THE FRAMING OF SEVENTEENTH-CENTURY MEN-OF-WAR IN ENGLAND AND OTHER NORTHERN EUROPEAN COUNTRIES

A Thesis

by

KROUM NICKOLAEV BATCHVAROV

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

May 2002

Major Subject: Anthropology

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Approved as to style and content by:

Kevin J. Crisman
(Chair of Committee)

Cemal M. Pulak
(Member)

James Bradford
(Member)

David Carlson
(Head of Department)

May 2002

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ABSTRACT

The Framing of Seventeenth-Century Men-of-War in England and Other Northern European Countries. (May 2002)

Kroum Nickolaev Batchvarov, B.A., Park College

Chair of Advisory Committee: Dr. Kevin Crisman

Nautical archaeology has enormously enriched our knowledge of ship construction, but so far most attention seems to have been lavished on ancient shipwrecks. The seventeenth century has attracted the least attention. No detailed studies of the construction of ships of this era have been published. When the subject is mentioned at all, it is a cursory overview, quite often inaccurate, always lacking depth. Extensive documentation, however, still survives in the form of shipbuilding treatises, contracts, correspondence, models, paintings and engravings, draughts, and last - but not least - archaeological remains. A number of modern attempts to describe the framing of the seventeenth-century ship exist, but none are dedicated studies of the subject. The most influential book is probably the work of Peter Goodwin - *Construction of the English Man of War 1650-1850*. Brian Lavery writes of construction in his books *Ship of the Line*, volume II, and *Susan Constant,* and he describes his reconstruction of *Resolution*, launched in 1667, in *Deane's Doctrine of Naval Architecture.* Lavery favors a multi-futtock arrangement, supporting the view that frames had no open spaces. Goodwin proposes a very similar model, but with double frames and his timbers are scarphed instead of butting. Yet the models and some illustrative material show a

different framing pattern of overlapping floors and futtocks. For most of the period all contemporary sources agree that no more than two futtocks were employed.

The following pages attempt to systematize the available evidence and, without claiming to be the last word on the subject or to have exhausted all sources, to show the development of framing in the sailing men-of-war throughout the seventeenth century. The emphasis will be on English warships, as evidence for them is more easily accessible and because English vessels of the seventeenth century, unlike those of the eighteenth, were well designed.

In loving memory of my father, Nickolay Batchvarov.

ACKNOWLEDGEMENTS

My late father is solely responsible for my interest in seventeenth-century ships. He was my very first instructor in shipbuilding practices and managed to beat some understanding of seamanship into my head. My debt to him is enormous.

I had the great luck of studying under Dr. Fred Hocker and am much obliged to him for all that he taught me. Dr. Kevin Crisman has been a tremendous source of encouragement. If there is any value in this work it is thanks to his advice. He has been a mountain of support in this endeavor.

Mr. Jon Adams spent hours of his time talking to me and discussing the framing of seventeenth-century ships. He kindly pointed out to me the probable origin of chock scarphs and encouraged me to search for other explanations besides the traditional material-availability theory for the changes in framing that took place in the seventeenth century.

I owe gratitude to Mr. Brian Lavery of the National Maritime Museum in Greenwich for finding the time to talk to me twice and for kindly arranging for me to view some of the Navy Board Models that are in storage. His advice has benefited me tremendously.

Mr. Peter Goodwin, Curator of HMS *Victory,* was very kind to fit me into his busy schedule on shamefully short notice. He took the time to discuss my theories and to give me advice. His encyclopedic knowledge is an inspiration. Information that he gave me fortified my belief that the reason for the changes in the framing patterns in the fourth quarter of the seventeenth century is to be found in the search for additional strength. His kindness and encouragement are much appreciated. His interest in my work is most flattering.

I would like to thank Dr. Peter Le Fevre for kindly answering my inquiries into the scantlings list of the 30-ship program. It is much appreciated.

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CHAPTER I

INTRODUCTION

Nautical archaeology has enormously enriched our knowledge of ship construction from the earliest days of seafaring to the present day. Thus far, much of the attention seems to have been focused on ancient shipwrecks, but medieval vessels have been studied in sufficient numbers to give an idea of major developments. Postmedieval shipbuilding has also received attention. The Basque Whaler *San Juan*, the Cattewater Wreck, and the *Mary Rose* give us a firm knowledge, not only of the realities of the actual construction, but even an understanding of the conceptualization of these ships. The eighteenth century is reasonably well documented, as far as ship construction and design go. For many naval shipwrecks, the original draughts of the vessels are still preserved. There are even examples of eighteenth-century warships still in existence: HMS *Victory* and USS *Constitution.*

The seventeenth century has attracted the least attention so far.[1] It is ironic that due to nautical archaeology we know more about Roman shipbuilding, than we do about this more-recent period. Some scholars have studied the exteriors and careers of Restoration naval vessels.[2] A study of the development of the 50-gun fourth rate in the

---

This thesis follows the model of the *Mariner's Mirror*.

English service has a few chapters dedicated to the seventeenth century.[3] As far as the construction of these ships goes, no comparative studies have been published. When the ships are mentioned at all, it is a cursory overview, quite often inaccurate, always lacking depth. Yet, fairly extensive documentary sources survive that can shed light on the subject. Perhaps best served will be the student of English ships, but even this category of scholars have taken meager advantage of the opportunities available to them. From England we have at least four shipbuilding treatises, a few rigging treatises, contracts, autobiographies, personal correspondence, models, paintings and engravings, draughts and last, but not least - archaeological remains. All that remains is to gather the material and study it in detail.

There are, however, a number of limitations to this body of evidence. The texts are not always very clear and there is more than one way of interpreting them. The draughts are not always perfectly clear, either. Navy Board models of identified ships seem to reflect the building practices of the period, but it has been argued time and again that they were simply built to an accepted convention, that had no bearing upon reality and, therefore, should not be accepted as evidence.[4] Finally, the great potential of nautical archaeology has yet to be realized fully.

The following pages are an attempt to systematize the available evidence and, without claiming to be the last word on the subject or to have exhausted all sources, to show the development of framing in the sailing man-of-war throughout the seventeenth

century. The emphasis will be on the English warships, as evidence for them is more accessible and because in the seventeenth century, unlike the eighteenth, English vessels were well designed. Between 1660 and 1688 shipbuilding developed rapidly under the patronage of King Charles II and James, Duke of York, later King James II. During the reigns of the two brothers English native ship design and construction were innovative, without any trace of conservatism.[5]

During the seventeenth century, the English nation had kings who rendered greater service for the fleet than Henry VIII and Elizabeth I in the sixteenth century. It was Charles I (1624-1649) who ordered the building of the first true three-decker in the world. At the time, all professionals claimed that such a ship was not only impractical, but also impossible to build and certainly of no use once built. The Anglo-Dutch wars were to prove doubters wrong and the king right. In Charles II (1660-1685) the island nation may have had its most intelligent and capable monarch, ever. His religious tolerance towards Catholics made it certain that he would never be venerated in the way he deserves to be, but under his intelligent guidance the fleet became a national institution. It was thanks to him and to James, Duke of York, that the navy became the dominant service for the English, in the way the army was for the French. Undoubtedly, at least some of the attraction of service at sea for the aristocracy was due to the Duke himself, who commanded the fleet in battle or if not him, another member of the Stuart Royal family - Prince Rupert of the Palatinate, one of the most experienced naval commanders and seamen of the time. The King, who was the driving power behind the

expansion and growing professionalism of the navy, should be given much of the credit, though usually that has been given entirely to the Clerk of the Acts and later Secretary of the Admiralty, Samuel Pepys. In recent years scholars have finally begun to re-evaluate the roles of Pepys and Charles II to the detriment of the first and the credit of the second.[6]

Charles II's contribution to the strengthening of his navy would have been quite sufficient even if he had limited himself to mere patronage and interest in the officer corps. His exceptional ability as a seaman and his deep technical understanding of shipbuilding and design made him interfere often in favor of building bigger and more powerful ships. Even such an enemy of the Stuarts as the Whig Bishop William Burnet could find no greater fault with Charles II than to say he understood the business of the shipwright rather more than became a Prince.[7] No one would ever level such a charge against the Kings of the House of Hanover, or even Dutch William III of Orange.

Before trying to determine how ships were framed in the seventeenth century it is necessary to define a few shipbuilding terms. Throughout the centuries some terms have changed their meaning, others have altogether disappeared. In this text they will be defined and used in the manner they were used in the seventeenth century. Reading contemporary documents allows one to develop a rather clear idea of what the terms meant to their contemporaries. In addition, some contemporary authors themselves give definitions.

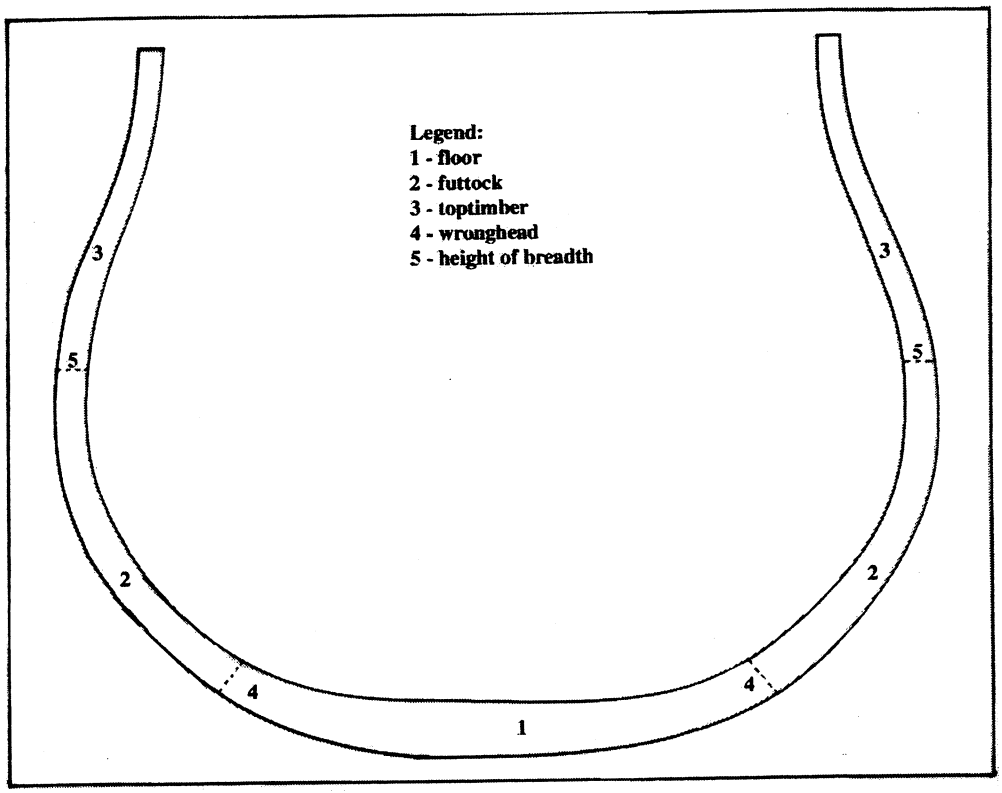


Figure 1. Parts of a frame or bend of timbers.

The shape or curvature given to frames determines the shape of a ship. They reach from the keel or backbone of the vessel to the top of its sides. It is clear that no single timber existed that could cover the entire distance with its compound curves and so frames had to be built up from different pieces of timber. Starting at the keel, the frame consisted of a floor, a number of futtocks that formed the sides of the ship below the waterline, and toptimbers, which extended from the last futtock to the top of the

sides. All the timbers forming a frame were sometimes called the bend of timbers (figure 1). The positioning and number of timbers that formed a bend underwent great changes throughout the seventeenth century, and are the subject of this study.

The number of frames to be fitted on a ship depended on the room and space measurement. Room and space is the distance from the edge of one timber to the same edge of the next such timber. Usually this was measured between one edge of a floor, to the same edge of the next floor along the keel (figure 2). Room is the part occupied by the timber and space is the empty part between the two timbers. It contained one floor, one futtock and any empty space. Contemporary documents are not consistent in the usage of the term. Some contracts for the building of ships refer to it as "room and space," others as "the room of timber and space." It is likely that the second version is the correct one, but, here, as in most of the original documentation, the term "room and space" will be used.

Floors are the timbers that cross the keel at right angles. Their extremities rise towards the sides of the ship. The rising ends were called wrongheads. No more consistency was exhibited in their naming than in any other term in the ship frame in this period. Other spellings used in the seventeenth century are "wrungheads" or "wrungs," or "rungs" and "rungheads." Floors were also called ground timbers.

Futtocks are the timbers that stretch from the wrongheads to the point of

maximum breadth of the ship. At this point the futtocks connected with the toptimbers, which spanned the upper sides of the ship. Futtocks were often called foot-hooks.

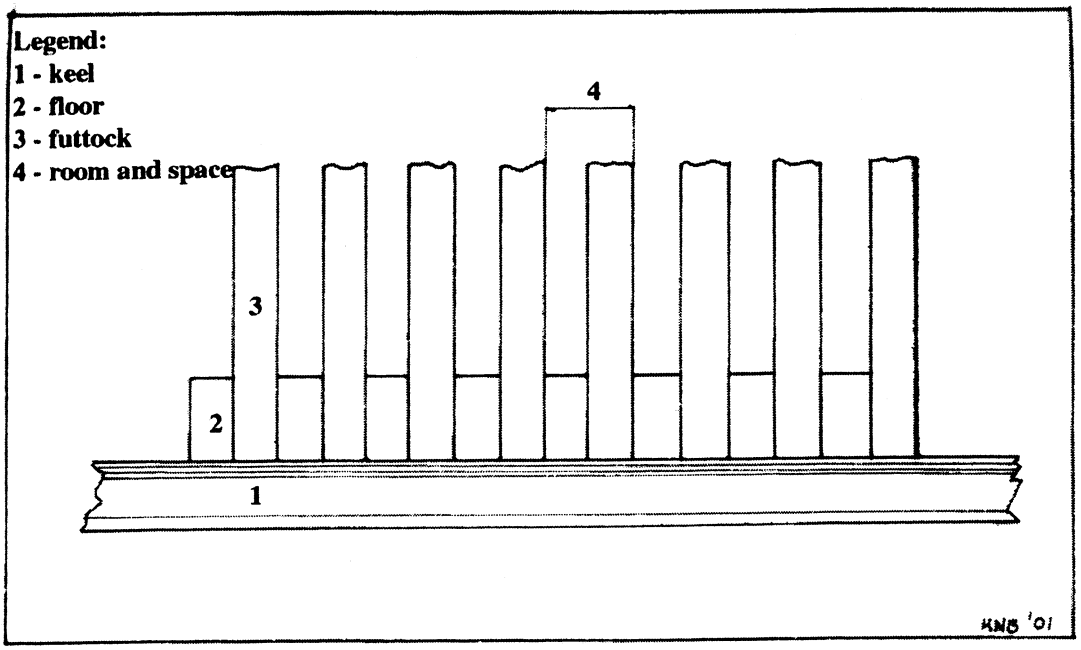


Figure 2. Room and space.

Scarphs were the overlaps between timbers composing the frame. The word had more than one meaning even in the seventeenth century. In hull framing, the term is used in the sense of one timber lying along another. The length of scarph was the length

of this overlap. A timber was said to "give scarph," when that timber was lying along two others that were butting into each other. The word was and still is spelled in more than one way. It is to be seen either as "scarph," or as "scarf." Nowadays, especially in American literature, it is more usual to see it spelled "scarf." In seventeenth-century sources it is more often spelled the other way, but sometimes in the same document, or even in the same sentence it could be spelled both ways.[8]

Chocks begin appearing in the contracts from the 1690s. Sutherland describes them as "a small Piece of Timber fitted to a larger to make out the Substance required"[9] and then: " Scarf (*sic*) chocks that shall go Part upon the Head and Part upon the Heel of every Timber, since it would unite the Parts, and strengthen the joining of the Timbers; which will farther appear, when the Plank is brought on, and treneld through Timber and Chock."[10] Chocks were wedges, or blocks of wood used to fill in areas between timbers. Here it will be used in describing a jointing of frame timbers end to end. Half of the wood on the inner side of joining timbers was cut away. The resulting empty space was filled with the chock, which then was nailed to both timbers. This type of joint is often called chock-scarph, or chock-joint. Occasionally it is also referred to as an anchor-joint (figure 3).

It was said that the frame of a ship consists of bottom (floor), sides (futtocks) and upper sides or topsides (toptimbers). The point where the bottom became the side was called the bulge. Nowadays the term used is bilge. The side became topsides above

the point of maximum breadth of the frame. Height of breadth was the point above the keel at which the frame reached its maximum breadth. This point roughly corresponded with the main deck. Throughout the seventeenth century the height of breadth was around the waterline of the ship (figure 1).

A number of modern attempts to describe the framing of the seventeenth-century ship exist. None of them is a dedicated study of the subject. The most influential book is Peter Goodwin's *Construction of the English Man of War 1650-1850.* Brian Lavery speaks of construction in his *Ship of the Line*, volume II, in *Susan Constant* and gives his reconstruction of *Resolution*, 1667, in *Deane's Doctrine of Naval Architecture.* The subject is mentioned in John S. Stevens's *An Account of the Construction and Embellishment of Old Time Ships.*

Lavery favors a multi-futtock arrangement, supporting the view that frames had no open spaces.[11] In *Susan Constant* he suggests three futtocks per side as early as the first decade of the century for a vessel of 100 tons.[12] For *Resolution* he gives three futtocks and a toptimber, stating that this is based on Deane's dimensions and Surveyor Edward Dummer's drawings of the 1680s.[13]

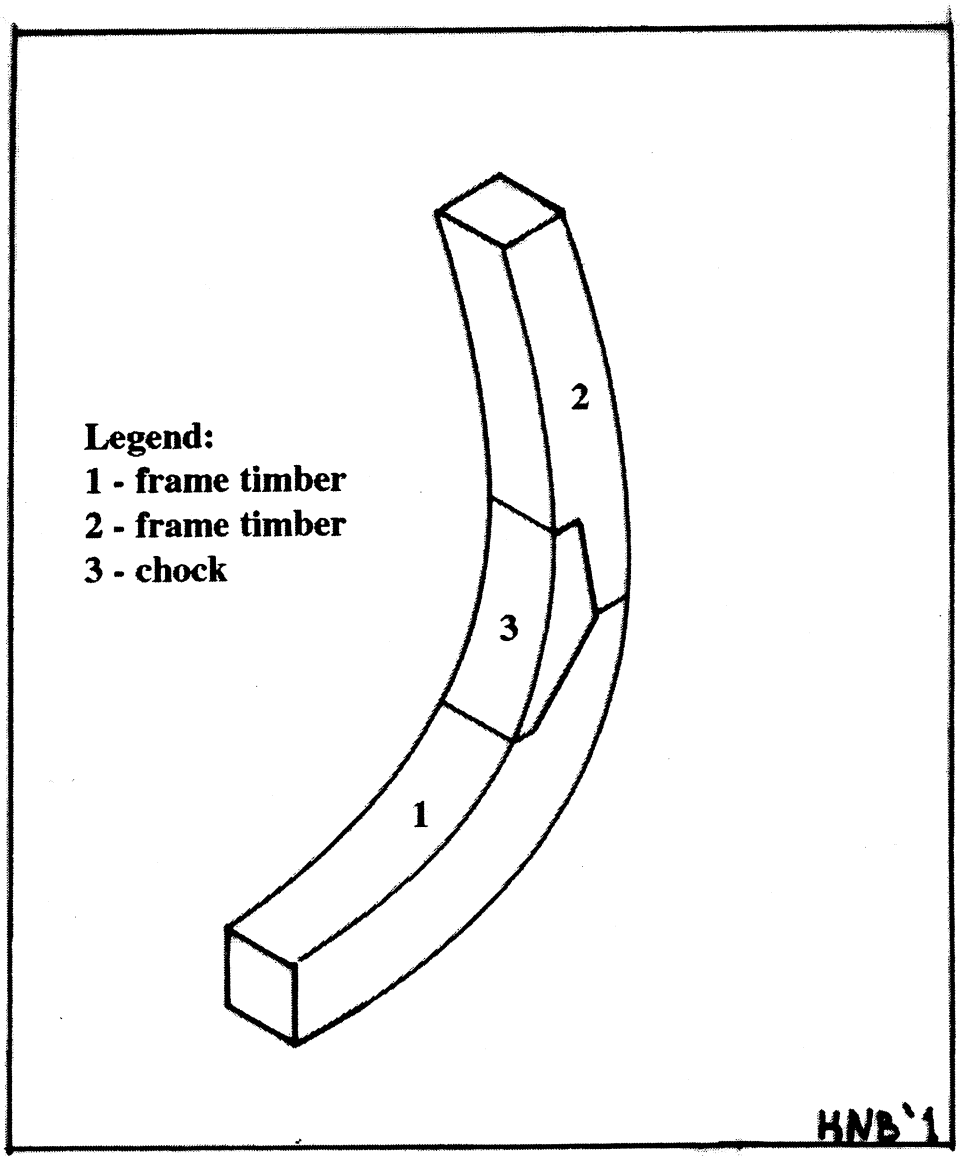


Figure 3. Chock scarph.

Goodwin offers essentially the same model as Lavery with the addition of filling frames.[14] In his proposal the futtocks are scarphed to the head of the timber below in eighteenth-century fashion.[15] Scarphs, as suggested by Goodwin, are not mentioned until the 1690s. Filling frames are not mentioned by contemporary sources, either. It is worth noting that both Lavery and Goodwin are unquestionably the foremost authorities on eighteenth-century English warship construction. The methods proposed by them were common practice in the eighteenth century.

The proposed patterns have nothing in common with the surviving models of this period. Were the models connected with real practice or were they just stylized objects of beauty? The contemporary documents, especially the contracts, may offer answers to these questions, too.

Finally, nautical archaeology has not even begun to realize its potential as a source on seventeenth-century framing. Very few wrecks have been excavated and even fewer have been published. Many of the discovered wrecks have become victims of treasure hunters and consequently no recording of the hull structures has been carried out. A fairly large number of Dutch East Indiamen have been found and excavated, but in most cases very little, if any, wood structure survived. A sad case is that of the Portuguese frigate *Santo Antonio de Tanna*, lost in 1697 at Mombassa, Kenya. It was partially excavated in the late 1970s, but the Kenyan Government halted the excavation. The remains of the hull were substantial and on one side may have survived to above

the lower deck.[16] Her rigging and armament have been studied and theses have been produced. Unfortunately, the hull has not yet received the same attention. The wreck of the *Dartmouth*, lost in 1690, has long been established as the benchmark wreck for the seventeenth century.[17] Yet, no final publication has come out on her, either. Among the worst-utilized potentials is the wreck of the Swedish Royal ship *Wasa*. Forty years after its salvage, the ship is beautifully restored, but little has been published on its construction. All in all, at this stage nautical archaeology is perhaps the least useful source of information on the construction of seventeenth-century ships – a sad thing to say for an aspiring nautical archaeologist.

CHAPTER II

FRAMING OF SHIPS IN THE FIRST HALF OF THE SEVENTEENTH CENTURY

A number of written sources survive that contain information relevant to the framing practices of the early seventeenth century. Among them are the autobiography of Phineas Pett, the works of Sir Henry Manwayring and Captain John Smith, and no less than two shipbuilding treatises.

Smith wrote his *Sea-Grammar* in 1627 and dedicated a whole chapter to the building of ships. The chapter gives the definition of a number of terms that bear upon the question under investigation. *The Seaman's Dictionary* by Sir Henry Manwayring was originally published in 1622, but reprinted in 1644, 1666 and 1670. The later editions attest not only to the popularity of the work, but also to its relevance. It is unlikely that it would have been reprinted it just for the bibliophilic pleasure of doing so, if its contents were out of date. A perusal of the dictionary reveals a remarkable similarity to the definitions in Captain Smith's *Sea-grammar*. As the *Dictionary* was published earlier it probably was the source for the shipbuilding chapter in the *Sea-grammar.*

Neither work gives a detailed description of the erection of a frame or bend of timber, yet much can be deduced from the definitions. Smith describes the building of a

ship starting with the keel, sternpost and stem; he then proposes to lay the "rungs, called floor-timbers, or ground timbers, thwart the keel."[18] The first significant passage is the following one:

> Rungheads, ...and doth direct the Sweep or Moulde of the Foot-hookes and Navall timbers, for there doth begin the compasse and bearing of the ship... those next the keel are called the ground Foot-hooks, the other the upper Foot-hooks....[19]

Manwayring gives somewhat similar information, but with a few significant details missing in Smith:

> Rungheads are the heads, or ends of the rung, which are made a little compassing; and to lead or direct as it were the sweep and mould of the futtocks; for in these rungheads the lines which give the compasse and bearing of the ship doe begin: also more generally, the outward ends of the hookes, which are in the same manner compassing, are called rung heads, is also Bolted into these, and they say, it is bolted fore and aft to the rung heads.[20]

Futtocks, Manwayring says,

> ...are those compassing timbers, which give the breadth and bearing of the ship, which are scarphed to the ground timbers; and because no timbers that compasse can be found long enough to go up through the all the side of the ship, these compassing timbers are scarphed one into the other and those next the keel, are called the lower or ground futtocks, the others are called the upper Futtocks....[21]

From the quoted passages it becomes clear that the floor of the ship is mostly flat with curving ends - the wrongheads or rungheads as the source indicates. Smith writes these ends are scarphed to the futtocks and Manwayring adds that the first

futtocks are bolted fore and aft into the wrongheads. This would argue in favor of pre-assembly. Manwayring writes of lower and upper futtocks, while Smith describes futtocks and naval timbers, and also indicates that there are ground and upper futtocks. At the same time Smith notes that the wrongheads direct the sweep of the futtocks and the naval timbers. Manwayring has nothing to tell us about naval timbers. How are these passages to be interpreted?

Smith is a little more sophisticated. From his text it is clear that the wrongheads control the sweep for both the naval timbers and the futtocks. It also suggests that both were somehow scarphed into the floor timbers (ground timbers in the text). Two possible ways for disposing them exist. The first has the futtocks butted into the wrongheads and thus form a part of the sweep or mould. The naval timbers lie between the floors and give scarph to the floors and futtocks (figure 4). The second disposition is possible by switching the places of the futtocks and the naval timbers. The evidence that supports such a proposition is that the lower futtocks are called also ground futtocks and so may reasonably be expected to touch the bottom of the ship. On balance this seems to be the correct interpretation (figure 5).

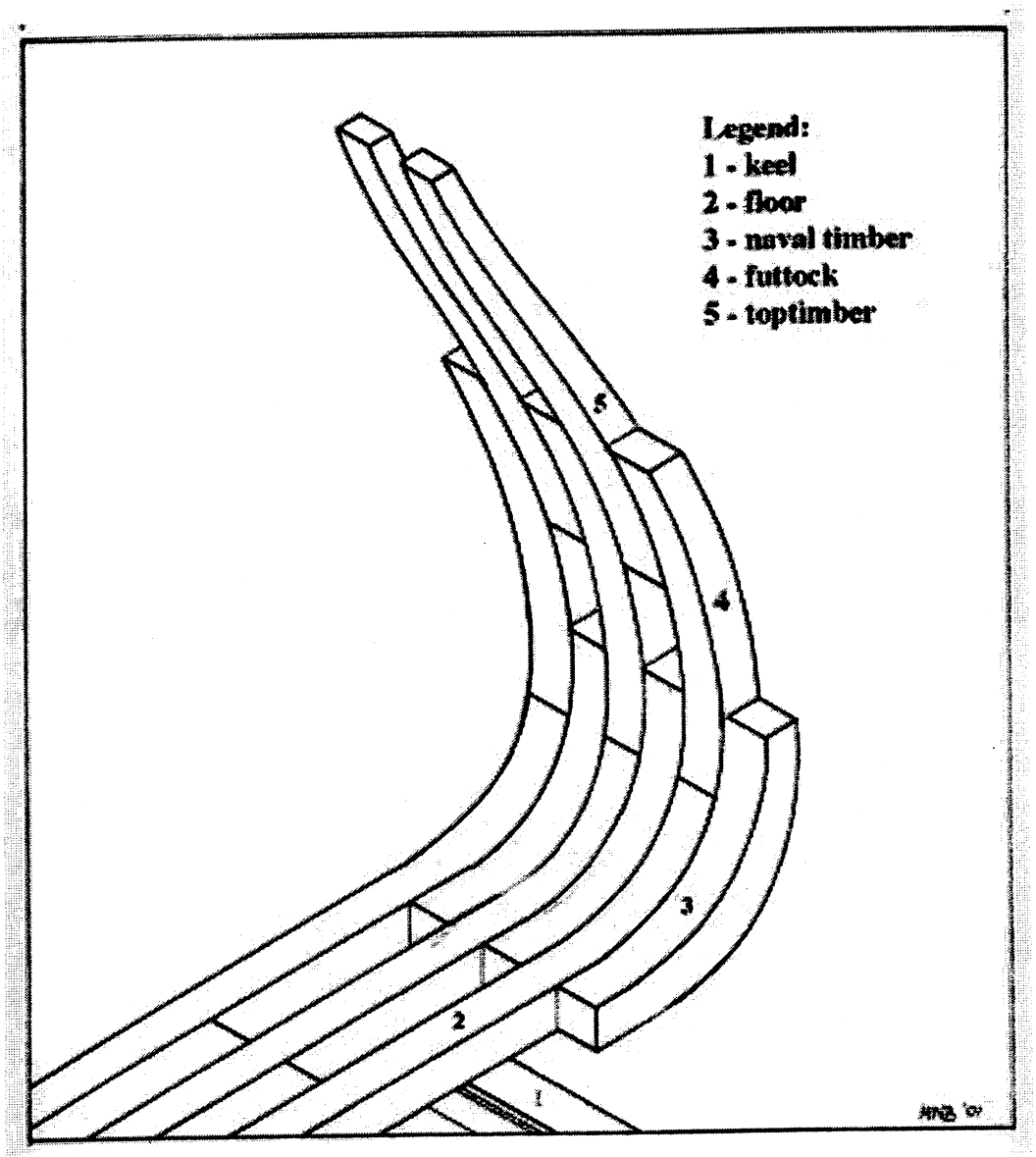


Figure 4. Interpretation of Smith's text.

For additional evidence we turn to the anonymously written *Treatise on Shipbuilding around 1625*.[22] The following definitions are taken from there:

> Futtocks or ribs of the ship are certain round pieces of compass timber swept out according to the mould of every bend, scarphed to the wronghead below and to the navall timbers aloft. In great ships they are framed into parts called upper and lower futtocks. The navall timbers is properly that part of the bend which is seldom framed apart, but moulded into the upper part of the futtock and into the lower part of the toptimbers....[23]

The toptimbers (not mentioned by Smith and Manwayring) reach from the breadth to the gunwale according to the *Treatise*. The significant part here is that the naval timbers are definitely located at the upper end of the futtock, at the maximum breadth.

The lower extremity of the naval timber then would be controlled by the sweep of the wrongheads, as would be the lower futtock. The upper part of the naval timber will extend to the breadth, where it would scarph with the toptimbers mentioned in the *Treatise*.

