

The Brigg 'raft' reassessed as a round bilge Bronze Age boat

Owain T. P. Roberts

*School of History and Welsh History, University College of North Wales, Bangor,
Gwynedd LL57 2DG, Wales*

Since they were first uncovered in 1888 the Brigg 'raft' archaeological remains have been interpreted as being those of a flat-bottom ferry derived from a raft-type construction by the addition of angular sides, (McGrail, 1981). This writer believes that a quite different interpretation may be made, thereby suggesting a sophisticated deployment of boats in Late Bronze Age Britain. Instead of a flat-bottom ferry, the remains may be reformed into a lean, round-bilged, stable, buoyant craft having a versatile operational capacity which would include coastal passage-making and short sea crossings.

Reassessment of the evidence

The strakes

The re-excavation strake plan (McGrail, 1981: fig. 2.1.19) shows planks of roughly equal length. Some distance away towards the right of the plan are two other shorter pieces. A narrower, lighter plank and some associated bits of wood are identified as the remains of a side strake. The relative positions of all the remains seem not to have changed since the vessel was abandoned. For a period after settling in the mud the stitching would have held the strakes together. Silting within and without the hull would give support to some strakes and press down others. In a flat-bottom ferry the bottom stitching, used to hold close-fitting strakes together, is not subjected to much tension. Disintegration of the sewing would have resulted in a realignment of some strakes. On the other hand, assuming a round bilge form, stitch disintegration would release the tension inherent in such a construction. Where strakes were supported, little if any separation would happen, as with the planking, which may have been supported by a rising bank when the 'raft' was finally beached (McGrail,

1981: 13). Where unsupported or loaded with silt, detached strakes would move apart, depending upon how much tension was in the stitching at that time. Anyone who has examined a long abandoned work-boat in a muddy creek will have seen these final stages of hull flattening and the resulting gaps between planking, usually, though not always, towards the hood ends.

In the Brigg 'Raft' Report, widths are given for the five main strakes as measured at their left (NW) and right (SE) ends and from these the Report concludes that the 'raft' tapers in its beam towards the left (McGrail, 1981: 224). No significance is attached to the strakes being close together in the middle of the 'raft' and splayed at the left end except to explain it as being due to shrinkage. If a shrinkage allowance of 12% (McGrail, 1981: 228) is added to both end-width measurements then the strake tapering becomes even more marked. Planks close together in the middle and splayed at the end indicate a springing apart as stitches part, as one would expect in a round-bilged boat.

It is assumed that the 'raft' was coffin-shaped in plan, as an explanation for the siting of the two smaller pieces of planking at the right end (McGrail, 1981: 244). After a very thorough interpretation of the evidence for the shape of the original logs, McGrail concludes that the 1888 measured drawing was incorrect where it showed strakes which were incurving. Investigation by the present writer leads him to believe that Thropp was justified in showing curvature, induced during the building process. Such a building process would explain the narrowness of strake no. 5 at its right-hand end. McGrail admits it would have been impossible with the widths of board probably available to carve nearly parallel-sided planks to shape.

Determination of strake development (Fig. 1)

Using the plan (McGrail, 1981: fig. 2.1.19), the writer placed a stiff spline through the line of stitch holes on each side of each strake. Strake edges were mostly too damaged to be used. The stitch holes provided a datum which had an average distance from a strake edge and were used rather as a set of points when drawing a graph. The result was a fair curve through each line of stitch holes which could be projected to produce each strake's full-width development.

The fair curves developed along both edges of strake nos. 4 and 5 were projected without distortion along the corresponding edges of the plank pieces located to the right. Strake nos. 4 and 5 showed tapering towards each of their ends.

The remains of strake nos. 1 and 2 show a curving taper towards their left-hand ends. However, no convenient controlling points were available to substantiate the tapering shapes of the missing right-hand ends as suggested by the fair curving of the splines.

Another datum was established by laying the spline along the cleats which are close to each strake's centreline. Again fair curves were established along the surfaces of strake nos. 4 and 5. The final cleat at the right of strake no. 5 is clearly offset to the outer edge. The cleats on strake no. 1 are in a straight line. Where a final cleat may be presumed, the cleat centreline is the same distance offset from the projected outer edge as in strake no. 5. This would seem to establish the flattened-out shape, or development of strake no. 1. According to McGrail (1981: 222), strake nos. 1 and 5 are from the same tree and, if so, they would be expected to be a 'handed' pair. However, no. 1 is not a true reflection of no. 5, though nearly so.

The cleat on the separated piece of strake no. 4 is centrally placed. The centreline through the cleats of strake no. 4 curves as far as this cleat. In developing strake no. 2 the centreline is seen to be straight. A position for the missing no. 2 right-hand cleat was determined to be at the intersection of the centreline of no. 2 with a line passing through those right-hand cleats in the separated ends of strake nos. 4 and 5. Confirmation of this position was gained by stepping-off the average cleat spacing four times along the cleat centreline from the last cleat on strake no. 2. Assuming that strake nos. 2 and 4 were

similar, the width of no. 4 at the right-hand cleat was transferred to no. 2 and fair curves were easily produced for both edges.

So far the reconstruction of the developments of strake nos. 1 and 2 suggest that they had sprung apart from each other and from no. 3 when their stitches had rotted. Strake no. 3 is deduced to have been symmetrical in its taper. The cleats' centreline datum makes a straight line when projected to the right. The top edge of the strake is slightly apart from the next strake and a stiff spline produces a fair curve to the right-hand end of the drawing. The bottom edge produces a similar, but rising, curve and both curves pass equidistant from the point on the centreline where the right-hand cleat might have been. This development also suggests that the centre strake pulled away and flattened out on coming free of its fastenings. A small projection of the left-hand ends of the strakes emphasises their splay and their taper.

Neither strake no. 1 nor no. 2 should be thought to be exactly the same shape as nos. 5 or 4. Neither in their remains nor in the present writer's development of the missing portions is this true. However, strake nos. 1 and 5 are similar and so are strake nos. 2 and 4. Within the constraints of early technology this would have been acceptable. For example, while measuring the boat from Årby before building a replica for the National Maritime Museum, Greenwich, the writer noted that the keel-plank was asymmetrical in plan, being considerably wider to starboard. The original builder had compensated for this in the starboard garboard strake and the same was done in the replica (Roberts & Greenhill, forthcoming).

Following the postulated development of the strakes as distorted *in situ* (Fig. 1), a development plan of the strakes in their pre-stitched shape was drawn (Fig. 2). From this there emerges the probability that all five strakes tapered in fair curves towards each of their ends. Pulling such shapes together, edge-to-edge by stitching, would not result in a flat-bottom vessel. Instead there would be a saucer-shaped cross-section with girth measurements at the ends shorter than amidships, a keel line showing distinct rocker and a gentle sheer line.

