Portuguese-derived ship design methods in southern India?

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Methods of deriving hull shape

Worldwide, there seem to be two main ways of conceiving hull shape. On the one band, the builder visualises his vessel as a hull of planks into which supporting framework is inserted: he builds plank-first; his ship is shell-built. The second builder, on the other hand, visualises a framework to which planks are subsequently fastened: he builds frame-first; his ship is skeleton-built.

How the plank-first builder gets the shape of hull he wants is a mystery, in the medieval sense of that word. It is also an art, since the builder uses his personal abilities and experience. Sometimes it is described as "building by eye", a process well understood by the practitioner but which he finds difficult to describe in words. Today in South Asia, boat builders who build plank-first supplement that art by rules of thumb, ratios, and simple building aids (Blue, et al, 1997; Kentley, Mcgrail and Blue, 1999). Using ethno-archaeological means, we may, in time, learn something about these rules and these aids; it is doubtful, however, whether we shall ever learn the true mystery of building by eye, unless we take the trouble to serve an apprenticeship with a plank-first boat builder.

The other method, building frame-first, is more familiar to us in 20th century Europe, since most wooden vessels are now built that way. In the plank — first method the design of the boat is in the head of the builder — a very personal thing. In frame-first, on the other hand, at least part of the design is recorded in some way: as a scale model or drawing, as a diagram, or as a table of numbers. We recognise such representational and symbolic evidence and may learn from it. It is this technical activity, the design of frame-first boats and ships, with which this paper is primarily concerned. Its main focus is on 20th century ships and boats of southern India, nevertheless it may cast some light on late-medieval Europe at the time when ship design methods were being introduced.

Frame-first in 20th Century Europe

In Europe, in the recent past, there were a number of ways boatwrights built a frame-first boat. In Eric McKee's words (1983, p. 118), they ranged from 'building mostly by eye' to 'total dependence on drawings'. In terms of design, this means that, at the "by eye" end of that spectrum, the builder himself had in mind an ideal framework that would produce the shape of boat he wanted. This framework was probably not conceived in its entirety and in detail, and the builder approached its design with a degree of flexibility: for example, the actual timber available to him would have influenced how close he could get to the ideal shape. Ribbands may have been used as well as frames to give the hull shape. Furthermore, this framework may not have been completed before planking was fastened to it: rather it was built in stages, as the design developed before the builder's eyes. As he built up the framework, he may well have modified his original ideas to incorporate some performance-enhancing feature or some strengthening fitting. In some ways this process is comparable with that used in plank-first building: "an act of sculpture" as Greenhill (1988, p. 32) has called it, but here using framing

timbers instead of planking. Greenhill's description of late-19th/early-20th century yards in which merchant schooners were built (Greenhill, 1978, p. 124-125) presents a vignette of this style of frame-first design.

At the other end of the spectrum, the second builder worked from naval architect's drawings. This builder had little scope for innovation and he ensured that he got the right timber to build the shape of hull that had already been designed by some specialist. His personal abilities and experience were still used in the building process, but not in the design of the boat.

Frame-first in the medieval Mediterranean and Atlantic

In the 14/15th century Mediterranean it seems that the design method used for frame-first ships was somewhere between the builder's informal approach and the naval architect's formal drawings (Anderson, 1925; Sarsfield, 1984; Bellabarba, 1993, 1996, p. 259; Steffy, 1994, p. 97--99; Greenhill, 1995, p. 256-273; Rieth, 1996). The basis for it was a set of rules (*partison* in Italian), within which there was scope for some individuality. Yet, like any good design method, this Venetian method ensured that a shape of hull that proved to have desirable qualities (for example, in terms of capacity, speed, stability etc) could be repeated again and again.

The essential requirements for a particular design of Venetian hull were:

1. The shape of the master frame - this could be in terms of X & Y coordinates or it may have been a thin wooden mould (template or pattern).
2. Data concerning the particular ship. For example:
   (a) The inclination of the posts — in terms of co-ordinates, or possibly the tangent of the angle from the horizontal;
   (b)A basic linear module, usually the length (L); and
   (c) The maximum breadth and depth of the hull, again in terms of ratios relative to (L).
   These parameters, (the midships mould and the data) defined the general shape of the hull. To get the detailed hull shape in terms of the framing, the builder needed two further para meters:
3. The total number of designed frames and/or their spacing.
4. The total rising and narrowing of the designed hull in relation to the depth and breadth of the master frame.