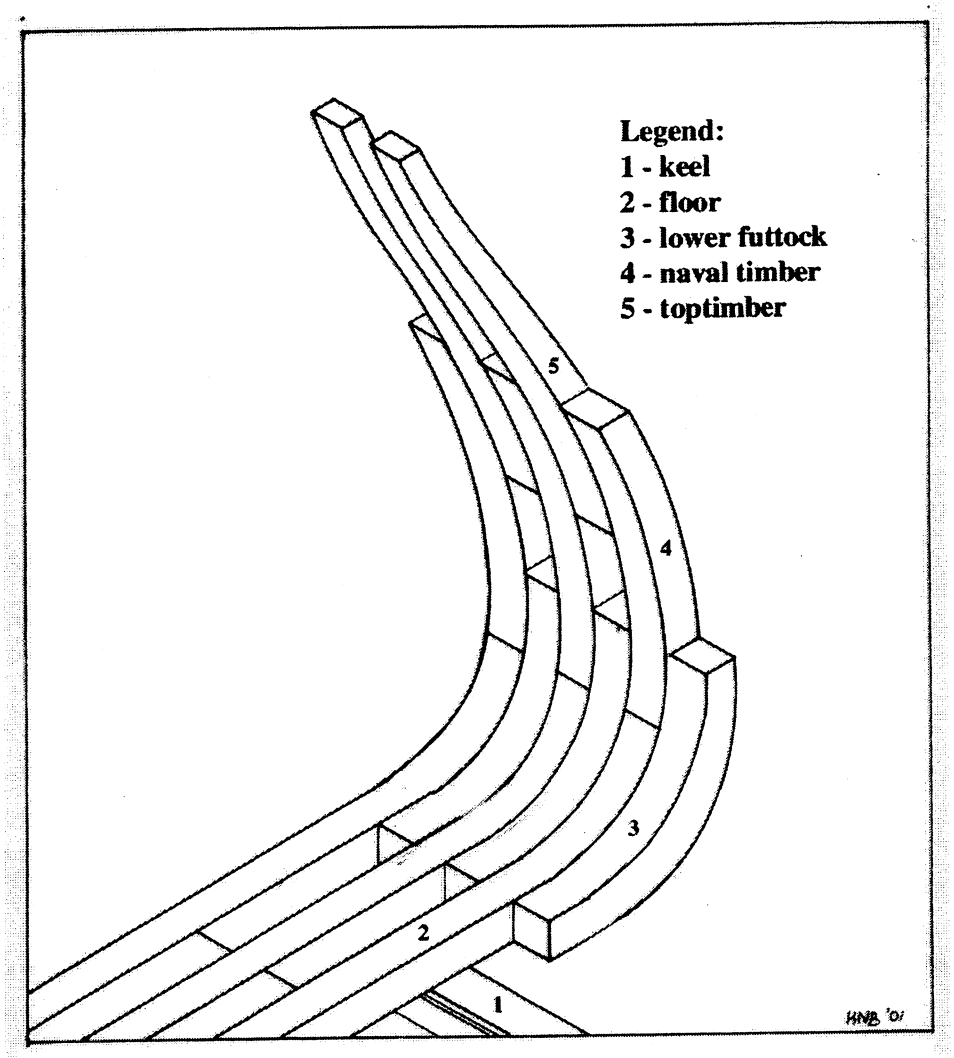


Figure 5. Alternative interpretation of Smith's text.

Some additional information on frames is contained in a manuscript copied by Sir Isaac Newton and published by Richard Barker who dates the manuscript to around 1600.[24] Material in the manuscript shows that the author was either a shipwright, or a

"very well informed observer."[25] Paragraph one says: "...[in] my own experience and practice I have found this to be the fittest...."[26] This seems to prove that the author was a practicing shipwright. This supposition is strengthened by his description of not only the development of the shape of the ship, but also practical building matters like the horning of timbers (squaring them to the centerline of the ship). Because of the inclusion of such practical elements, the treatise deserves careful attention.

It is hard to reconcile the differences in the sources. All of them (excluding the *Newton Manuscript*, which could be earlier) date to the third decade of the century. Yet, neither the total number of elements, nor the nomenclature are consistent. Three of four sources do not mention naval timbers or state that they are rarely employed. Only Smith insists on their function as an integral part of the construction. This leaves two levels of futtocks - upper and lower - mentioned in three out of four sources. This time the differing source is the Newton Manuscript. Toptimbers are mentioned in the two treatises.

Captain Smith was a gentleman-adventurer who was as comfortable on shore as on water. How much of a seaman he was is questionable. He certainly was no shipwright and whatever he knew, it was from hearsay and looking at exposed ship frames. Sir Henry Manwayring was a seaman of some experience, who sailed and commanded ships, including privateers. He was not a shipwright, either, but is most likely more reliable than Smith. The *Treatise of 1625* was probably written by John

Wells, Store Keeper at Deptford Yard and a close friend and heir of Matthew Baker. He was a mathematician, not a shipwright. Nevertheless, Baker respected him enough to will him his notebook.[27] It is known that he did work with Baker at least on theoretical aspects of ship design. On the whole he probably is a reliable source, even though William Salisbury believes he never saw his methods put to practice.[28]

The manuscript copied by Sir Isaac Newton has been dated to the turn of the century, but Barker clearly states the main text may have been written significantly later.[29] With its dislike for big ships, it is probably no earlier than the second decade of the century, possibly even later, as earlier there were no very large ships like the *Prince Royal* of 1610. Thus it is close in age to the other sources and should be considered in the same group. Its importance lies in the accurate and detailed instructions for the solution of practical problems in the actual building. It gives details about horning floors, transferring the moulds to the actual timbers, locating the floors on their intended stations, beveling the frames, and disposing of the futtocks in relation to their corresponding floors. The author most probably was a practicing shipwright. This gives us reason to pay particular attention to the manuscript.

Returning to the parts of the frame in accordance with our sources, it is curious that only the two treatises mention toptimbers. In fact, if we ignore the naval timbers, it seems that both treatises are listing the same parts. The Newton manuscript speaks of only one futtock and a toptimber. The *Treatise* does mention two futtocks, but it says

this is due to problems obtaining timber of sufficient length. In other words, in an ideal world there would be one futtock (figure 6). Thus the two are giving us the same basic parts of the frame.

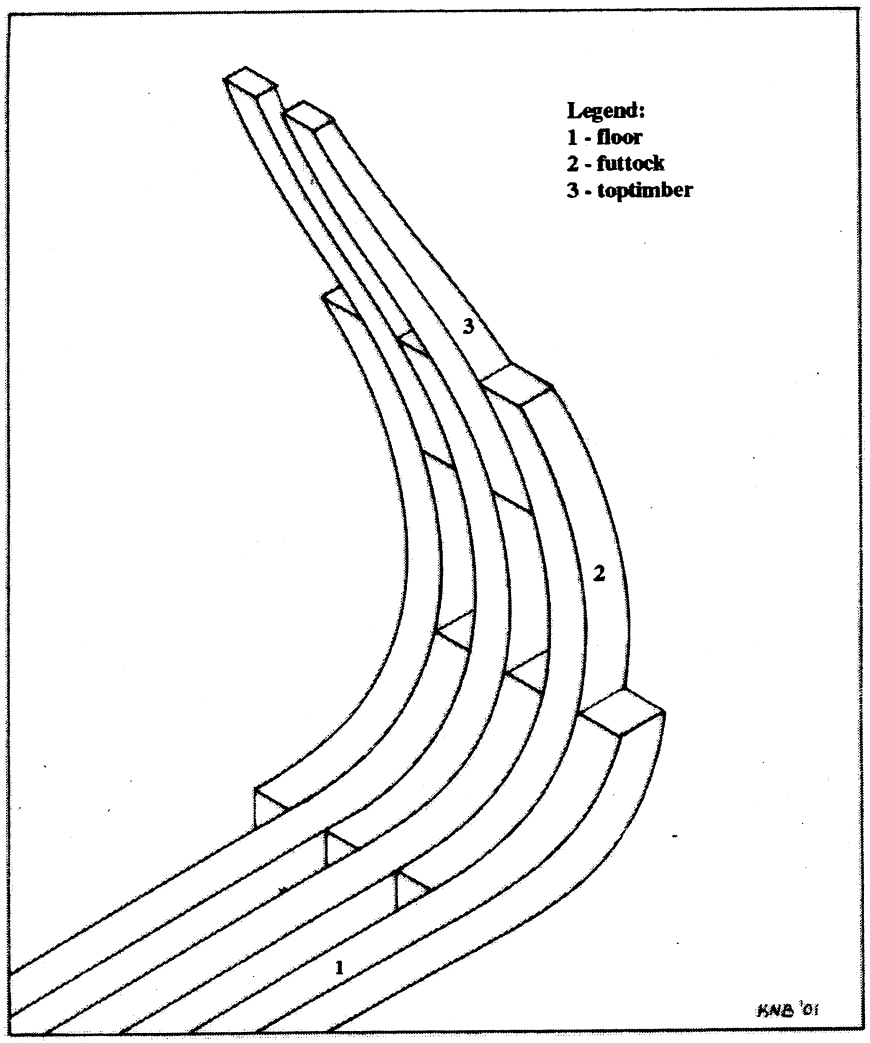


Figure 6. Single-futtock frame.

Smith and Manwayring say nothing about toptimbers. Toptimbers were not only a constructional feature, but also part of the design, as well. So why were they left out? The answer is most probably that the upperworks of the ship were not considered an integral part of the frames, as they were the most frequently damaged part of the hull. Consequently, they often underwent repair and replacement. Toptimbers also had to be installed in such a way as not to interfere with the gunports. This meant that some of the timbers had to be cut and "filling" pieces incorporated in the fabric of the topsides. Therefore, there was no system to describe in the assembly of the upper works of the ship.The final matter to be discussed is the construction sequence, as gleaned from contemporary evidence. Manwayring writes of bolting futtocks to floors at the wrongheads. This implies pre-assembly of the frame. Master Shipwright Phineas Pett, in his autobiography, relates something about the building of ships in the late years of the first decade and early years of the second decade. While describing the inquiry into the building of his *Prince Royal,* launched in 1610, and the King's inspection of the vessel on the stocks, he writes that the floors and first futtocks were already installed as were some of the second futtocks (figure 7).[30] This passage is certain evidence against pre-assembly of the frames. As Salisbury correctly points out, we can assume the construction of the ship to have been conventional.[31] Had it been otherwise, Pett's enemies would undoubtedly have used it in support of their case against him. The *Treatise of 1625* states that futtocks were kept in place by the sleepers and filled up the spaces between the floors, starting a short distance from the keel - in other words, no lateral connection to the wrongheads (and no pre-assembly) was the normal practice. It

may be that lateral fastening was employed between the futtocks and floors of the master bend and a few additional frames around which a ribband could be sprung to support the rest of the futtocks while the planking advanced. This solution tallies well with Pett's statement that some but not all of the second futtocks were installed.

An interesting statement recorded by Pett regarding *Prince Royal* was that the king claimed "if the ship had a third less timbers it still would be too strong."[32] What did James I have in mind? We have no evidence that he had anything like the expertise of his grandson, Charles II, so it may not be wise to pay too much attention to this statement. Assuming, however, that he had at least some understanding of the subject, then we have to consider possible explanations. One obvious explanation is that it had too many frames. Salisbury suggests that *Prince Royal* might have been framed in the manner French three deckers were framed later in the century - numerous pieces of timber, leaving practically no spaces unfilled. The meaning of the King's statement then would be that even if not all the spaces were filled, the ship would still be sufficiently strong. While this is a possible explanation, it does not seem to be supported by the bulk of the evidence. When the king inspected the ship, not even all the second futtocks were installed, so James I's opinion probably was in relation to timbers that were already in

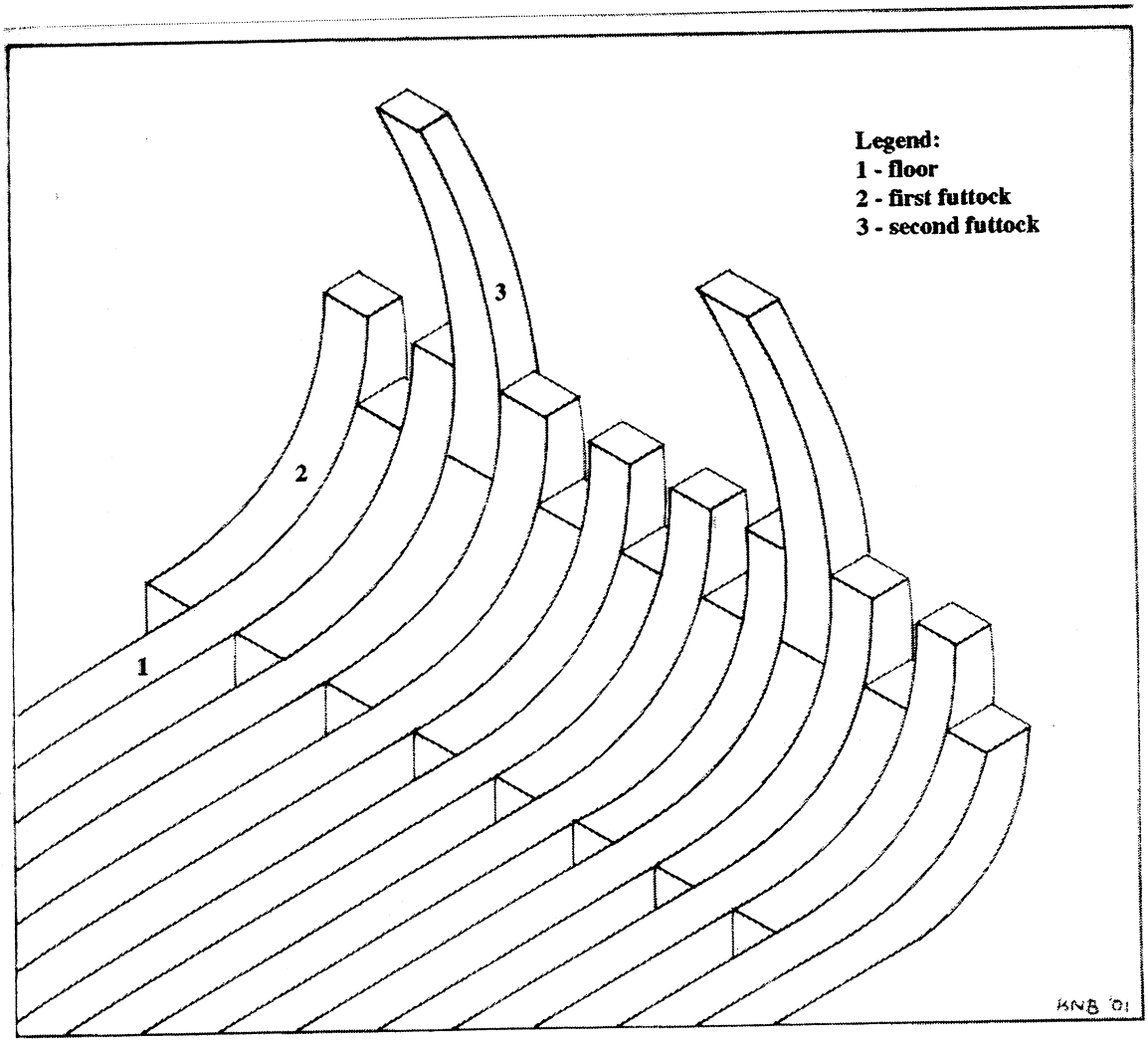


Figure 7. Framing of *Prince Royal*.

place, as were the floors and first futtocks. Since the number and scantlings of floors were determined by rules, it is not likely that they varied on such a big ship. I believe the king was suggesting that there was no need for two futtocks: the single futtock

scarphed to the floors and the toptimbers would have been sufficient for strength. With first futtocks slipped between the floors and giving scarph to a second tier of futtocks, the line of solid timber would have extended higher above the turn of the bilge than with a single futtock. This would have cut the number of timbers by a third without seemingly jeopardizing the structural integrity of the ship. This seems to support the conclusion, derived form the other sources, that frames could be built with one or two futtocks, and this did not necessarily depend on the size of the ship.

In the first half of the seventeenth century, it seems that the usual shipbuilding practice was to bolt the floors to the keel first, then to slip the first futtocks between them. The futtocks would be secured with the sleepers (footwaling) and the planking. Pett writes that *Prince Royal* was planked simultaneously with the erection of the frame timbers. The next step would be to erect the second futtocks between the heads of the first, if two futtocks were to be employed. Then the planking continued until the wales were reached and, in the hold, the shelf clamps were added to support the beams. There were two options for securing the toptimbers. One was to scarph them to the upper futtock by overlapping them. The second option was to use separate naval timbers (figure 8). It seems logical to expect naval timbers to be employed with two-futtock frames. This system probably would have been used on bigger ships, but it is possible the choice had no connection with size and, instead, depended on the preferences of the builder, timber availability and cost.

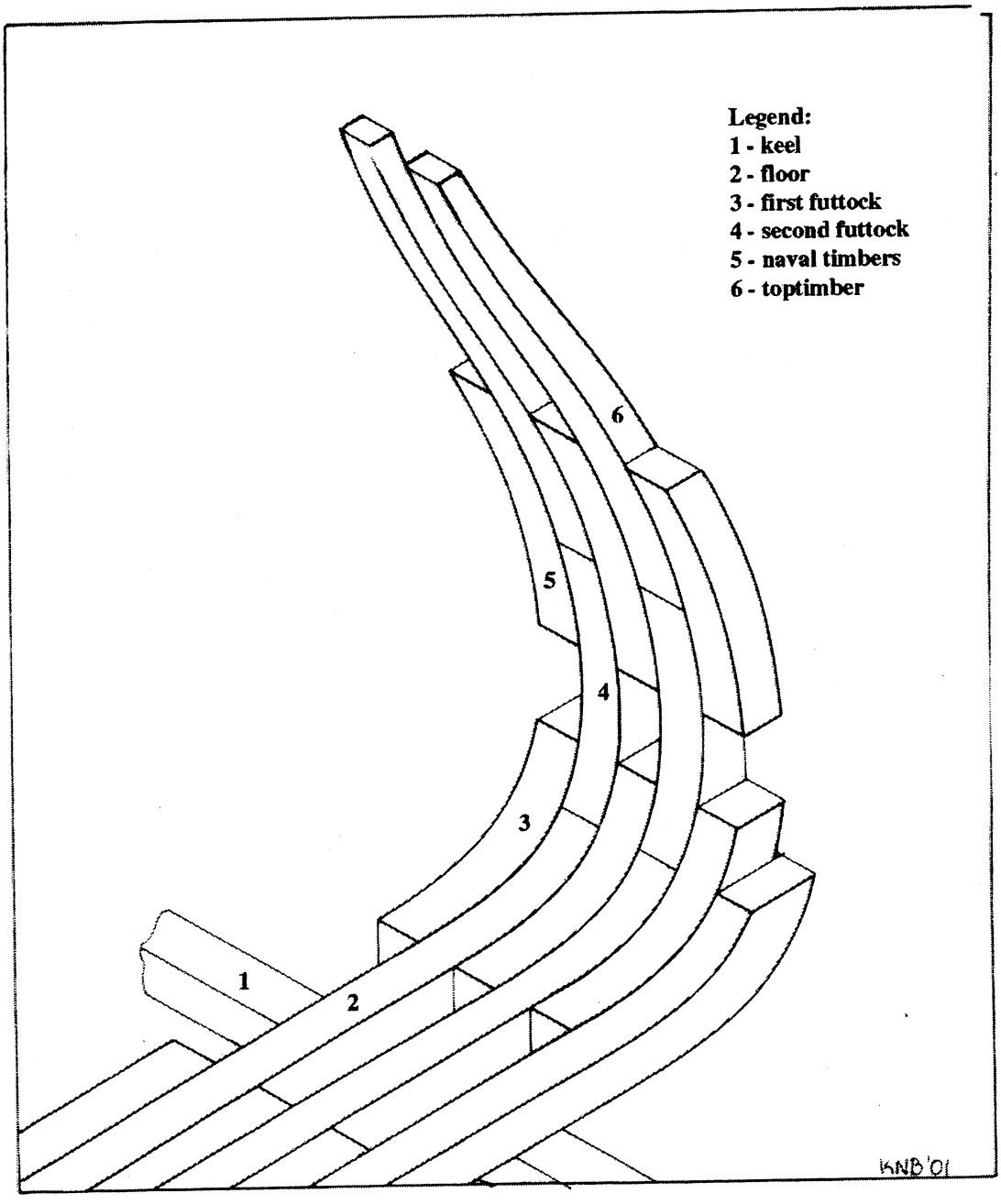


Figure 8. Frame with two futtocks and separate naval timbers

CHAPTER III

FRAMING OF SHIPS IN THE SECOND HALF OF THE SEVENTEENTH CENTURY

Sweeping changes in ship design and construction took place in the second half of the seventeenth century. By the later period, it was recognized that the strength of a fleet lay in its guns and the ability of the ships to take damage and remain in the battle line. To meet these demands the ships of the fleet increased in size and firepower. The Restoration Navy carried heavier broadside weight of metal per ton than was common later.[33] For example, *Royal Sovereign* of 1637 carried 42-pound guns on the lower deck. Nelson's flagship at Trafalgar, *Victory* of 1759, was armed with 32-pounders. The heavy artillery was necessary in this period, for the Royal Navy was pitted against the most dangerous and capable foe that it ever faced in the age of sail: the Dutch. The Dutch had the edge in seamanship and were better at boarding tactics, but the heavy English cannon and stronger, larger ships usually won the day, or at worst prevented major disasters.

The operational experience the Royal Navy acquired in the wars with the United Provinces of the Netherlands was of immense benefit in the coming wars. What is less often recognized is that naval shipbuilding benefited, too. The battles in the North Sea confirmed English trust in their three-deckers, as the Dutch had nothing to oppose to

these vessels. Besides the huge concentration of firepower, the three decks offered better resistance to torsion and the working of the hull in a seaway. After the failure of the third rate, two-decked 80-gun ships in the War of the League of Augsburg (1689-1697), Master Shipwright William Lee suggested the addition of a third deck to these ships. Most shipwrights agreed with him and the three-decked 80-gun ships that achieved such ill reputation in the next century were born.[34] They were a product of experience and for the seventeenth century proved to be the right solution. Their adoption is example of the adaptability of the shipwrights of this period. In the eighteenth century, however, changed circumstances lead to their abandonment in favor of large two-deckers, again.

In the light of experience gained in the wars of the second half of the seventeenth century, the shape and dimensions of the ships changed. So too, apparently, did their construction. In the following pages an attempt is made to determine the nature of these changes and to establish approximate dates for them.

Fortunately for the student of ship construction in this exciting period, a substantial body of information has survived in the form of builder's contracts. Their detailed nature gives us an excellent opportunity to see what parts entered the fabric of the hull and to determine their dimensions. Some information can also be found in contemporary letters. A very important document of the period is the manuscript known as *Deane's Doctrine of Naval Architecture*.

In 1650 Jonas Shish launched one of the earliest Commonwealth frigates, *Foresight,* at the Deptford yard. The ship was a fourth rate of 48 guns built in a period when the new rulers of England had to face an onslaught of royalist privateers from Prince Rupert's squadron, and privateers operating out of Ostende and Dunquerque. The most important quality of the new ships ordered by the Commonwealth was speed. R. C. Anderson has identified the contract for the *Foresight* among a collection of documents in the National Maritime Museum in Greenwich.[35]

The contract is quite detailed and contains much valuable information, but for the study at hand the discussion will be limited, here and in the following contracts, to the framing. For the *Foresight* room and space was 26 inches (66.0 cm). The sided dimensions of the timbers are not given but, in keeping with other contracts, it is likely to have been about half the room and space, or 13 inches (33.0 cm). The naval timbers were to have a scarph of at least 5.5 to 6 feet (1.7 - 1.8 meters) and to fill the room, although their exact location is not specified. The timbers "upwards of the gundeck" were to be 8 inches (20.3 cm) moulded and to have a scarph of similar length to that of the naval timbers. The room at the gundeck level was to be filled with timber. The specification, therefore, implies that the naval timbers were located at the bottom of the ship, between the floors. This contradicts the *Treatise of 1625*, but seems to be supported by most of the contracts in the second half of the seventeenth century (see below). No toptimbers are mentioned and "timbers upwards of the gundeck" is a description that remains open to at least two interpretations.

First, the naval timbers represented the only futtocks in the assembly and extended from the floor wrongheads to the height of breadth.[36] The timbers "upwards" of the gundeck were the toptimbers and they covered the distance from the main wale to the gunwale. The second scarph corresponds to the overlap between them and the naval timbers, or futtocks. The room to be filled with timber could therefore mean that the sided dimensions of the toptimbers are to be such as to form a solid band of timber at the height of breadth (figure 9).

A second interpretation is that the naval timbers simply correspond to the first futtocks, and the timbers above of the gundeck represent the second futtocks; and the word "upwards" means that they extended above the gundeck and so formed the characteristic solid timber band. The rooms were to be filled by the toptimbers, not mentioned in the text. The scarphs were between naval timbers and floors, and also between naval timbers and second futtocks – both of 5.5 to 6 feet (1.7 to1.8 m) length. The third scarph was between the second futtocks and the toptimbers. Both interpretations seem probable, but when later contracts are taken into account, the second interpretation is the more likely one (figure 10).

Lavery believes a contract dated December 1664 to have been originally prepared for *Speaker* (renamed *Mary* in 1660) in 1649.[37] It was the first of the new third rates and had a long and distinguished carrier. The original contract is preserved in the Public Record Office at Kew, in London.[38]

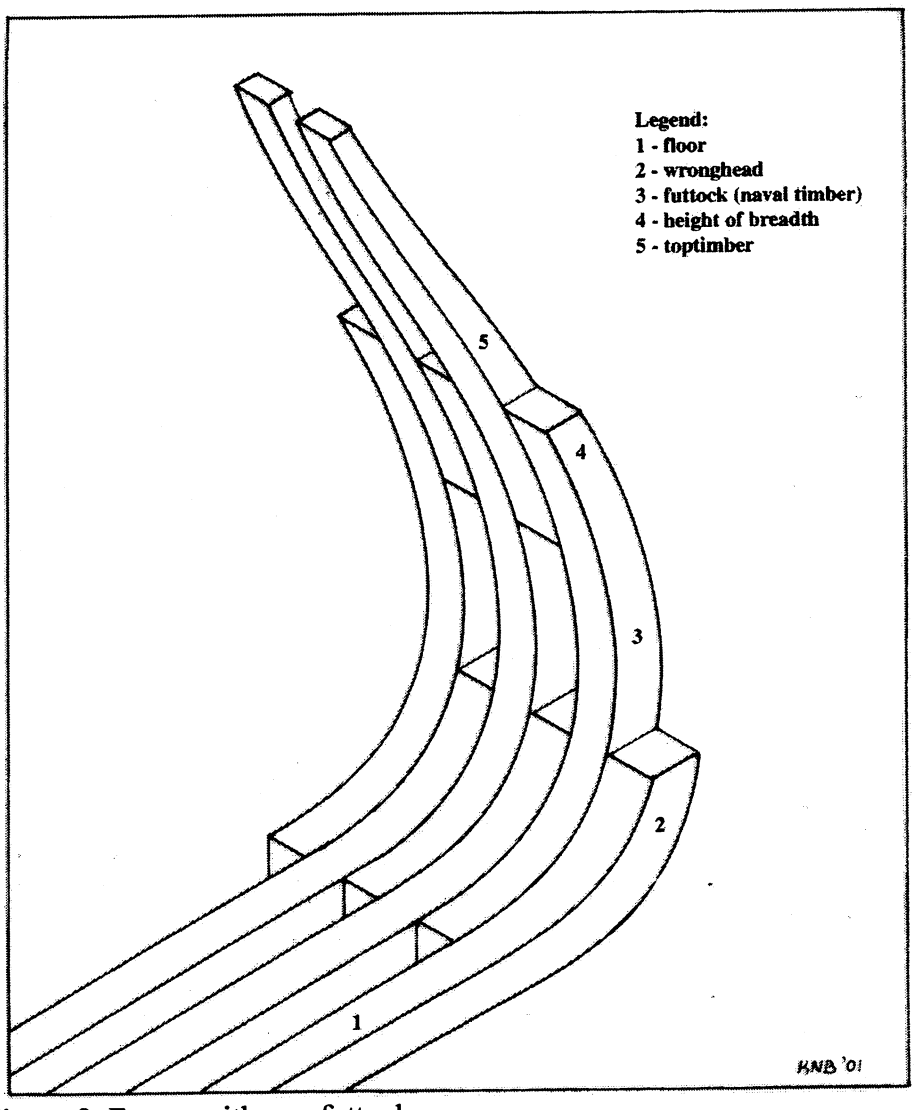


Figure 9. Frame with one futtock.

The contract lists the room and space as 2 feet, 4 inches (71 cm). The floor was to be sided 14 inches (35.6 cm) and the lower (or first) futtocks were to fill the room. In other words, the futtocks were to have the same sided dimension as that of the floors. The scarph of the lower futtocks was to be 6 to 7 feet (1.8 – 2.1 meters). The second scarph was to be 6 feet (1.8 meters) and is probably that between the toptimbers and the "other tier" of futtocks. The only other dimension given is the moulded scantling of the naval timbers: "...and the naval timbers to be 10 inches in and out at the breadth."