In the light of this discovery the other parts of this boat-find need re-examining to understand their function within the structure.

Strake-edge interaction

Whatever type of fastening is used in the strakes of an edge-joined hull the aim is the same, that is, to create a homogenous shell from disparate elements without the immediate need of a supporting internal structure. Added bonuses are a controllable measure of leakiness and dynamic stiffness of the shell.

In a flat-bottom craft whose bottom strake edges are merely butted before being edge-joined, the bottom's fore-and-aft stiffness is a result of the thickness of the planking. Butting of joined edges in itself leads to a stiffness athwartships. The thicker the bottom planking the greater is this resistance to curvature across the bottom as long as the fastenings are holding each plank tightly edge to edge. Where stitching is employed the articulation of one edge relative to the next is resisted not only by stitch tension, since the stitch material is still pliable, but also by the contact of the edges. If the bottom of one edge-joint begins to open, the top of that edge joint presses tightly because the stitching is tight. In this craft, heavy transverse timbers through the cleats would be essential to control the cycle of flexing which otherwise would wear the stitching.

If the Brigg vessel had indeed a flat bottom, one would expect its strakes to retain their full thickness throughout. In fact, the edges are carved out on their under-sides to leave a butting edge averaging 6 mm thick whereas the general strake thickness is 40 to 50 mm (McGrail, 1981: 235). It is suggested by McGrail that this construction was intended to give protection to the stitching. However, better methods for thick-edged planks had long been known, Fig. 3 (Wright, 1976).

Such thin butting-edges would contribute little if anything to across-bottom stiffness, requiring heavy framing to keep them in the same plane. The Brigg 'raft' is reported to have had light, even flexible, transverse timbers. Retention of caulking material would be poor and even reliance on luting and battening, as in the Report (McGrail, 1981: 234), would be misplaced in this hull form.

However, in a round bilge Brigg craft (Fig. 4), the advantage of such narrow edges is obvious in that before or during framing the strakes would be able to flex within the tension of the sewing to assume a comfortable angle. When sewing

together strakes which taper towards both ends, such a tendency is inevitable. These considerations show that the Brigg craft's strakes were intended to articulate within each stitch. Creating a hull in this manner has implications for the method of framing which are discussed below.

Seam battens

Seam battens are enclosed within the continuous stitching of each seam and press a luting material against the butt joints of adjacent strakes (McGrail, 1981: 230). Such waterproofing of the seams was essential since the 6 mm wide strake edges were too narrow to hold caulking material effectively. The narrowness of the edges gave the seam battens another equally important function, namely, to prevent the displacement of strake edges over each other within the confines of the stitching. In the various Ferriby boats (Wright, 1976), this possibility is prevented by a form of tongue-and-groove joint carved along the strake edges. Without seam battens, overlapping of the strake edges in the Brigg craft would be certain to occur and one wonders if, by default, it might have led to an early form of sewn clinker construction.

Cleats, transverse timbers and framing

The few short lengths of what would be transverse timbers in a Brigg flat-bottom ferry refused perversely to match the holes cut through the cleats. It is of little importance that the width dimension is not a close fit in flat-bottom construction since the transverse or athwartship bottom stiffness is due mostly to the solidity of the transverse timber. During construction the builder would be expected to insert the tightest-fitting timbers possible with regard to the thickness dimension. Wedges or inserted dunnage would suggest a less than perfect job. The critical dimension for a cleat hole must be its height above the plane of the edge joints. If not the same as the adjacent cleats in its section its strake may be pulled up or pushed down relative to the others, when a transverse timber is inserted. Adjustment of the hole must only occur at its bottom edge.

Here a round bilge Brigg boat is being proposed and so the fit of the thin transverse timbers is not a problem. That they are thin is conceded in the Report for their maximum thickness or moulding is about 25 mm, though their widths or

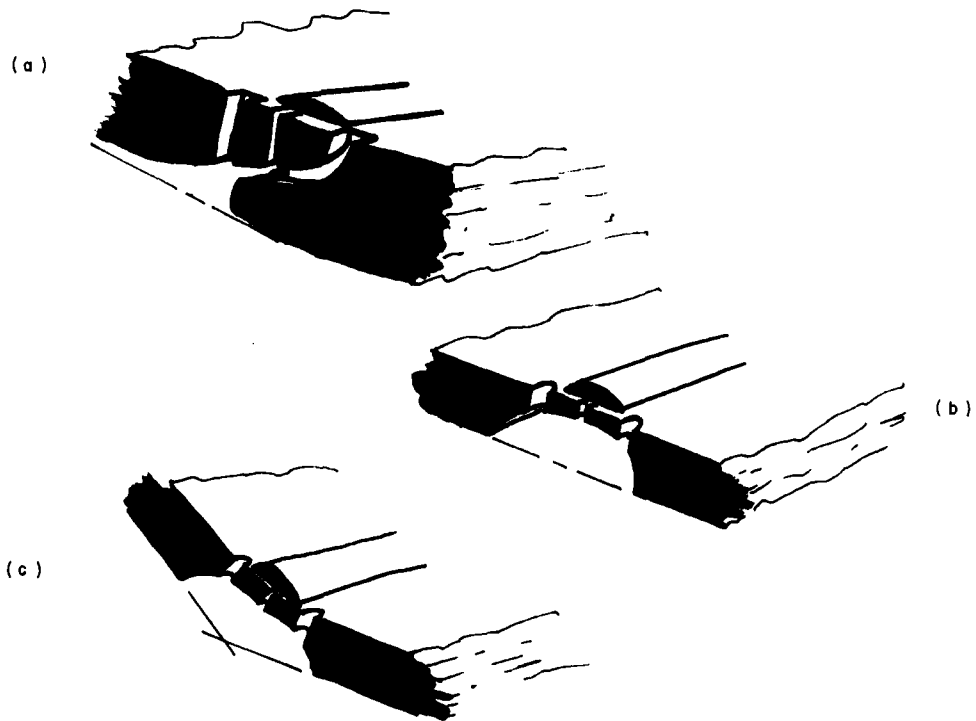


Figure 3. Bottom strake stitching: (a) *Ferriby 1* (Wright, 1976); (b) Brigg 'raft'—flat-bottom (McGrail, 1981); (c) Brigg craft—round bilge.

