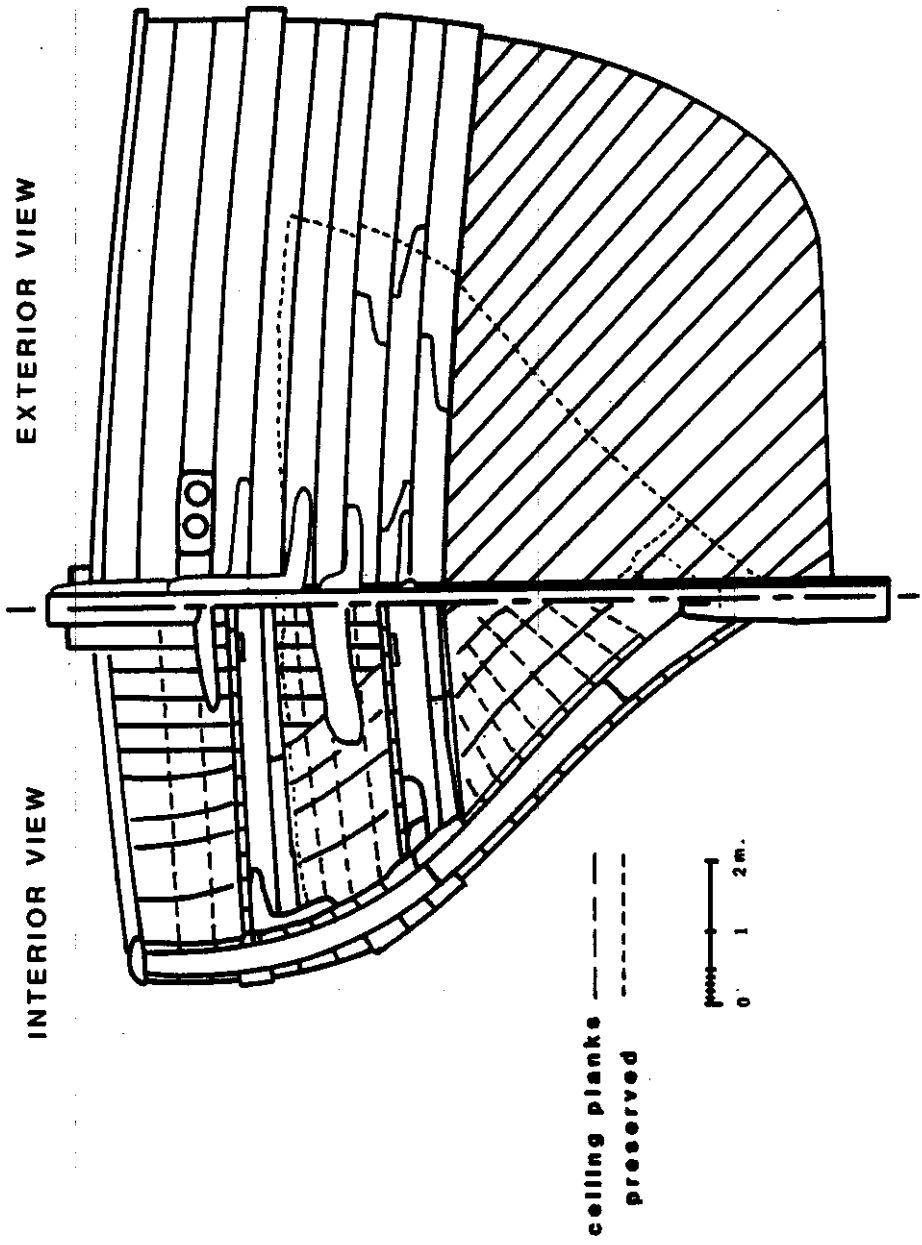
It should be noted that my chosen orientation requires a nearly vertical stempost above the main wales. Contemporary stemposts for a ship of similar size range between 18 and 22 feet (5.5 and 6.7 m.) in length.<sup>86</sup>



Ill. 21. Water Street ship. Reconstruction of the bow, interior view of port side.  
(Drawing author)



Ill. 22. Water Street ship. Reconstruction of the bow, exterior view of port side.  
(Drawing author)



Ill. 23. Water Street ship. Reconstruction of the bow, end view. (Drawing author)

### The Frames

It will be noted that the frames achieve a slight inclination forward, but not a true cant.

The lengths of the top timbers are calculated on the basis of the height of the weather deck (see: Upper Deck, below).

### The Lower Hull

The lower hull planks were not recovered at the time of the excavation. I estimate that there were five additional strakes of 24 to 28 cm. breadth between the surviving hull planks and the assumed planking rabbet in the keel. The only contemporaneous records I have found indicate that "14 strakes" or "16 seams" were to be found below the main wale in ships built in English shipyards, but this would pertain to the maximum number of planks found amidships.<sup>87</sup>

### The Upper Deck

Vessels the size of the Water Street ship generally had one or two decks. Excavations near amidships revealed a portion of an upper, or weather, deck there. Although the sheer of the vessel is minimal, it proved sufficient to result in the loss of any trace of the upper deck in the forward area.