The expression "other tier of futtocks" proves that there were to be two futtocks, and therefore the term naval timbers can not correspond to the first futtocks extending to the height of breadth, where the contract locates them. That both "other tier" of futtocks and naval timbers are mentioned implies that the naval timbers were not separate timbers at all. Following the *Treatise of 1625,* naval timbers designate simply the upper part of the second futtocks and the lower part of the toptimbers (figure 10). Some support for this interpretation is to be gleaned from a letter that Peter Pett wrote in 1664 in response to an inquiry from Samuel Pepys. Pett was asked to comment on a draught and scantlings list for a third-rate frigate. The design, unknown to Pett, was by Anthony Deane, a protégé of Pepys. The proposal met with the approval of the experienced Pett, but he suggested that: "...only your second foot-hookes ought to have at least saeven feet and a halfe If not eight feete scarfe upward that so if possible the upper ends of them may be knit within the knees that fastens the Beames of ye maine orlop."[39]

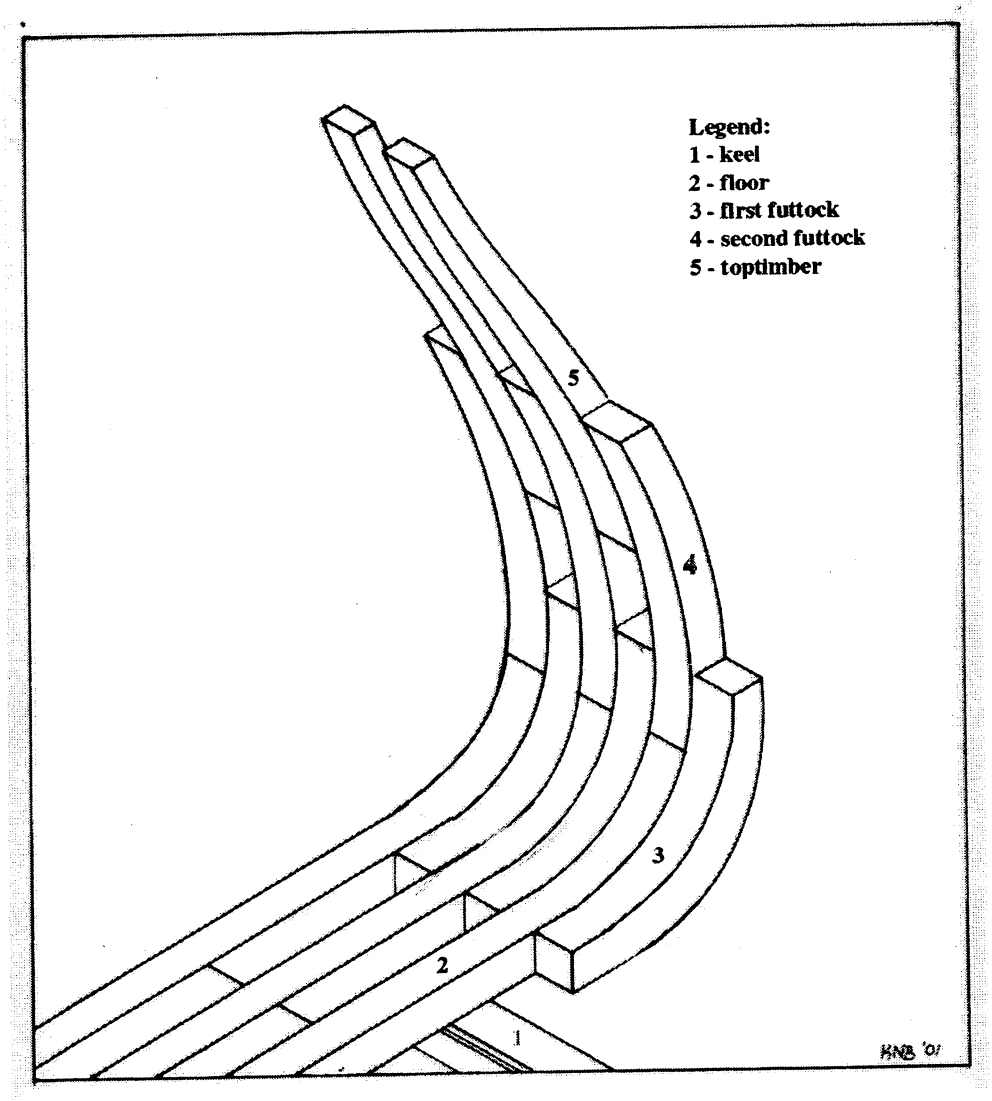


Figure 10. Two-futtock frame.

By "main orlop" Pette was obviously referring to the gundeck. Earlier in the century, both Smith and Manwayring call it orlop. The proposed scarph is almost certainly the one between the second futtocks and the toptimbers. In order for the upper ends of the futtocks to be knit to the main deck knees, Pett must have had in mind the lodging, rather than the hanging, knees. Otherwise, only a few of the futtocks would have been in contact with them. If the lodging knees were meant, then given sufficient length all the upper (or second) futtocks should be fayed ("knit") to the knees and, in fact, should extend above them (figure 11).

Chronologically, the next important source for our study is the Doctrine of Sir Anthony Deane. He was charged with the building of 25 ships in a space of nine years, between 1666 and 1675. These included three first rates and four third rates. It is believed that he was very influential in defining the specifications for the Thirty-Ship Program in the late 1670s.[40]

Even if Deane was not as far superior to the other shipwrights as Pepys would like us to believe, Deane certainly was of unquestionable abilities, many of his ships being very well spoken of - among the third rates *Rupert*, *Resolution,* and *Harwich* were considered fast and weatherly; *Greyhound,* a sixth rate, was thought to be among the fastest ships afloat.

The *Fan Fan*, built for Prince Rupert, earned distinction as perhaps the only

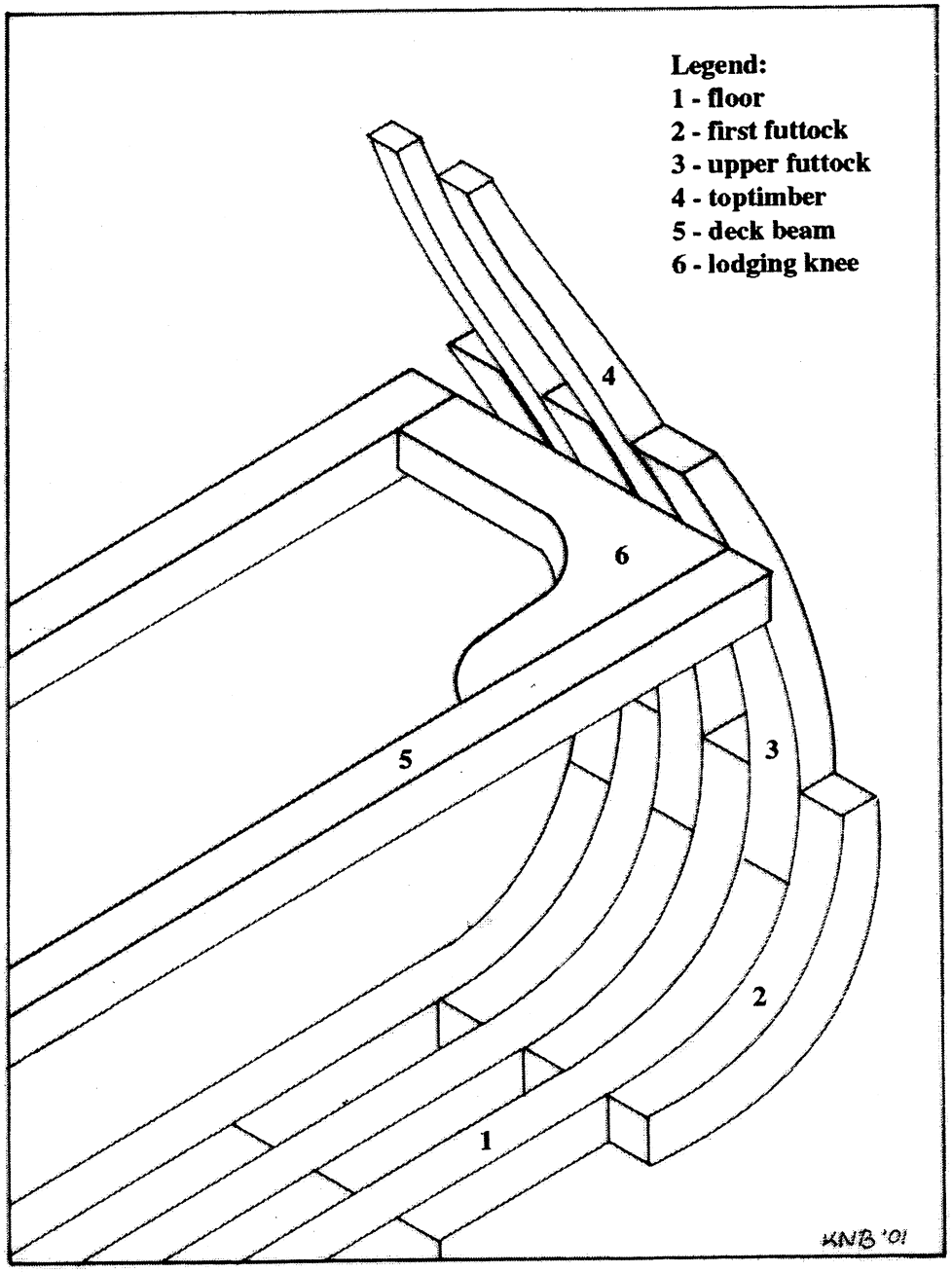


Figure 11. Framing after Peter Pett.

two-gun ship in history to attack an 80-gun vessel (De Ruyter's *De Zeven Provincien*), and later served as the flagship of Sir Robert Holmes at his Bonfire. The battle honors won by his ships show that Deane was a capable shipwright and his views on shipbuilding were influential. His Doctrine was no theoretician's brainchild. For the present discussion, of most importance is the list of scantlings that he provides for all rates.

For a third rate, Deane specifies a room and space of 2 feet, 4 inches (71.1 cm) - just as in the contract of 1664. The sided dimensions for the floors in both sources are the same: 14 inches (35.6 cm). For the lower futtock, Deane specifies 13.5 inches (34.3 cm) sided dimension, as opposed to the clause "fill the space" in the contract. The upper futtocks' sided scantling decreases further to 12 inches (30.5 cm), the moulded dimension at the height of breadth (at the main wales) is 9.5 inches (24.1 cm),which is reasonably close to the 10 inches (25.4 cm) of the contract. Toptimbers are specifically listed, with sided dimension decreasing from 12 to 8 inches (30.5 cm to 20.3 cm). Naval timbers and scarphs are not mentioned.

This is the first document to explicitly specify two futtocks *and* toptimbers. Clearly, the futtocks were to be positioned below the main wales. The lack of naval timbers in the list suggests that Deane moulded them within the upper futtocks and the toptimber. That no mention is made of scarphs is probably due to the format in which the data is presented - Deane gives his scantlings in table form, unlike the contracts,

which are descriptive. Thus, Deane makes no mention of bolts and other fastenings anywhere, while the contracts specify both their sizes and uses. Noteworthy are the gradually decreasing sided dimensions of the timbers. This is not seen in the contracts and may not have been carried out in practice, at least not to the narrow tolerances given in the Doctrine. For a similar specification (although the source is identified only as "a manuscript from 1676") to Deane's, Anderson argued that it implies doubled frames and no continuous bands of solid timber at bilges and breadth.[41] William Baker believed the difference of between 0.25 and 0.5 inches (0.6 cm to 1.3 cm) to be "engineering" tolerances, considering the technology available to the shipwrights at the time.[42] He believed that such small differences would certainly have looked like uninterrupted bands of timber in full size. The sided dimensions of the frames at the main wales in Deane's tables are 4 inches (10.2 cm) smaller than at the turn of the bilge. The four-inch difference should be taken as the total difference within the room and space, but does not mean that it was concentrated in one place. Most probably there were about 2 inches (5.1 cm) of empty space, or room, between the toptimbers and the futtocks. Thus the timber distribution at the breadth would be timber-room-timber-room (figure 12).

This interpretation is supported by the data for the smaller rates, especially the cruisers of the fifth and sixth rates. For the fifth rates, with a room and space of 26 inches (66 cm), upper futtocks of 10 inches (25.4 cm), and toptimbers of 8.5 inches (21.6 cm), the unfilled room at the height of breadth would be 7.5 inches (19 cm).

Room between adjacent timbers would be 3.75 inches (9.5 cm) – perhaps rounded to 4 inches (10.2 cm), or 3 inches (7.62 cm). At the turn of the bilge the distance between the floors and futtocks would be about 1 inch (2.5 cm), which is remarkably

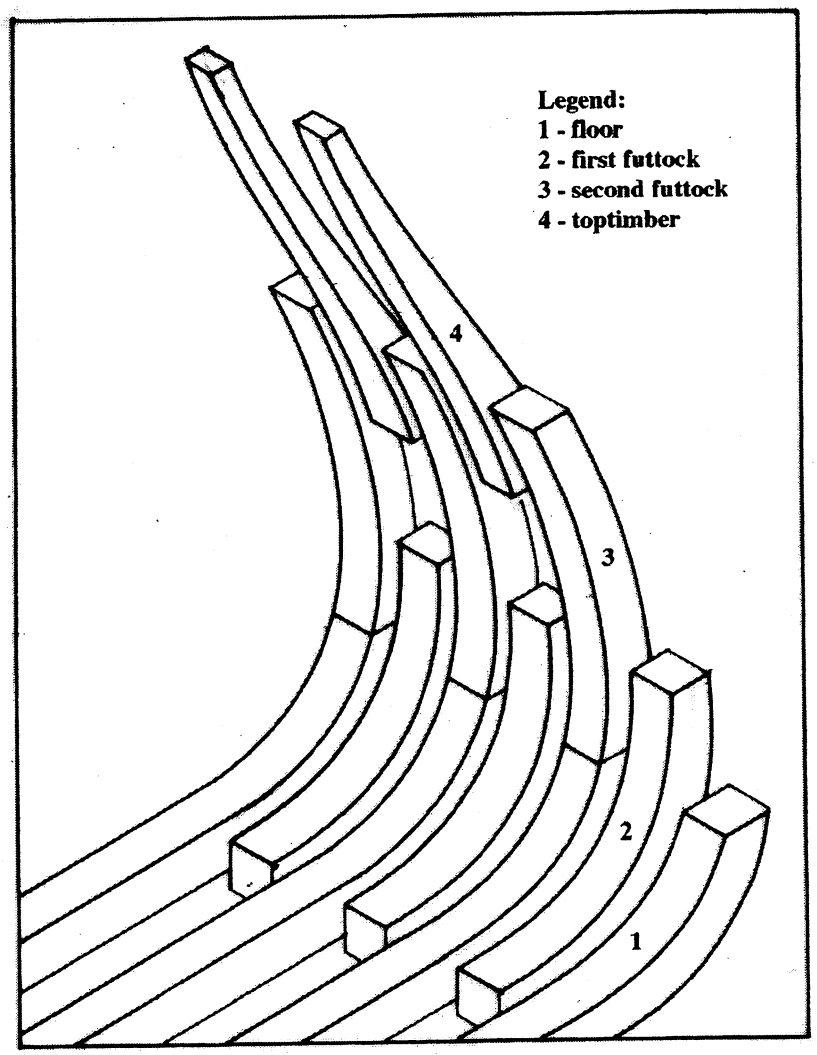


Figure 12. Spaces between frame timbers.

close to what was found on *Dartmouth,* a fifth rate built in 1655.[43] For sixth rates to be in accordance with Deane's dimensions, the room between the timbers at the height of breadth would have been 5 inches (12.7 cm). For the third rates, the distance between the timbers totals 2 inches and for the fourth rates it would be 3 inches (7.6 cm).

In 1673 Sir Edward Spragge and the Crown entered into a contract for the building of four frigates in Ireland. Spragge was killed at the Battle of Texel while serving as flag officer under Prince Rupert and the contract was subsequently dropped. However, the same specifications may have been used for the building of *Oxford,* a fourth rate, in 1674.[44] The contract for the four frigates is fairly similar to the one for *Foresight.*[45] The room and space is the same at 26 inches (66 cm). In Spragge's contract the floors are given as 13 inches (33 cm) and the naval timbers (lower futtocks) are to fill the room, but are not to be less than 12 inches (30.5 cm) sided. The timbers "upwards at the gundeck" are to be sided 10 inches (25.4 cm) and the room to be filled with timber. The toptimbers are to be "in proportion to the floors." This probably referred to the amount of tumblehome, as that was calculated as percentage of the length of floor. The specific mention made of toptimbers negates the chance of their concealement under the category of "timbers upward at the gundeck." Therefore, the ships were to be framed with two futtocks and a toptimber. The room was to be filled with timber, which meant that the toptimbers overlapped the futtocks, but probably did not form a completely solid band of timber. The sided dimension of the toptimbers must have fallen between 10 and 12 inches (25.4 and 30.5 cm). Logically, it seems likely that

their sided dimension was equal to that of the upper futtocks. This left a gap of 3 inches (7.6 cm) between timbers within the room and space, which is exactly what Deane recommends.

An important document in the National Maritime Museum is a small manuscript notebook entitled "William Keltridge His Book April 24th 1675."[46] The notebook contains "lecture notes" from the owner's apprenticeship as a shipwright. Among the topics covered are the proportions for ships, boats, capstans, rigging, masting, mathematical and geometrical instructions, and tables of scantlings for first through sixth rates. Table 1 is derived from information contained in the Keltridge notebook. The arrangement of the tables in the notebook is very similar to those in Deane's Doctrine, supporting the view that William Keltridge was a student of Sir Anthony Deane.[47] Internal evidence suggests that the book was in use over a number of years and information was added on a regular basis. The clearest evidence of this is the list of the navy. Ships that were part of the navy around the year 1675 are entered in very dark ink and with some care. Below these entries are added the names of the 30 ships of the 1677 building program, some of which were not launched until 1685, including the second rate *Coronation.* The ink is much lighter in hue and the handwriting, while clearly the same, has undergone some changes. The extreme care in writing up the earlier entries is not evident in the later entries. Of greatest interest value to this study are the tables of scantlings. It is difficult to determine at what date the tables were compiled, but they must have been prepared probably around the time the Admiralty commission was

trying to establish the scantlings for the 30 ships.[48]

Table 1. Scantlings from William Keltridge. Second half of the 1670s.

TIMBERS	1ST RATE	2ND RATE	3RD RATE	4TH RATE	5TH RATE	6TH RATE
ROOM &SPACE	28.75"	28"	27"	25"	22"	18.75"
FLOORS SIDED	14.25"	14"	13.25"	12.5"	11"	9.5"
LOWER FUTTOCK SIDED ALOW	14"	13.75"	13.25"	12.25"	10"	8"
LOWER FUTTOCK SIDED ALOFT	14"	13.75"	13.25"	12.25"	10"	8"
SECOND FUTTOCK SIDED ALOW	13.5"	13.25"	13"	12"	9.5"	7.75"
SECOND FUTTOCK ALOFT	13.25"	13"	12.75"	12"	9.25"	7.25"
THIRD FUTTOCK SIDED ALOW	13.75"	13"	12.75"	12"	9.5"	0
THIRD FUTTOCK SIDED ALOFT	13"	12.75"	11.75"	11.25"	8.75"	0
FOURTH FUTTOCK SIDED ALOW	13"	12.75"	0	0	0	0
FOURTH FUTTOCK SIDED ALOFT	12.75"	12.5"	0	0	0	0
TOPTIMBERS SIDED ALOW	12.75"	12.5"	11.5"	10.5"	8"	6.5"
TOPTIMBERS SIDED ALOFT	8.25"	8"	7.75"	6.75"	5.5"	4"

Two points deserve special attention. First, the room and space and the scantlings are smaller than those in Deane's Doctrine, with the exception of the second futtocks which were lighter in Deane than in Keltridge. Second, William Keltridge lists three futtocks for third through fifth rates, two for sixth rates, and four for first and second rate three-deckers. Sadly, no contracts seem to have survived for three-deckers,

probably because all of them were built in royal dockyards and the shipwrights there could be trusted to do the work without specific instruction. It is likely that sufficient information is preserved in official correspondence and progress reports from the building of the first rate *Britannia*, launched in 1682, and the nine second rates in order to determine whether four futtocks were used in their framing and how they were distributed.[49] About half of the third rates under the 1677 program were built by private yards, yet I am not aware of any contracts to have surfaced for them. Evidence that they indeed were framed with three futtocks can be seen in a draught, believed to be of one of the third rates (see Chapter IV).

In 1686, Edward Battine compiled a small manuscript book with the title *Proportions for Ships with Directions for Drawing and Deleniating Ships Bodies* (sic).[50] Essentially, the book is a repetition of the earlier Keltridge notebook. The table format for presenting the data here is used again as in Deane and Keltridge. There are some weaknesses to Battine's work that are absent in the others. He does not provide the room and space; and, for the toptimbers, does not give the sided dimensions except at the heads. The scantlings of the frame timbers are closer to those listed by Keltridge than those given by Deane. Battine confirms that the two-deckers were framed with three futtocks and the three-deckers with four. Perhaps the most surprising feature of his table is that single-decked sixth rates are given three futtocks, whereas Keltridge specifies only two. Later contracts for building sixth-rate frigates confirm that only two futtocks were used (see below). All in all, the Battine book is interesting, but less

trustworthy than the other sources. Mr. Samuel Pepys, at the time Secretary to the Admiralty, was unimpressed by the work and was not complimentary in his correspondence with the author.[51]

After the success of the fourth rate galley-frigates *Charles Galley* and *James Galley* of the second half of the 1670s, John Deane, the son of Sir Anthony Deane, undertook the building of another galley-frigate similar to *James*. The contract was signed on July 31, 1686 and the ship, named after Queen Mary of Modena, the *Mary Galley,* was launched in 1687.[52] The new ship was a fourth rate and the room and space was to be 2 feet, 2 inches (66 cm), with floor timbers sided 10 inches (25.4 cm). Five of the first futtocks at midships were to have the same sided dimension as that of the floors, while those fore and aft of midships were to be 9 inches (22.9 cm). Two scarphs are listed for the lower futtocks and for the "Tymbers upwards at the Orlop," both of which were to be 5 feet (1.5 m). The only mention of toptimbers is that they were to be in proportion to the floors. As with Spragge's contract, I believe this to mean that their tumblehome was to be in proportion to the length of the floors. The contract speaks of only two futtock timbers and it is likely that *Mary Galley* did not have middle futtocks. Only two scarphs are given for the frame as compared with contracts that clearly refer to ships with three futtocks (see below), which give three scarphs. *Mary Galley* had smaller depth in hold than most contemporary fourth rates: 11 feet (3.4 meters) compared to an average of 13 feet 6 inches (4.05 meters).[53] The shallower hull and the number of scarphs argue in favor of a two-futtock frame.

After the coup that put Dutch William on the English throne in 1688, England joined his war against France. An extensive building program became necessary and large numbers of ships were ordered. Many contracts survive from this period, too.[54] Priority was given to third rates of up to 80 guns on two decks, and fourth rates of 50 and 60 guns, but a substantial number of sixth rates, fireships, and ketches were built, too. In the war of the League of Augsburg (1689-1697), fourth rates were considered to be capital ships and formed the backbone of the fleet.[55] A detailed reading of the preserved contracts revealed that they fell into categories of standardized texts with only the handwriting and dates differing. All contracts for third rates, many of them named, were the same with no substantial differences noted in scantlings, or any specifications. The information is tabulated in Table 2. Essentially, the room and space, the scantlings of the timbers, and the number of futtocks are the same as those listed in William Keltridge's notebook, thus giving weight to the supposition that the ships of the 1690s were based on the Thirty-Ship program.

A contract from 1690 in the Public Record Office preserves a description of the third rate ship, *Yarmouth* of 70 guns, launched in 1695.[56] The scantlings are identical

Table 2. Scantlings of third rates. All dimensions are in English inches. Key to tables: FL-floor; FT-futtock; L-lower end of timber; U-upper end of timber; R&S-room and space; TT-toptimbers; SCA -scarph.

SOURCE	DATE	RATE	R&S	FL	1FT L	1FT U	2FT L	2FT U	3FT L	3FT U	TT	SCA
CONTRACT	1664	3	28	14	14?	N/A	N/A	N/A	0	0	N/A	YES
DEANE	1670	3	28	14	13.5	13.5	12	12	0	0	12	N/A
KELTRDIGE	1675	3	27	13.25	13.25	13.25	13	12.75	12.75	11.75	12	N/A
BATTINE	1686	3	N/A	13	N/A	13	N/A	13	N/A	13	7.5	N/A
CORNWALL	1690	3	27	13.25	13.5	N/A	N/A	N/A	N/A	12	12	YES
NORFOLKE	1691	3	27	13.25	13.5	N/A	N/A	N/A	N/A	12	12	YES
NEWARKE	1693	3	27	13.25	13.5	N/A	N/A	N/A	N/A	12	12	YES

with those given by Keltridge. The room and space is 27 inches (68.6 cm) and the sided dimensions for the floors and naval timbers are the same as for his first futtocks – 13.5 inches (34.3 cm). The timbers at the gundeck and the toptimbers would have left 3 inches (7.6 cm) between them instead of 4 inches (10.2 cm), as per Deane. Among the ships built in the 1690s were some 80-gun third rates. The earliest contract for an 80-gun ship is that for *Devonshire.*[57] It is noteworthy that the scantlings in it agree very closely with those given by Deane for a *fourth* rate. This is important on two accounts. The two-decked 80-gun ships proved to be very weak and Master Shipwright William Lee believed they would have performed better if a third deck had been added for the same total number of guns.[58] The small timber dimensions may explain the inherent weakness of these ships. On the other hand, that the scantlings were decreased as compared to earlier third rates, suggests that shipwrights had a reason to hope that

something in their construction - probably the addition of a third futtock - would make them sufficiently strong: a mistaken belief, at least for the big ships, as it turned out.

A new development during this time was the introduction of a third futtock given in the contract as "middle" futtock, for which only the scarph is given. The middle or second futtock is present in Keltridge's tables of scantlings and in Battine, but these contracts are the earliest preserved to specifically mention them. With the exception of third futtocks, nothing significantly differs from the earlier examples. The shipwrights still saw the strength of the frame in the overlap, or scarph between the timbers in it. John Franklin believes the sections of the frame were arranged so that the timbers at the gundeck backed the butt between the toptimbers and the middle futtock. The basis of his proposal, which takes into account the length of scarphs, is the gap in timbering visible on contemporary models.[59] The Keltridge sections of a fourth and a sixth rates do not show open spaces.[60] It is more likely, therefore, that the contracts for the third rates of this group are among the earliest examples specifying a double frame and that no open space along the length of the futtocks existed (figure 13).

The second group of contracts are for the building of 60-gun fourth rates.[61] They were longer, broader and deeper than the 50-gun ships, but the scantlings and even the room and space were the same. The data on 60-gun fourth rates has been tabulated in Table 3.[62] A contract from 1693 is believed to be for the building of *Pembroke*, a fourth rate of 60 guns.[63] The room and space is the same as in the earlier ships of this rate.

Nothing differs in the specifications for the lower or naval futtocks, either. Third futtocks are specified and again nothing except the scarph is given for them. Neither is there much written about the upper futtock. The only additional information that we can glean from the 60-gun ship documents concerns the timbers at the gundeck. While in the earlier examples they were given as timbers *upwards* at the gundeck, in this instance they are *at* the gundeck. They were to be 11 inches (27.9 cm) sided, the same given for the toptimbers. The timbers at the gundeck were also to have a scarph no less than 6 feet (1.8 m) in length. The specification also states that 1.5 inches (3.8 cm) should be left between the timbers for airing. This gives a total gap of 3 inches (7.6 cm), the same as that listed by Deane. This may mean that either the toptimber was still separate from the frame, and that the bends were to be 1.5 inches (3.8 cm) from each other, or that it was not a true double frame and the timbers were still not fastened to each other. Keltridge, however, shows the location of the bends on the keel and gives them as doubled. The construction of the 60-gun fourth rates, as revealed by the contracts, does not differ from the third rates except in dimensions and scantlings.

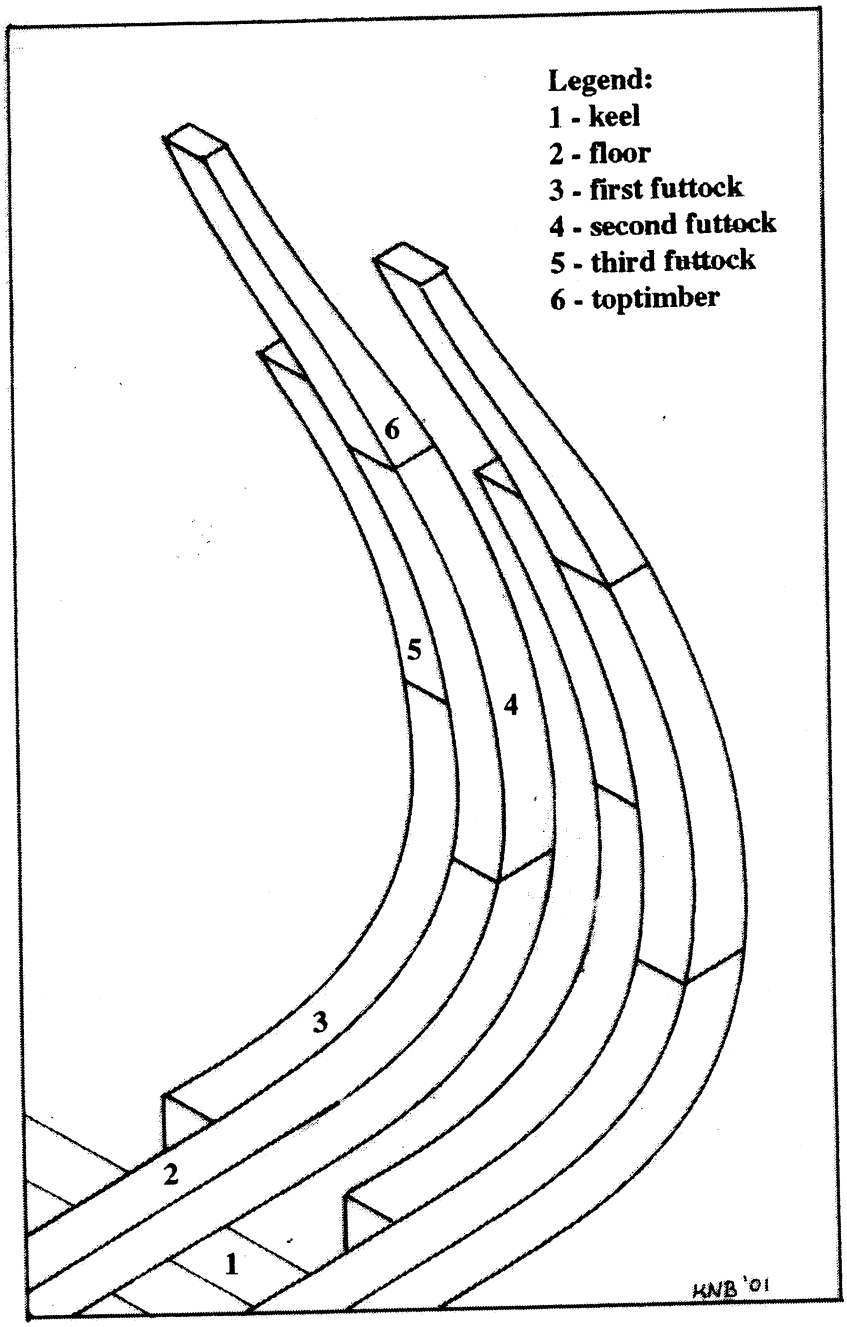


Figure 13. Double frame with butted joints and overlapping scarphs.

Table 3. Scantlings of 60-gun fourth rates. All dimensions in English inches.

SOURCE	DATE	RATE	R&S	FL	1FT L	1FT U	2FT L	2FT U	3FT L	3FT U	TT	SCARPH
60-GUN	1693	4	26	13	12 /FILL	N/A	N/A	N/A	N/A	11	11	YES
SUNDERLAND	1693	4	26	13	12/FILL	N/A	N/A	N/A	N/A	11	11	YES
60-GUN	1694	4	26	13	12/FILL	N/A	N/A	N/A	N/A	11	11	YES

The specifications for 50-gun fourth rates offer some new elements that are not available for the larger vessels. The contract for *Norwich,* signed on August 5, 1692, specifies the same room and space of 26 inches (66 cm), sided dimension of the floor of 13 inches (33 cm), and requires the lower futtock to fill the room "full and workmanlike."[64] This is followed by information not seen in earlier contracts. The lower futtock is to have a length of at least 12 feet (3.7 m) and "to be chocked down within 20 inches (50.8 cm) of the keel." Chocks were angular blocks or wedges used to fill space between timbers.[65] They were used also for strengthening the joint between butting timbers (figure 14). The timbers to be jointed were cut at an angle and the chock was fastened in the resulting triangular space. A distance of 20 inches from the keel is very close to the 18 inches (45.7 cm) that the *Treatise of 1625* specifies the first futtocks to come short of the keel. If the lower futtocks on both sides came 20 inches (50.8 cm) short of the keel and were to be chocked down, it is likely that their heels were connected to each other by the chock, which would have crossed the keel. This is a constructional feature typical of eighteenth-century ships, but was believed not to have been in use in the seventeenth century.[66] The contract does not mention any scarphs.