The builder then used a special wooden tablet (*mezza luna*), inscribed with a geometrically spaced series of lines, to derive the shape of the designed frames from the shape of the master frame. The result was a family of curves, each one the shape of a designed frame.

In this method the designed part of the hull was usually slightly less than the keel length, and the last of the designed frames (both aft and forward) had a special name (*capo di sesto*). Beyond these two frames, towards the posts, the hull shape changed too rapidly for the frame shapes to be calculated by the *partison* method. The bow and stern frames were therefore fitted later, after the hull had been partly planked. These were not active (that is designed) frames but passive, their shape being determined by ribbands.

These Venetian design methods spread widely in the Mediterranean and into Atlantic Europe, especially Iberia. A dozen years ago Patrick Sarsfield (1985, 1988) documented a generally similar method in Brazil, which he subsequently used when building a reconstruction of Columbus' Nina (Carrell and Keith, 1992; Barker, 1993). Taylor (1988) has described the recent use of related methods in Newfoundland.

Frame-first in 20th century Tamil Nadu

During an exploratory visit to Tamil Nadu in 1994 (Fig. 1), wooden vessels being built by frame-first methods were noted at a shipbuilding site in Tuticorin (Fig. 2) and in a boatyard at Atirampattinam. This was in contrast to all other types of traditional vessel on the Bay of Bengal coast, which are built plank-first. During a subsequent visit, with colleagues, in 1997, the design and building of the Tuticorin *thoni* and the Atirampattinam *vattai* (Fig. 3) were documented (Blue, Kentley and McGrail, 1998).