The weather deck's only surviving support, a hanging knee, was found in fragmentary condition immediately beneath an intrusive nineteenth-century foundation wall transecting the vessel near amidship. The knee was revealed when the

balk wall supporting the footing collapsed. Although the footing had shifted slightly, Sheli Smith and I concurred on an estimated four feet (122 cm.) for the distance between decks.

An analysis of the jeer capstan has somewhat refined this interdeck distance. The length of the capstan's spindle, plus the thickness of its step and bed, is approximately 1.40 m. If one subtracts 5 cm. for the upper deck planking, the maximum headroom between the decks is 1.35 m. (53 in.), but if one allows for an upper deck beam depth of 20 to 25 cm. (8 to 10 in.), the continuous clearance is only 1.1 m. (43 in.).<sup>88</sup>

#### The Hawse Timbers

The surviving hawse pieces are not pierced, indicating the hawse holes were located somewhat higher in the bow, probably at about the level of the jeer capstan's whelps. It is possible that naval bolsters externally reinforced the hawse holes.

The knight heads may or may not have risen above the level of the stempost. If so, they would have helped to secure the bowsprit.

#### The Head and its Knee

None of the ship's head was present at the time of the excavation. Of the knee of the head, the upper and forward portions of the cutwater are eroded and missing, as are the lower portions of the gripe. The eroded standing knee has lost virtually all of its vertical arm.

Some authors have maintained that profiles of ships' heads are a means of identifying national type and period of origin.<sup>89</sup> Although this may be true for the broadest generalizations over the course of centuries, close examination will prove that the record is too small, the range of variation too great, and the migrations of shipwrights too widespread, to allow creation of a predictive model.<sup>90</sup> Regardless, the question of establishing a predictive model for the configuration of the head and its knee for the Water Street ship is moot. At this time we have no firm evidence for its national origin, nor can we date the construction of the vessel to any period narrower than that of the second quarter of the eighteenth century.

The surviving profile lies within the general parameters of heads recorded in Chapman which provide models for my reconstruction.<sup>91</sup>

#### The Jeer Capstan

Traditionally, jeer capstans were placed abaft the foremast at a level to assist the main capstan in hauling in the anchor cable or mooring line. As we know, the hawse holes were above the level of the weather decks. It would appear that the whelps of the jeer capstan were on that deck while the spindle rotated in a metal bearing affixed within the step nailed to the main deck, below.

## CONCLUSIONS

In general form and construction, the bow of the Water Street ship conforms to a pattern common among eighteenth-century merchant ships; that is, a bluff-bowed vessel, hollowed slightly below the wales, whose forward frames were installed vertically. It was built largely of oak, possessed two decks, and was equipped with a head. A similar vessel of the period is presented in plate 2.

Most of the details of the ship's construction were long established and nearly ubiquitous in Western ship construction by the middle of the eighteenth century. These techniques include dovetailing of deck beams into clamps, mixing iron and wooden hull fastenings, dovetailing deck beams in clamps and reinforcing them with lodging knees, and sheathing the hull with boards over a layer of hair and tar.

The Water Street vessel additionally exhibits a mixture of constructional traits characteristic of the second and later decades of the eighteenth century. Most notably these include the fabrication of frames prior to their erection; the fabrication of frames with nearly solid, double rows of timber; and a multi-straked main-wale belt.

Our knowledge of early eighteenth-century traditions is insufficient to allow us to attribute a national origin to the Water Street ship or its shipwright.

Judgment regarding quality of construction must be subjective; without contemporary comparative structures it is impossible to relate the vessel to the standards of the day. Yet, a few observations on the matter may be allowed. The shipwright installed a portside knight head which had previously been axed nearly through, one of the whelps on the jeer capstan was a re-used timber, and the gammoning piece was installed with a gammoning hole so miscut that the piece later broke. Another variation from the ideal, the oddly-angled forwardmost deck beam, contributes to the impression of a shipwright willing and able to make use of materials at hand.

The shipwright was also conservative in his expenditure of labor. One also notes that despite the frames being built of a double row of timbers, the contact surfaces between the frames and hull planks were often limited to a few square centimeters, and several larger portions of the frames were never in contact with the hull planking. Further indication as to what was "good enough" in the shipwright's eyes is the difference in the heights between the port and starboard main-wale belts, and the imprecision of the lading markings. However, it is his failure to square off the deck beams, breasthooks, or even the jeer capstan step's bed, that I find most illustrative of this trait.

Compensating for the shipwright's disregard of strict rules of symmetry was his sense of balance. While the breasthooks may be asymmetrical, their heavier arms are alternated from port to starboard, as are the heavier arms of the rising floor timbers. Where one lodging knee is stout, its companion is long. Witness also the hawse pieces, where timbers of disparate widths are assembled to span similar distances.

In 1976, Goldenberg wrote:

It must be emphasized that the shipwright was not bound by mathematical formulas or textbook methods for building. In fact, strict adherence to regulations could not guarantee a smooth or symmetrical hull at all. As with many maritime problems, the skilled craftsmen knew when and how to adjust the rules. The ship he launched, not plans or books, was the testament of his workmanship. Thus the ... shipwright leaves modern historians puzzling over the literature of his trade, without substantial records to settle the issue of how his craft was actually produced.<sup>92</sup>

The archaeological value of the Water Street ship therefore lies within the insight it offers us toward understanding eighteenth-century merchant ship construction.