The contracts for *Severn* and *Burlington*, 50-gun fourth rates of 1695, mention only lower and upper futtocks.[67] The heads of the upper futtocks were supposed to reach the lower gunport sill and the lower futtocks were to be chocked down within 20 inches (50.8 cm) of the keel. Thus, the contract is practically identical to that of the *Norwich* and the other 50-gun ships. Data for this class of ships is listed in Table 4. Table 5 contains data for comparison of fourth rates in the second half of the seventeenth century. Nothing suggests the presence of a middle (second) futtock and, yet, it is likely that they were used, as with the earlier ships. The lower futtock had to be chocked down. Is it a coincidence that the chocks appear in contracts that do not list scarph lengths?

The surviving specifications for two sixth-rate frigates from the 1690s show that smaller ships continued to be built with two futtocks.[68] Comparative data for sixth rates is given in Table 6. *Biddeford,* launched in 1695, was to have room and space of 22 inches (55.9 cm) and floor timbers of 9 inches (22.9 cm) at midships, and the rest 8.5 inches (21.6 cm) sided dimensions.[69] The lower futtocks were to be the same as the floors in dimensions - 11.5 feet long (3.5 m) - and were to be chocked down within 18 inches (45.7 cm) of the keel. The second futtocks are given in the contract as 8 inches (20.3 cm) sided at their heels and 7 inches (17.8 cm) at their heads, or the height of breadth. The wording in the contract is "Second or Upper futtocks" and these were to rise above the upper edge of the deck-beam clamp. Toptimbers were to be 7.5 inches (19.1 cm) at their heels. The heels of the toptimbers were "to stand on ye lower futtock head."

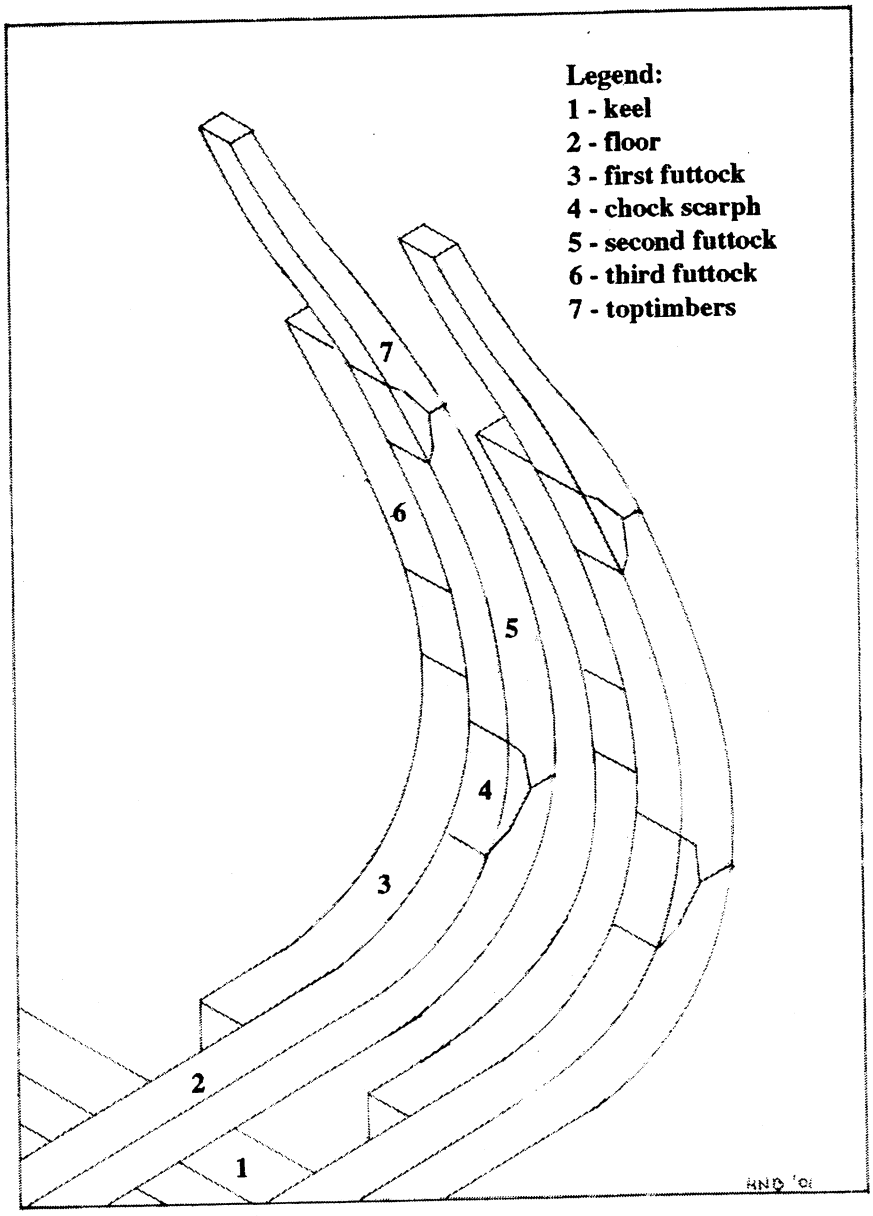


Figure 14. Double frame with chocks.

Table 4. Scantlings of 50-gun fourth rates. All dimensions in English inches. RT-rate; R&S-room and space; FL-floor; FT-futtock; L-lower end of timber; U-upper end of timber; TT-toptimber; CHK- chock.

SOURCE	DATE	RT	R&S	FL	1FT L	1FT U	2FT L	2FT U	3FT L	3FT U	TT	CHK
NORWICH	1692	4	26	13	FILL	N/A	N/A	N/A	N/A	10	N/A	YES
COLCHESTER	1693	4	26	13	FILL	N/A	N/A	N/A	N/A	10?	10	YES
ROMNEY HARWICH PENDENNIS 50-GUN 4TH	1694	4	26	13	13?	N/A	N/A	N/A	N/A	10	10?	YES
	1696	4	26	12	12/FIL	N/A	N/A	N/A	N/A	N/A	10	YES

Table 5. Comparison of fourth rate scantlings. All dimensions in inches. DT-date; RT-rate; R&S-room and space; FL-floor; FT-futtock; L-lower end of timber; U-upper end of timber; TT-toptimber; JT-joint; SC-scarph; CH-chock.

SOURCE	DT	RT	R&S	FL	1FT L	1FT U	2FT L	2FT U	3FT L	3FT U	TT	JT
FORESIGHT	1650	4	26	13?	13?	N/A	N/A	N/A	0	0	N/A	SC
DEANE	1670	4	27	13	12.5	12.5	11	11	0	0	10	N/A
KELTRIDGE	1675	4	25	12.5	12.25	12.25	12	12	12	11.3	11	N/A
BATTINE	1686	4	N/A	11	N/A	12	N/A	12	N/A	12	6	N/A
MARY	1686	4	26	10	10(9)	N/A	0	8	N/A	8	N/A	SC
NORWICH	1692	4	26	13	FILL	N/A	N/A	N/A	N/A	10	N/A	CH
60-GUN 4TH	1693	4	26	13	12/FIL	N/A	N/A	N/A	N/A	11	11	SC
COLCHESTER	1693	4	26	13	FILL	N/A	N/A	N/A	N/A	10?	10	CH
SUNDERLAND	1693	4	26	13	12/FIL	N/A	N/A	N/A	N/A	11	11	SC
60-GUN 4TH	1694	4	26	13	12/FIL	N/A	N/A	N/A	N/A	11	11	SC
HARWICH	1694	4	26	13	13?	N/A	N/A	N/A	N/A	10	10?	CH
50-GUN 4TH	1696	4	26	12,25	12/FIL	N/A	N/A	N/A	N/A	N/A	10	CH

In addition "ye whole frame to be well chocked with good sound timber." As with the contracts for the 50-gun fourth rates, the contracts for sixth rates specify that four of the heaviest footwaling strakes were to "lye upon ye chocking of ye Floor head and the foot of ye upper Futtock." If the toptimbers were to step on the lower futtocks and the upper futtocks were to step on the floor heads, then there was no room for a middle futtock. Therefore, sixth rates were framed with only two futtocks per side - and not three, as Keltridge and Battine claim in their tables of scantlings. If the whole frame was to be well chocked and the toptimbers placed on the heads of the lower futtocks, it is certain that the entire frame was chock-scarphed, a feature that is not visible in contemporary draughts.[70] The other preserved contracts for sixth rates show no departure from the one for *Biddeford*.[71]

Table 6. Scantlings of sixth rates. All dimensions in English inches.

SOURCE	DT	RT	R&S	FL	1FT L	1FT U	2FT L	2FT U	3FT L	3FT U	TT	CH
DEANE	1670	6	24	10	8.5	8.5	7	7	0	0	7	N/A
KELTRIDGE	1675	6	18.8	9.5	8	8	7.75	7.25	0	0	6.5	N/A
BATTINE	1686	6	N/A	9	N/A	8	N/A	7	N/A	7	4	N/A
BIDDEFORD	1694	6	22	9	9	N/A	8	7	0	0	7.5	YES
FAULCON	1694	6	22	9	9	N/A	8	7	0	0	7.5	YES
SEAHORSE	1694	6	22	9-8.5	9-8.5	N/A	8	7	0	0	7.5	YES
SWAN	1694	6	22	9	9	N/A	8	7	0	0	7.5	YES

At the beginning of the War of the League of Augsburg the navy ordered the construction of fireships. In dimensions and tonnage they were almost identical to the sixth rates of the same era, yet their framing was different. Table 7 presents data derived from the contracts and Table 8 compares fireships to sixth rates.[72] As with the other ships of the 1690s, the fireships were built to the same specification. The room and space at 22 inches (55.9 cm) was the same as for the sixth rates. The floors were to be 10 inches (25.4 cm) sided. The lower futtocks were to be 10 inches (25.4 cm) at the midship frame and in the four frames fore and aft of the midship frame. The remaining frames were to be only 8 inches (20.3 cm) sided and all were to taper to 7 inches (17.8 cm) at the height of breadth. The heads of the upper futtocks were to rise one foot (30 cm) above the lower deck. No information is given for the toptimbers, but comparing these ships to the sixth rates, it is likely that they were about 7 inches (17.8 cm) at the lower ends. The scarphs between the timbers were to be at least 4 feet (1.2 m), but the contract does not mention chocks. The likely explanation for this is that chocks were more expensive to fit than simple scarphs, due to increased labor and, not as necessary in a lighter vessel intended for a relatively short career and not expected to have to withstand cannon fire.

Table 7. Scantlings of fireships. All dimensions in inches. DT-date; RT-rate; R&S-roomand space; FL-floor; FT-futtock; L-lower end of timber; U-upper end of timber; TT-toptimber; SCH-scarph.

SOURCE	DT	RT	R&S	FL	1FT L	1FT U	2FT L	2FT U	3FT L	3FT U	TT	SCH
FOX	1689	FS	22	10	10	7?	N/A	7	N/A	N/A	N/A	YES
GRIFFIN	1689	FS	22	10	10	7	N/A	7	0	0	N/A	YES
PHAETON	1690	FS	22	10	10	7	N/A	7	0	0	N/A	YES
VULCAN	1690	FS	22	10	10	7	N/A	7	0	0	N/A	YES
PHENIX	1693	FS	22	10	10	7	N/A	7	0	0	N/A	YES

A contract for a sixth rate from 1699 had the same room and space as *Biddeford*, but her scantlings differ.[73] The floors and first futtocks at midships were to be 10 inches (25.4 cm.) sided. The futtocks from about four frames forward and aft of midships were to decrease to 8 inches (20.3 cm.) sided at the lower end and 7 inches (17.8 cm.) sided at the breadth. The upper futtock was to rise one foot above the lower deck. As is usual for this type of contract no information is given about the toptimbers. If the earlier contracts are a guide, then it is likely that the toptimbers had about the same sided dimension as that of the futtocks. The data contained in this document makes it certain that the contract was for a fireship and certifies that the contracts from 1689 were in use as late as 1699.

Table 8. Comparison of sixth rates and fireships. All dimensions in English inches. DT-date; RT-rate; R&S-room and space; FL-floor; FT-futtock; L-lower end of timber; U-upper end of timber; TT-toptimber; JT-joint; CK-chock; SH-scarph.

SOURCE	DT	RT	R&S	FL	1FT L	1FT U	2FT L	2FT U	3FT L	3FT U	TT	JT
DEANE	1670	6	24	10	8.5	8.5	7	7	0	0	7	CK
KELTRIDGE	1675	6	18.75	9.5	8	8	7.75	7.25	0	0	6.5	CK
BATTINE	1686	6	N/A	9	N/A	8	N/A	7	N/A	7	4	CK
BIDDEFORD	1694	6	22	9	9	N/A	8	7	0	0	7.5	CK
FAULCON	1694	6	22	9	9	N/A	8	7	0	0	7.5	CK
SEAHORSE	1694	6	22	9(8.5)	9(8.5)	N/A	8	7	0	0	7.5	CK
SWAN	1694	6	22	9	9	N/A	8	7	0	0	7.5	CK
FOX	1689	FS	22	10	10	7?	N/A	7	N/A	N/A	N/A	SH
GRIFFIN	1689	FS	22	10	10	7	N/A	7	0	0	N/A	SH
PHAETON	1690	FS	22	10	10	7	N/A	7	0	0	N/A	SH
VULCAN	1690	FS	22	10	10	7	N/A	7	0	0	N/A	SH
PHENIX	1693	FS	22	10	10	7	N/A	7	0	0	N/A	SH

Unrated vessels of the Royal Navy rarely receive much attention.[74] This, however is not justified, as sufficient information exists to study them. The archives in the Public Record Office contain contracts for ketches ordered during the War of the League of Augsburg.[75] With a room and space of 20 inches (50 cm), the floors of these small vessels were to be 9 inches (22.9 cm) sided. As with fireships, the first futtocks at midships and the four on each side of it were to be of the same sided dimensions as the floors; the rest were to be only 7 inches (17.8 cm) sided. At the height of breadth, the sided dimensions tapered to 6.5 inches (16.5 cm). No mention is made of second or upper futtocks and the only suggestion that they were used at all is that the futtocks described are referred to as "lower" futtocks. The toptimbers were to be 5 inches (12.7

cm) sided. The contract states that the scarphs were to be at least 4 feet (1.2 m). No chocks were used. An obvious possibility is that these vessels were built with single futtocks. Their smaller size would seem to support such an interpretation. Yet, if one looks more carefully, it is noticeable that the dimension that has bearing on the girth of the vessel and, therefore, on the length to be framed, is the depth of the hold. For ketches this was to be 9 feet (2.7 m) as compared to fireships with depth in hold of 9 feet 8 inches (3 m). The difference is so small that it can be ignored. Since the futtocks are specifically referred to as the "lower," I favor the view that ketches were framed with two futtocks.

In 1701 *Warspight* (*sic* in contract) was rebuilt as part of the repair program that the Admiralty launched after the conclusion of peace in September 1697.[76] If the specifications of 1664 were indeed used for the building of this ship, then after the rebuilding the vessel must have had only the name in common with its previous self. She emerged from the dockyard with completely new scantlings. Even the room and space was changed to what has become the standard for third rates after the mid-1670s. The frame construction was also different, since it now it had three futtocks, but still retained the scarphs, which are evident from the contract for her rebuilding.[77]

In 1702, with the renewal of war with France imminent, the Admiralty ordered new ships. The contracts for a pair of 40-gun fifth rates and for two 50-gun fourth rates are practically identical.[78] Neither contract mentions any scarphs, but both specify

chocks. The most interesting sentence in the contract for the fifth rates says that " *the whole frame to be well chocked with good sound timber.*" In the contract for the 50-gun ships, there is also an important sentence: "*Footwaling the six inche shifte to lye upon the chocking of the floor head.*"

The material presented demonstrates that until the third quarter of the seventeenth century ships were being built in the same manner as they were at the beginning of that century. The building sequence is described briefly by Phineas Pett in his autobiography. As described in the previous chapter, after the crossing of floors, planking and framing progressed almost simultaneously. How was shipbuilding modified after the introduction of the third futtock in the third quarter of the seventeenth century? This would have depended on whether or not the futtocks were laterally fastened to each other. Since, the contracts do not describe any lateral fastening, the help of nautical archaeology will be indispensable in resolving this issue. Until evidence derived from the excavation of late seventeenth-century men-of-war becomes available, the following information will be useful. Sutherland's work of 1711 indicates that frames were laterally fastened. He notes that the timbers of small ships were fastened and raised entire with the toptimbers, while for big ships only the timbers up to the breadth were fastened together before they were raised. A question that needs to be answered before accepting Sutherland as evidence is whether transposing practices from around 1711 to the last decade of the seventeenth century is justifiable. To some extent Sutherland himself answers this question:

> Formerly the Method was to put the Ground-timbers, as Floor and Lower Foot-hooks, close together; but it being observed to cause putrefication, and also prejudicial in over-scantling the ships, it was left off.[79]

Apparently the contracts describe the earlier method that was abandoned. Sutherland does not indicate when the method was abandoned, but a likely time frame is the period between the end of the War of the League of Augsburg in 1697 and the beginning of the War of the Spanish Succession in 1703, when most of the navy was rebuilt and repaired.

The new method of building left more space between the timbers of the frame. Sutherland writes: "...I mean by spacing that according to the Magnitude of the Ship there be a Allowance made for two of the first Floor-timbers besides a Vacancy between them for Air...."[80] The filling of the spaces has definitely been abandoned. Further on, Sutherland continues "...at the Head and Feet of each Tire of Timbers Half is cut off..."[81] The cutting off of the timbers at the head and heels of the timbers is in order to accommodate the chocks for the scarphing of the timbers. The same source informs us that it was necessary for "...Timbers to be equally scarfed, the Middle of one Timber being in the Wake of the Head and Heels of the others...."[82] Essentially, this means that the overlapping scarphing was not completely abandoned, but rather a chock scarph was added. The advantage of the chock scarph was that it helped form a continuous, monolithic timber throughout the side of the ship, because "...with one Piece, she would be much stronger than to have a great many Pieces...."[83] Frames so described are true double frames.

Supporting evidence and basic building sequence comes from another section of the quoted work. Sutherland advises builders to "Get on first the Frame-timbers, which in some Ships is every fourth, and in some every third; but in crossing the Floor-timbers, every other Timber is commonly put on...."[84] What he means by "Frame-timbers" (and that is not exactly what we mean by it today) is clear from the next passage (italics mine):

> The Fashion is to frame every third, or every fourth Timber, that is, to *fit or join all the Foot-hooks and Top-timbers together,* if it be a small Ship; but if a large one, then all the foot-hooks, as high as the Breadth Ribbon; and observe to join the Frame-timbers very exactly, and true to the Mould.[85]

For Sutherland "Frame-timbers" were pre-assembled, double frames that were lofted, or moulded from the draught. The others were the so-called filling frames and were erected piece by piece within the fairing ribbands, used to ascertain that the bilge and breadth ran true to the draught. It is noteworthy that the frames were only partially pre-assembled. The floors were already bolted to the keel, when the futtocks were secured to them. Sufficient room would not have been available to bolt the futtocks to the floors fore and aft - with either the mould frames, or the filling frames. It was possible, however, to assemble the frames only with the introduction of chock scarphs.

Sutherland describes the sequence of building ships that was introduced likely in the early 1690s and had become the dominant way of building ships by 1711. After the keel was laid down, the moulded floors were crossed. Ribbands were passed around the

wrongheads to help fair them. The rest of the floors were filled in, followed by the deadwoods fore and aft. The pre-assembled futtocks were mounted on their respective floors and a breadth ribbon was passed down each side for support and guide. Then the filling timbers and half frames were added followed by the planking. Ship framing has reached a stage that would last until sweeping changes were introduced at the end of the Napoleonic wars.

In conclusion, the following model of development can be offered for the framing of English men-of-war in the second half of the seventeenth century. The battles of the Anglo-Dutch wars demonstrated the overwhelming superiority of the heavily timbered and armed English battleship. Speed was of secondary importance, as the Dutch were only too happy to engage. The smaller fifth and sixth rates, however, were not expected to lie in the line of battle, but were used as support vessels, scouts and cruisers. The tasks that they had to perform required them to be fast and therefore light. Consequently, their assigned tasks were reflected in their timbering.

In response to gained experience in war, between 1673 and 1677 shipwrights incorporated third futtocks in their ships. Galley-frigates, though, like sixth rates, continued to be framed with two futtocks. For both vessels, speed was the primary concern, and their shallow hulls would not have required large amounts of grown timber. For larger vessels the addition of a third futtock may have allowed the decrease in room and space and timber dimensions, but would not have eased the timber supply

problem dramatically. Rather the opposite, as now two additional timbers per frame had to be supplied. The addition of the third futtock would have eliminated the empty spaces within the frame, so dramatically illustrated by the Navy Board models. This would have decreased the length of planking unsupported by frame timbers. In turn, this ought to have increased the stiffness and strength of the hull. Stiffer hulls are less prone to working in seaway and spitting out caulking from the planking seams. This increases seaworthiness of a ship and lengthens the periods of service between refits - an important step towards allowing wider geographical deployment of a navy.

Seventeenth-century contracts contain evidence that ships were not built simply by adjusting the scantlings and dimensions for 50-gun fourth rates and sixth rates. The 1702 contract for fifth rates shows that fifth rates in the last decade of the seventeenth century were framed like the 50-gun ships and sixth rates. For all three types of vessels the important characteristic was speed under sail, since they were used as cruisers. The fourth rates of this group were also expected to lay in the line of battle. The duties that ships of these rates had to perform required strength and lightness. The introduction of chock scarphs perhaps allowed them to be built with inferior material. The most difficult timber to find would have been the floor with sufficient length and curvature on both sides at the wrongheads. The introduction of the chock would have eased this logistical problem. Another benefit would have been the additional stiffness of an essentially solid band of timber from the bottom of the ship to the height of breadth. This reduced the weight of the scantlings without compromising strength. Fireships, in

contrast, were expected to have short careers, but nevertheless had to be seaworthy enough to keep up with the fleet, had heavy scantlings amidships, and were significantly lighter in the ends. The necessity for stiffness was not present and no chocks were fitted. Larger fourth and third rates did not use chock scarphs, but continued to derive their strength from overlapping scarphs. The nearly solid bands of timber at the bilges and the height of breadth added to the shot resistance of the hulls. It is likely that by the early years of the eighteenth century shipwrights incorporated chock scarphs on bigger ships, too. In bigger ships the chock scarphs allowed increased of strength while maintaining airing spaces between timbers.

In summary, on all ship rates the two-futtock system reigned supreme from the early years of the seventeenth century to about the second half of the 1670s, when the third futtock was added and widely used in framing of the four larger rates. The conversion process must have been completed in the early 1700s, when overlapping scarphs disappear from the contracts and chock scarphs are substituted for them.

CHAPTER IV

DRAUGHTS AND DRAWINGS

A few draughts of English ships from the second half of the seventeenth century still survive. One such draught in the Danish archives has been published by Brian Lavery.[86] It is very likely that Lavery used this draught in his reconstruction of Deane's *Resolution*, 1667. The draught depicts a 70-gun third rate, and may be that of one of the twenty ships built as part of the 1677 program. If so, the ship still remains unidentified. Of interest for this work is the midship section shown in the upper part of the draught. It is almost certain that it depicts three futtocks and a toptimber (figure 15). Lavery associates the contracts from the 1690s with this drawing, claiming that the later ships were built after those of the 1677 program.[87] The draught presents possibly the earliest graphic evidence of a three-futtock frame. As late as 1670, Sir Anthony Deane speaks of only two futtocks.

For framing practices around the mid-1680s, there is a collection of drawings prepared by William Keltridge, a shipwright who may have been a student of Deane.[88] The collection consists four sixth rates, one fifth, and two fourth rates.[89]

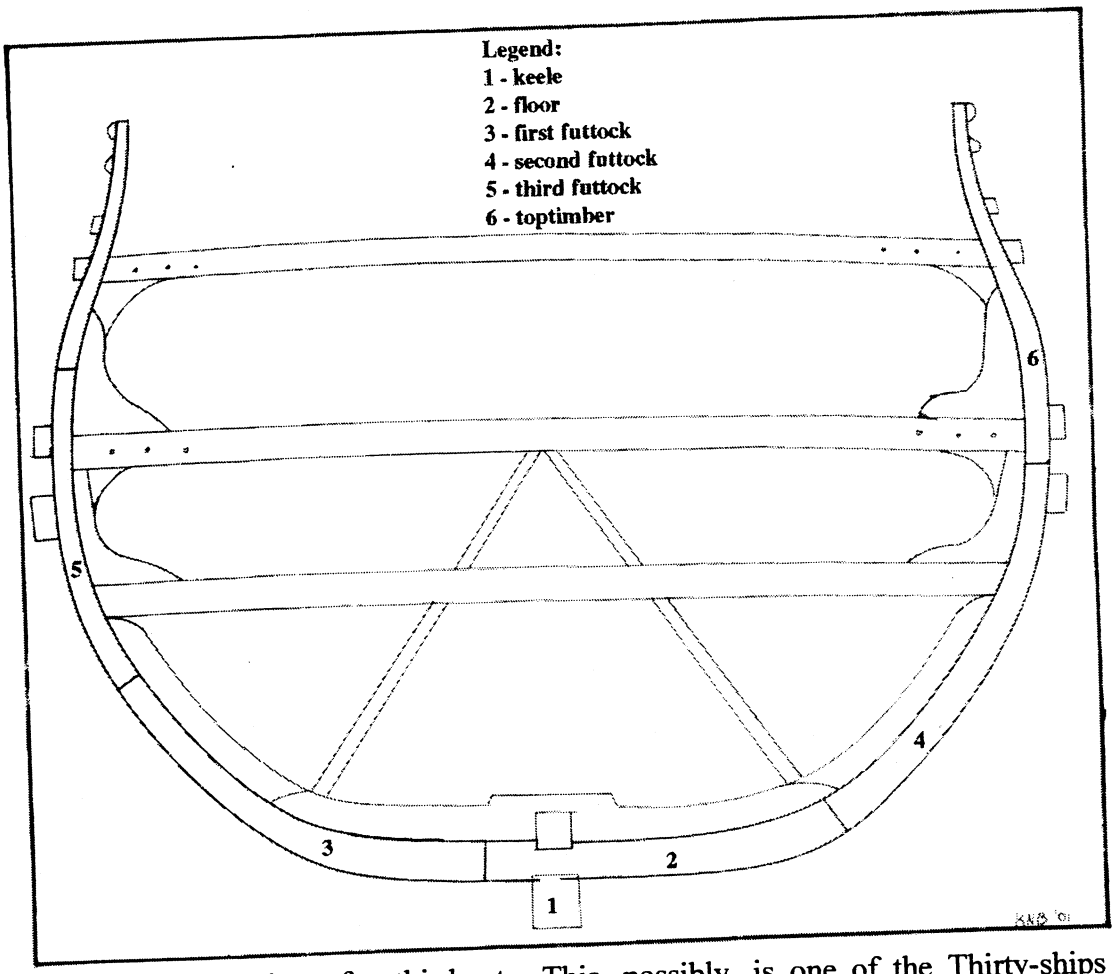


Figure 15. Section of a third rate. This, possibly, is one of the Thirty-ships program. Redrawn from original published by Lavery.

Two of the drawings show midship sections, one for a fourth-rate, the other for a sixth rate. The fourth rate section seems to provide the earliest positive evidence for the use of double frames, with the exception of two models to be discussed in the next

chapter. The section shows the buttings and surmarks. Every member is labeled, thereby eliminating any misinterpretation. The frame consisted of a floor, lower, second, upper futtocks, and toptimber. Keltridge distinguishes the two fourth rates through short descriptions. The one is said to be "...near ye dimensions of ye *Adventure*..." For the other the shipwright simply states that it is a fourth rate of "...ye largest dimensions...". The section seems to belong to the second example. It is drawn at a scale of 3/8 inches to the foot, rather than one of 1/4 inches to the foot used for the sheer, plan, and body views. This may be significant, it may be an attempt to highlight an unusual aspect that may otherwise confuse the observer. Besides the constructional details shown, the drawing contains the outline of a narrower section with longer floor, which bears a close resemblance to the section generated through Deane's method. In fact, the floor as given in the construction drawing, is about a foot too narrow in comparison with Deane's proportions. The broader outline does fall within his specifications.

Of special interest are the sixth rate ships in the Keltridge drawings. They are grouped in pairs on two sheets, and it is clear that they belong to different periods. Two show the initials IR of James II, and evidently were drawn after the accession of this monarch in early 1685. Thus, they can be taken as a good representation of mid-1680s small cruisers. The other sheet shows two vessels drawn to a smaller scale (1/8 inch to the foot) than the previous examples. The lower one is described as "...a sixth rate of ye old fashion," the other - "...of ye largest dimensions...." They can be roughly dated to the 1660s (or perhaps even earlier) for the first and the 1670s for the second example.

The dating is based on the decoration and even more so on the shape of the bow. The rake of the bow underwent extensive changes throughout the Restoration period. At its beginning, the stem was shaped as an arc, tangential to the keel, with constant radius. The 1670s saw an interest in longer keels at the expense of decreasing rakes. The stem shape was derived from either two arcs, or an arc and a straight line. The lower arc was still tangential to the keel, but with significantly smaller radius. In the 1680s the stem, while still determined by the segment of a circle, stood at an almost 90-degree angle to the keel. During the 1690s the rake was slightly increased again.[90]

The draught of the earlier ships shows every third section. The distance between the sections is 5 feet (1.5 m), which works out to 20 inches (50.8 cm) of room and space. In his notebook, Keltridge gives room and space for sixth rates as 18.75 inches (47.6 cm). These figures are the same for vessels both of the 1660s and 1670s. On the draught of the latter, at midships on the sheer view, Keltridge has drawn a small rectangle that is bisected by the station line (figure 16). The scale is too small to give precision of better than an inch or two, but it is sufficient to estimate that the size of the rectangle is either 20 inches (50.8 cm), or slightly less so. Probably this rectangle represents the "step" of the frame on the face of the keel. It gives only the sided dimension of the floor/futtock and must have been drawn there to show the distribution of the frames throughout the length of the keel. Keltridge does not provide the actual scantlings on the drawing, but his notebook lists both floors and first futtocks. Their total sided dimensions are 17.5 inches (44.5 cm), a figure close to that estimated on the

drawing. For comparison we can turn to Deane's list and see how closely the two agree. The list gives fore and aft dimension for the floors as 10 inches (25.4 cm), and for the lower futtock as 8.5 inches (21.6 cm). The total of 18.5 inches (47 cm) is reasonably close to the 20 inches (50.8 cm) of the room and space. It is clear that the band of timber at the turn of the bilge would be practically uninterrupted. This would argue in favor of a first futtock slid next to the floor, and giving scarph to the second, which butts into the wronghead, if we accept the Deane specification of two futtocks (see figure 10).