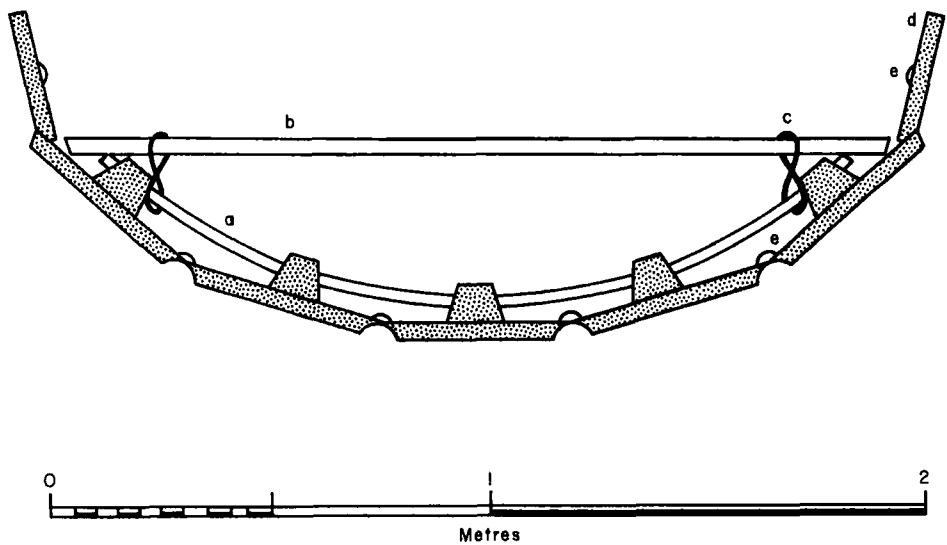


Figure 4. The Brigg craft—a proposed midship section. (a) bent frame through cleats; (b) beam/thwart; (c) lashing; (d) sheer strake/wash strake; (e) seam batten.

siding match the holes in the cleats. There is no inherent difficulty in bending green oak of such dimensions sufficiently to pass through all the

holes in a curving line of cleats. Temporary lashings across the tops of the frames would allow adjustment of each section's shape until it

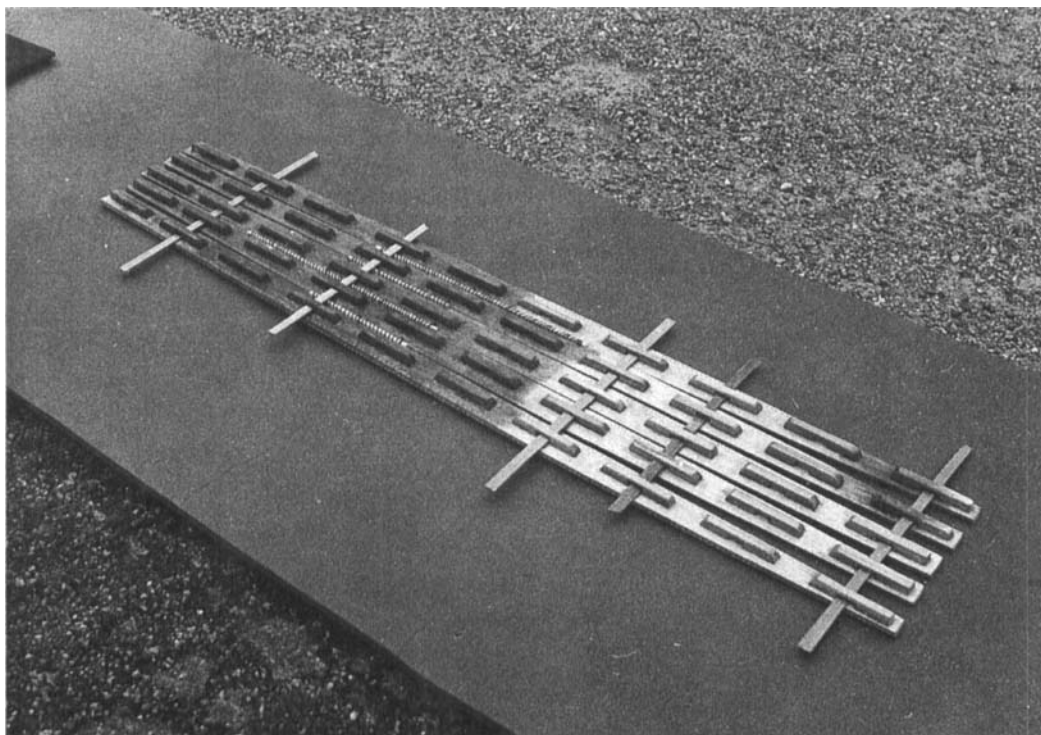


Figure 5. Research model—the first stitches.

was locked by beams in tension or compression. For the same reason the height of the upper edge of each cleat hole would be vital in this form of construction. Once the new frame was in place it would be necessary to lash it to the top edge of each cleat. Thin frames would slide easily through over-size holes and indeed this would be an advantage if the strakes were sewn beforehand as a preliminary to the act of hull shaping. Alternatively (Fig. 5), frames could have been inserted before sewing. Frames might then have been tensioned to a roughly boat-shaped form, drawing up the strakes to their approximate sewn position ready for the stitchers. Final adjustment of the frame shapes after sewing would enable the desired hull form to be attained within the limits of strake flexure.

Side strakes

In those parts identified as side strakes there is no sign of there having been any support other than the stitching. No evidence exists to suggest knees or framing of any kind. Having interpreted the 'raft' as a flat-bottom craft, McGrail shows a

logical method of sewing the lower side strake to the outer bottom strake and to the upper side strake (McGrail, 1981).

In a round bilge reconstruction a different method is needed since the outer strakes, nos. 1 and 5, are inclined substantially. The writer favours placing the side strake within the top edge of the outer strake. Indeed, if the side strake is considered to be nearly vertical then the bevel edge at the bottom of the side strake indicates the inclination of the outer bottom strake. Sheer and curvature of the hull side give a twist to the side strake and make it self-supporting (Fig. 6).

The building of a research model

To explore the construction of a round-bilged Brigg craft a model was built to a scale of about 1:13.5. This was the result of doubling that scale used for the plan in the original report (McGrail, 1981: fig. 2.1.19) and for the writer's proposed strakes plan (Fig. 2). Prior to this a card model had been built directly from the strakes plan in order to confirm the matching of the strakes and to discover the likely cross-section about