## NOTES

1. The cost of the excavation was underwritten by Howard Ronson & Associates, New York. It was conducted under contract by Soil Systems, Inc. of Marietta, Georgia, which also provided conservation facilities in Groton, Massachusetts.

2. Popular articles concerning the find are: N. Dean, "Manhattan's Mystery Merchant Ship," Wooden Boat 63 (1984) 96-100; R.L. Snow, "Manhattan's Mystery Merchant Ship, Her Probable Past," Wooden Boat 63 (1984) 101-104; W. Riess and S.O. Smith, "The Ronson Ship Finds a Good Home," Sea History 37 (Autumn 1985) 34-35; W. Riess, "The Ship Beneath the City," in The Mariners' Museum Journal 12.3 (1985) 1-6; J.O. Sands, "The Journey to the Mariners' Museum," The Mariners' Museum Journal 12.3 (1985) 7.

3. The research represented by this thesis will assist Warren Riess and Sheli Smith in their investigations. Graphic reconstruction and analysis of the balance of the vessel are being undertaken by Sheli Smith.

4. Stabilization and conservation techniques are described in B. Seifert and Richard Jagels, "Conservation of the Ronson Ship's Bow," in Waterlogged Wood, Proceedings of the 2nd ICOM Waterlogged Wood Working Group Conference (Grenoble 1984) 269-97.

5. The drawings were made by Kerri Horn, under the supervision of the project directors. Conservation notes and drawings were produced by Heidi Misch, Betty Siefert, and Lisa Goldberg of the Soil Systems Conservation Facility (supra n. 1). I am confident that cartography of the recording process is better than 98% accurate. The remaining uncertainty factor of  $\pm 2$  cm./meter is significant in larger timbers where the factor may be cumulative rather than mutually negating, as well as when determining scantlings and clearances to within 0.3 cm.

6. In "An Index to the Parts of the Sixth Size," Sutherland notes "The Stem in Two Pieces," and while writing of converting ship timber, "the Stem of a Ship, which I allow to be of that size which is generally made in two Pieces; tho' it cannot be deny'd, but that it would be much stronger, if it was made out of one entire Piece." The number of pieces from which a stem may be made is left open in his sample: "The Contracting Part in Ship-Building Full and Methodical," in W. Sutherland, Britian's Glory: or, Shipbuilding Unvail'd. (London 1717) I, 33, 118, 75, 76.

7. Sutherland (supra n. 6) I, 118.

8. Sutherland (supra n. 6) I, 36, 37.
9. M. Murray, A Treatise on Ship-Building and Navigation, 2nd ed. (London 1765) 187, 188. The identical table, but indicated for vessels 10% larger, is presented in W. Sutherland, The Ship-Builder's Assistant: or, Marine Architecture (London 1766) 73,74. Both works were published by J. Mount and T. Page.
10. Sutherland (infra n. 85).
11. Sutherland (supra n. 6 ) I, 76.
12. J.D. Broadwater, "The Yorktown shipwreck archaeological project: results from the 1978 survey," The International Journal of Nautical Archaeology 9 (1980) fig. 4.
13. Murray (supra n. 9) 164.
14. C. Allard, Nieuwe Hollandse Scheeps-Bouw (Amsterdam 1705) pls. 7, 8; N. Witsen, Architectura Navalis et Regimen Nauticum Ofte Aaloude en Hedendaagsche Scheeps-Bouw en Bestier (Amsterdam 1690) pls. XLIII, LII.
15. J. Fincham, A History of Naval Architecture (London 1851, reprint 1979) 73.
16. Fractured futtocks were not necessarily fatal to a vessel. In one instance the not-then famous Captain John Paul arrived in Cork with 30 of his ship's futtocks broken, in S.E. Morison, John Paul Jones (Boston, Toronto 1959) 23.
17. Stevens also states that until English shipwrights were imported to Amsterdam in the early 18th century, cant frames were unknown there; see J.R. Stevens, An Account of the Construction and Embellishment of Old Time Ships (Toronto 1949) 18. Public Records Office (PRO) (Adm. 106/3551, 4/10/1715) ordered that frames near the bow were to be fitted at an angle; see B. Lavery, The Ship of the Line (London 1984) II, 33.
18. C. van Yk, De Nederlandsche Scheeps-Bouw-Konst Open Gestelt (Amsterdam 1697) 18, 19.
19. Sutherland (supra n. 6) I, 36, 37.
20. W. Abell, The Shipwright's Trade (London 1981) 77.
21. Lavery (supra n. 17) II, 37.