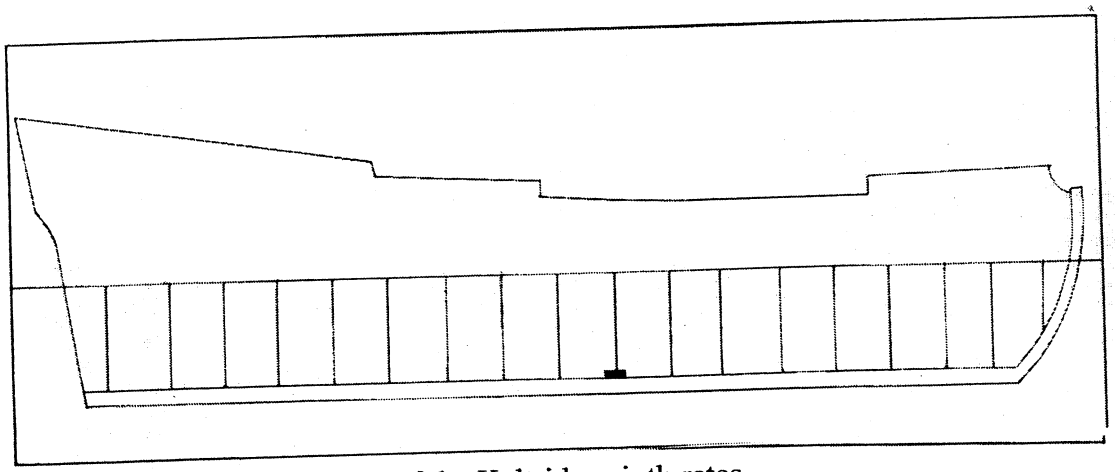


Figure 16. "Footprint" on one of the Keltridge sixth rates.

It is probable that Keltridge is showing an overlapping frame for the older vessel. Although the scantlings of floors and lower futtocks are practically identical, the room and space differs significantly from that on Deane's tables, yet is close to that on his own tables from the 1670s. Deane lists sixth rates as having a room and space of 24 inches (61 cm) as opposed to Keltridge, who specifies a value of 18.75 inches (47.6 cm). This leaves a 5.5-inch (14 cm) gap in the first case and 1.25 inches (3.2 cm) in the second, between the timbers at the bilge. It means that Deane's ship had no solid line of timber at the bilges and the gradually-decreasing sided dimensions of the upper futtocks and toptimbers make it certain that it had no solid timber at the breadth, either. Probably, the timbers were distributed throughout with gaps between them as in figure 12. It seems that the gaps would have been about 2 to 2.25 inches (5.1-5.7 cm) wide, which is comparable to those found on *Dartmouth*.[91] The sixth rate proposed by Keltridge has much smaller space between the timbers – about half of that given by Deane. The scantlings between the two ships do not differ by much, with Keltridge's vessel having the smaller sided dimensions. The differences are within 0.5 inch (1.3 cm) and are compensated for by the smaller room and space, which, in turn, results in an almost solid band of timber. As such, it would have been a more heavily timbered ship than that of Deane's. Since Deane is well known for his interest in fast sailing ships, his proposed distribution of timbers would have made for lighter and, hence faster ships.[92] The scantlings from Deane's list do not show the same timber pattern for the bigger rates. There the differences are within the 1-1.5 inch (2.5-3.8 cm) limits dictated in the

contracts, since these ships were required to withstand repeated heavy broadsides from their own guns as well as hits by enemy shot.

Having established that Deane favored wider-spaced timbers for his small cruisers, it is of interest to examine what timbering dimensions Keltridge gives for his later two sixth-rate ships. His drawing is most helpful, as it also gives a construction plan at midships, similar to the one for his fourth rate.

The two ships are drawn to the more usual scale of 1/4 inch to the foot. They differ in dimensions and somewhat in body shape. More important is that they also differ in room and space. One has a spacing of 22 inches (55.9 cm), while that of the other is 20 inches (50.8 cm). Both have the rectangle representing the "footprint" on the keel and, again the station line bisects it. In these examples Keltridge has drawn every section, instead of every third. The timbers have a combined sided dimension of 13 inches (33 cm) in both cases, leaving a gap of 9 inches (22.9 cm) and 7 inches (17.8 cm) between bends, respectively. It is noticeable that the scantlings from Keltridge's notebook and do not match his draughts. Either the draughts are inaccurate or, sometime between the 1670s and the mid-1680s, Keltridge changed his views on framing. There is a second notebook of dimensions that he compiled in the 1680s that should clarify the issue, but it proved impossible to study the document for this work.[93] It should be noted, though, that Keltridge gives the smallest room and space of all sources. The gaps are bigger even than those recommended by Deane, and the timbers

have significantly smaller scantlings. The result is that the Keltridge ships would have been even lighter than the ones proposed by Deane. The lighter framing may have been brought about by the experience gained in the Algerine Wars of this period in which English ships proved inferior sailers to those of the pirates. Light scantlings would have resulted in faster sailing ships, but the draught shows a main armament of large cannon - demi-culverins (firing a 9-pound ball), a somewhat unusual armament, as the list of sixth rates in 1685 shows only two out of eight sixth rates in service at the time carrying demi-culverins *(Saudadoes* and *Two Lions),* the others having lighter armament.[94]

On the section of the two sixth rates from the reign of King James II, Keltridge seems to be illustrating different parts of a frame on the left and right side of the centerline (figure 17). On the left is shown a surmark at the level of the main wale, while on the right there is only a straight line signifying the end of a timber. Careful examination of the drawing, reveals that the frame consisted of a floor, lower and upper futtocks, and a toptimber. The frame is almost certainly double. Cutouts of the different timbers were made in accordance to different interpretations of the evidence. The only model to satisfy the data seems to be the proposed pattern. At first look, it was believed that an overlapping frame is shown. The sirmark at the middle of the futtock sweep, however, suggests that the frame is double. The analysis of the distribution of frames upon the keel confirm this. Both Keltridge and Battine are unanimous in assigning a third futtock to sixth rates. The contracts for these ships from the 1690s, however, contradict both of them. Indeed, there does not seem to be a good reason to use three

futtocks on such small ships. Yet, examples of even smaller vessels built with three futtocks do exist – the French *barque longue, La Belle* of 1684, has three futtocks, laterally fastened to one another.[95]

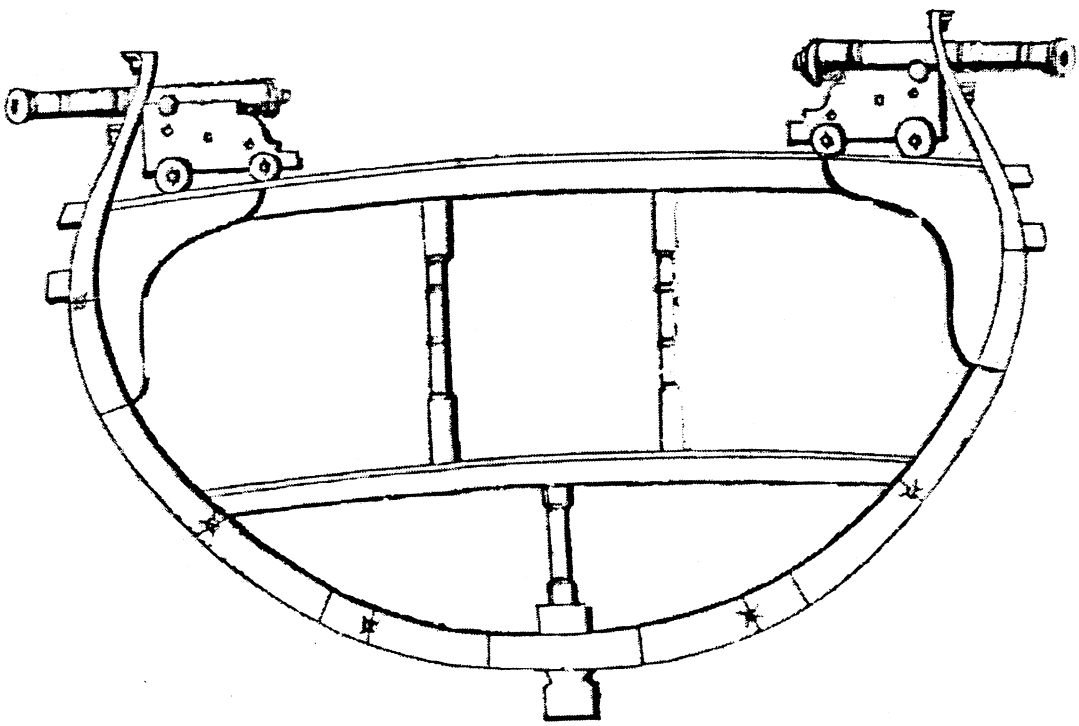


Figure 17. Section of a sixth rate from Keltridge.

Keltridge's fifth rate is presented in an interesting manner. On the plan view, the upper half shows the lines, but the lower half depicts the beams and sections of the frames. As in most of Keltrdige's drawings, all sections are again given. The room and space works out to be 24 inches (61 cm). Unfortunately, the same inconsistency noted on the other draughts is also visible here and the room and space varies, the figure quoted being the average value. This drawing offers an unusual view of the deck structure of a man-of-war, for which I believe there are no parallels from this period.

It is noticeable that at the stern the gun deck is below the height of breadth, which roughly follows the lower and upper wales. The framing of the gun deck is shown in detail: beams, carlings, ledges, and the hanging and lodging knees are clearly depicted. The mast partners, hatch openings, breast hook, main transom, and its lodging knees show that the draftsman was intimately acquainted with ship construction. The most interesting detail of the drawing is, however, the sections through the frame timbers as seen at the outline of the deck. The drawing includes alternating black and white quadrangles, depicting timbers and spaces. Dimensionally they vary significantly from about 6 inches (15.2 cm) to about 9 inches (22.9 cm), or even 10 inches (25.4 cm). Space varies between 3 (7.6 cm) and 5 inches (12.7 cm). Two white and two black quadrangles fit between the station lines delineating the room and space. In his notebook Keltridge records the room and space as 22 inches (55.9 cm), with the timbers of the second and third futtocks and the toptimbers varying between 8 and 9.5 inches (20.3 cm to 24.1 cm). A comparison with the scantlings listed by Deane reveals that

Keltridge's fifth rate is timbered more lightly than the ship proposed by Deane. This again may be due to the experience of the long Algerine Wars in which the navy was engaged after the termination of the Third Anglo-Dutch War.

The deck is shown at the level where the toptimbers should be scarphed the futtocks. If the ship had the three-futtock frame shown on the other vessels drawn by Keltridge, the section at deck level should have shown a timber–space pattern between the station lines, rather than timber-space-timber-space pattern. The small dimensions of the timbers make it unlikely that a double frame is shown, and that two separate frames lie between adjacent station lines. As the difference in the scantlings does not show a pattern, it is unlikely that a double frame and a filling frame are depicted, either. No particularly satisfactory explanation comes to mind, yet the most probable is that the quadrangles show single timbers that are not assembled into a double frame. In other words, the fifth rate is framed in the old manner with overlapping futtocks. The quadrangles between the station lines correspond to the upper part of a futtock and the lower part of a toptimber, with rooms between them and the subsequent ones. The small rooms – usually around three inches – make it likely that if this framing was shown on a model a line of solid timber would be visible at the breadth. Similarly distributed timbers are known from the wreck of *Dartmouth*. It is not clear how many futtocks its frame had. Keltridge records three futtocks in his notebook, and it is likely that his ship drawing also includes three futtocks. Yet, it is possible that it had only two futtocks. The *Mary Galley* launched in 1687 had only two futtocks, as shown by its contract. If

the fifth rate depicted indeed had three futtocks - after all Keltridge gives three futtocks even to his sixth rates - it is notable that the timbers of the frame were not laterally fastened to each other. Therefore, this was essentially the old overlapping frame style with a third futtock added to it.

The English bomb vessel *Mortar* was launched in 1693, and shipwright Edmund Dummer's still extant drawing of the vessel includes a midship section (figure 18) for it. At the time, bomb vessels were rated as fifth rates and were the commands of post-captains. When not equipped with mortars, they were conventionally armed, rigged as frigates, and served as such.[96] Therefore, the framing of the vessel can be assumed typical for small frigates. Any differences from conventional vessels would be in the scantlings and in the additional support structure for the mortar beds, but not in the construction of the frames. *Mortar*'s section shows, as clearly as the Keltridge drawings, a frame with three futtocks.

In conclusion, it can be said that the illustrative material – Keltridge's in particular – closely support the information provided by the contemporary texts discussed in Chapter III.

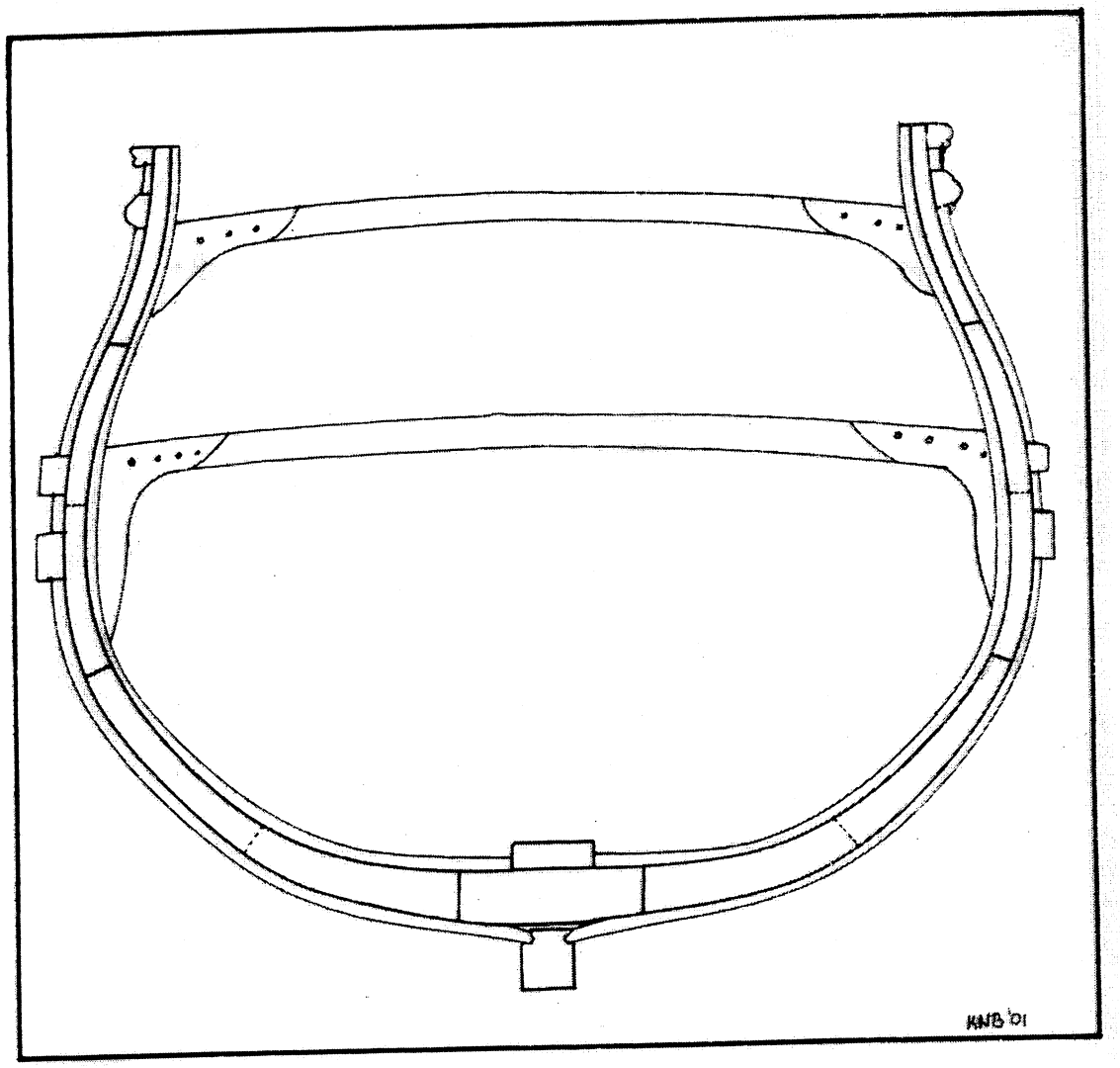


Figure 18. Section of *Mortar* of 1693. Redrawn from original by Edmund Dummer.

CHAPTER V

NAVY BOARD MODELS

We are fortunate that the seventeenth century represents the high point of Dutch maritime art. This is not the place to describe and exalt the achievements of masters Hendrick Vroom, Reinier Zeeman, Ludolf Backhuizen or the Father and Son Willem Van de Velde. It will suffice to remember their accuracy of detail and thorough understanding of their subject. For the ship student of this period, the works of these masters are invaluable. Through them we not only know what the ships looked like, but can also and can trace changes in the appearance of the sailing man-of-war from the galleon to the ship-of-the-line. Unfortunately, no comparable sources exist for determining the interior construction of these vessels.

One might expect the highly detailed models of the so-called Navy Board, or Admiralty type, to supply information on construction aspects. Yet, their reliability as a source for shipbuilding practices of the time has been questioned. For models representing eighteenth-century ships the preserved archival material, the original draughts in many of the cases, prove beyond a trace of doubt that the models did not show actual framing practices. A man of no lesser eminence than R. C. Anderson, probably the foremost specialist on seventeenth-century English ships, expressed the opinion that the only thing these models can be trusted is limited to the room and space.

He supports his conclusion with information from a manuscript dated to 1676.[97] The source is not named, but it was probably the Keltridge notebook, as that work came to the Museum from the collection of Dr. Anderson. He used a second rate as an example and listed the scantlings for a floor, four futtocks per side, and the toptimbers. Each of the successive futtocks was a little narrower than the previous one and also diminished along its respective length. The difference between the heel and head of each futtock was about 0.25 inch.

William Baker, designer of the *Mayflower* "replica" *Mayflower II,* disagreed with Anderson.[98] He quotes Manwayring on the definition of spurketts[99] and presents it as definite evidence for the existence of spaces between the parts of the frame, as shown on the models. He notes that the second futtocks overlap the first futtocks in the same manner that the first futtocks overlap the floor. With time, it seems, the spurketts became smaller and smaller until they disappeared completely. This became evident to Baker from the drawings of a French three-decker in *L'Album de Colbert.*[100] To replicate the real ship's frame in model form, Baker suggests that the modelers united the first and third futtocks and ignored the second, since the last would have prevented seeing the inside of the model. For the upper futtocks (*i.e.,* the fourth), it was immaterial what happened to them as they were covered over with planking. Thus, Baker suggests that the models represented "stylized" expressions of real framing practices.[101]

Salisbury also accepts that the "single foothook" frame in models had nothing to do with reality, except possibly in the smallest ships. At the same time, he perceives the two belts of uninterrupted timber at the bilge and at the breadth as features of the real ships. His explanation for the single futtock is that the futtock was scarphed from two or more pieces. He interprets scarphing as two pieces of timber let into one another, to form a single piece. In such a case, the modeler could justifiably ignore the scarphs and build the frames with only a pair of futtocks. By the middle of the seventeenth century, however, Salisbury suggests that it became necessary in large ships to back a scarph with another timber, which led to the introduction of additional futtocks.[102]

The earliest surviving models date to the later years of the Interregnum, or Commonwealth. By this time it is clear that a tradition of building scale ship models was already in existence, as Salisbury rightly notes that a convention does not spring out fully formed over night.[103] Something must initiate it and time certain amount of has to pass for its acceptance. The early surviving models are clearly built by different artisans and show slightly different characteristics. Pepys speaks in his diary of large numbers of models in existence by the end of the Interregnum.[104] In his autobiography, Phenias Pett writes of models that he built as early as the turn of the seventeenth century and then makes two even more definite and important references. In the year 1608 he built a detailed model, just the way a real ship was built, for King James I. It was a proposal for *Prince Royal*, a ship of a size never before built. Pett himself gives us an answer to the question whether or not models were accurate representations of real

practice. The King, approving the building of the leviathan, told Pett that he would carefully compare the model with the actual ship.[105]

The inquiry stirred by Pett's enemies (not least by shipwright Matthew Baker) need not be retold in detail here, but a few points about it should be reviewed, as they have a direct bearing on the question under investigation. One of the charges was that the timber used in the construction was of poor quality and did not extend to sufficient length. To determine the truthfulness of the charge the King himself entered the unfinished framework of the ship.[106] Had it differed in any detail from the model, James I surely would have noticed it and, as Pett was not at the height of his popularity, undoubtedly, the matter would have been mentioned to the builder's detriment.

Another occurrence of a somewhat similar circumstance took place under Charles I, when he ordered the *Sovereign of the Seas* to be built. Again, Pett built a detailed model of the future vessel for royal approval.[107] This ship, too, was highly controversial and very much in the public eye for its size and expense. Any differences from the proposed model and the actual vessel on the stocks (actually in the dock) would have been noted. It seems reasonable to conclude, therefore, that the models Pett built *did* represent the actual construction practice at that time. It is unfortunate that neither model seems to have survived. Salisbury expresses the opinion that in these two scale models the origins of the Admiralty models are to be found. He believes that their style was widely copied by other builders as "nothing brings success like success."[108]

The oldest surviving examples of models show a single futtock system and alternating floor-futtock-toptimber (figure 19).

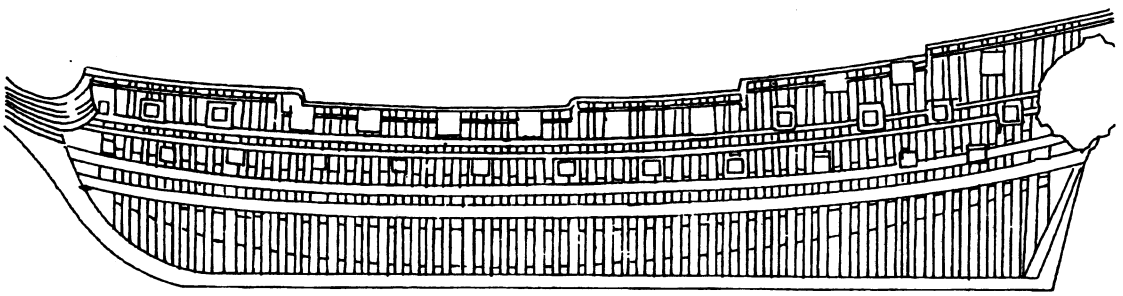


Figure 19. Unplanked model of a Parliamentarian third rate. Drawn from a photograph.

By the second half of the seventeenth century, a large number of models were apparently in existence. Besides the models of the *Sovereign of the Seas* and *Prince Royal*, that probably were still extant, there were models of *Richard*, 1658, later renamed *Royal James*, *Speaker* (renamed *Mary*), and others. The talented bureaucrat Mr. Pepys, often given credit for the successes of the Restoration Navy and always excused of its failures by historians, has left an alluring but, for once, an incomplete record of models. The first reference is from June 6, 1662. In a chest left in his office

from Interregnum times, he found a model of an unidentified ship that he appropriated. Later references in his diary suggest that the model was rigged. That it was of what we today term Navy Board, or Admiralty style, is suggested by the entry:

> 30 July, 1662. Up early and to the office where Cooper came to me and begun his lecture upon the body of a ship, which my having a modell in the office is of great use to me[109]

Cooper was a Sailing Master for whom Pepys later found a ship. If he was reading a lecture to Pepys, the Clerk of the Acts, on the body of a ship, and the model was useful for the purpose than one must conclude that the model illustrated actual building practice. Pepys was not the phoenix that most historians make him to be, but he certainly was intelligent and interested in his job (he went so far as to learn how to measure timber). He would not have been satisfied with a model that displayed stylized forms of construction, for he plainly considered models not just pleasant looking decorations, but important learning tools.

Mr. Pepys' interest in models continued throughout his entire life. He amassed a vast collection that unfortunately has been either destroyed or dispersed. The first model specifically presented to him came from Anthony Deane on September 29, 1662 and this gift proved to be an excellent investment on the part of the young shipwright.[110] As the model was promised to Pepys on August 11, it is unlikely that Deane built it specifically for him; it was almost certainly of an older vessel built or repaired at Woolwich, where Deane was an assistant shipwright. John Franklin surmises that it may

have been that of either *Speaker* or *Swiftsure*.[111] With a major dockyard as its likely source, the model was surely representative of contemporary building practices. As Pepys does not suggest that there was any difference between it and the other models he had seen, or appropriated, it is likely that these models all were of the same type. From this it may be surmised that at least around the middle of the seventeenth-century the Navy Board models were built according to actual building practice.

Having reasoned that the models likely showed contemporary construction practices, or something very close to it, it is necessary to give a brief description of what these models actually present. Generally speaking, they fall into four categories. In the first is the standard model, the frame of which consists of a floor, two futtocks and two toptimbers. By far the majority of the extant models fall into this category.[112] Some variations in the models are visible, though. There is a model of *circa* 1655 that has no planks at all (figure 19), but most are planked above the main wale. In this category should be included also a fine model from the Rogers Collection in which the futtocks extend through the entire side of the vessel and terminate at the hances. Thus, the upper works are solid timber, without being planked.[113]

A second category, that seems more of a sub category of the first, is limited to only a few examples. Here, the frames are of the same construction as before, but only every other bend is represented, and the futtocks meet on top of the keel. This is extremely rare for models of the seventeenth century and does not represent real

practice. The models of *Boyne* and *St. Albans* are probably the only two known examples with these characteristics. It may be significant that Master Shipwright Fisher Harding at Deptford built both ships.[114]

The third category seems to consist of a single example and, strictly speaking, is outside the time frame of this study. Yet, since it shows an interesting frame construction similar to what the contracts of the 1660s and 1670s imply it has been included here. It consists of a floor, a first futtock that fills the room, a second futtock butting into the wronghead, a toptimber that butts into the second futtock, and an additional third futtock that gives scarph to the butting of the toptimber (figure 10). The only model known to be framed in this manner is that of a third rate dated to about 1705.[115]

The last category shows a double frame. To it belong the model of the three-decker *Loyal London* of 1665 and a small fifth rate. No filling frames are shown. Each frame has two futtocks and the independent toptimbers are placed between the bends and held in place only by fastenings through the wales. As Franklin points out, this does not seem to have been the normal practice of the period, but suggests that alternative constructions were possible.[116] It should be emphasized that none of the models show a trace of cant frames before *circa* 1715.[117]

Models in frame present the least likelihood of having been built merely as ornaments, sacrificing accuracy for looks and, therefore, the closest attention should be paid to them. Besides the *Loyal London,* two other unplanked models should be mentioned. The first is a model published by Franklin. Its date is uncertain, but it may well be from the late 1640s, before the legalized murder of King Charles I. Its dimensions at the usual scale of 1/48 are close to a number of Parliamentarian Third Rate frigates from the early 1650s, the closest being the *Antelope* of 1651. The model may have been a design proposal that was realized after the King was executed.[118] The hull is in an excellent state of preservation, with practically no damage. It is believed to be the oldest extant Admiralty model. The framing consists of overlapping floors, single futtocks, and toptimbers. The toptimbers frame the gunports and, to accommodate them, they are cut in places. From personal observation and Franklin's description, it is clear that the model does not have any unattached toptimbers or irregularities in framing. The futtocks are brought close to the keel, thus forming an uninterrupted band of solid timber at the bilge. Franklin gives the room and space for the model as 2 feet, 5 inches (73.7 cm).

The other model is preserved in Stockholm. It is associated with the English shipwright Francis Sheldon, who immigrated to Sweden in 1658. In England he was involved in building *Naseby* in 1655 and *London* in 1656. The model represents a three-decker and has traditionally been considered to be that of the *Naseby.* It is almost certain now that it is not as neither the dimensions nor the disposition of the gunports

support such identification. In 1661, Sheldon launched at Goeteborg the 84- to 90-gun ship *Riks-Applet*. The model is now believed to represent that ship, designed under the strong influence of Sheldon's earlier association with *London* and *Naseby*.[119] The framing pattern shows single futtocks forming uninterrupted bands of timber at the bilges and at the level of the main wales where they overlap the toptimbers. The framing from the main wale up is not unlike that of the *Loyal London*. Toptimbers form the sides of the gunports and in order to accommodate their spacing, were cut and doubled in places. Independent, unattached toptimbers are also clearly visible in photographs.[120] This characteristic in common with *Loyal London*, makes it unlikely that the independent toptimbers on the *London* are associated with filling frames. No room and space is reported for this model.

Boyne of 1692 and *St. Albans* rate only the briefest attention, as they do not show anything substantially different from the previously described models. *St. Albans*, a fourth rate of 1687, is one of the few Navy Board models whose lines have been taken. The only other example that comes to mind is *Prince* of 1670. On both *Boyne* and *St. Albans* the midship station is very easily discernible, as the modeler has gone through the trouble of switching on either side of midships the positions of the futtocks in relation to their floors.[121]

The model of a 70-gun third rate is of great interest due to the framing of its hull. It is one of the oldest models with complete original rigging. This is probably the

earliest model for which the purpose for building, the original owner, and the model builder are known. Franklin makes a strong case that the model is of the *Resolution* of 1705, built by William Lee.[122] The model was originally considered simply to have a very long scarph and almost escaped the attention that it deserves. Briefly, the model has two futtocks, the lower, or first slipped between the wrongheads of the floors, the second butting into them and extending to the height of breadth. Franklin refers to the first futtocks as naval timbers, following most contracts.[123] The topsides of the model are planked, so the framing there is not visible. It can either be a simple overlap between the second futtock and the toptimber, or the toptimber may butt into the futtock and an additional timber may be backing the scarph.[124] These timbers are usually referred to as timbers of the breadth, or gundeck timbers. This is perhaps the most interesting model among the group as it illustrates the framing described in contracts in the early second half of the seventeenth century. It is a bit surprising to see this system of framing on a model that likely belongs to the early years of the following century. By then, the bulk of the evidence suggests that at least three futtocks were employed and that there were no longer open spaces in the frame, with uninterrupted bands of solid timber at the breadth and the bilge.[125] Franklin suggests that the use of three futtocks is not inconsistent with open spaces.[126] It should be noted, however, that the Keltridge drawings do not support his view.[127]

Loyal London of 1666 and another model thought to date to the late 1650s, or early 1660s are completely out of this tradition, since they clearly represent double

frames. The *Loyal London* is in frame and so it is likely that the builder took trouble to do it accurately. It is a model of the type that Pett built for James I and Charles I. The ship was built by the merchants of London to replace a ship that accidentally blew up at the beginning of the second Anglo-Dutch war.[128] It was built in a Royal dockyard, but on contract between the builder and the merchants, and so may have shown more merchantman building practices than naval, as Salisbury suggests.[129] It is not clear, though, whether merchantmen and men-of-war construction practice (as opposed to design) differed that much from each other, except possibly in scantlings. Edmund Bushnell's work also seems to describe the same construction that is suggested by the contracts for warships in this period. Another argument against Salisbury's opinion is that the ship was built in a royal dockyard.[130]

The second model is not identified as of yet and likely never will be. On its stern is the name *Sheerness*, but there is no record of a fifth rate of this name as belonging to the navy prior to the 1690s. The details of the model, according to Franklin, date it to the 1660s, but some features, such as the shape of the stern, push it back to the Commonwealth period, when a number of similarly sized fourth rates were built. Franklin suggests that the ship may have been built after the *Adventure* of 1646, as it had a reputation for having ideal proportions.[131] The model displays round gun port wreaths and from Deane's Doctrine it is known that they were introduced in the 1670s. The capstan visible through the missing gratings forward of the quarterdeck bulkhead is also of the older type, which was replaced with the drumhead capstan by the 1680s.