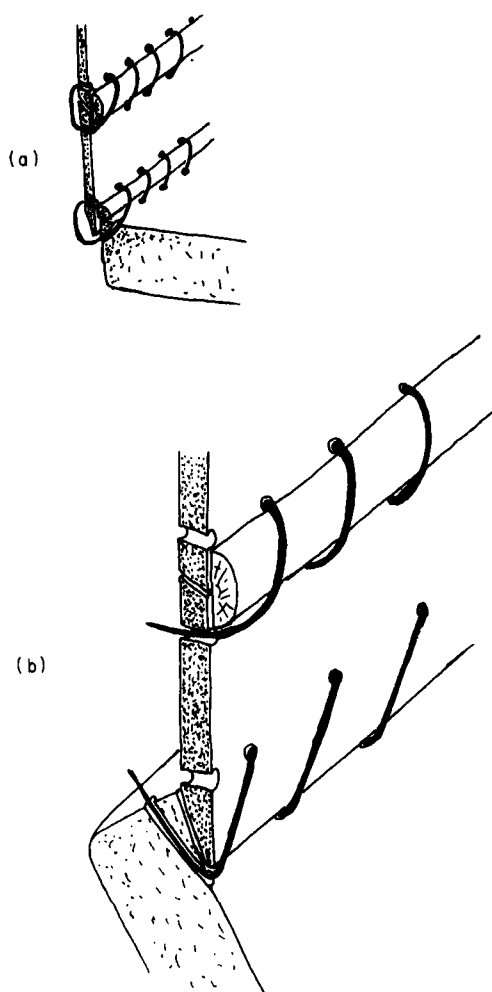


Figure 6. Side-strake fastenings: (a) as postulated by S. McGrail (1981: fig. 4.1.14); (b) possible fastening for a postulated round-bilged Brigg craft.

midships and at both ends. In the wooden model the parts recovered by archaeologists were stained brown so that the proportion of original to proposed timber was distinct.

Preparation of the timber

- (1) The cross-section of the strakes was obtained by laminating shaped fir planks with very thin shaped planks which overlapped all round. The radiused corner between the two was a fillet of 'extended' epoxy resin made by drawing a finger down the corner over the excess which had oozed

out while glueing. Strakes were made overly long at this stage to allow for unforeseen problems in building.

- (2) Cleats were made to a standard shape and glued to the strakes, copying the spacing of the original.
- (3) The wash strakes were not made until the five bottom strakes were sewn and fixed by beams/thwarts. Plywood 1.5 mm thick was used.
- (4) All holes were drilled before sewing began. Linen thread was used throughout. No attempt was made to use scale-diameter holes since these would have been too small for needle and thread.
- (5) Lollipop sticks 5 mm in diameter reduced to a half-moon section were used as battens beneath the stitching.

Building sequence

A building sequence was followed which attempted to simulate that of the full-size construction process (Fig. 7).

- (1) While in flat format with a few frames inserted as guides, all the strake seams over the area of cleats 5, 6 and 7 were sewn. There is least curvature in the strakes in this area but even this small section of sewing imparts the beginnings of a transverse curvature (Fig. 5).
- (2) The middle strake, no. 3, was supported at the ends while a heavy weight was placed amidships, over the sewn area, to impart rocker sufficient to cause strake nos. 2 and 4 to close up with no. 3.
- (3) The ends of strake nos. 2 and 4 were drawn in by Spanish windlasses attached to their cleats. These strakes were then sewn to no. 3, working from the sewn middle area towards the ends. This created a very obvious transverse curvature along the hull (Fig. 8).
- (4) All the frames were inserted and pulled into the curvature by lashings across their tops. Rocker was retained by a heavy weight. A lashing was tightened around both ends of the strakes. Strake nos. 1 and 5 were sewn towards the ends.

As sewing progressed towards the ends the seam battens had their flat faces bevelled to match the decreasing angle made by adjacent strakes.

- (5) The middle cleats were lashed to their respective frames. Packing was inserted

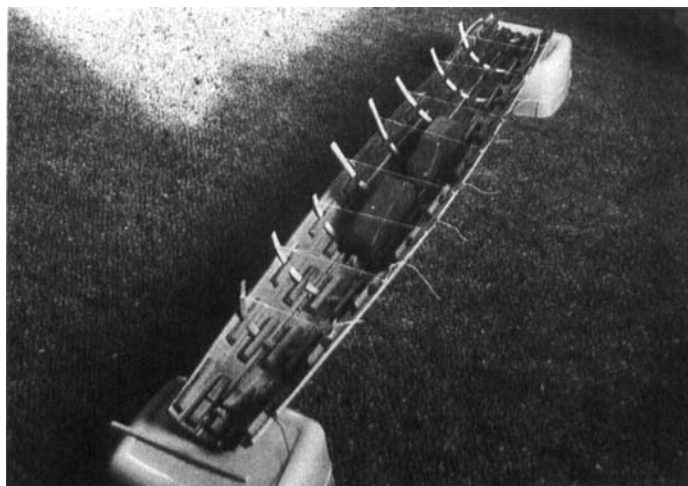


Figure 7. Research model showing the tensioned frames, weight applied to create rocker and much of the stitching completed.

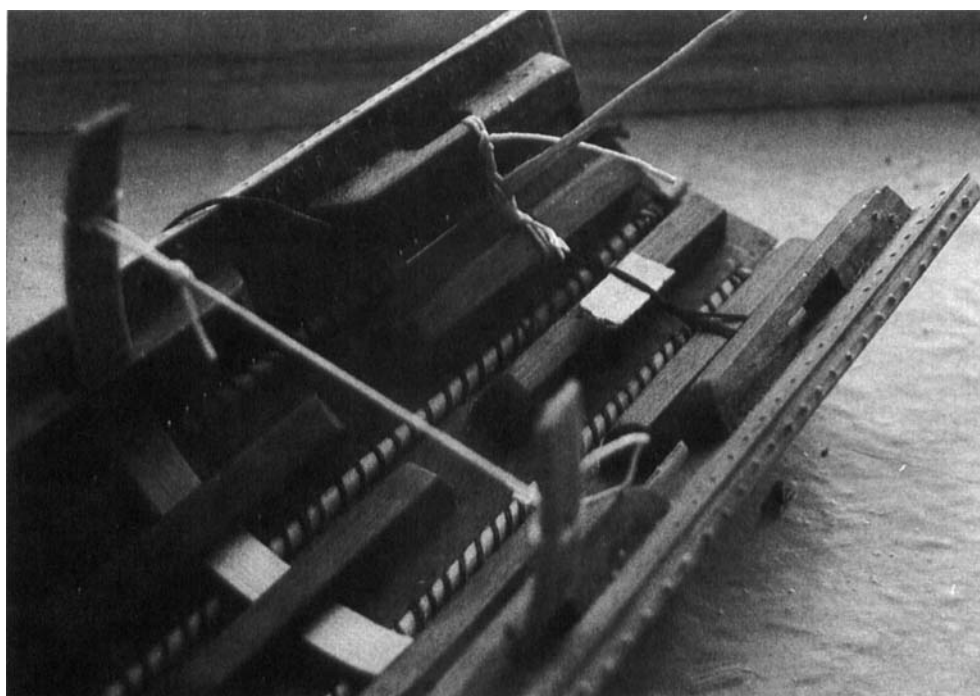


Figure 8. Research model showing a method of drawing the strake ends together.

behind the frame heads within the top cleats to maintain the even spacing between the planking and the frames (Fig. 9).

- (6) Beams or thwarts were fitted to rest on the upper cleats, (Fig. 10). These retained the width of the hull when the lashings and

the excess frame tops were removed. The maximum beam, estimated by the present writer to be about 2 m, settled at 2.15 m.