22. F. Howard, Sailing Ships of War, 1400 - 1860 (Greenwich, London 1979) 181.
23. A. Raalamb, Skeps Byggerij eller Adeling Öfnings Tionde Tom (Stockholm 1691) pl. I.
24. H.C. Bjerg and J. Erichsen, Danske Orlogsskibe 1690-1860 2 (Copenhagen 1980) pl 6.
25. Allard (supra n. 14) 10.
26. Lavery (supra n. 17) I, 79.
27. R.C. Anderson, "Comparative Naval Architecture," Mariner's Mirror 7 (1921) 313-14.
28. Fincham (supra n. 15) xx.
29. Sutherland (supra n. 6) II, 7.
30. Murray (supra n. 9) 187, 188.
31. The characteristics of the configuration of the vessel's bow are consistent with those of whole moulded vessels. There is probably little to be learned from an exhaustive comparison with contemporary lines drawings as they are generally unreliable, especially at the extremities of the vessel, in H. Chapelle, The Search for Speed Under Sail (New York 1967) 16-17, 21.
32. F. af Chapman, Architectura Navalis Mercatoria (Stockholm 1768) pl. XVI.
33. Raalamb (supra n. 23) pl. I, figs. 81-82; etching reproduced in I. de Groot and R. Vorstman, Sailing Ships, Prints by the Dutch Masters from the Sixteenth to the Nineteenth Century (New York 1980) pl. 91.
34. Sutherland (supra n. 6) I, 123.
35. Abell (supra n. 20) 97.
36. Fincham (supra n. 15) 76-77. This is followed by Abell (supra n. 19); a different, but I believe erroneous version is related in E. van Konijnenburg, Shipbuilding from its Beginnings (Brussels 1905) I, 53.
37. M. Oppenheim, The Naval Tracts of Sir William Momson (London 1913) IV, 49; and J. Smith, A Seaman's Grammar (London 1627) 16.
38. Sutherland (supra n. 6) I, 36-37, II, 158; Murray (supra n. 9).

39. Sutherland (supra n. 6) II, 14.
40. Sutherland (supra n. 6) II, 160.
41. The sequence of construction outlined by Sutherland suggests the breasthooks to be the last timbers installed; see Sutherland (supra n. 6) I, 47. Also, "In addition, several hooks in the nature of riders were placed before the step of the foremast," in Stevens (supra n. 16) 25.
42. In all cases the quality of draftsmanship is poor. At best, the breast hooks are reduced to vague, pillow-like shapes, such as those in Raalamb, (supra n. 23) pl. H.
43. B. Ford and D.C. Switzer, Underwater Dig: The Excavation of a Revolutionary War Privateer (New York 1982) plan pp. 112-13, plan pp. 132-33, plan p. 142.
44. Illustrations of both longitudinal and thwartships mast steps are shown in Howard (supra n. 22) 109, 215, 270.
45. Clamp thicknesses 4 to 4 1/2" (10 to 11.5 cm.) are indicated in Murray (supra n. 9).
46. Dovetailing is illustrated in Raalamb (supra n. 23) pl. I, figs. 101, 102; Smith (supra n. 37) 16. It is recommended that "Every Beam to be Dove-tail'd in the Clamps two Inches....," in Sutherland (supra n. 6) I, 38.
47. The ends some of the Mary Rose's deck beams are strengthened with lodging knees; see M. Rule, The Mary Rose. The Excavation and Raising of Henry VIII's Flagship (London 1982) plans p. 120.
48. Sutherland (supra n. 6) I 36-45 recommends lodging knees sided at 6 1/2" (16.5 cm.). Lodging knees sided at 6.5" (16.5 cm.) for vessels of 200 Tuns, and 7" (17.8 cm.) for ships of 300 Tuns are indicated in Murray (supra. n 9).
49. The "Flat of the Deck to be Fir," at 2 9/10" th. on "Sixth Siz'd" ships of 250 Tuns, and 2 37/40" th. on "Fifth Siz'd" ships of 400 Tuns, in Sutherland (supra n. 6) I, 40, 41; also that the deck planks of the lower deck should be 2 1/4"; in Sutherland (supra n. 6) II, 164.
50. They were also hazardous to the integrity of the hull: "The Knee of the Head is also a very dangerous Passenger, and very assisting towards causing Leakage in the Bows of a Ship," in Sutherland (supra n. 6) II, 81.

51. A knee with a large gripe before the keel is specifically identified as an English style by Anderson (supra n. 27) 42-43.
52. Howard (supra n. 22) 51.
53. "Such Knees are variously perform'd, as may be seen in Figure L 1, and M 1: Some Men will endeavour, if it's possible, to have the principal Piece fit entirely to the Stem, without putting Chocks between, . . . That it's only a made Knee, since the Parts are every one of them . . . straight Pieces." in Sutherland (supra n. 6) I, 128.
54. Maximum load marks were instituted by the Doge of Venice in the 12th century, while English colliers carried marks from 1422 onward; see N. Upham, The Load Line - A Hallmark of Safety (Basildon 1978) 1. Also in the 15th century, the Genoese were checking nail-marked waterlines; see C.M. Cipolla, Guns and Sails in the Early Phase of European Expansion, 1400-1700 (New York 1965) 198.
55. E.K. Chatterton, Old East Indiamen (London 1933) 122-23. Also, Nederlandsch Historisch Scheepvaart Museum, Beschrijvende Catalogus de Scheepsmodellen en Scheepsbouwkundige Teekeningen, 1600-1900 (Amsterdam 1943) pl. 13.
56. C.O. Cederlund, The Old Wrecks of the Baltic Sea, Archaeological Recording of the Wrecks of Carvel-built Ships, trnsl., R. Kelley, (Oxford 1983) 193. The numeral "VIII" also appears on a combination lock from Worms, dated to 1783; see D. Prochnow and R. Fahrenkrog, Schonheit von Schloss Schlüssel Beshlag (Dusseldorf 1966) 101.
57. W. Zacharchuk, "The Restigouche Excavation. An Interim report," The International Journal of Nautical Archaeology 1 (1972) fig. 8 on p. 157.
58. Internal variations among lading marks are not unique to the Water Street ship. The previously mentioned 1730s sternpost, recovered from Huvudskar, was carved with the Roman numerals III, IIII, V, VI, and VII. The variation in distance between any two of those marks is as much as two inches per foot; see Cederlund (supra n. 56) 193.
59. Representing an additional displacement of 20 to 30 tons.
60. "A Proportion for the Parts of the Sixth Size," allows 6" more draught abaft than afore, in Sutherland (supra n. 6) I, 34. The Establishment of 1719 allows 12" more draught aft for a 20 Gun ship of 106' on the gun-deck