Therefore, the model is probably from the early 1670s, or very late 1660s.[132] The dimensions taken at the probable 1/48 scale relate it to a number of vessels built at that time. Unlike *Loyal London*, this model is planked above the wales. The distribution of the toptimbers is noteworthy. The frame is built in detail - all the parts butting to each other - in the manner proposed by Anderson.[133] It consists of a floor, two futtocks, and single toptimber on either side. Additional toptimbers are slid between the frames, terminating with the upper edge of the lower main wale. They seem to be distributed *ad hoc*, often without relation to the frames, with only the wales keeping them in place. This suggests two things: either the "independent" toptimbers belong to filling frames or, more probably, that they were indeed independent. In fact, Franklin notes that the framing of topsides does not correspond with the positions of the gunports. Therefore, the toptimbers were often scarphed, cut, or simply added on in order to form the sides of the gunports.[134] It must be remembered that in a number of the shipbuilding contracts toptimbers are not even mentioned, suggesting that they may have been placed *ad hoc*. The model has 28 frames.[135]

Comparing the frames of different models with the written evidence shows that one model indeed displays actual framing practice of the second half of the seventeenth century. From the written evidence it can be seen that at least some models were built with actual practices represented. The foremost of these are those made by Phineas Pett. Yet, the largest number of surviving ship models show a framing pattern that differs

from what we know to have been the one used on *Prince Royal*. Additional problems are posed by the two examples that have double frames.

With the exception of two, all the other models have one thing in common: they have solid timberlines at the bilges and at the breadth. That this was a feature of the actual ships has been shown in Chapter III. It seems, therefore, the builders were trying to give the *impression* of how the ships appeared, rather than the actual construction. That the two patterns are difficult to distinguish is confirmed by the story of the William Lee model, described above. At present, this seems to be the most reasonable explanation though it is only a working hypothesis that deeper research into these magnificent monuments of the seventeenth century will either refute or confirm.

CHAPTER VI

ARCHAEOLOGICAL EVIDENCE FROM SEVENTEENTH-CENTURY SHIPWRECKS

Archaeology ought to have given us definite evidence for the construction of ships in the seventeenth century, but its huge potential has been meagerly utilized. Sufficient numbers of important shipwrecks are known, but few have been studied in any detail. Yet, the information that has been extracted from them thus far seems to support the available evidence.

In the mid-nineteenth century the remains of an old ship were discovered close to Cape Cod. The remains still survive, but have not yet attracted the attention of serious ship archaeologists. The vessel has been tentatively identified as the *Sparrow-Hawk* of 1626.[136] The identification and dating are extremely uncertain, but some of the constructional features seem to support, or at least do not contradict this date.[137] The floors overlap what remains of the futtocks. After the hull remains were recovered, shipbuilders reassembled her and wrote a detailed description of the remains. Lines too were produced, but they are clearly inaccurate and the reconstruction is faulty. For the present discussion it is of it is of greater pertinence to discuss the extant remains, rather than the reconstruction.

The surviving hull structure is believed to include close to the entire length of the keel, part of the sternpost, stern knee, part of the keelson, the floor timbers, and many of the lower parts of the first futtocks.[138] The floor timbers overlap the futtocks, as described by those who reassembled them. They are certain that the futtocks were not bolted to the wrongheads and almost filled the space between the floors. The futtocks are described being kept in position by chocks driven between them and the following floor. No second futtocks survived, but the re-assemblers suggest that they overlapped in the same manner as did the first futtocks and floors. The reconstruction drawing suggests remains of second futtocks. Since this contradicts what is shown in the photographs and the description of the remains, it should be ignored.

This brief description of the remains of this ship should be compared with the information extracted from textual evidence. The two agree remarkably well, but this still does not mean the dating and identification of the shipwreck are correct. The overlapping, or scarphing, of the timbers is supported by the planking. The chocks were used only to keep the timbers in position while the planking progressed. The section drawing of the remains shows a through fastening at the turn of the bilge (within the overlapping area), while it does not indicate fastenings anywhere else for planking. This is probably because the draftsman indicated only the through fastenings to emphasize that they sandwiched the timbers between the footwales and the external planking. No doubt, a detailed study of the remains by nautical archaeologists would clarify the situation. For now it must remain a hypotheses, supported by what we know to have

been the practice of the time.Considering the size of the vessel, the suggestion that it could have had second futtocks should be dismissed. It may have had toptimbers that overlapped the futtocks in the same way the futtocks overlap the floors.

To summarize, the ship was a smallish vessel, possibly from the early seventeenth century, built with single futtocks in accordance with the descriptions in the *Treatise of 1625* and other documentary evidence described here.

Another early seventeenth century vessel, excavated by Jonathan Adams in Bermuda, has been identified with reasonable certainty as the *Sea Venture*, which sank in 1609. On the better preserved port side the floors survive to their original length, and the lower ends of futtocks are also extant. Some of the ceiling planks are still in place, making the investigation of the wrongheads difficult. At the publishing of the preliminary report, they had not yet been removed. The following description is from the report by Jonathan Adams and all conclusions are based on this, as well as the photo mosaic and the site plan therein. The first futtocks are set between the wrongheads and fill the space. It is stated that they gave overlapping scarph to the second futtock and the floor timber. No fore-and-aft fastening between them is recorded.[139] Sleepers, or footwaling, were bolted to the timbers at the overlap area. On the outside of the wreck were found concreted bolts that probably held the stringers to the frames. Treenails were used extensively as fastenings, most of them non-wedged. No pattern was discernible in their arrangement.[140]

There is only one timber piece that may be interpreted as a second futtock. It lies between the futtocks of floors 11 and 12, thus possibly butting floor 12. The concreted bolts found around the shipwreck site may then be from the clamp and wales, which sandwiched the overlap between the toptimbers and the second futtock or, more probably, the overlap between naval timbers, second futtocks, and toptimbers. This would be consistent with the written sources, as well. If the interpretation is correct, this than is an archaeological example of the model proposed for the framing pattern of the *Prince Royal*, a contemporary with *Sea Venture*.

The textual and archaeological evidence leads us to the conclusion that two closely related patterns of framing co-existed in the first half of the seventeenth century, with only minor differences. The first incorporated a single futtock that overlapped the wrongheads below and the toptimbers at the breadth. It was used on small to middle sized ships and possibly even bigger ships, timber supply allowing. The second called for two futtocks, the first located between the floors and giving scarph to the second, which butted into the wronghead. At the breadth, in order to maintain the even spacing, toptimbers were butted into the second futtocks, while naval timbers gave them scarph, or overlapped the second futtocks. The system was probably used for middle-sized and bigger ships. The advantages were that it provided stronger bottoms and allowed shorter futtocks to be used.

A large number of seventeenth-century shipwrecks have been found and identified, but unfortunately few have actually been studied and even fewer decently published. In chronological order these are the *Prince Royal* of 1610,[141] *Swan* of 1643,[142] *Mary* of 1649, *Dartmouth* of 1655,[143] *Edgar* of 1668, *Restoration*, *Northumberland*, *Sterling Castle*, *Sapphire* of 1675, *Anne* of 1678, *Coronation* of 1685. Of the entire group, only the *Dartmouth* has received more than cursory attention. *Swan* is a very promising site, but there seem to be no plans to excavate it in the near future. The identification of the wrecks of *Mary* and *Northumberland* are uncertain and the remains may be parts of *Restoration*, rather than those of two other ships. Nothing seems to have come of the plans to excavate and record the remains of the fifth rate *Sapphire*. *Coronation* and *Anne* have been surveyed, but not extensively studied. At least, nothing, or very little has been published so far. *Edgar,* discovered in the Solent, does not seem to have been the subject of a study, and I have not been able to locate any detailed information on it. The rest of the ships were lost on the Goodwin Sands and the shifting sands pose a serious problem to their study.

The wreck of *Swan* was studied in 1990 and was identified by the Archaeological Diving Unit of St. Andrews University. The vessel had an interesting career, starting the English Civil War on the side of the King as the pinnace *Swan*. It was captured by Parliamentarian forces and its subsequent career was in their service. The pinnace was lost in 1651 off Duart Point in the Sound of Mull, Scotland while attempting to subjugate the Maclean clan, supporters of Charles II.[144] To date, the site

has only been monitored and surface finds gathered. They are a tantalizing promise of what may be found should excavation be undertaken. The survival of wooden decorative elements, like the badge of the Heir Apparent, cherubs, paneling, etc., suggests that organic preservation on the site is good. The published site plan does not show enough detail to comment on the possible framing of the ship, but visible timbers may represent the overlap between parts of the frame, either that of floor and futtocks, or futtocks and toptimbers.[145] A photograph shows a diver recording timbers that may be frames.[146] Martin does not give any dimensions of the exposed frame timbers, but from his site plan it is evident that they are somewhat smaller than the space. It is to be hoped that the site will eventually be excavated and thoroughly published.

Mary, ex-*Speaker,* a third rate of 1649 was lost off the Southeast coast of England on the Goodwin Sands in the Great Storm of 1703. Its excavation would add significantly to our knowledge of ship construction in this period. Debris mounds found in the vicinity of where the *Restoration* (1679) sank may belong to either *Mary* or *Northumberland* (1679), or may even be those of *Restoration* itself. While these remains consist mostly of debris mounds, some coherent ship structure has survived and may be identified as frame timbers.[147] No dimensions or sketches have been published.

The fifth-rate *Dartmouth,* built in 1655 by John Tippets, enjoyed an active career that included fleet service and a round of duty in the Caribbean and the Mediterranean. This fifth-rate frigate underwent a major repair, re-keeling included, in

1678 and was finally lost in the Sound of Mull in 1690. It was fully excavated by Colin Martin, and some of the remains were raised for recording and conservation. The surviving hull parts do not extend beyond the turn of the bilge. The construction of the ship, as revealed by the extant hull, is puzzling and probably does not represent standard building practice of the period.

During repairs, it received a new keel as the old one was rotten and had suffered extensive worm damage. It is perfectly possible, in fact probable, that the floors and lower parts of the futtocks also suffered extensive damage, and drastic surgery had to be undertaken in order to prevent complete rebuilding or condemnation of the hull. The date of the re-keeling – 1678 – is also supportive of this conclusion, as it was during the rapid and short-funded mobilization of the Navy for a war with France that did not materialize. The lack of sufficient funds for a complete rebuilding of the ship may have brought about a deviation from normal practice.

The deadwood described by Colin Martin is of extreme interest as are the frame attachments to it. Frames 1 to 4 butt into the upper edge of the deadwood, while 5 to 9 are clamped with tapering chocks into recesses cut in its under surface. Only a short distance aft of midships the frames are not continuous, but evidently clamped with chocks. Martin speculates that this was true for the entire length of the ship, as frame 11, the forward-most surviving frame, is not continuous, either. He admits that the chocks come very close to each other, though.[148] Due to the deadwood piece on the

keel, it was proposed that the ship may not have needed a conventional keelson. Martin recognizes that the frames are "complimentary pairs with joints set alternate for strength," but sees them as chock-scarphed, an element believed to have been introduced by the Admiralty around 1714.[149] He makes a special point of the lack of lateral connection between the frame pieces as something surprising, evidently seeing here an early version of a double frame.[150]

For supporting evidence Martin turns to the drawing of the fifth rate by Keltridge, dated 1684. For one, as Martin notes, it does show a 2-foot spacing between the station lines as with *Dartmouth*, but the scantlings do not match. While those described by Martin are more or less within the limits of what can be expected - 10 inches sided (25.4 cm) as opposed to Deane's 12 inches sided (30.5 cm) - the Keltridge scantlings vary widely, but none seem to be more than 6 inches (15.2 cm). These scantlings are smaller than those used on sixth rates! It is unfortunate that William Keltridge did not show the "footprint" of the timbers on the keel, in the manner he has for the other rates, the timbers being shown in plan view at the level of the gundeck. Finally, within the distance between two stations, two timbers and two spaces are shown. This supports what was found on *Dartmouth*, except on the Keltridge drawing the distance is as wide as the timber itself. On *Dartmouth*, it is 1/5th the timber wide- 2 inches. The difference in the draught may be due to the decrease in sided dimensions at the breadth in comparison to the bilge. Deane's tables list the taper of the scantlings, but they are not to such extent.

Colin Martin is certain that the deadwood and the chock scarphes are elements of the original construction of the ship. In support of this view he points the irregular nail spacing on the first three strakes, which were replaced in the 1678 overhaul. The explanation is that the pattern was changed to avoid hitting the openings for the earlier fasteners. If such extensive and costly modifications were carried out, surely there would be some mention of it in the accounts of the refit.[151] In the *Dartmouth*, Martin sees an early example of chock scarphed frame.

The conclusions are somewhat doubtful. The nailing pattern is not unique to this wreck, as Adams reports the lack of a regular nailing pattern on the *Sea Venture*, as well. In the archaeological report no mention is made of old, unused fastening holes on the deadwood timber. It is highly unlikely that the shipwright (the frigate was re-keeled in Captain Castle's dock on the Thames) would leave holes under the planks without filling them in. Furthermore, the substitution of the deadwood for the decayed floors and lower futtocks would have been significantly less costly in either effort or material, than a conventional rebuilding. From the remains it is no longer possible to estimate which were the floors and which the futtocks since none of the timbers now cross the keel. It is known that first futtocks normally terminated close to the keel, so if the fifth-rate was "conventionally" framed, the remains on the bottom would have looked the same way – regardless of whether the deadwood was a repair or original. The chocks and the lack of description of this apparently unconventional repair are seen as possibly the strongest evidence in favor of Martin's hypothesis. A document signed by Edward

Dummer and William Lee, shipwrights, on November 16, 1691 and titled *An Explanation of the terms of Distinction commonly used in the Navy, of Ordinary Repairs, Extra Repairs, and Rebuilding* (sic!), provides a much more reasonable explanation. The importance of the document makes it necessary to quote a passage in full (the emphasis is mine):

> An Extra Repair is taken to be such a defect in a ship's outward matter to the weather, that their frames cannot be preserved nor the ship fit for any service at sea by an ordinary trimming, without stripping such decayed materials of the outside planking and wales; also the in-board works about the bulkheads and the sides of the ship that lie to the weather; **therewith putting in short chocks and pieces in such part of the timbering of the frame** as in this opening and stripping do appear decayed, and to repair the same all anew: and many times to drive out all decayed iron bolts in the frame above and under water, placing upon the decks and sides an addition of standarts, or riders, or both, that never was there before, for better strengthening the frame of a ship under such repair.[152]

From the text is clear that it was common practice to repair rotten, or otherwise decayed, frames with chocks and so their presence in the remains of an old and worn vessel like *Dartmouth* does not mean that it originally was fitted with them. The regularity with which chocks were employed in the repair of old ships made it unnecessary to list them specifically in the repair reports. The deadwood itself can be looked upon as a giant chock, as this is certainly the role it played. Furthermore, it must have been nearly impossible to remove and replace the keel without splitting the keelson and at least some of the floors bolted to it, even if they had been spared the ravages of marine borers and rot. In the light of the quoted document and the location of the chocks it seems certain that whatever irregularities were observed on *Dartmouth*'s

remains were due to repairs and not to original construction. Therefore, it is clear that the ship was constructed in the standard practice of overlapping floors, futtocks, and toptimbers. The spaces between the timbers are consistent with the tables prepared by Deane and thus the wreck of *Dartmouth* helps us determine how the parts of the frame were allocated along the keel, within the room and space (figure 12).

In addition to the remains of these warships there is some supporting evidence from excavated shipwrecks in the Caribbean. One of them is under excavation in the Dominican Republic by the Pan-American Institute of Maritime Archaeology (PIMA) under Dr. Jerome Hall.[153] The question of the ships identity is still open, but a case can be made for English origins. Samples of wood submitted to the Dutch Dendrochronological Center suggested that the timber had been cut in 1642/3, probably in England, as they do not match the continental chronologies.[154] It is probable that the vessel was a merchantman, so its inclusion in an investigation of men-of-war may be questioned. It is known however, that up to the mid-seventeenth century. merchantmen were hired as warships in time of war, especially the large and powerfully armed East and West Indiamen.[155] They rarely proved satisfactory warships due to inferior speed and inadequate strength, but do not seem otherwise to have differed in construction very drastically.[156] Based on this, it is permissible to include the wrecks of merchantmen from this period, in the discussion.

Fifteen floors and thirteen first futtocks were observed and recorded by PIMA.[157] Most of these were highly eroded, to the point that no floors actually crossed the keel. The better preserved first futtocks were offset from the keel a distance of 14 to 16 inches (35.6-40.6 cm), which is consistent with the information provided by the *Treatise of 1625* and the various dictionaries, though usually the figure is 18 inches (45.7 cm).[158] The scantlings of the frames varied between 7 to 10.6 inches (17.8 and 26.9 cm) for the sided and 5.7 to 8 inches (14.5 to 20.3 cm) for the moulded dimensions. The futtocks were set between the floors and had no lateral connection to them. The evidence led Hall to believe that the futtocks were added after the floors were already in place.[159]

The frame spacing center-to-center was 21.25 inches (54.0 cm). Floors were spaced every 7 to 12.25 inches (17.8 to 31.1 cm), with an average of 10.5 inches (26.7 cm).[160] The site plan shows rather irregular pattern of fastenings and a certain amount of space between the frames. It is unfortunate that the large concretions overlaying the wreck could not be removed and the frame timbers under it recorded and drawn. The resulting plan would likely be similar to that of *Dartmouth*. Not enough of the Monte Christi Bay hull is left to be certain exactly what framing system it had, but what remains is consistent with what can be gleaned from written sources. It had frames consisting of floors with the futtocks lying alongside them. It is possible that the vessel had second futtocks that butted into the wrongheads, but they have not survived.

During the excavations of Port Royal, Jamaica, a city that was inundated by an earthquake in 1692, the remains of a ship were found.[161] In addition to the 74 feet (22.6 m) portion of the keel that had survived the depredations of *teredo navalis,* parts of 33 frames were also preserved. The frames were assigned numbers from 1 to 33, starting from the bow. The eastern end of the wreck was determined to be the stern based on two encrustations that proved to be gudgeons.[162]

The frames survived only on the port side of the wreck, and had suffered extensive abrasion and *teredo* damage, so their molded dimensions were not dependable.[163] For the record they varied between 8 inches (20.3 cm) at the keel to 2-4 inches (5.1-10.2 cm) at the outer extremities. Clifford gives the average sided dimensions of the frames as 9 inches (22.9 cm). Her fig. 29 shows great variation between the few surviving timbers. From the same figure it is clear that the first futtocks (no evidence for second futtocks survives) were intended to "fill the room," yet, they do not lie tightly against their associated floors. The heels of the futtocks were offset about 20 inches (50.8 cm) from the edge of the keel.[164] The futtocks and floors were not laterally connected and in the surviving part of the hull the futtocks were forward of the floors.[165] From bolt concretions on the keel it can be concluded that the floors were spaced on 2-foot (61.0 cm) centers.[166]

Clifford suggests that this wreck was the *Swan*, a sixth rate, stationed at Port Royal when the earthquake engulfed the city. Based upon information in the memoirs of

Edward Barlow, Clifford believes her to be a Dutch prize taken in 1672. Yet, archival research shows that *Swan* (yet another warship of the same name) was purchased from a Captain Young in 1673.[167] This somewhat diminishes the probability of the ship being a captured Dutch frigate , unless captured by a privateer, and I have not seen any references to privately captured small frigates to be bought into the Royal Navy. Additionally, the keel is made from slippery elm, a North American species of timber.[168] The main timber supply for the Netherlands, however, was coming from the Baltic region, and oak was the preferred timber for the entire hull structure.[169] On the other hand, the irregular sided scantlings of the frames support a Dutch or merchant origin for the *Swan.* [170]

The poor preservation of the hull prevents us from determining with any certainty whether a second futtock was used. The remains, though, show us that the framing pattern is consistent with the description derived from the seventeenth-century contracts: overlapping first futtocks and floors, with no lateral connection between them.

From this brief overview of excavated and published wrecks dating to the seventeenth century, it can be seen that the archaeological evidence confirms the conclusions made on the basis of written sources, contracts, draughts, and even models. During most of the century, ships were built with overlapping frames that formed almost solid bands of timber at the bilge and the height of breadth. The recorded

distribution of timbers on the keel in such wrecks as *Dartmouth*, for example, explains the difference between the room and space and the scantlings listed in Deane.

CHAPTER VII

DUTCH SHIPBUILDING

Comparing iconographic evidence from the seventeenth century, it becomes clear that vessels of different nationalities differed much more than in later periods.[171] What is not clear is the extent to which shipbuilding practices differed as well. The present chapter will explore this question.

Throughout the seventeenth century the Dutch were the most formidable competition in naval affairs that the English were ever to see. The Dutch shipbuilding industry proved strong enough in the years of the Second Anglo-Dutch war to produce six men-of–war for the rapidly expanding French Navy while also embarked on a 40-ship building program for their own navy.[172]

Evidence of Dutch shipbuilding comes from sources somewhat similar to the English. There are surviving charters or specifications, some limited iconographic evidence, models and two major contemporary treatises on Dutch shipbuilding, Nicolaes Witsen's *Aeoloude en Hedendaegse Scheepsbouwen Bestier* of 1671, and Cornelisz van Yk's *Nederlandse Scheepbouwkonst Opengesteld* of 1697.

The Dutch models, though themselves splendid examples of the modeler's craft, are probably of even less use than the English Navy Board models, as they are completely planked. There are also fewer examples surviving. The draughts that exist in the English archives are non-existent for the Dutch, as they did not use them in building their ships.[173] This leaves as the most important sources the works of Witsen and van Yk.

The Dutch seafaring tradition has only recently attracted the interest that it so richly deserves. Early attempts include those of Rolf Hoeckel in *Risse von Schiffen des 16 und 17 Jahrhunderts*, a work that is supposed to show Dutch-tradition vessels even if many of the draughts are vessels of the Brandenburg fleet [174]. A cursory examination shows that the lines were probably developed using the English *Treatise of 1625* and certainly have no connection with the Dutch tradition. Attempts by Richard Unger and Bjorn Landstrom still have significant shortcomings.[175]

Herman Keting's book on *De Prins Willem* deals with a surviving contemporary model of an East Indiaman.[176] It is a valuable work, but later research has put some of his writings under question.[177] A work of excellent scholarship, but again limited to a single model is the work of the late Heinrich Winter, *Der Hollaendischer Zweidecker von 1660/1670.*[178] G. C. Dik produced a magnificent attempt at the reconstruction of Admiral De Ruyter's famous flagship, *De Zeven Provincien*, launched in 1665.[179] The work is based almost exclusively on van Yk.

The most important work has been done by Albert Hoving. In his numerous publications on Dutch shipbuilding methods and practices he has made a huge contribution to the state of our knowledge. Of especial interest is his rendition of Witsen's book.[180] This chapter owes a tremendous debt to Hoving's work.

From the works of Witsen and van Yk, it is clear that the Dutch seventeenth-century shipwrights did not do things the same way that their English counterparts did. While in England the practice was to develop a draught before laying down the keel and then lofting the frames, the Dutch shipwright did nothing of the kind. He worked completely without drawings. English shipwrights and naval architects were still one and the same person at this time, but at least the theoretical possibility of one person developing the lines and another building the ship from the drawings existed. That theoretical possibility did not exist in the Netherlands, as drawings were not used until 1724 and then only under the influence of English shipwrights.[181]

Witsen and van Yk speak of two different traditions of building ships: the northern method and the southern. The border between the two ran roughly along the Meuse or Maaskant. The largest shipbuilding centers in each tradition were Rotterdam for the south and Amsterdam for the north. From van Yk it is clear that the northern method was the older.[182] It probably survived until the introduction of English practice in 1724, though a drawing of Ludolf Backhuyzen showing the Admiralty dockyard in

Amsterdam around the end of the seventeenth century already shows the southern way of building.

In order to present the Dutch system of framing ships it is necessary to follow the building and designing methods that they used. As the northern method was the older one it is logical to start with it.

In the Dutch-shipbuilding tradition, the shipwright used formulas for all the proportions. The building started with the contract in which the main dimensions of the vessel were determined. From there it was mostly the experience of the builder and the purpose of the ship that determined the rest. In the North the keel was laid on top of blocks, just as in the English dockyards. Ships were built on slips. In England the main measurement until the last quarter of the seventeenth century was the length of keel and then it became the length on deck. In the Netherlands, length was measured between perpendiculars dropped from the extremes of the stem and sternpost.[183] The rake of both was determined by contract, and depended on the purpose of the vessel. From there the length of the keel and the breadth (usually about a quarter of the length) were deduced. These were no more than guidelines and it was possible for the shipwright to vary from them.[184] As Witsen noted, two ships built by two different builders, but to the same charter or contract would not be the same.[185] Once the scantlings of the stem were determined the dimension of its after face became a very important measurement, all other scantlings being derived from it.[186] It was based on the length of ship: for each ten

Amsterdam feet (2.83 m) length the thickness was one inch (2.5 cm).[187] The next step was more or less similar to English practice. The stem and the sternpost were erected with the wing transom and fashion pieces. A feature of Dutch ships that the English no longer had was the square tucks, or flat transoms. A string was strung between the stem and stern to serve as centerline. This was the point where the two traditions went completely separate ways. At this stage in England the floors would be laid and then the planking would follow. The Dutch went the other way around. The shipwright fitted the garboard strake next. It was usually fitted at an angle to the plane of the bottom to provide limber passages. The rest of the bottom was laid with the help of large "pincers" – *boeitangen* – that kept the planks from moving in the horizontal plane. To keep them tight the shipwright used the *hel,* a system of chains and poles that forced the planks close to each other. Temporary clamps could be nailed to keep everything aligned. [188]

Once the bottom had reached the needed breadth (usually about two-thirds of the beam) the first floor was installed at one-third the length aft of the stem (figure 20). The wrongheads of the floor were drilled laterally for two fastenings on either side for fastening the *sitters*, or first futtocks in English parlance, to the floor. Then the planking of the bilge was added. The shaping of the hull at this critical location gave the hull a pronounced sharp turn from bottom into bilge.[189]

The drawing published in Hoving's *Nicolaes Witsens* suggests that the futtocks and toptimbers were also fastened to each other in the same manner the floor and first futtocks were.[190] I was unable to locate the reference to this in Witsen's book. On the contrary, Witsen himself writes that the *oplang* (second futtock) was nailed to a clamp connected to a crosstimber stuck between the first futtocks.[191] The clamp is located on the outside of the

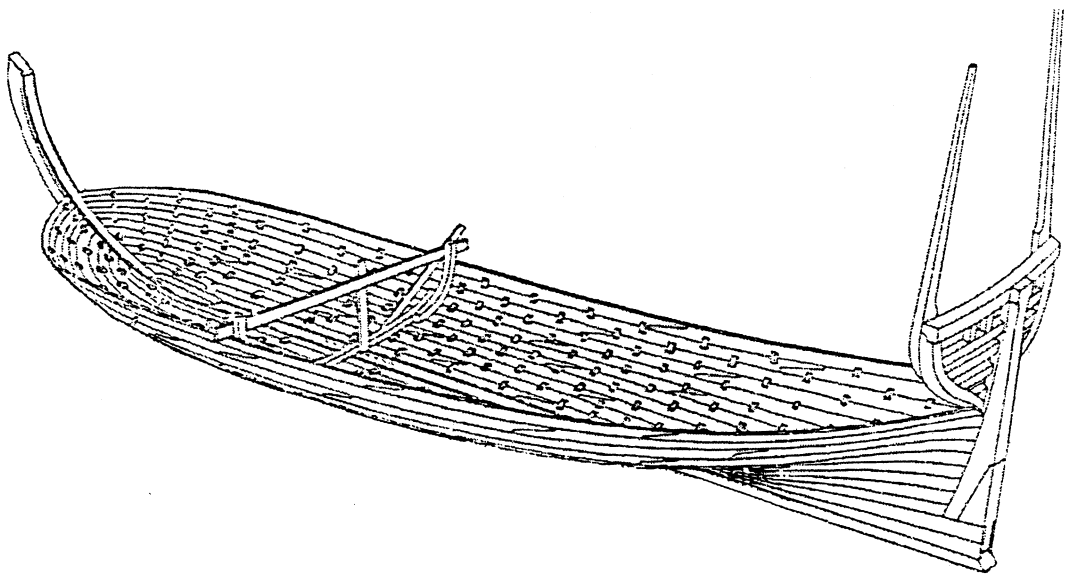


Figure 20. *Norderkvartier* method of building. From Hoving's *Nicolaes Witsen.*

futtock and is temporary. This clearly signifies that the second futtock was held in place later by the planking, and clamps and wales, or the *scheerstrook.*

Once the timbers were erected, a support structure of poles was driven into the ground on the outside of the ship. As the frames were set, the *scheerstrook* (a strake corresponding to the height of breadth and for all practical purposes coinciding with the main wale) was brought up and supported with poles. Its importance was enormous, as it dictated the shape of the ship. After the *scheerstrook* was in place, the remaining floors and *sitters*, futtocks, and rising frames were installed.[192] The original text leaves the impression that the *scheerstrook* was raised with only one set of second futtocks erected amidships. Hoving shows a few complete frames erected before the *scheerstrook* is put in place.[193] This sounds more probable, but he himself says in an article that the *scheerstrook* was attached to the support structure at first.[194] In either case the rest of the frame timbers were fitted after the *scheerstrook* was already in place.[195] The building continued with the planking of the bilges, then the installation of the beam shelf, or clamp and the beams themselves.

Witsen describes the whole building procedure, but for this study it is only the framing that is of importance. It is notable that everywhere the important dimension for the frame pieces is the moulded thickness; the sided dimension, when given, seems to be an afterthought. Similarly, Witsen gives the proportion for calculating the moulded dimensions, but not the sided. The floors were to be moulded at the keel three-quarters

of the aft side of the stem; the first futtocks were to be one half the stem at the upper edge of the bilge (usually about one-third the depth in hold). At the *scheerstrook*, the second futtock was half the thickness of the stem and two-fifths at the top of the side.[196] From this list it is apparent that the first and second futtocks are of the same thickness. The reason is that they overlapped each other and the ceiling planks had to lie flat on them.

The only mention that Witsen makes of the sided dimension, which was so important in all English contracts, is in his specification for a 134-foot *pinaas*.[197] There he lists the scantlings for nearly every timber that goes into the ship. While giving the thickness of the second futtocks and toptimbers, he also records they are broad (*zyn breedt*) and are distant from each other (*en staan van elkander*) 9 Dutch inches (22.9 cm). The floors are separated by a space of 9.5 inches (24.1 cm) and have the same breadth (sided dimensions) as the second futtocks.[198] This leaves half an inch of room between the floors and the futtock. In other words, the engineering tolerance is the same as on English ships. It is logical to assume, then, that the pattern was similar to the English practice: the futtocks fill the room between the floors. For the upper futtocks and the toptimbers it is said that they stand from each other a distance equivalent to their width. The frames in the extreme ends of the hull are supposed to be smaller, lighter, and thinner.[199] The overlapping between the toptimbers and the second futtocks, and that between the second and first futtocks, almost certainly form uninterrupted belts of timber.