- (7) Transoms were fitted and sewn in. The cross-section at each end was judged correct when the strakes came together during progressive

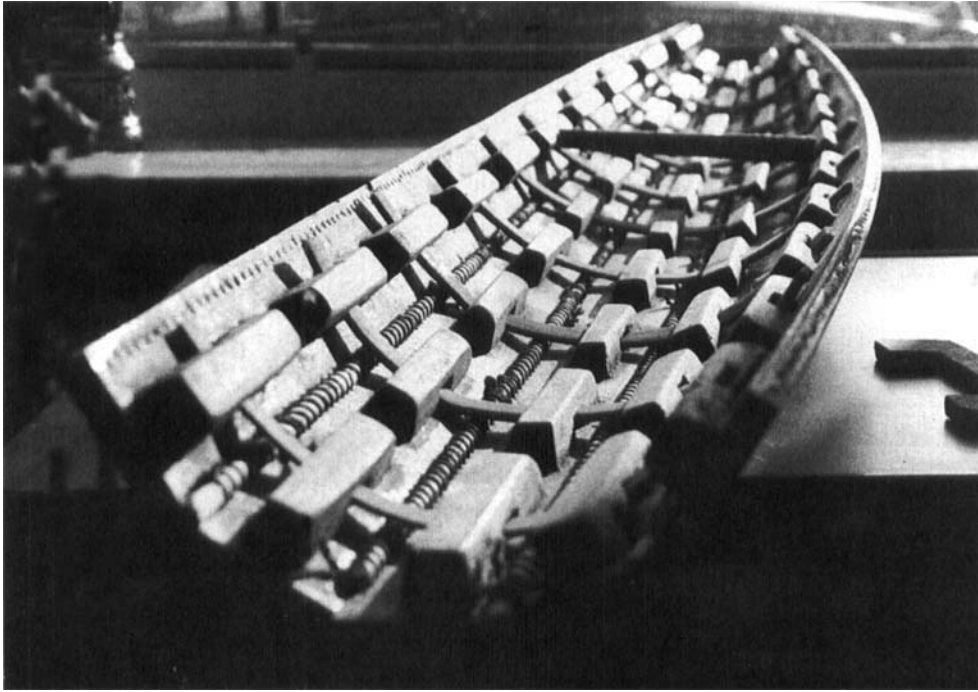


Figure 9. Research model bottom strakes sewn prior to fitting the transoms, etc.

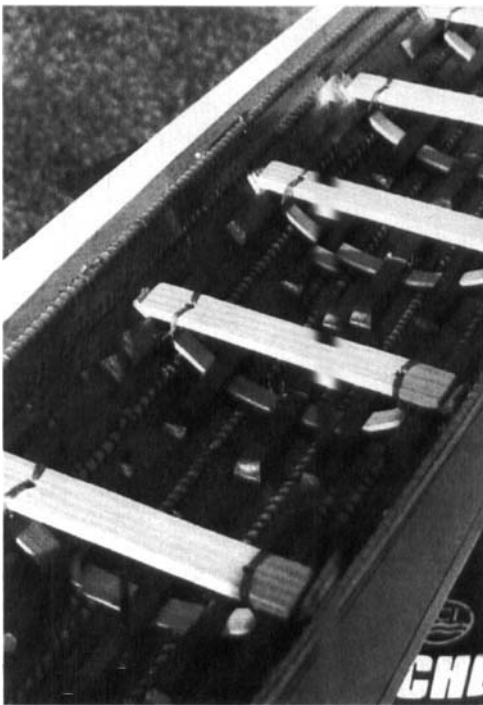


Figure 10. Research model showing finished interior.

tightening of a tourniquet round the hood-ends (Fig. 11).

- (8) The wash strakes were marked and cut out from measurements on McGrail's plan (1981). Very little fitting was needed to make them lie along the edge of the sheer strake.

Conclusions arising from the research model

- (1) Even though stitch holes were drilled at regular spacings, when the stitching is viewed it is seen to vary in its angle, leaning one way for a while then another. It cannot be regarded as a zig-zag stitch. As the strakes are curved the positions of the stitch holes in adjacent strakes change position relative to each other. They have the relationship that two sides of a vernier scale display.

To obtain a regular zig-zag stitch it would be necessary for the strakes to be in their finished position before holes were drilled. The writer thinks such a sequence of building would be unlikely.

- (2) The beam measurement of about 2 m had been predicted from reconstruction drawings and from the manipulation of information

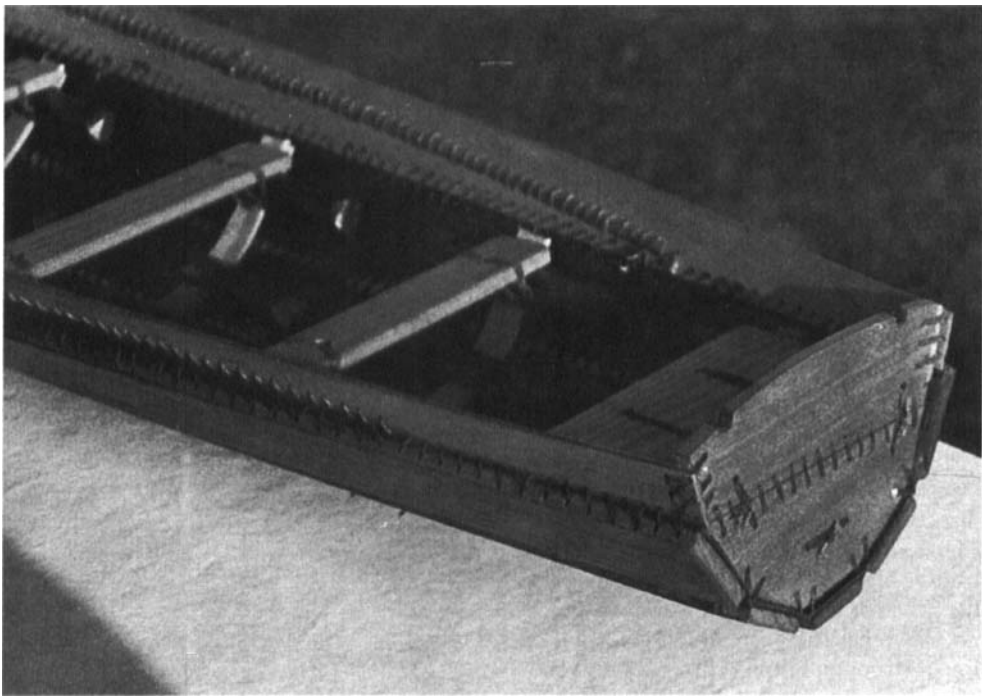


Figure 11. Research model—stern transom.