in J. Charnock, An History of Marine Architecture (London 1802) 128. "Extracts of Bouguer's Traite du Navire," in Murray (supra n. 9) 10-11, allows for an increase in draught aft equal to about 1/6th of the hold, or 16" for the Water Street ship. This is somewhat greater than the 16" allowed for a vessel of 120' by Deane, in B. Lavery, Deane's Doctrine of Naval Architecture 1670 (Greenwich, London 1981) 56.

61. Modern use of lead sheathing appears to have been used as early as the 16th century in both Iberia and England; see Oppenheim (supra n. 36) IV 4, 52, 54. Trials of the first Royal Navy vessel to have lead sheathing installed, the Phoenix, in 1671, were a failure, apparently due to the electrolytic action between iron and lead, in B. Lavery (supra n. 59) 19. Lead was occasionally used into the 18th century, but the reasons for its discontinuance are varied: "It [lead] had the disadvantages of being quite expensive, very heavy, and rather brittle. Furthermore, most English shipyard workers hated the idea of using lead because it worked too well; they feared the extensive use of lead on ships' hulls might so increase the lives of ships as to put them out of work," in E. Dethlefsen, Widah: Cape Cod's Mystery Treasure Ship (Woodstock, Vt. & Key West 1984) 81, 96. While he may have had an understandably poor knowledge of galvanic processes leading to differential sacrifice between metals, Sutherland had a practical knowledge of its effects: "Experience has inform'd us, that Mineral Productions, or Metals, are Offensive, and will Corrode, Eat, or consume one another; it being a general Custom in preceding Ages to cover Ships, or what Shipwrights term Sheathing a Ship with Lead, and Nailing of it with Copper-Nails; but then it was observ'd, that all the Iron-work under the Lead was miserably eat and consumed: Notwithstanding I am apt to believe that it was not altogether the Lead that was the Cause, but the long Continuance of the Iron-work under the Lead, as not being able to shift the Iron-work without uncovering the Ship, and ripping of the Lead, since I have observed the Bolts in the Scarphs of the Keel to be as consumed to as great a Degree as could possibly be under Lead, and never any Lead near such Scarph-bolts; so that in all Likelyhood it is the Salt Water that wastes the Iron, and not altogether the Lead Sheathing." He observes that Floor Rider bolts are protected with lead and hair and are not eroded, but that other bolts are quite eaten in the absence of sheathing. "The second Objection against Lead Sheathing is, that it will soon be rubb'd off, and so become useless: This may easily be prevented, by Sheathing with Wood at the Waters Edge, and 1 Foot below it; and also above the Water;" Sutherland recommends the use of an elm shoe on the keel's bottom to prevent abrasion there, in Sutherland (supra n. 6) II, 128, 219.

62. "Dat het Schip om de Zuid of West bestieren sal, heeft sy om de Hout-knagende Worm daar van te keeren, Stevenswaarts met Kooper doen bekleden," attributed to van Yk (supra n. 18) n.p., by van Konijnenburg, (supra n. 36) I, 121. Also, "...in the first half of the seventeenth century East Indiamen were accustomed to 'sheathe their rudders with thin plates of copper to preserve the edges of them from being eaten flat by the worm.' In 1708 the Navy Board rejected a proposal to use copper generally on the ground that it was very expensive and would require a long time to put on and take off." in Oppenheim (supra n. 37) I, 54.

63. Oppenheim attributes the introduction of tar and hair sheathing to Sir John Hawkyns. Monson notes that, "The best is with thin boards, half inch thick, the thinner the better, and elm better than oak for it does not split, it endures better under water and yields better the ship's side. The manner is thus; before the sheathing-board be nailed on, upon the inner side of it they smear it over with tar, half a finger thick, and upon the tar another half finger thick with hair, such as the white limers use, and so nail it on, the nails not above a span distant one from another. Some impute the killing of the worm to the tar, others to the hair that involves and chokes it. This is the best, and of least cost." In Oppenheim (supra n. 37) I, 54, 53. Note, however, that it was recognized that the hair, not the tar was the material which provided resistance, if any, to the effects of marine boring organisms as early as Smith (supra n. 37) 16. Sheathing a ship took about four days; see J.A. Goldenberg, Shipbuilding in Colonial America (Charlottesville, Va. 1976) 90. A Dutch vessel, the Kennemerland, lost in 1664, is an archaeological example of 1/2" (1.3 cm.) pine sheathing, in J. Green, "East Indiaman wrecks: later 1660's," in K. Muckelroy, ed., Archaeology Under Water: An Atlas of the World's Submerged Sites (London, NY 1982) 125.