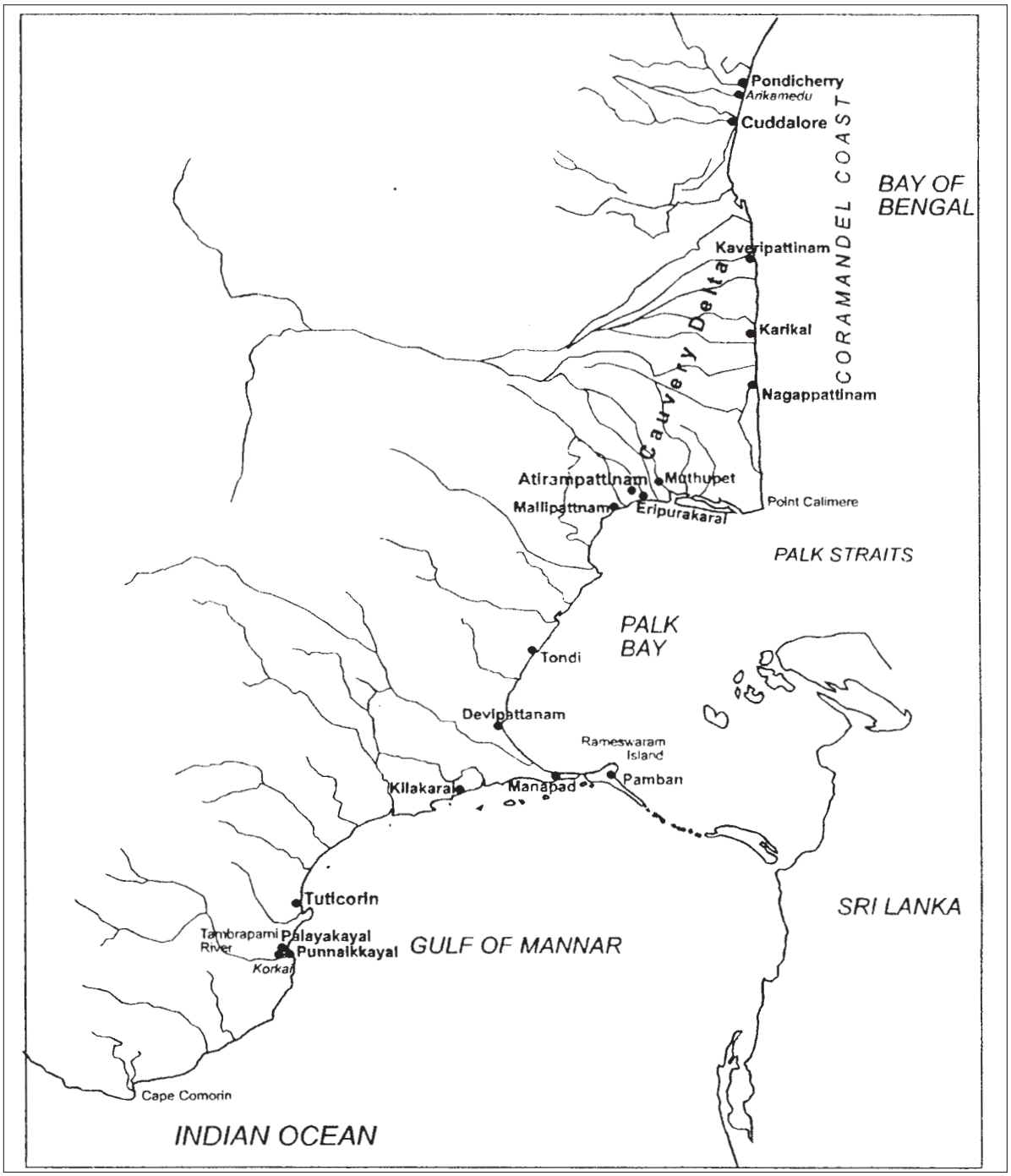

FIG. 1 – Coastal sites in southern Tamil Nadu. Map: L. Blue.

FIG. 2 – A *thoni* nearing completion on a foreshore building site at Tuticorin. Photo: S. McGrail

FIG. 3 – A *vattai* under foresail & mainsail taking the ground at the beach landing place at Eripurakarai, near Atirampattinam. Photo: E. Kentley

Tuticorin *thoni* are sailing cargo ships of 250 to 650 tonnes capacity (Fig. 4). They have three masts and can set twelve and more sails, and are used on the Tamil Nadu/Sri Lanka trade route (Kinghorn, 1996). Their framework is designed on a lofting floor using a single two-part mould (Fig. 5) and a simple geometric construction. This method is comparable with, and evidently related to, the Venetian/Atlantic methods.

FIG.4 – A *thoni* under all plain sail in Colombo harbour, April, 1994. Photo: Captain A.W. Kinghorn.

FIG. 5 – A *thoni* two-part mould on a lofting floor in Tuticorin. Photo: S. McGrail.

The Atirampattinam *vattai* is a fishing boat, some 12m. In length, used in the northern parts of Palk Bay. Since the method of designing the *vattai* is similar to that of the *thoni*, but easier to describe, this will be the method presented here. The *vattai* is double-ended & has a simple hull form with a long, box-like central part; only in the regions approaching the ends, where the hull is rising and narrowing, does the cross section change (Fig. 6). Thus the builder has to determine only four frame shapes to fix the shape of the main hull:

(a) One frame shape direct from the master mould. This shape is used again & again for the frames in the central part of the hull. These frames are known by the Tamil builders as 'equal' frames (Fig.7)
(b) Three frame shapes derived from that mould. These three different shapes are for frames beyond the central part, towards the ends of the boat. These frames, which are paired one forward and one aft, are known in Tamil as 'unequal' frames.
The *vattai* frames are designed using a single mould, a simple rule-of-thumb and a scrieve board (Fig. 8) that is slightly bigger than the breadth and depth of the *vattai* hull amidships (1,70 x 0,85 m). The curved L-shaped mould is positioned within a pattern of orthogonal and diagonal lines (previously scribed on the board) to give the shape of one half of the master frame (Fig. 9). The mould is then flipped over and the other half of this frame is drawn.

The rising and the narrowing of the hull towards the ends is allowed for by marking two points on the board (one on a diagonal, the other on the upper horizontal line) using the rule of thumb: "for every inch along the diagonal (from the last drawn frame), the half-breadth narrows by 3/4 inch". The mould is positioned on these two points & the upper part of the curve drawn. It is then rotated in the plane of the board and the lower part of the curve drawn, giving the shape of the first pair of 'unequal' frames. The shapes of the other 'unequal' frames are derived in a similar manner. These curves are then transferred to timbers, and one master frame, fourteen 'equal' frames, and three pairs of 'unequal' frames are fashioned.