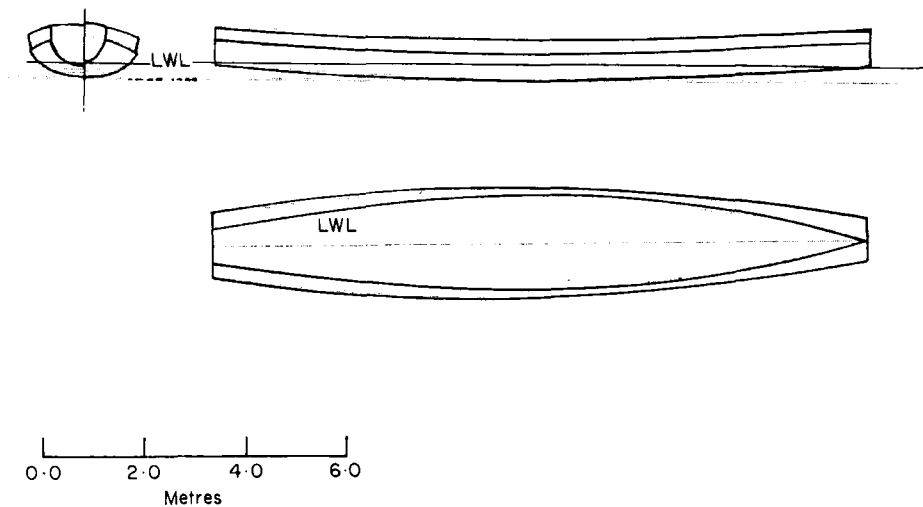


Figure 12. The Brigg craft—lines enhanced after computer print-out.

within a computer hull-design programme. When all strakes were sewn up, the resulting scale-beam of 2.15 m was attained with very little tensioning of lashings (Fig. 12).

- (3) The change in curvature of the sections from an open, saucer-like shape over much of the hull to the increasingly tight curves

at the ends required the use of thinner, more flexible frames towards each end of the hull. This arrangement seems supported by the thickness of what is considered framing found in the Brigg 'raft', the thickest being in the middle and the thinnest at one end.

- (4) The placing of beams/thwarts upon the top cleats was a minimum solution meeting both structural and ergonomic requirements. It gave the correct seating or part-kneeling position for a paddler wielding a single paddle. The freeboard from the wash strake was also correct for paddling when the Brigg craft was at her loaded waterline as computed. Paddling is assumed since the wash strake is not supported to take the strain of oars.
- (5) The right-hand end of the strake plan is identified as the bow because of the smaller girth and increasing rocker of the central strake in the model. The load waterline is below the bow transom, whereas the stern transom is just in the water. The waterline plane shows more fullness aft.
- (6) The writer considered extending the strakes by long tapers at each end. This would avoid the need for transoms. However, this could not be regarded as a minimum solution. Reconstructing the end cleats to finish short of each strake length added nothing to the likely remains of this craft but gave a convenient ledge upon which to sit a transom. The use of transoms in the Bronze Age is confirmed (McGrail, 1981: 220), so no new technology is being added. Load waterline calculations support the viability of abrupt ends in this reconstruction (Fig. 13). In fact this method causes the model to be finished marginally shorter than the strakes plan indicated. Lengthening the end cleats by a few millimetres more than the average dimension would have corrected this but, by implication, in its original form each strake may have ended with an athwartships cleat created specifically to hold a transom.

An operational assessment of the proposed Brigg craft displacement

In the naval architect's assessment of the Brigg 'raft' (J. F. Coates in McGrail, 1981: section 4.3), the total weight is calculated as 1600 kg for a reconstruction of the remains with a side strake having the widest possible measurement. That figure is used in the present reconstruction since slight differences in the scantlings of both versions balance out.

Loaded weight is calculated from the number of thwarts postulated; doubled, this gives 16

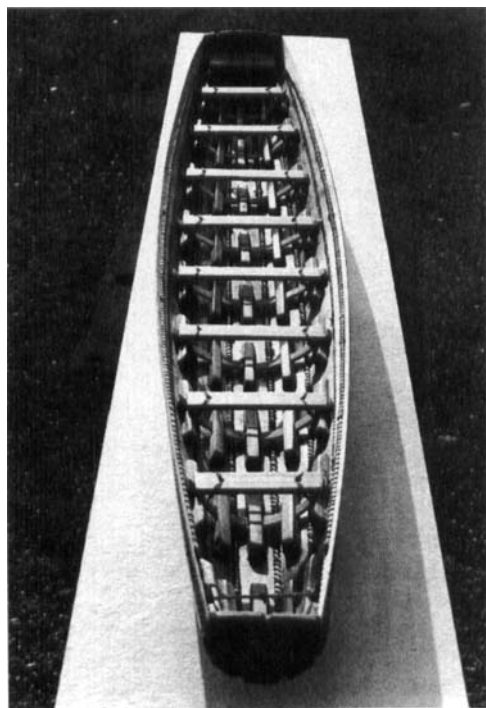


Figure 13. Research model completed.

paddlers. Three other men are considered necessary to complete the crew. Each man weighs 60 kg as suggested by Coates. No calculation has included cargo. Loaded weight or displacement was calculated as:

$$1600 \text{ kg} + (19 \times 60 \text{ kg}) = 2740 \text{ kg}.$$

Calculating from the lines plan drawn by computer (Fig. 12), displacement consistently gave a figure of about 2750 kg at a draft of 0.3 m. This allowed the bow transom to be clear of the load waterline and the stern transom just dipping, which seemed a satisfactory trim.

Stability

In Fig. 14 showing freeboard and stability, the likely positions of the various items affecting operational capability indicate useful stability coupled with freeboard which would make the Brigg craft a safe vessel to use on the sea. The stability curve (Fig. 15) demonstrates a range of stability extending well beyond the point at which she would start to be swamped and shows that the presence of water in the bilge would not cause an uncontrollable stability problem. To