64. Sutherland (supra n. 6) II, 220.

65. Sutherland (supra n. 6) II, 184, 216.

66. Sutherland (supra n. 6) I, xvi; II, 217.

67. The problem is severe for iron fastenings, where concretion build-up, or erosion due to acids generated by bacterial action, can alter the cross-section of the remaining hole. Measuring treenails and their holes is also difficult due to the faceted surface of the treenails and the separation along the grain of pierced timbers. When fasteners penetrate timbers at oblique angles (as most do), exit holes are oval, presenting additional difficulties to the recorder.

68. "A contract for 3rd rate 1666-67," probably originally dating to 1649, calls for iron bolts of 1/2", 3/4", 1", 1 1/8" (one half quarter), and 1 1/4", in Lavery (supra. n. 21) 116-19. Although specifications may have called for incrementation as small as 1/16" (1.6 mm.), in Sutherland (supra n. 6) I, 74, II, 106; typical bolt specifications are in 1/8" (3.2 mm.) increments, in Sutherland (supra n. 6) II, 102; and J. Sutton, Lords of the East (Greenwich, London 1981) 70-71.

69. Sutherland (supra n. 6) II, 55. A hole of 1/8" less diameter than a bolt of 1 1/4" diameter is requested in a contract for a 105' long East Indiaman, in Sutton (supra n. 68).

70. Sutton (supra n. 68); Sutherland (supra n. 6) II, 133.

71. The total iron-work of a 246 tun Sixth Rate is 2T 7c 1q 20l, or about one ton of iron per 100 tons of vessel, in Sutherland (supra n. 6) I 107. The thesis that iron fittings became more numerous as the eighteenth century progressed, in Goldenberg (supra n. 63) 16, is supported by excavations of the Amsterdam, where the exposed hull was attached almost exclusively with iron nails, according to a personal communication from excavation member Shirley Gotilepe.

72. Sutherland (supra n. 6) II, 184, 131, 136.

73. Examples of 16th-century mixed fastenings are found in D.H. Keith, et. al., "The Molasses Reef Wreck, Turks and Caicos Islands, B.W.I.: A Preliminary Report," The International Journal of Nautical Archaeology 13 (1984) 53; and J.B. Arnold III and R. Weddle, The Nautical Archeology of Padre Island (New York, San Francisco, London 1978) 230-34.

74. Sutherland (supra n. 6) II, 7. The holes were probably bored with augers about 1/4" (0.64 cm.) less in diameter than the treenails; see Sutherland (supra n. 6) II, 55.

75. Sutherland (supra n. 6) II, 184.

76. Sutherland (supra n. 6) I, 88. A 1747 contract for a 105' long East Indiaman indicates that "The treenails that are drove inward to be wedg'd and Rim'd"; see Sutton (supra n. 68) 160.

77. Sutherland (supra n. 6) I, 94; II, 149.
78. C.J.M. Martin, "The Dartmouth, a British Frigate Wrecked off Mull, 1690," The International Journal of Nautical Archaeology 7 (1978) 47.
79. Murray (supra n. 9) 36-37.
80. Sutherland (supra n. 6) I, 88.
81. The earliest representation of a capstan in shipboard use, on a Roman mosaic in Ostia, shows a simple vertical beam turned by means of crossed turning bars; see L. Casson, Illustrated History of Ships and Boats (Garden City, NY 1964) ill. 69 and caption. The 13th-century Bremen Cog was equipped with a squat, almost conical barrel and spindle cut from a single log; see S. Fließner and R. Pohl-Weber, The Cog of Bremen (Bremen 1972) 31. A spool-shaped capstan figures in a painting of a carrack by Boticelli, in the second half of the fifteenth century, but no 16th-century representations have come down to us; see Howard (supra n. 22) 161, 58. A preliminary site plan of a 16th-century Basque whaling ship currently undergoing excavation in Red Bay, Canada, shows a capstan, but no details are as yet available. The first mention of whelps is by Monson, in the 16th century, in Oppenheim (supra n. 37) IV, 48.
82. Raalamb (supra n. 23) pl. I, figs. 99-100.
83. Its invention is specifically attributed to Sir Samuel Moreland during the period 1660-1680, in Howard (supra n. 22) 112.
84. J.R. Steffy, "The Brown's Ferry Vessel, South Carolina, Preliminary Report," in The International Journal of Nautical Archaeology 8 (1979) 121-42; P. Marsden, The Amsterdam (London 1980).
85. The sided dimension of the keel for a "Sixth Siz'd Ship," of 250 tuns is 11" (27.9 cm.), in Sutherland (supra n. 6) I, 36-37. The sided dimension of the keel for a merchant ship of 220 tons is 11 1/2" (29.2 cm.) and 12" (30.5 cm.) for one of 330 tons, in Murray (supra. n. 9).
86. Sutherland (supra n. 6) I, 36, 37.
87. Sutherland (supra n. 6) II, 14; II, 158.
88. While this may seem a trifle round-shouldered for a berth deck, where a similarly-sized warship might carry between 85 and 100 men (Sutherland [supra n. 6] I, 34, 132),