Witsen presents the northern building method through the example of the *pinaas*. Were the methods applicable for warships, too? The short answer is, yes. The difference would come in proportions, as he notes the bottom of a merchantman will be broader than that of a frigate. Otherwise, nothing seems to differ, not even the scantlings.

When studying Dutch charters for building ships, it has to be kept in mind that the determining characteristic of Dutch ships – merchantmen and men-of-war alike– was the length between perpendiculars. The Dutch did not have an equivalent to the English rates, but used instead general descriptions like warships, frigates, and war-yachts instead. Even the guns were not always mentioned as they varied even more than these in English service. It is known that during the Second Anglo-Dutch War the arming of ships, not the numbers of ships, was the main problem the Netherlands faced.[200]

In his book, Witsen lists the specifications for three warships. The first ship is unidentified, but is for a vessel of 150 Amsterdam feet (137.5 English feet, or 41.1 m).[201] The contract differs quite significantly from English contracts of the era. Nowhere are the dimensions of the frames listed, but their quantity is. It is said that 80 floors, 180 first futtocks, 180 second futtocks, and 200 toptimbers are to be used in the building of the vessel. Considerable attention is given to the description of the bottom: it was to be of 6 strakes on either side of the keel, of three and a half planks each.

Clearly, a plank was a standard length. Altogether, the bottom was to be built of 42 planks. The bilges were to have 5 strakes each and to contain a total of 44 planks; that is each strake was to contain 4.5 planks.

The contract does not describe the rakes of the stem and sternpost, although this is usually specified in the Dutch contracts and in most examples that Witsen gives. The most probable explanation is that they could be figured out from the overall length of the hull, the length of the bottom, and the number of floors, futtocks, and toptimbers that were to be fitted in this length.

The second specification is for *De Vreede* of 1667.[202] The contract does not provide any information on the number of guns that she was supposed to carry. This document is much more like the English contracts, except that again nothing is said about the sided dimensions of the frames. The moulded dimensions are given for the floors, the second futtocks, and the toptimbers, but are omitted for the *sitters*, or first futtocks. This shows that the floors and the second futtocks governed the *sitters*. *De Vreede* was a 170 Dutch feet (48.1 m) long ship, longer than United Provinces' flagship *De Zeven Provincien*, yet, *De Vreede* was smaller than the English second rates. This is even more visible when comparing the scantlings. She was to have a floor of 14 Dutch inches (36.2 cm) moulded dimensions and timbers of the breadth – only 10 Dutch inches (25.7 cm) moulded. English second rates by contrast had floors of 17 English

inches (43.2 cm) the timbers at the breadth being practically the same – 10 English inches (25.4 cm).[203]

A third example from Witsen is a description of a warship built in 1669.[204] It was 160 Dutch feet long (145 English feet or 44.1 m) or the size of a third rate in the English service. For the Dutch service this big ship was above average. Interestingly, the length after the rakes were deducted is also given: 134 Amsterdam feet (122 English feet, or 37.1 m). The floors were to be moulded 13 Dutch inches (33.4 cm) on the keel, the futtocks (the second futtock, again) the same as for *De Vreede*. As is usual, the sided dimensions are not listed. The corresponding figures for an English third rate would be 120 English feet (36.6 meters) length on the keel, floors 16.5 English inches (41.9 cm) moulded on the keel and 9.25 English inches (23.5 cm) at the breadth.

Cornelisz van Yk was a shipwright himself and his book has always been recognized as a practical guide to building ships. Unlike Witsen's work, his is rather straightforward to follow, with much less extraneous material. He provides the reader with logically laid out information, following the building of a ship. Fairly early on in the text, it becomes clear that he and Witsen are describing completely different methods of construction. In fact, he himself notes that in the *Noorderkwartier,* or the northern quarter of the country, the vessels were built differently. From his text it can be deduced that the southern method was the newer one.[205]

In the south, or the Maaskant, the shipwright started from more or less the same point that he did in the north: the ship's length was measured between the outer edges of stem and sternpost.[206] The keel was laid on six Amsterdam feet (1.7 m) tall blocks.[207] The building of the stem, the sternpost, and the transom did not materially differ between the two traditions. The first notable difference is in the *stuurlast,* the narrowing and deepening of the stern to aid the steering of the vessel. It was to be one Dutch foot (28.3 cm) for every fifty feet (14.15 m) of ship's length. In other words, it was the down-by-the-stern trim of the ship. [208] Yet, in the southern method this was included in the design and was not only a question of balasting once the ship was afloat. In Witsen, there is no equivalent for it.

Once the stem and sternpost were raised the shipwright fitted the garboard strakes. Van Yk says that at the stern, or in the *stuurlast,* the planks are almost parallel to each other; at midships the outer edge of the plank was to be perpendicular to the outer edge of the rabbet or, in other words, the plane of the plank was to be parallel to the upper face of the keel. In the bow the planks depended on the rake.[209] Unlike Witsen, he does not calculate the thickness of plank from the aft edge of the stem, but simply gives ranges in proportion to the length of ship. The plank widths that were used may seem surprising: 18, 20, or even 22 Dutch inches (46.3, 51.4, or 56.5 cm).[210]

At this stage of the construction, the shipwrights of the Maaskant and the *Norderkwartier* went separate ways. The southern builder next installed two complete

frames at the place of maximum beam. The distance between them was dependent on the length of the vessel. The aft midship frame was located by adding the stem rake and the length of ship, then dividing the result by 2. The final result was the distance from the sternpost. The forward of the two was located a quarter of the distance to the stem forward of the aft midship frame. The actual distance between the two was to be such as to fit the floors. The two frames and all those located between them were of the same shape.[211] In the Maaskant two more frames were raised fore and aft of the midship frames (figure 21). For the aft frame the height above the keel was determined by the *stuurlast*.[212] Having thus established the general shape of the hull, the shipwright attached eight to eleven ribbands.[213]

The floors were to be filled in and they were to be spaced at 14 to 15 Dutch inches (36 to 38.6 cm), the exact figure depending on the shipwright.[214] As in the north, the important scantling for the frame timbers is the thickness, which is determined by formulas given in the text, but nothing is recorded for the sided dimensions. Van Yk says that for each three Amsterdam feet (84.9 cm) of beam the floor should be one Amsterdam inch (2.57 cm) thick.[215]

The following paragraph is of even more interest. It indicates that each floor has two futtocks (*oplangen)* that butt into the floors. The thickness is again given and while the sided dimensions are not specifically listed it is clear that the frames were

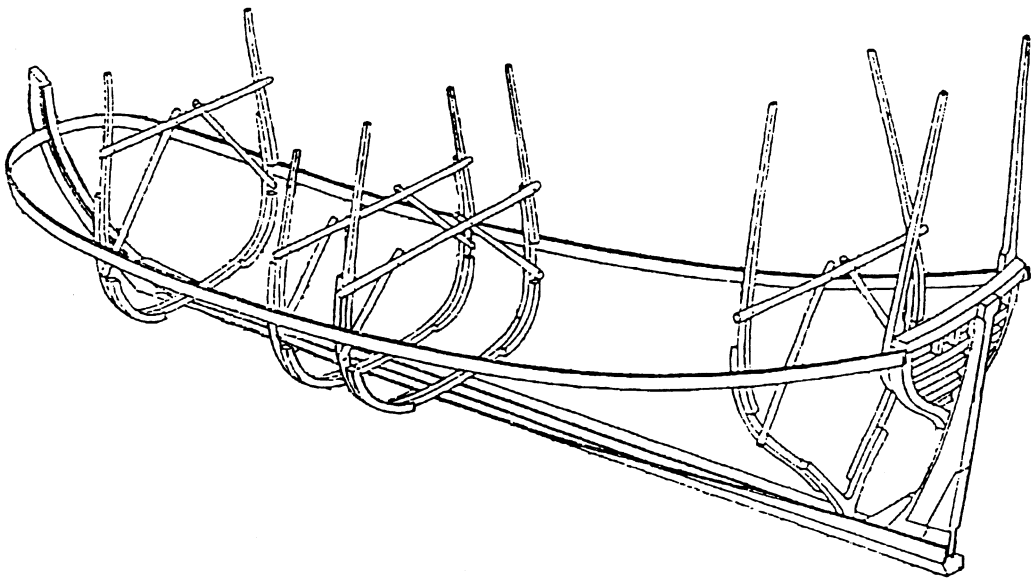


Figure 21. The Maaskant method of shipbuilding. From Hoving's *Nicolaes Witsen.*

roughly square.[216] To connect the floors (*leggers*) and the futtocks (*oplangen*) are laid the first futtocks (*buikstukken*). Their thickness is to be the same as that of the adjacent timbers and their sided dimensions to fit the available space. Van Yk does not speak of any fore and aft fastenings between the frame timbers and this is not surprising, as it would have been quite impossible to fit the frames inside the ribbands if they were pre-assembled. Above the first futtocks or *buikstukken* were the toptimbers.[217]

Witsen provides specifications for warships, but although devoting an entire chapter to ship specifications van Yk, does not mention any specifically. From the length of the vessels, however, is clear that some could be men-of-war for they match certain charters set by the States and the dates agree with the building programs at the time of the Second Anglo-Dutch war. Yet, nothing in them except for the length specifically points to a warship. In almost all of the ships mentioned the sided dimensions of the frames are not given. One exception is a specification for a 154-Dutch foot (43.6 m) ship built in 1667.[218] Van Yk does not indicate whether it is a warship or a large merchantman. The floors are given both the molded and sided dimensions: 11 Dutch inches (28.3 cm) on the keel and 10 Dutch inches (25.7 cm) respectively. Listed are also the first futtocks (*buikstukken*): 10 Dutch inches (25.7 cm) moulded and 7, 8, or 9 Dutch inches (18, 20.6,or 23.1 cm) sided. The moulded dimension is equivalent to what the floors would be at the wrongheads. The different listings for the sided dimension suggests that size did not matter significantly and whatever was available was pressed into service. For the second futtocks (*oplangen*) as usual, only the moulded dimension is given at the height of breadth.[219]

Van Yk's second example is a frigate (*Fregat-Schip*), a designation that does not necessarily mean a warship.[220] Nevertheless it is at least a possibility. It was to be 148-Dutch feet (41.9 m) long and the document lists the floors (*leggers*) as being molded 1 foot, 1 inch (30.8 cm) and sided 10 inches (25.7 cm). The futtocks are given only in the moulded dimension. The most interesting part of this specification, dated to 1670, is

that the first futtock is called a *sitter*, instead of using the southern term *buikstuk*. It is possible that the contract has reached van Yk from the *Norderkwartier*.

Three things should be noted. The terms for the parts of the frame between the north and the south differed. Sometimes the same words meant different things, i.e., *buikstukken* were either the floors (*Norderkwartier*), or first futtocks (Maaskant). Hoving is probably correct regarding this as evidence that the southern tradition was imported from somewhere and was not an evolution of the northern.[221] Second, the shape of the bottom would have differed somewhat between the two regions. Van Yk himself says that the northern ships had a definite sharp edge to their bilges.[222] Third, despite the different approaches to deriving the scantlings of the ship's timbers, the results are materially the same in both van Yk's and Witsen's books.

While differences are notable between the two traditions, it is evident that the frames of a northern and a southern ship actually looked the same. To use the English terms, both had a floor, first futtocks, second futtocks and toptimbers arranged the same way that they would be on an English ship. In the archaeological record a Dutch-built vessel is likely to have irregularly sided dimensions of its frames. An interesting and perhaps surprising fact is that neither Witsen nor the experienced shipwright Cornelis van Yk increase the scantlings for warships.[223] They do suggest some differences in proportion for the shaping the hull, as mentioned, but not of scantlings. Clearly, both types of vessels were built using similarly sized timbers.

A profile drawing of a 136-Dutch foot (38.5 m) ship of 46 guns is preserved in the Netherlands Scheepvartmuseum in Amsterdam. It was drawn by Johannes Sturckenburgh about the middle of the seventeenth century and shows the ship in frame with the first few strakes next to the garboard already in place. The rest of the frame is open, only the wales being in place.

The topsides of the ship are very lightly built and this clearly explains the heavy losses that the Dutch suffered in comparison with the heavily-timbered English ships. In itself, the scantlings of their warships alone explain their defeats, especially in the First Anglo-Dutch war. The hull below the wales shows the single futtock of the middle sweep just as is to be seen on the English Navy Board models. The timbers of the whole ship are irregular in dimensions, the sided only being visible, of course. This confirms the impression already created on the basis of the written material. Moving farther down, we reach the most interesting aspect of the hull for this study: the framing of the bilge. Unfortunately, the few planking strakes obscure exactly the turn of the bilge. Therefore, it is not possible to determine whether the futtocks are butted into the wrongheads, or overlap them. The draught generally supports the textual evidence and therefore it is most likely that the ship has two futtocks, as both van Yk and Witsen describe.

CHAPTER VIII

FRENCH, DANISH, AND SWEDISH SHIPBUILDING

With the accession of Dutch William to the English throne in the Glorious Revolution of 1688, the pattern of naval warfare of the previous decades changed. The Dutch and English were now allied against the French and Louis XIV's growing naval might. The English were familiar with the French fleet, as they had been allies in the Third Anglo-Dutch war.

Twice in the seventeenth century the French tried to build a fleet. The first time was in the 1620s under Duc de Richelieu and the next when Jean Baptiste Colbert became first minister of Louis XIV in 1661. Colbert had a strong interest in France's merchant marine and realized the necessity of having a strong navy to protect it. His first years in office were dedicated to building up the support structure of dockyards and most warships were purchased abroad. The largest suppliers were the Dutch, who despite an intense building program of their own were able to build ten ships for the French service. Another warship was purchased from Denmark.

The French Navy deserves a detailed study but for lack of space here only a few general comments will be offered. The documentation that has survived to our times

may not be as abundant as it is for the English, but still a number of important documents exist, of which only two will be mentioned here.

One of the most important and noteworthy documents is a set of figures showing the construction of a three-decker of 70 to 80 guns. The collection bears the arms of Colbert's son and so is likely to be fairly accurate in its depiction of shipbuilding practices. The plates are not dated, but they must be prior to the year 1677, as the rope tarring house in the Toulon Yard depicted on Plate 1 burnt in that year.[224] Four three-deckers were built in the Toulon Yard between 1663 and 1670: *St. Philippe* in 1663, *Lys*, in 1669, and both *Sceptre* and *Royale Therese*, in 1670. The vessel shown on the plates probably does not correspond to any one of them, but rather a generic three-decker of this type that owes something to all the named ships. At any rate, the ship agrees closely with the regulations of 1670, confirmed in 1671 and 1673. They state that ships of more than 70 guns should be three–deckers with no forecastles. The only two exceptions were the flagships *Soleil Royalle* and *Royalle Louis*, both of which were allowed forecastles.[225]

For the purposes of this study, the plates of interest are those that show the timbering of the frame. The sequence starts with Plate 3 in which the keel, stem, and sternpost are already raised and the floors follow suit. Two floors are already mounted at midships, one forward of it and one aft. First futtocks overlap the wrongheads of the floors. Ribbands are attached and help give shape to the ship. Plates 5 through 7 show

the hull completed to the stage of attachment of all first futtocks. Plate 9 depicts second futtocks placed between the heads of the first futtocks, but space is left between the wrongheads and their heels. A few third futtocks have also been installed, again with room between the timbers, and a ribband at the height of breadth is mounted (figure 22). The very small sheer of the ship is notable. The constructional sequence continues in Plates 10 and 11 with the attachment of the ceiling planking. Thus far the only exterior planks installed are the garboard strakes which overlap the stern post, rather than terminating in a rabbet cut in it.

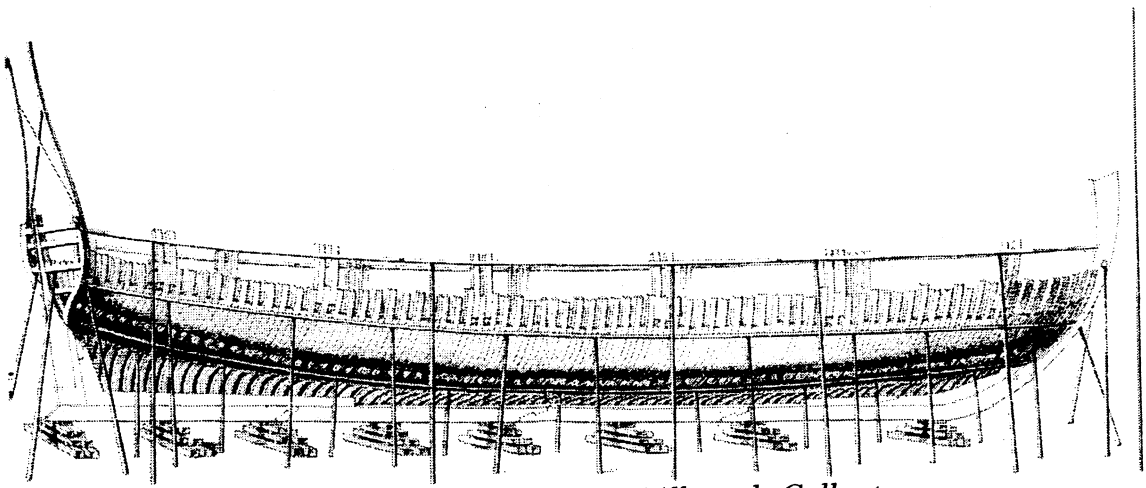


Figure 22. A French three-decker from *L'Album de Colbert.*

Plate 12 shows the ship completed, as far as the framing is concerned, to the breadth ribband. Some exterior planks are also installed, notably the one at the top of the bilge – approximately one-third of the depth in hold. The open spaces between the floors and the second futtocks, and between the first and third futtocks are clearly visible. In Plate 13, the shipwrights have installed fourteen pairs of riders across the ceiling planking.

The following plates are concerned with the building of the interior spaces of the ship, and the next to show framing is Plate 21. Some of the bottom planking is attached, additional frame timbers are installed and a ribband has been stretched around them to shape the topsides. These timbers are too short to be toptimbers, as they do not reach what would be the upper deck, so it is likely that they are fourth futtocks. Plate 26 shows the entire structure completed: the toptimbers are installed and the planking of the exterior is completed to the lower deck gunports. In Plate 29 the ship is being launched, bow first, without the planking being completed above the middle deck. At gundeck and middle deck the sides are formed of solid framing. This must have added significantly to the strength and resistance to gunshot.

The represented first rate is about 148 French feet long (48.1 m, measured between sternpost and stem, in the same way the Dutch measured ship length), has a beam of 40 French feet (13 m) and depth in hold of about 20 French feet (6.5 m). The plates cannot be taken as constructional drawings in the way the Keltridge drawings are,

but nevertheless the engraver has given scales on every one of them. Thus, it is possible to measure the length of the futtocks. All of them are fairly short, less than 13 French feet (4.2 m), thereby reducing the need for compass timber to a minimum. On the debit side, the fairly short pieces, not attached laterally to each other, must have created a weaker structure, dependant more on the strong planking and wales than would be the case with a two-futtock system.

In the notes accompanying the modern edition of *L'Album de Colbert* a very emphatic statement is made that the ship's decoration does not show any foreign influence, least of all Dutch.[226]As far as the decoration is concerned, the author of the notes is quite correct. Nevertheless, as far as the actual construction goes, the influence seems to be precisely Dutch, probably from the Maaskant. The first floors installed are more or less at the locations specified by van Yk. A minor difference is that while the Dutch shipwright leaves a significant distance between the two midship floors, the French puts them next to each other and so eliminates a "dead-flat" part of the hull. This may well have proven detrimental to the stability of the ship. It is known that in the seventeenth century French design was nowhere close to having the reputation it acquired in the eighteenth century. One of the most experienced French admirals, Duquesne, refused to take the *Royalle Louis* to sea because of its lack of stability until directly ordered by Louis XIV. A number of other French ships, including *La Superbe* (much admired by the English) had very short lives.[227] The reason may well have been the short futtocks.

Additional support for Dutch influence in French naval building can be seen in the sequence of planking (which matches that shown by Witsen and van Yk), in the launching of the ship before the topsides were finished in order to make room on the stocks, and in the attachment of the garboard strake across the sternpost. All of these features are visible in Dutch shipbuilding. The erection of the timbers between the ribbands and not building the bottom first, means that the origins of the influence should be looked for around the Maaskant. The differences, however, show a local, French, interpretation of Dutch practice. From the plates it is clear that the timbers of the frame were overlapping, giving scarph to each other, not unlike the recognizable framing of the Navy Board models. The difference comes from the use of more than two futtocks.

Another interesting document that shows the same concept of framing (overlapping timbers) at a fairly late date, when the English had already introduced the double frame, are the specifications for a small frigate of 14 guns, dated 5 August 1679 and signed by the French shipwrights Hubac, Levasseur and Laurent.[228]

The entire document is constructed using Dutch specifications. For example, the length of the ship is measured between the perpendiculars and the fore, aft, and inside thickness of the stem are given, which makes it likely that many of the scantlings were derived in the Dutch way. Listing the number of floors, futtocks, and toptimbers is also recognizable from Dutch specifications. One interesting addition is the specification of

timber lengths. Examining the scantlings, it is notable that only the moulded dimensions are given. The floors are 9 French inches (24.4 cm) deep at keel and then decrease to 7 to 8 French inches (19 – 21.7 cm). The first futtocks (120 in total) were to be 8 feet (2.6 m) long and 6 to 8 inches (16.3 – 21.7 cm) square. The second futtocks (120 in total again) were to be 8 to 10 French feet (2.6 – 3.3 m) long and 6 to 7.5 French inches (16.3 – 20.3 cm) thick. The toptimbers (100) were to be 8 French feet (2.6 m) long and 6.5 French inches (17.6 cm) square.

From the list of dimensions it is evident that the first futtock would have reached slightly above one-third the depth of the hull, specified as 9.5 French feet (3.1 m). It is likely that the use of two futtocks was necessitated by the building system, probably a derivative of the Dutch method. In connection with this, it may be significant that the document is from Brest on the Atlantic coast of France, which is fairly close to the Netherlands.

Two archaeological examples of French shipbuilding in the seventeenth century have been excavated lately. The older of the two is the wreck of Sieur de La Salle's *barque longue*, *La Belle,* built in 1684 and lost in 1686. The site was excavated quite recently by the Texas Historical Commission and construction details of the hull have yet to be published. Nevertheless, photographs of the excavation and recording of the hull show its the framing pattern, but scantlings are not available. Nevertheless, this information is sufficient to make some general observations.

The vessel shows a complete departure from the framing practices described in the previous section. *La Belle* has three futtocks per side, laterally connected and the frames are in pairs (double), as is shown on the Keltridge drawing. Between the double frames are visible open spaces. The futtocks of the frame are butted into each other. [229] The remains of *La Belle* are among the earliest to be framed in a manner that requires the complete assembly of the frames before erecting them on the keel.

A little more detail is available for another French warship, the third rate *Hazardous*. When lost in 1706 the ship was in English hands, having been captured in 1703. The vessel was built in 1698 as the third rate *Le Hazardeux*.[230] The shipwreck has fairly extensive hull structure surviving; certainly enough to allow discussion of her timbering. The frames are in pairs and spaced between 10 and 12.5 centimeters from each other. The excavator, Norman Owen, notes that the spacing was very consistent throughout the wreck, though he describes only the section identified as the stern. The frames themselves also show a remarkable consistency: 48 to 53 centimeters sided and 40 centimeters moulded.[231]

The team that undertook the pre-disturbance survey returned to carry out excavations on the site later.[232] It was established that the frames in the stern part of the wreck were fastened laterally with iron bolts. The average sided dimension of a pair was recorded as 52 centimeters. And the space was confirmed to be the same as originally recorded. The frames consist of futtocks about 4 meters long. This

approximates 12 French feet and so is consistent with the lengths already seen from the specification for the light frigate and in *L'Album de Colbert*. The futtocks are butt-jointed.[233]

For the bow section, Owen proposes a different framing pattern. He identifies three "station frames," separated by four pairs of filling frames. The pairs in this context, evidently, refer to the starboard and port halves of a frame and do not signify a double frame. By "station frames" Owen probably means the double frames that were moulded and raised before the filling frames were added within the ribbands. He concluded that this type of construction, consisting of section frames with filling frames, "appears to be French." In support of this conclusion, he cites the *Dartmouth*.[234] Owen also compares *Le Hazardeux* to Jean Boudriot's reconstruction of *Duc De Duras/Bonhomme Richard*, of 1769. Noticing that the second ship, as reconstructed, shows "station frames" and "filling frames" between them, he concludes that this was purely French style of framing, as "it would appear that English warships of the same period are constructed of single frames, which are narrower, but positioned closer together as in the construction of the *Dartmouth* in 1690...."[235]

The proposed framing pattern does not make any sense, so it is likely to be incorrect. For one, it is extremely doubtful that the bow and stern sections of a ship would be framed differently and in the after part of the ship "station frames" and "filling frames" are not evident. For two, a reconstruction is not certain evidence.

Thirdly, Owen compares vessels separated by half a century from one another. *Dartmouth* was not built in 1690 as he implies, but in 1655. *Duc de Duras* is even further removed from *Le Hazardeux*, having been launched in 1769. It should also be noted that even Martin has some doubts about *Dartmouth*'s construction and how representative it is of ships built in the period. It should also be kept in mind that it is dangerous to make generalizations from a single example. The remains of *La Belle* are nearly the same age as *Le Hazardeux* and *La Belle* has no filling frames. In fact, the system that Owen considers to be typically French is described by Sutherland as English practice around 1711.[236]

On the basis of presently available evidence, it is safe to assume that *Le Hazardeux* was framed in the same manner as *La Belle*. The explanation for the different pattern of framing observed in the bow certainly lies in the freakish survival of the frames. An Ottoman period shipwreck in the Bay of Kiten, excavated by an Institute of Nautical Archaeology/Center for Underwater Archaeology, Bulgaria, team in 2000 exhibited the same pattern of survival over a rather improbable length. Only after the rest of the timbers were observed and recorded, was it recognized that this was a coincidence and that the framing consists of overlapping timbers.[237]

On the basis of the current evidence it is safe to conclude, that up to the late 1670s French warships were built with overlapping frames of fairly short timbers that were not laterally fastened. The double frame probably became widely used at the end

of the 1670s and early years of the following decade. It is unlikely that the change happened overnight, but rather that the two systems co-existed for a short period. Additional documentary or archaeological evidence may define the exact date of this change more precisely. As it now stands, it would seem that the English led the way in the adoption of the double frame. Most changes in construction are ascribable to the availability of, or lack, of material, in this case timber. For French shipbuilding, this explanation is rather unlikely, since the length of the frame parts did not change appreciably with the new system and neither did the requirements for compass timber, as the short timbers employed made them modest anyway. The explanation is probably in the need for additional strength in warships. The experience of the Dutch War in the 1670s likely showed that French ships were weaker than was realized. The change may also have been due to a change in the method of developing the lines of the ships.[238]

The Danish fleet was never very large, but it possessed some fine, powerful vessels, sometimes built by foreigners, sometimes by native Danish builders. The first half of the seventeenth century passed for Denmark-Norway under the scepter of King Christian IV (1588-1648), a monarch who loved the sea and was happiest when cruising with his fleet.[239] The navy benefited much from the royal interest. Just like Charles II of England, Christian IV was quite technically competent and was able to communicate directly with his builders. He himself gave the specifications for the draft of a contract with his shipbuilder Peter Mychelsen, the final version of which was signed on December 28, 1613.[240]

The vessel was to be a single-decked frigate with heavy armament on the gundeck consisting of 18-pounders. The contract specifies the length on keel to be 90 Danish feet (28.3 m), the beam - 30 Danish feet (9.4 m), and the depth in hold 10 Danish feet (3.1 m).[241] With the fore and aft rakes the ship would have been 124 Danish feet (38.9 m). Dr. Anderson translated the document, and the following comments are based on this translation. Fortunately, most important hull parts were also given in the original language in footnotes. On a few minor details my translation and his do not fully agree.

The contract lists the floors as 1 Danish foot thick (31.4 cm), but does not give any sided dimensions for them, presumably they were to be square, or nearly so. The futtocks (*auflangen*, quite close to the Dutch *oplangen*), Anderson writes, are given from the wrongheads to the deck as 9 Danish inch (23.5 cm) thick timbers.[242] He translates the word *kymmen* as *rungheads*. He gives the same interpretation of the word in his transcription of a Dutch specification of 1664, found in the Swedish archives.[243] From the Dutch sources already discussed, it is known that the word really means top of the bilge (about one third the depth in hold, usually) and signifies the upper end of the first futtocks – the *sitters* (*buickstukken* in the Maaskant). The present author believes that here it means the same thing that it did in Dutch. Interpreted thus, the next passage makes more sense than it does as printed. In the translation, Anderson has two wales sandwiching the wrongheads – one outside, one inside. Bolts tie the two wales together.[244] It was shown in previous chapters that footwaling was placed on the

wrongheads to strengthen the overlap between them and the futtocks. More surprising is the wale on the outside. No reference suggests such a protruding timber, located practically on the bottom of the ship. If we take *kymmen* to mean the top of the bilge, however, the outside wale sounds more probable, as there is evidence for the existence of very low placed wales: the Royal Ship *Wasa*, built by a Dutch shipwright.[245] It would appear that the two wales strengthen the overlap between the first futtocks, not mentioned in the contract, and the second futtocks. In many Dutch specifications the *sitters*, to use the *Norderkwartier* terminology, are not given any dimensions and are treated in an offhand manner that suggests they were simply backing pieces for the joint between the floor and the futtock of the vessel and took their dimensions from the associated futtocks floors. The same may be the case with the Danish contract.

In summary, the likeliest interpretation is that this fairly large frigate had two futtocks and was built in a similar manner to the Dutch method. As the bottom width is not given in the contract, the method must have been close to that employed at the Maaskant. The similarity of terminology between the Dutch and the Danish cannot be taken as definite evidence for influence, but it is a possibility. At the same time, it should be remembered that the king's chief shipbuilder, David Balfour, was a Scotsman, and influence from that corner of the world should not be excluded, either.

In the late 1990s construction work on the site of *B&W* Shops in Copenhagen led to the discovery of a veritable graveyard of early modern ships, mostly from the

seventeenth century. All of them had suffered damage during construction work, but enough survived to place them among the most important nautical archaeology finds ever made.

Of special interest are Wrecks 1 and 2. Both were damaged heavily by the installation of oil tanks in the 1960s. Nevertheless, their dimensions and constructional features are discernable. Both ships were intentionally sunk to build a careening site.