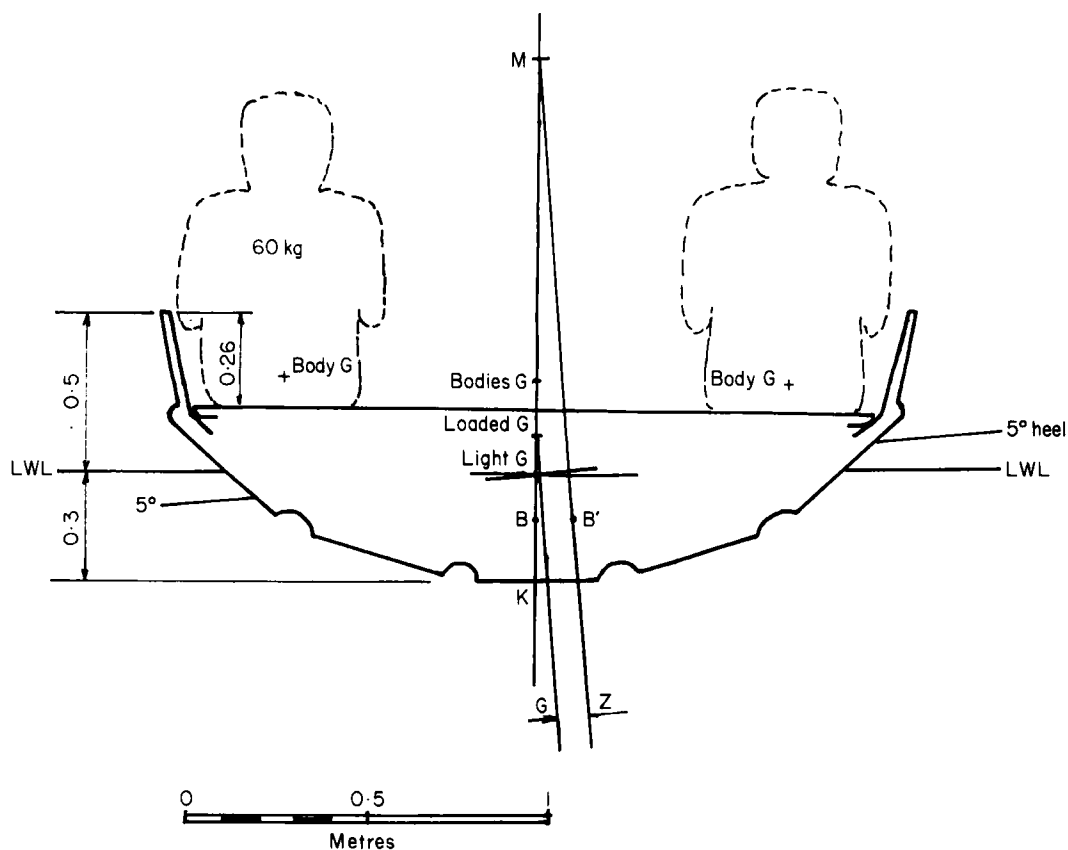


Figure 14. The Brigg craft—freeboard and stability in a loaded state. GM 1.032 (loaded); GK 0.4 (loaded); GZ 0.089 at 5° heel and GM 1.027; loaded displacements 2750 kg (19 persons); light displacement 1600 kg.

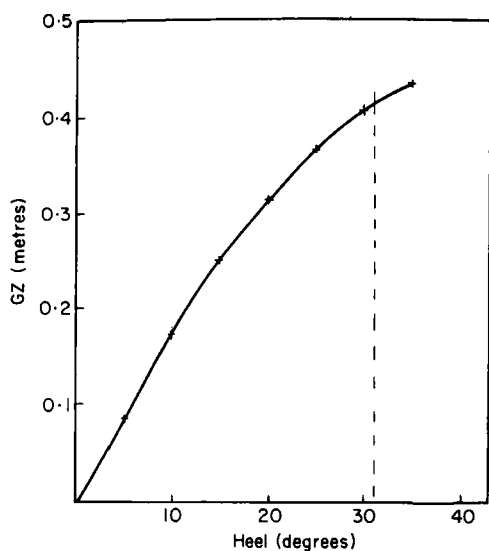


Figure 15. Brigg craft stability curve at loaded displacement 2750 kg.

reach that angle of heel all the crew would need to sit to one side. The Brigg craft would be buoyant in rough seas, and with steady bailing would survive bad weather.

Speed

Estimates of those factors affecting the speeds attainable from a proposed Brigg craft were prepared by computer. Probably the Reynolds numbers (for flow) and the Froud numbers (for hull smoothness) used by the computer tended to be optimistic for an ancient hull. These levels of resistance or speed are likely to be just slightly more or less than those shown.

In Fig. 16 drag or resistance is shown to increase with speed. Because of the Brigg craft's fine hull form most of the drag is due to skin friction at the lower speed and only at about 7 to 8 knots does form resistance equal and then exceed it. The drag increases dramatically from

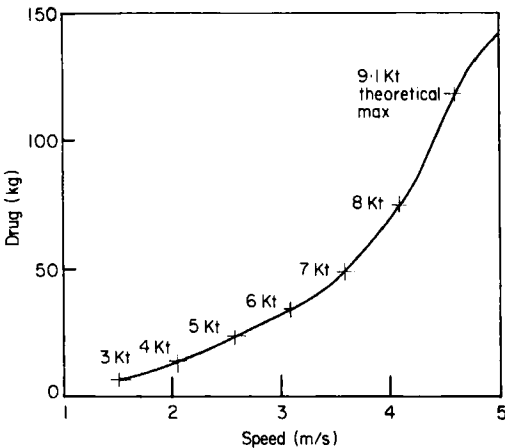


Figure 16. Brigg craft drag with speed.

7 knots upwards to the theoretical maximum speed. Power required to overcome the drag at any speed is shown as a table in Fig. 17. The table implies that in attaining 6 knots the paddlers would hardly be exerting themselves and more importantly, could maintain that speed for long periods. The possibility of completing long journeys is evident. About 8 knots a paddler is exerting himself as much as a modern dragon boat paddler at sprint speeds and is not going to last more than a few minutes (Coates *et al.*, 1990: fig. 14).

Features of a hull may be defined as ratios and these are listed for comparison with a number of ancient boats in Fig. 18. The proposed Brigg craft has features which invite comparison with the Hjortspring boat and suggest that the operational demands made on them by their respective crews would be similar.

Similar features found in other ancient boats

Although the Brigg craft cannot be thought of as having directly influenced any known later boat finds, they may exhibit apparently similar features resulting from advances made in other North European Bronze Age boat-dependent cultures using similar craft.

Bent frames, cleat spacing and room

As postulated, the Brigg craft represents the earliest found example of construction using bent frames. Bent frames have been considered by Wright (1976) and McGrail & Kentley (1985), among other solutions, for the reconstruction of Ferriby 1, but there is not the evidence to substantiate them.

The Hjortspring boat, (Rosenberg, 1937), has bent frames which are pulled down over the tops of cleats to which they are lashed. This might seem to be a progression in techniques from that suggested for the Brigg craft. Cleats may be made smaller, sufficient for the smaller hole needed for a lashing, while the drilling of holes to line up with the bent frames may be done as lashing proceeds. Multiple cleats spread the support of each frame to the edge of each strake, necessary when thin planking is used. In the Nydam (Akerlund, 1965) and Kvalsund boats (Shetelig & Johannessen, 1929) a step removed from the use of lashings is taken by the use of rigid crooks for frames which nevertheless are still lashed to cleats. They open up the possibilities of rigid fastenings in the future without the need for careful cleat carving.