or a privateer about 25 men (J.G. Lydon, Pirates, Privateers, and Profits [New York 1970] 171, the typical crew for a merchantman of this size was only 12 to 20 (P.W. Bamford, Forests and French Sea Power, 1660-1789 [Toronto 1956] 165. A more probable use was cargo stowage. Barrels are shown stored on a similarly decked Cat, the 95', 267 ton, Exeter, as redrawn in D. R. MacGregor, Merchant Sailing Ships 1775-1815, Their Design and Construction (Watford, Herts 1980) fig. 40, caption p. 58.

89. Anderson (supra n. 27) 42-43; Howard (supra n. 22) ill. 302.

90. In addition to those cases where shipwrights were recruited, as in the example of Swedes and the French in regard to shipwrights from Amsterdam (R. Unger, Dutch Shipbuilding before 1800 [Assen 1978] 205, many emigrated to improve their fortunes, such as the Sheldons from England to Sweden, or Englishman Thomas Davies to Amsterdam (Howard [supra n. 22] 94, 197). So many, in fact had left England for the American colonies that in 1724 the master shipwrights of the River Thames petitioned to restrict shipbuilding here, claiming half the shipwrights had departed England already (Goldenberg [supra n. 63] 52-53). Many went abroad to study shipbuilding. Notably, Czar Peter Romanov and his fifty nobles dispersed to Italy, Holland, and England. In 1727, the Danes recalled their four nautical architects from France and England and in 1731 held trials of vessels built to the old and new techniques of those countries (Bjerg and Erichsen [supra n. 24] 198). Even where shipwrights were not mobile, ships were. Deane was himself instructed to study and copy the the French Superbe, 74 (Lavery [supra n. 60] 13), while at least one American-made vessel had been studied in England by 1736 (Goldenberg [supra n. 63] 78). Additionally, several shipbuilding texts were published in the late seventeenth, and early eighteenth centuries. These include: Witsen (supra n. 42), van Yk (supra n. 18), Allard (supra n. 14), Raalamb (supra n. 23), Sutherland (supra n. 6), Sutherland (supra n. 9), and Murray (supra n. 9).