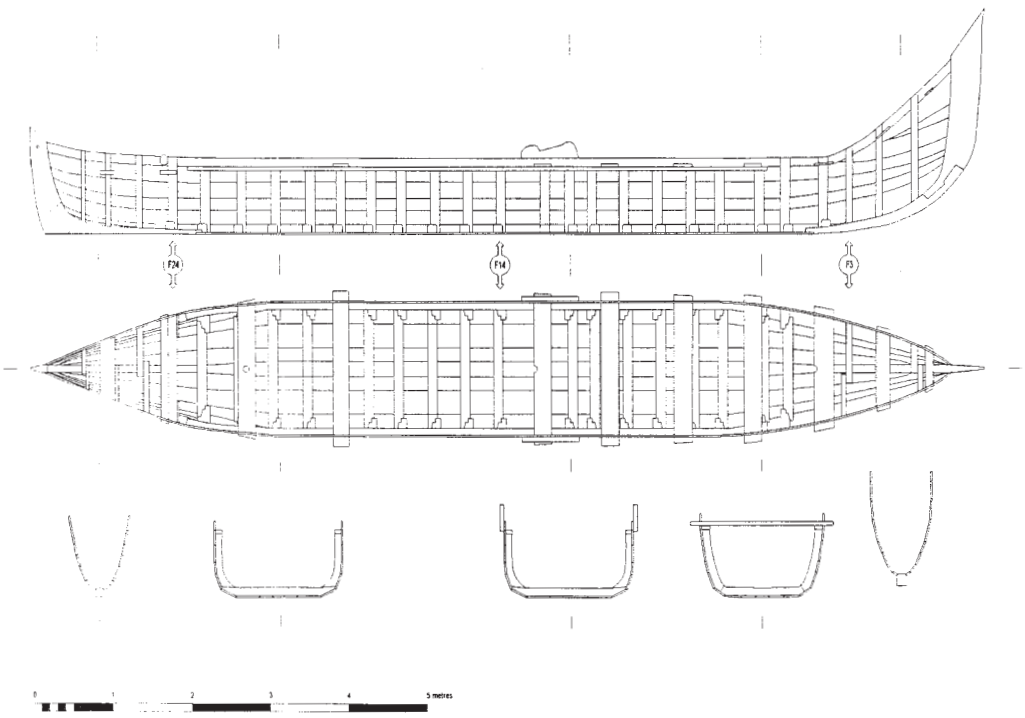

FIG. 6 – Rectified plans of a *vattai* recorded on the Eripurakarai foreshore in January, 1997. Drawing: E. Kentley.

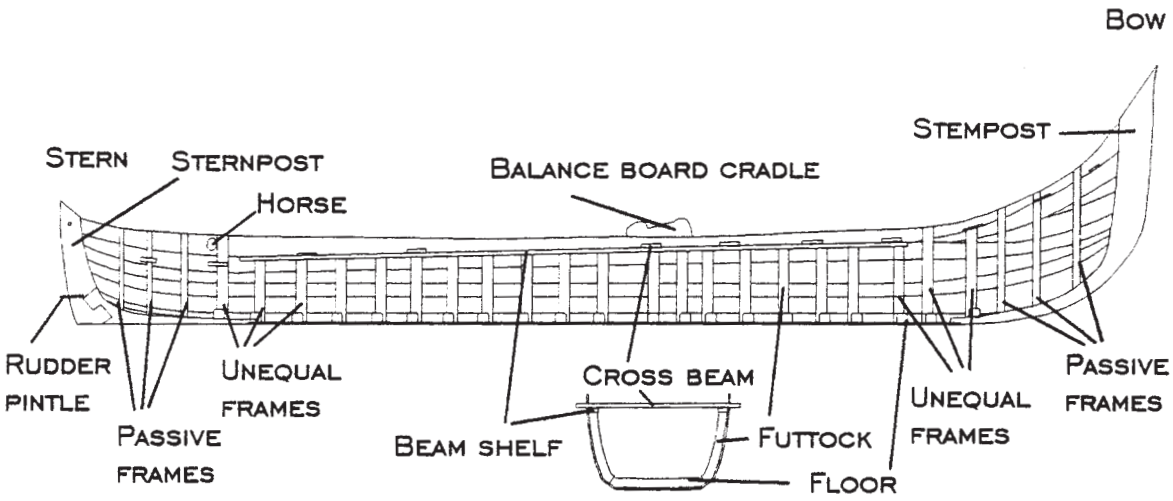

FIG. 7 – Terms used in the text to describe parts of the *vattai*. Drawing: E. Kentley.