In a boat whose frames are to be lashed to cleats a decision on the position of the cleats has to be made, before the strakes are carved. The

Knots	m/sec	Drag (kg)	Newtons	(16 paddlers) watts	Power per paddler
3	1.5	6.5	64	99	6.2
4	2.1	13.5	132	271	17
5	2.6	23.9	234	608	38
6	3.1	34	333	1032	65
7	3.6	47	461	1660	104
8	4.1	75	735	3014	188
9	4.6	120	1176	5410	338
9.5	4.9	138	1352	6627	414

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Figure 17. Table of the Brigg craft power for speed.

Boat	LWL (M)	Vol. coeff.	Block coeff.	Prismatic coeff.	Length	Slenderness coeff.	Theor. max. speed (kt)
					$\frac{\text{Length}}{3\sqrt{\text{Disp. ratio}}}$		
Ferriby 1	14	3.8×10^{-3}	0.75	0.94	6.4	5.6	9.5
Brigg craft	12.9	1.3×10^{-3}	0.371	0.531	9.3	7	9.1
Brigg 1 'raft'	12.3	6.7×10^{-3}	0.96	0.97	5.3	5.3	8.8
Hjortspring	14.7	0.83×10^{-3}	0.36	0.69	10.6	9.8	9.7
Gokstad 1	22.5	1.58×10^{-3}	0.21	0.60	8.6	5.4	12
Gokstad 3	5.5	1.88×10^{-3}	0.21	0.42	8.1	5.4	5.9
Sutton Hoo	19	2.8×10^{-3}	0.36	0.56	7.2	5.1	11
Skuldelev 3	11.68	4.77×10^{-3}	0.27	0.50	5.9	4.0	8.7
Skuldelev 1	15.6	8.96×10^{-3}	0.38	0.54	4.8	3.5	10
Graveney	10.1	10.7×10^{-3}	0.46	0.59	4.5	2.8	8

Figure 18. Table of speed indicators for the Brigg craft and others from NW Europe. Note the unconformity of the 'raft' interpretation of the Brigg 1 remains within this groups and the gross theoretical maximum speed attributed to this low-freeboard, box-like form. It is suspected that the volume coefficients are calculated from a mix of displacements for sea and fresh water. (Much of this table is based on S. McGrail, 1987: tables 11.2 and 11.3).

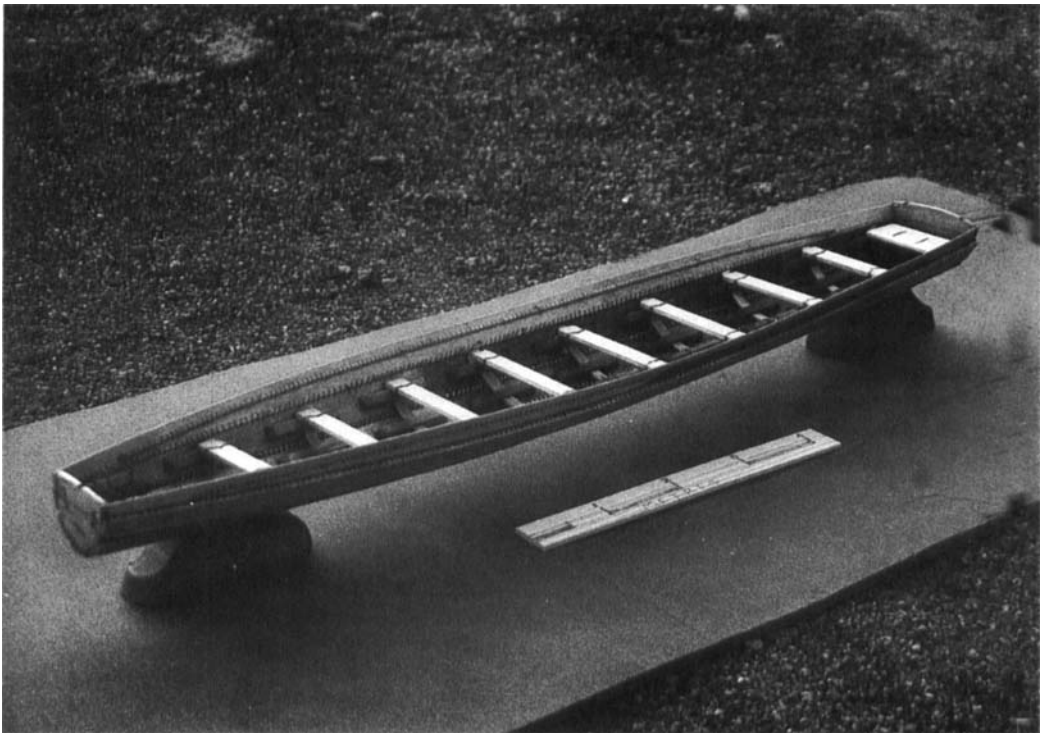


Figure 19. Research model completed.

spacing used in the Brigg craft is 1.28 m centre to centre. This happens to be the same as an exaggerated pace taken by a man 5' 8" (1.72 m) tall. Cleat spacing in the Nydam and Kvalsund boats is 1.15 m and 1.20 m respectively. In boats where

frames are fastened directly to the planking, spacing reduces to 1 m or less. It would seem that cleat/frame spacing is maintained at an easily repeated standard, based on the human body. As soon as cleats are no longer present to dictate

frame spacing a new norm emerges. This relates to the amount of room needed to pull an oar, a distinctly reduced distance which may be decided at a late stage in the building of the hull.

Keel-plank cross-sections

Attention must be drawn to those flat plank-keels found in the earliest clinker planked boats so far discovered, for instance the Nydam ship. These are remarkably similar in cross-section to those strakes found in the Brigg craft. Mention was made earlier of how the Brigg craft strakes could easily slip into a form of over-lapped planking if for any reason there were inadequate battens beneath the stitching.

Conclusion

The reassessed Brigg craft (Fig. 19) fits easily into that useful category of light craft suited to being rowed or paddled without a fearful regard for the weather or manhandled up a beach without too much exertion, by that optimum number of men needed for successfully exploring, hunting, defending and attacking as a

self-motivated, organised unit. Many ancient and recent North European boats come close to this ergonomic and social ideal comprising a length of about 13 m and a crew of about 20. Some of the physical laws governing performance are applied here to the reassessed Brigg craft.

It is believed that this proposed reinterpretation of the Brigg 'raft' has been amply supported by the ease with which the research model came together and by the hydrostatic calculations which so plausibly define such a hull. It is suggested that in future the remains from Brigg 1 should not be regarded as those of a flat-bottom ferry but as those of a well-developed craft capable of taking the sea in its stride and maintaining contact with places along the British coastline and even the Continental fringes of the North Sea.

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