91. Chapman (supra n. 32) pls. LI, 1; LII, 2.

92. Goldenberg (supra n. 63) 88-89.

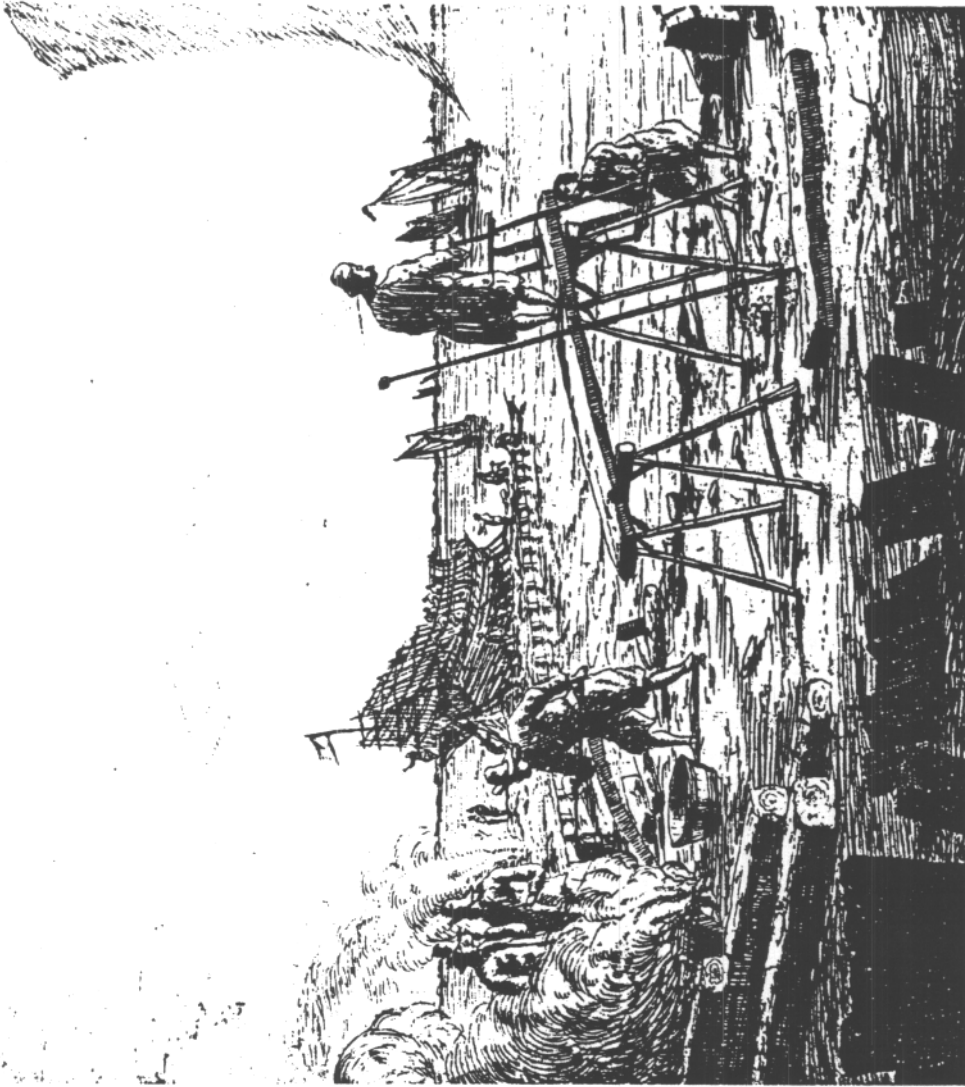
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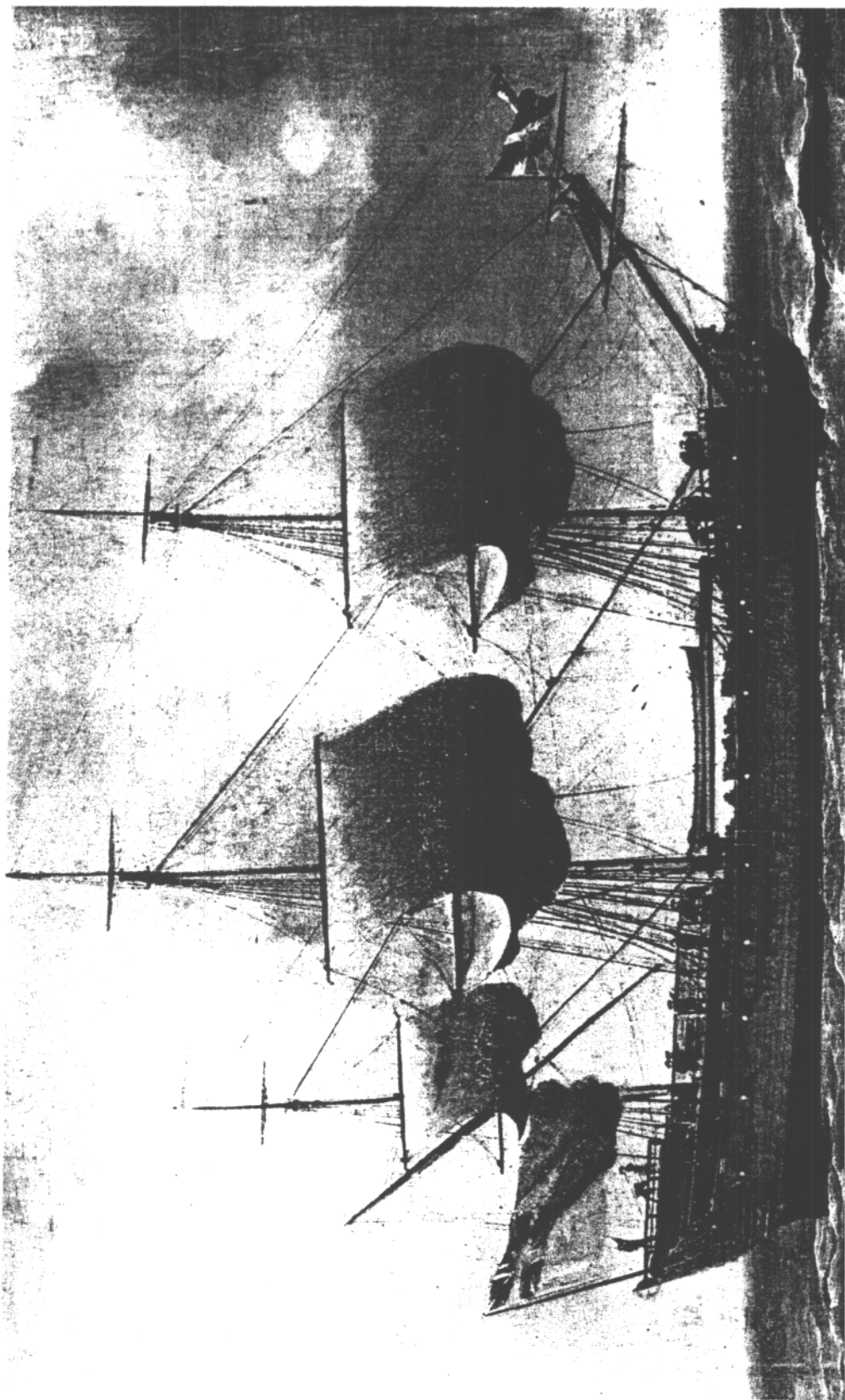
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APPENDIX  
PLATES

Pl. 1. "Charring" planks in order to bend them (left) and two men sawing planks (right).  
Etching from drawing by Reinier Nooms (d. 1664).



Pl. 2. The Bethel, an American merchant vessel similar to the Water Street ship.  
(Unsigned oil, dated 1749, courtesy Peabody Museum)

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