FIG. 8 – A scrieve board and mould used in a boatbuilding shed at Atirampattinam. The preparatory lines and the shapes of the master frame and the three unequal frames have been highlighted in chalk. The angled parallel lines are not part of the design system, but merely outline one of the pieces of wood used to make the board. Photo: S. McGrail.

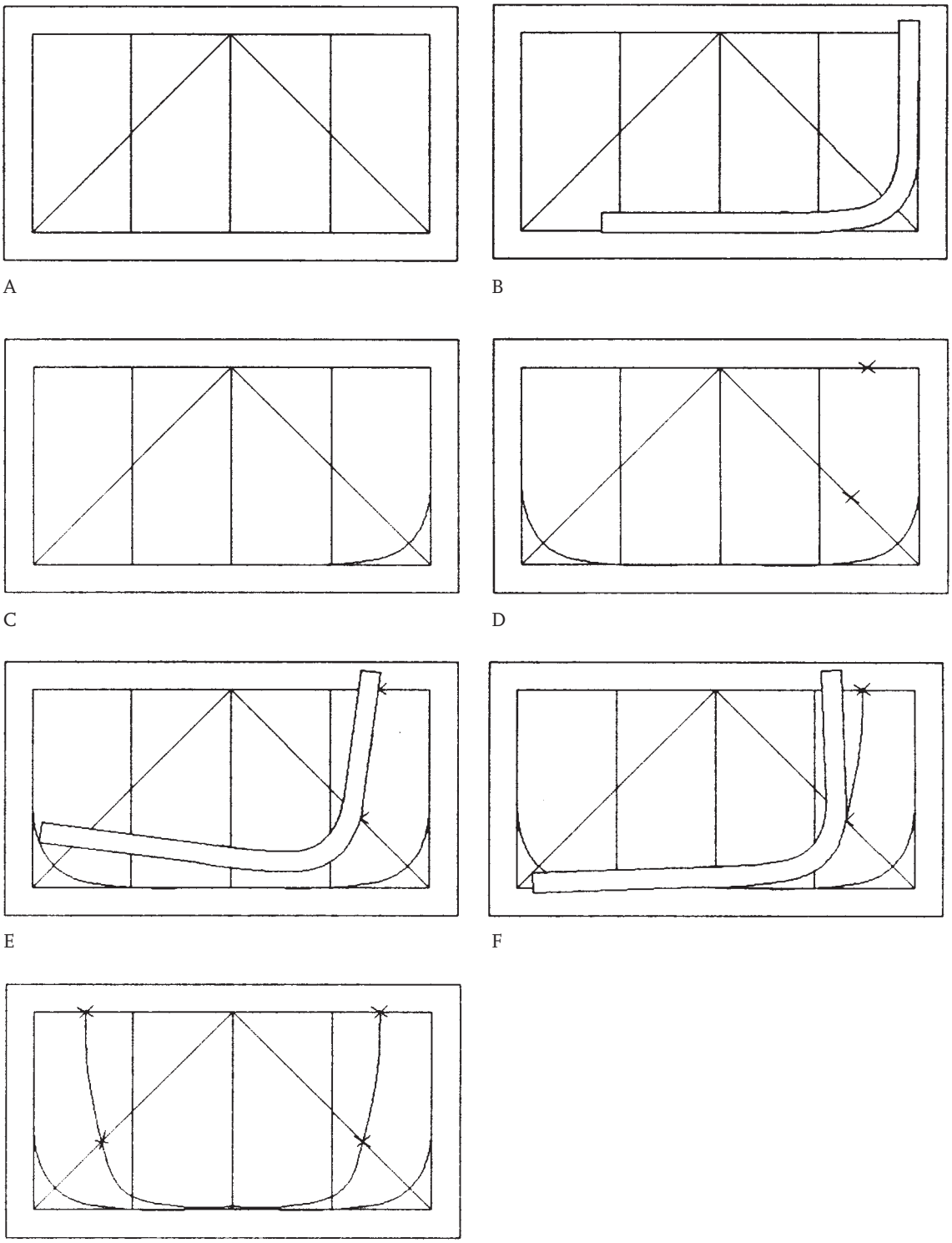

FIG. 9 – Diagram to illustrate the design of *vattai* frames using a scrieve board and a single mould. Drawing: E. Kentley
A. Preparatory marking of the scrieve board.
B. Mould positioned on the board to give the shape of one-half of the master frame.
C. The shape of one-half of the master frame (also that of all the equal frames) marked on the board.
D. Points (X) marked on the board to give the rising (along the diagonal) and the narrowing (along the top edge) of a pair of unequal frames.
E&F. Mould positioned on the two points and then rotated to give the shape of one-half of a pair of unequal frames.
G. The shape of a pair of unequal frames marked on the board, alongside that of the master frame.

Mediterranean/Atlantic and Tamil design methods compared

The features of the 20th century Tamil design method are generally similar to the medieval Mediterranean / Atlantic methods. There are some differences between the two systems, but they have very much in common:

A. Both are based on the following parameters:
- Basic length module = L
- General shape specified by ratios relative to L.
- Shape of the master frame.
- Number or spacing of frames.
- Total narrowing and rising of the designed hull.

B. In both cases, the shape of the hull is obtained by a combination of 'equal' and 'unequal' frames; passive (non-designed) frames are added later.
(i) the shape of the 'equal' frames comes direct from the mould of the master frame.
(ii) the shapes of the 'unequal' frames are obtained by modification of the shape of the master frame, using:
(a) the tablet system, or
(b) the rule of thumb & scrieve board system.
(iii) the shapes of the passive frames at the extreme ends of the vessel are obtained from ribbands.

Furthermore, in both the Atlantic and the Tamil systems, the position of the foremost and the aftermost designed frame is emphasised by giving these frames a specific name. There is also a remarkable similarity in the way that dovetail joints are used to join the futtocks to the floors both in the *thoni* and *vattai* (Fig. 10), and in several 16th century Iberian wrecks excavated from American and British waters, which were probably designed by the Atlantic method (Redknap, 1984; Grenier, 1988; Grenier, Loewen and Proulx, 1994; Keith, 1988; Oertling, 1989; Hutchinson, 1991).

It seems possible therefore that the forerunner of the design system used in Tamil Nadu today was taken there (and to Brazil, and perhaps elsewhere) by the Portuguese in the 16th century. The Tamil 20th century design system seems to be a simplification of the Atlantic coast design method, more suitable for the less complex hull forms of the *thoni* and, particularly, the *vattai*.

Tamil design methods and Medieval Europe

Two tentative conclusions about European shipbuilding practices in medieval times may be drawn in the light of the likely European origin of Tamil design methods. First: the differences, significant but not fundamental, between the Atlantic and Tamil design methods (see Blue, et al 1998 for a full discussion) suggest that the methods so far documented for late-medieval and early-modern Europe (for example, by Bellabarba, 1993, and by Rieth, 1996) may not have been the only ones used. Within a common European approach to the problem of designing frameworks, variations on the main theme may have arisen in different times & places, some of them possibly on the lines of the Tamil design system.

Second. The Tamil frame-first vessels are not fully designed: there is still an element of "building by eye" and the use of personal experience — for example, when fairing the framework before it is planked, and when determining the run of the sheerline. The Tamil builder also uses "art & craft" when he works bevels on the 'unequal' frames, and when he spiles the shapes

FIG. 10 – A *vattai* floor timber showing the futtock scarf. Photo: S. McGrail.

of the passive frames from planking used as ribbands. This blend of techniques, frame-first mainly but with some "by eye" or "free-arm" elements, suggests that there probably was a similar blend of techniques in the frame-first shipyards of late-Medieval Europe. Furthermore, from other evidence it seems likely that, by this time, certain plank-first yards were familiar with aspects of frame-first design methods. Builders of large, clinker-fastened, nominally plank-first ships of the Nordic tradition, such as Henry V's warship *Grace Dieu* of 1418, may well have had to use some form of framework to help them get the hull shape which, on such a grand scale, was probably difficult to conceive in the mind's eye alone (McGrail, 1993, p. 47-48). This adoption of some frame-first methods in plank-first yards, and the continued use of some "by eye" methods in frame-first yards, would have smoothed the transition from solely plank-first procedures, used from time out of mind, to the new fangled techniques needed to design and build a frame-first vessel.

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