Wreck 1 is about 26 meters in length by 6 meters in breadth. The bottom is almost completely flat, suggesting a merchantman, and a very definite sharp bilge is clearly visible. The plan drawn after the ceiling was removed shows floors, first futtocks between them and remains of second futtocks.[246] A surprising feature is that the bow and stern are double planked, while the section in between is single-planked. The explanation is that at some point in her life the ship was lengthened by 7.7 meters. The frames of the additional sections are placed in such a way that the ceiling planking still runs fair. The frame timbers are trunneled to both the exterior and ceiling planks, very few nails or spikes were used. The bilge stringer still survives and was reinforced at the lengthening section by three additional strakes. An opening near the turn of the bilge on the port side housed the pump. This location for the pump is typical for flat-floored ships. The remains of the sternpost show draught marks graduated in Amsterdam feet. Dendrochronological analysis of the timbers showed that the trees were felled in 1584, probably in the Netherlands. The extension, however, was made of timber felled around

1608 in western Sweden, a territory that was part of Denmark-Norway at the time. It is likely that the lengthening was carried out when the ship was already in Danish hands.[247]

Christian Lemee has published the sections of Wrecks 1 and 2, together with plans of the remains. He has tentatively identified Wreck 1 by archival accounts that mention a vessel on a voyage to Spain that was called "The Long Dutchman." The plan of the ship remains does suggest a rather long vessel and dendro analysis has shown her to be Dutch built, thus supporting Lemee's conclusion.[248]All in all, the shape of Wreck I conforms fairly closely to a vessel built in the Dutch *Norderkwartier*.

Wreck 1 is included in the Danish section, mostly because the extension is likely to have been made in Denmark, and as there is always the slight chance that she was altogether Danish built.

Wreck 2 is a vessel of 25 to 30 meters in length by about 7.5 meters in width, but only about 14 meters of it are preserved. The ship is sturdily built and shows a high level of craftsmanship, which Lemee considers characteristics of a warship. The hull was double planked in oak and sheathed with pine planking. The innermost planking is fixed to the frames with trunnels. Dendrochronology gave dates of 1606 for the main part of the vessel and 1622 for the outer layer of oak planks. In the bottom of the hull were found two coconut shells. This suggested that the ship sailed to the East Indies,

where a Danish colony was established in 1620. An entry in Christian IV's diary may give a clue to the identity of this vessel. The king recorded in February 1624 that two big ships, which made the voyage to the East Indies, had been set aground. They were the *David* and *Elefanten*. Records also show that both were prepared for their voyage by attaching a second layer of oak planks.[249]

Lemee does not indicate where the timber was felled, but probably it was in Denmark, and the ship shows how Danish ships were built in the beginning of the seventeenth century. The wreck plan has floors with first futtocks between them, and remains of second futtocks between the heads of the first futtocks – not exactly unexpected.[250] Of special interest are the remains of small wooden pegs in the first layer of the planking. These pegs fillers for fastening holes left after the removal of temporary cleats that held the bottom planking prior to the installation of floors.Such cleats and filler pegs (*spijkerpennen*) are associated with the northern Dutch shipbuilding tradition and suggest bottom-first construction. Should this be taken as definite evidence that the ship was Dutch built? Lemee does not give any additional information that can answer the question. His section of Wreck 2, however, does not show the clear sharp bilge on Wreck 1 and that is a characteristic of ships built in the northern Dutch tradition.[251] It could be argued that in a warship, where cargo capacity is not of primary importance, a certain rounding of the bilge is to be expected. Yet, Hoving's model of a war yacht, based on data from Witsen, still retains a sharp bilge.[252]

It is probable that an answer is to be found in the archives, for there may well be records showing the origins of *Elefanten* and *David*.

Wreck 5 is of the largest ship found. About 28 meters survive of what is estimated to have been a 35- to 40-meter long ship. A large portion of the starboard side is extant to the lowermost deck. Lemee believes that her "rounded and ample lines" are evidence for "pre-meditated, geometric design," and thus the ship may have been one of Christian IV's naval ships. Surviving timbers include floors, futtocks, and knees, all of oak. Surviving draft marks are in Amsterdam feet. Dendrochronology puts the felling of the timber to about 1640-1644. This date, however, is provisional and the origin of the timber has yet to be established.[253]

No drawing is published for Wreck 5, just a photograph.[254] It is difficult to advance any thoughts based on a single photo (especially one taken before the ceiling planks were removed). The bilge is not as sharp as we might expect of a northern Dutch ship. The ship appears to have been built on the Amsterdam foot, but its use is not conclusive evidence for the origin of the ship, as van Yk works with the same unite of measurement. Very little is visible of the frames in the photograph, but what can be seen, suggests the same pattern observed on the other two wrecks.

Based on these wrecks, it can be said that in Denmark the norm for framing ships was to have two futtocks per side. The archaeological evidence also supports the interpretation of the 1613 contract.

Lemee writes that draughts were not used in shipbuilding in Denmark until the early eighteenth century.[255] One wonders what is the basis for this statement, as Danish archives contain both Danish and foreign draughts from the seventeenth century,. Among the foreign draughts is the 70-gun third rate already described and the draught of *Mortar* of 1693. Why were these draughts collected if they were not used in shipbuilding? The foreign draughts probably served for comparison and perhaps even inspiration. Among the early Danish draughts are those of the *Dannebroge* of 1691. In my opinion at least, this presence suggests the use of draughts in shipbuilding at least as early as the last decades of the seventeenth century.

Dannebroge was a large two-decker of more than 90 guns. The draught shows the ship to have been rather shallow and broad-beamed. Of utmost interest is the midship section (figure 23). If there are any doubts about the number of futtocks in the Keltridge section of a sixth rate, the 70-gun ship, and the *Mortar*, none is possible for *Dannebroge*, for the frame is clearly depicted. Here, the ends of the timbers hidden from view are shown in dotted lines. It is easy to count three futtocks and a toptimber that extends down to the main wale. The first futtocks are offset from the keel, and the third futtocks reach almost to the upper deck. Unfortunately, the draughts do not show

the sided dimensions of the frame, which makes it impossible to say whether any space was left between them on the keel. Judging by later practice, however, it is likely that such a spacing existed.[256]

It seems that the Danes moved towards the use of three futtocks and double frame at roughly the same time as did the other great maritime powers of the Atlantic and the North did. Looking at the distribution of timbers within the frame, it does not seem likely that a shortage of compass timber was the main reason behind this change. After all, the most complex and consequently hard to find shape is that of the toptimber; and in the *Dannebroge*, this timber is also the longest. The explanation must lie somewhere else.

At the turn of the seventeenth century, records show that most of the shipwrights employed in the Swedish royal dockyards were Swedes. From about 1600, Dutch names begin to appear, suggesting that Dutch shipbuilding was deemed superior to the native. By the 1620s, reorganization in the dockyards led to two Dutch shipwrights attaining high posts and so significantly influencing the building of ships for the Crown.[257] Best known among their achievements – and notoriously so – is the ill-fated *Wasa*. The raising and restoration, and study of this ship could have provided a wealth of information on Dutch ship construction, but unfortunately 40 years after her raising no final report on the hull construction has been published.

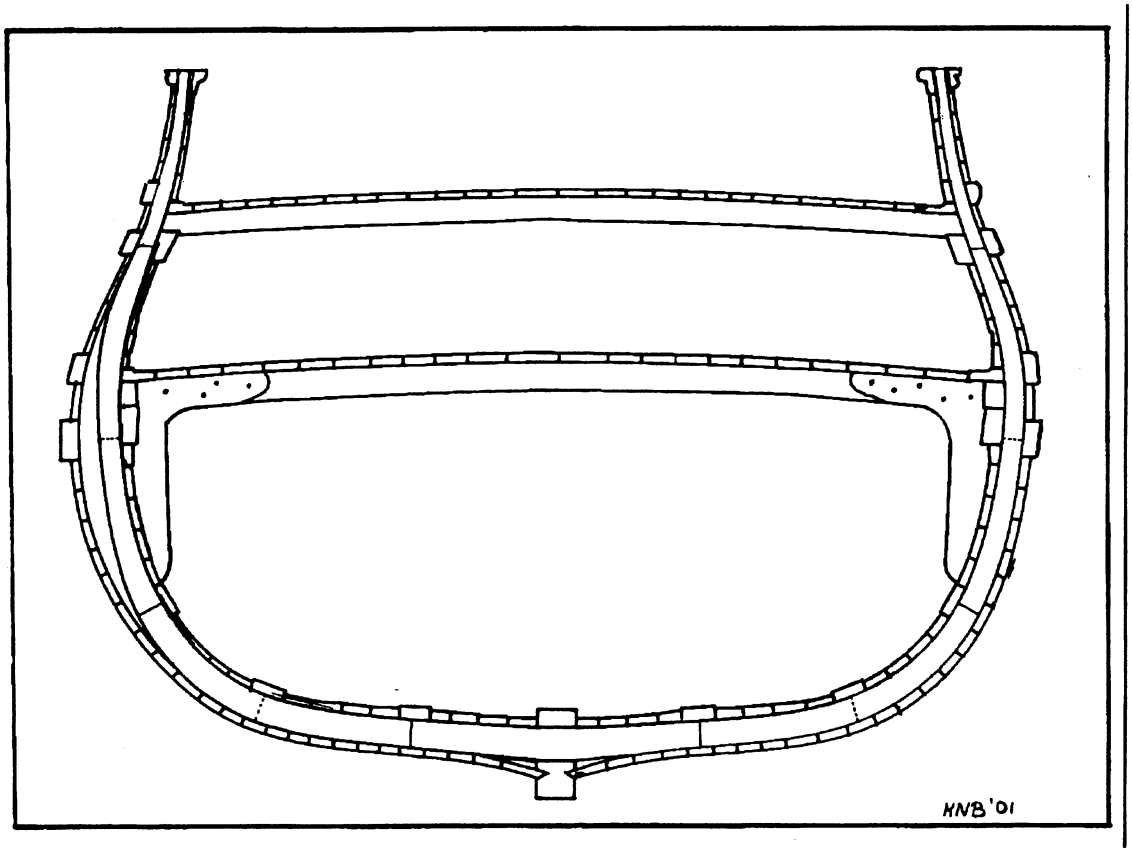


Figure 23. *Dannebroge* of 1691. Redrawn from *Danske Orlogskibbe.* Note the difference in half-breadths, due probably to girdling of the ship.

In general, it seems that Swedish ships in the first half of the seventeenth century showed marked similarities to Dutch shipbuilding, but differed in external decoration.[258] In the late 1650s the English shipwright Francis Sheldon moved to Sweden and persuaded the authorities of his abilities to build large ships.[259] The model

of his *Riks Applet* has already been described in some detail, so needs not be repeated here. It seems likely that this first rate was framed with overlapping timbers.

At the end of the Skane War in 1679 the Swedish yards embarked on a massive building program to make up the losses of two disastrous defeats at the hands of the Danes. Little seems to be known of these vessels, except for what can be learned from some contemporary models. The photograph of one of them is to be seen in Fox's *Great Ships*.[260] It is the *Victoria* of 1683, a 70-gun ship. The model lacks the ornate appearance of the English Navy Board models and is unlikely to have been built purely for decorative purposes. Most of the stern is either unfinished or missing. The hull is planked above the wale, but not below it, thereby giving unobstructed view of the frames. It seems likely that the model does indeed show real practice, as the hull is unmistakably built with double frames. From the photograph, it is impossible to determine how many futtocks were used, but it could not have been less than three in the actual ship.

The model shows very little sheer in its wales, something that is also visible on the plates in *L'Album de Colbert*. It is known that some of the largest vessels of the new building program were built and decorated from draughts prepared in France and French ships are characterized by very little sheer.[261]

In 1691, Ake Classon Ralamb published his work on Swedish shipbuilding, *Skepps byggerij eller Adelig Oefnings Tionde Tom*. Of great interest is a figure showing the work in a shipyard as carried out during his time. Vessels are shown being careened and on the stocks in different stages of construction. Three of the ships are in the process of being framed and therefore deserve special attention. In the upper left corner of the figure is a ship with only a few frames in place, but the bottom apparently is already built up. The flute stern identifies the ship as being built in the Dutch tradition. For certain types of vessels influence from the Netherlands was still present in Sweden at the end of the century. The other two ships differ in framing. The upper of the two has some toptimbers in place and ribbands attached to give the shape of the vessel, but not all frames have yet been erected. It seems that the artist was trying to present every third or, in some places, every second band of timber. This corresponds well with what is generally seen on English draughts (figure 24). Vertical posts driven around the ship, following the maximum breadth at each frame support the hull and the ribbands. Such support is typical of the southern Dutch shipyard.[262] Three interesting features make it improbable that Dutch influence played a role in the building of this vessel. First, the garboard is not installed, while a large proportion of the floors already is. The stern post and its supporting knee are depicted in a way that suggest the planks were to lie in a rabbet and not overlap the lower part of the sternpost. Second, the sternpost is attached on the inside of the wing transom and not on the outside as shown by Witsen and van Yk. The timbers above the transom form a counter as in English ships and do not extend in line with the fashion pieces as in Dutch vessels. Third, the lower heels of the fashion

pieces do not end on the post, but are at an angle and seem to butt into the next floor forward. This characteristic is well illustrated on English Navy Board models and is associated with round tucks, not square ones.

The frames of the vessel are barely discernible (at least in the reproductions of the figure to which I have had access) and are in different stages of completion. Futtocks overlapping the floors are visible throughout the length of the ship. Yet it is hard to say how many futtocks were to be used. At midships the frame is certainly doubled and so is every second, or at most every third bend of timbers. The rest are apparently filling timbers. William Sutherland, active at the beginning of the eighteenth century describes this way of building a ship.[263]

The depicted ship is likely evidence for strong English influence on Swedish shipbuilding. This is not surprising, as both of Sheldon's sons obtained important dockyard positions.[264] It could also be an example of native assimilation and re-working of the different influences, for by the eighteenth century Swedish ship design and construction were admired in their own right, one example of this being the ships of the prolific Frederick Hendrik af Chapman.[265]

Throughout the seventeenth century Swedish warship construction seems to have followed the same trends already noted for other nations. From the early years until about the late 1670s or early 1680s ships were framed with overlapping timbers, most

probably in the established manner of two futtocks per bend per side. By the early 1680s the double frame becomes dominant.

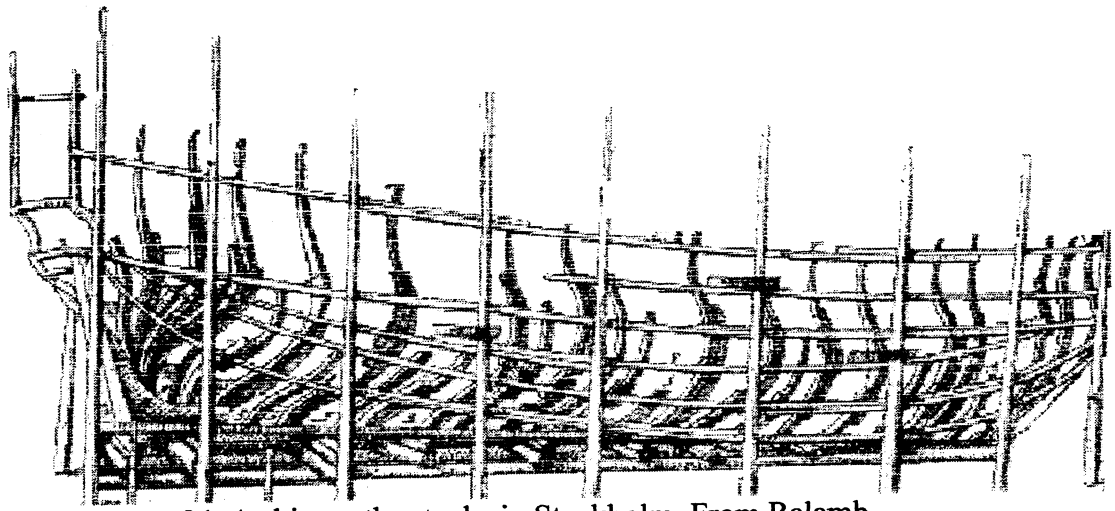


Figure 24. A ship on the stocks in Stockholm. From Ralamb.

All three of the powers discussed in this chapter – France, Denmark-Norway, and Sweden – employed Dutch expertise in the building of their navies. In the case of Sweden and to some extend in Denmark, influence from the British Isles was probably also at play. It is not surprising, therefore, to see that the development of ship construction generally follows either the English or Dutch practice.

CHAPTER IX

TIMBER SHORTAGE AND THE DOUBLE FRAME

The rapid adoption of the new system of framing by so many nations at almost the same time argues in favor of a common condition that necessitated it. Changes are normally ascribed to the availability (or lack) of materials and their cost. It has been suggested that English supplies of oak were beginning to dwindle under the strain imposed by the rapid expansion of the fleet through the Interregnum and Restoration eras. Yet, the same timber problem is unlikely to have hit the other nations with the same severity and at the same time as England. France had a larger timber supply and, even as late as the Napoleonic wars, apparently did not suffer from the shortages that plagued Great Britain.

The Scandinavian countries were even better off in this respect, as they were a major source of timber imports for the rest of Europe. Finally, if availability of timber was the driving force behind the change, the Dutch should have been the first to switch. They had practically no supply of their own and the timber trade with the Baltic was their main source. Yet, they are the ones who adhered to the older system of construction the longest. Furthermore, it should be noted that the dimensions of the compass timber needed did not decrease, neither did the quantity required. From *L'Album de Colbert* we know the length of the futtocks employed in the building of a

three-decker. The specification for the light frigate gives the length of floors, futtocks, and toptimbers. They are, strangely enough, practically identical. The lengths of the timbers as revealed by *Le Hazardeux* are also the same. Sutherland's specifications for the length of futtocks and floors are remarkably similar to the French.[266] In other words, the new system did not offer savings in timber and, therefore, another explanation for the change must be advanced.

It is worth looking into the question of timber supply in England. The 30-ship program put a tremendous logistical strain on the Navy Board and Admiralty. The Parliament added to the burden by insisting that the ships should be completed within two years and then voted funds that were drastically short of what was required. Consequently, King Charles II had to cover much of the financial burden from his own purse.

Among the problems faced in 1677 was the likelihood that timber could not be provided for all 20 third rates, nine second rates and one first rate. Sir Anthony Deane believed that not enough compass timber existed in England, let alone in the dockyards, for these ships. However, even he did not claim that there was a serious shortage of straight timber.[267] This quote concerning compass timber has often been taken as a definitive conclusion that a serious timber shortage existed, but it is worthwhile to examine the evidence in some detail.

On June 2, 1677, Charles II, who attended the meetings of the Admiralty commission more regularly than anyone else,[268] announced that a Colonel Norton had offered him a large supply of timber without raising the prices.[269] In the same meeting, the Officers of the Navy informed the King that in the dockyards there was timber for the regular maintenance of the navy that was more appropriate for new building than repairs. Consequently, he was asked to allow its use for the new ships and the material to be replaced by the expected new supplies. That not enough was on hand is clear from the minutes of the next meeting, when the king ordered building to start without waiting for all the timber to be supplied. Thus, the building could be sped up.[270]

Still, there were some concerns that shortages might be encountered. It was recognized that they might occur due to "backwardness of gentlemen to part with their timber beyond what was expected," but it was not impossible that "real want of timber of some sorts proper for this work not to be supplied in the nation."[271] It was indicated at the meeting that perhaps the suggestion of Prince Rupert – the ever practical, technical man – should be followed and someone should be sent to Germany to search in the oak forests for timber. The Officers of the Navy decided that this was not yet necessary and all concerned should wait to see if shortages materialized.[272] At the next meeting four days later, a suggestion was made that "his Majesty owns good supply of beechen wood and plank" and this could be used to alleviate the shortage of oak by its use in the building of the submerged parts of the ships. The longevity of beech in submerged conditions was considered as good as that of oak. Yet again, the Officers of

the Navy decided that there was no need for such extreme measures.[273] From these discussions becomes clear that while concern about the availability of timber existed, it was not so overwhelming that alternative sources had to be found or any departures from traditional species had to be considered.

Timber still had to be imported, however. The decision to use some imported material came under much criticism later, when the 30 ships were found to be in poor condition after only a few years of service. Samuel Pepys wrote his *Memoirs of the Royal Navy* mostly as a defense of his conduct. It has been shown that his comments therein should be read with extreme suspicion, for he was self-serving to the extreme and had no scruples about adjusting the facts to serve his purpose.[274] Nevertheless, his comments on the timber situation at the commencement of the 30-ship program are valuable, as they are confirmed by the Admiralty minutes.

Pepys states that no more than 500 loads out of the 30,000 needed were imported from the East Country (the Baltic region).[275] This works out to about 1.6 percent of the total supply! If this data is reliable there could not have been a very severe timber shortage in England at that time.

This conclusion is at least partially confirmed by the Admiralty journal. On August 3, 1678, the minutes record that the "Officers do declare that timber is everywhere drawing into his Majesty's yards as fast as may be this season."[276] By the

following April the same officers were already concerned with disposing of the leftovers.[277] The bulk of the evidence suggests that timber shortage was not nearly as acute as we are led to believe and was satisfactorily resolved at a rapid pace. This, however, leaves us with the necessity of finding an alternative explanation for the change of construction methods. Timber shortage seems to have been at most a contributing factor, but certainly not a leading one.

The admiralty journal may also give some clues about this matter. References to departure from standard construction and design are numerous and a surprising number of them are attributable to the king himself. As early as July 3, 1674 it is mentioned that "His Majesty owns his having given order to Commissioner Deane for the increasing of the scantlings and dimensions in several particulars of the new ships lately built by Mr. Deane at Harwich."[278] The word *scantlings* implies that changes were beginning to be made in the frames, though it cannot be claimed on basis of this quote that the construction of the frames had already changed. Another innovation proposed by the king that proved a great success was the introduction of the galley-frigates: "building a vessel of the design lately proposed by his Majesty for the (*sic*) answering the service both of a frigate and a galley."[279]

That the King strongly influenced the design and construction of his fleet is confirmed by the next passage in connection with the proposed dimensions for the 30-ship program. The Navy Board, led by Pepys, presented the King with a table of

burthens and dimensions for the vessels of the different rates, but he did not approve it: "To which his Majesty took exceptions, as not coming up to the full length upon the gun-deck, and other measures which he judged fit they should be of."[280] The Officers of the Navy, mostly Pepys, opposed the King by stating that the dimensions they proposed were as close as possible to Pepys' proposal to Parliament. Yet the King overruled Pepys, stating "his opinion that the dimensions he now offers are as small as will serve to make the ships to answer all the ends of force and quality which such ships ought to have, delivereth back the said table of dimensions to the Officers of the Navy, directing them to calculate another anew, suitable to those lengths of the gun-decks in each rate which he had now given them."[281]

The King was responsible for yet another innovation in ship design and construction, the upright stem. On July 7, 1677, the minutes of the Admiralty record that Mr. Pett of Chatham dockyard "with the late proposition and determination of his Majesty's for the building of ships with upright stems he, the said Mr. Pett, did design to add another great alteration in the method of building at this day generally practiced, viz., in the bringing the draught of water to 2 foot less in a 2nd or 3rd-rate."[282] This specific innovation was not introduced, but it is clear that the spirit of change was in the air and a driving force behind it was Charles II, not Pepys.

Two weeks later Sir Anthony Deane and Sir John Tippets, both experienced shipwrights, suggested that the scantlings of the proposed ships should be significantly

augmented. They themselves explained that the increase proposed was beyond what could reasonably be expected, but nevertheless was well worth it: "...others less knowing, when charge of a ship comes to be seen may censure [the scantlings] as too large."[283] The "less knowing" may very well be a reference to Pepys himself, as he vehemently opposed the increase of dimensions over what he himself had proposed.[284] This note in the minutes gives another tantalizing glimpse that changes were incorporated in the construction of ships' frames at this time.

From the quoted passages in the Admiralty minutes, it is clear that the navy, under the patronage of an intelligent and knowledgeable monarch, was in a rare moment of inspired innovation. If any changes in the framing were to be made, this would have been the right time. The increased dimensions and scantlings support the idea that the frames differed from what was done up to that time. This circumstantial evidence may, therefore, point to the time when the new system of framing was widely introduced. Even so, it does not explain what made the change necessary in the first place.

The experience of the last Dutch war was quite fresh in the minds of the commissioners when the new ships were proposed. After all, Prince Rupert, the man who had participated in it most directly, was sitting on the Admiralty Commission. Unlike the Second Anglo-Dutch war, in the Third the strategic objective was not just to sweep the States' fleet from the seas, but to destroy it and make the landing of troops possible. This forced the allies to spend much more extensive periods of time on the

Dutch coast and fight battles with less frequent withdrawals for repairs and replenishments.[285] A case in point is the campaign of 1673. After the two battles off Schooneveld, the allied fleet under Prince Rupert sailed to the Dutch coast. There it anchored and endured series of severe storms that they barely managed to weather. The strength of the wind forced them to strike topmasts and yards and lie bare-poled. Riding in the shallow waters must have added twisting to the hulls, as shallow waters build steep waves – the worst possible condition for overloaded wooden ships. As the weather improved, the heavy fighting at the Battle of Texel followed. On August 14, two days after the battle, the allies were again at anchor. Another severe storm followed that must have caused even more damage and strain to the battle-mauled fleet. Yet, it was not until August 24 that Rupert had finally given up and returned to the Gunfleet anchorage. The fleet had spent a total of 39 days away from its base, had ridden out at least three severe storm systems and fought a heavy action in between. That Rupert did not suffer a disaster under these adverse conditions is much to his credit as commander and seaman. More to the point, it must have brought him in close contact with the weakening of the ships caused by the stresses to which they were subjected.

The traditional frame with futtocks, floors, and toptimbers that were not fastened to each other would have been less able to resist the stresses, since these independently moving timbers would have been unable to transfer the shear and bending moments to the rest of the hull. A double frame, on the other hand, forms a truss of laterally fastened timbers, and is thus able to impart stiffness to the structure and allows a much better

distribution of forces to the entire hull. In practice, a stiffer ship works less in a seaway and, therefore, its caulking, fastenings, and timbers are subject to less wear and tear. That this was understood at the time is evident from William Sutherland's *The Ship-builders Assistant*:

> ...that the Plank be well supported, that the extream Distance may not cause Drumming, as the Shipwrights term it, which will not only cause Weakness where Strength is required, but also the Caulking to drum, being nothing so durable nor so dry, as if suitable Strength was made to support and stiffen the Work.[286]

A stiffer ship also makes for a better gun platform, as it resists the stress of recoil more effectively. To illustrate this point it should be noted that a demi-cannon firing a 32-pound shot exerts 18 tons of pull on the timbers to which the breeching is attached.[287] It is now recognized that many ships of the Spanish Armada of 1588 were eventually lost due to such straining of hulls during battle.[288] Since English ships of the seventeenth century were stronger than the Mediterranean *urcas* that sailed with the Armada, their weakness did not become quite apparent until the extended campaigns and battles of the Dutch wars in which the line of battle was employed for the first time. The battles became essentially artillery duels and, unlike in the Armada campaign, some ships succumbed to cannon balls. The sustained firing of the guns, the over-gunning of the ships of the English fleet, and the heavy storms in the campaign of 1673 all must have contributed to the realization that ships were not sufficiently stiff. The double frame was then the answer devised by shipwrights of the time to a problem that was to

plague wooden warships until the innovations introduced by Sir Robert Seppings at the end of the Napoleonic Wars.

CHAPTER X

CONCLUSIONS

In the preceding pages an attempt was made to systematize the available evidence and to trace the development of shipbuilding during the seventeenth century. The emphasise was on the English practice since more material is readily accessible than for most other countries, not because the traditions of the latter are less significant. Based on memoirs, treatises, contracts, draughts, models, and archaeology a general pattern of development was established that, perhaps not surprisingly, seems to have been followed by all the northern European traditions studied here. Undoubtedly details differ, but the general model is consistently the same. Until the late 1670s ships were framed in a manner that resulted in two distinctive bands of timber at the turn of the bilge and at the height of breadth. Normally, two futtocks per side formed a bend, but the number could vary in accordance with the size of the vessel as illustrated by *L'Album de Colbert*. The archaeological record confirms the conclusions advamced. The wreck of the *Dartmouth* is the most thoroughly published of the excavated shipwrecks, and is studied in the deepest detail. For this reason, it has long been the benchmark wreck for the seventeenth century. Yet, the evidence presented by it has been misunderstood and, therefore, has led to wrong inferences. Martin has assumed that it was framed with chock-scarphed timbers. This, he implies, suggests an early version of a double frame and so seventeenth-century practice did not differ

significantly from eighteenth-century practice. It has been shown in this study that the use of chocks was a standard procedure for repairing decayed timbers. The chocks and deadwood excluded, the remains of the *Dartmouth* do not present unusual construction practice. The scantlings are close to what Deane lists a decade and a half after her building, and the empty spaces between them are consistent with those listed on his tables. When these factors are taken into consideration, it becomes clear that in the remains of the hull, we have before us the typical overlap between floors and first futtocks, all indicative of a conventional ship of the seventeenth century.

Sometime in the third quarter of the seventeenth century, a distinct change took place. A third futtock was added (as shown by Keltridge) and the frames became double, with the timbers lying almost face to face within each bend. It is quite likely that at this time the shipwrights started laterally fastening the timbers within a bend. The double frame may have been introduced in England earlier than in other countries, and the Dutch builders were possibly the last to take the step.

Dutch ships also featured overlapping frames with two futtocks. Due to their methods of design and construction, the Dutch persisted building ships in this way until about 1725. For the first three decades of the seventeenth century, other western and northern European nations had very similar methods of construction to those employed in the Netherlands. This is only to be expected as the Dutch sold ships to them and these nations employed Dutch shipbuilders in their respective countries. At about the same

time as the English, but perhaps a few years later, they all switched to the new method of double framing.

The draught of a 70-gun ship that supposedly depicts a vessel of the 30-ships program may be interpreted to show three futtocks with no open spaces within the frame. If this is correct, then the change to double frames must have taken place in the mid-1670s. France apparently followed suit slightly later. A specification for a light frigate dated 1679 and signed by leading French builders, speaks of two futtocks and therefore overlapping frames, but *La Belle*, lost in 1686 and built a couple of years earlier, has double frames of three futtocks per side. The model of the Swedish man-of-war *Victoria*, 1683, is constructed with double frames, as well. The surviving draughts of the Danish 90-gun ship *Dannebroge* of 1691 also show three futtocks and no open spaces in the frames. Only the Dutch apparently stayed away from the new system, as van Yk in 1691 still describes the overlapping two-futtock framing. Their reluctance to accept the new method may be due to building ships from proportions, rather than draughts, and so their method of construction was best fitted to their method of conceptualization of the hull's shape.

As the Netherlands were the only major power entirely dependant on imported timber and they were the ones who persisted in the old style of framing the longest, it is unlikely that shortages of material forced the introduction of double frames. Evidence has been presented that even the strain on resources the building of 30 capital ships

simultaneously in England did not present serious and insurmountable problem in this respect. Consequently, a different explanation must exist for the need to introduce a new framing pattern. The years after 1674 were a period of innovation in England with many changes and improvements introduced, some even by the king himself. Yet, that in itself is not an explanation. Even small changes such as the introduction of upright stems, were resisted by members of the Navy Board or Officers of the Navy. A major change in construction must have brought much more vigorous resistance. Records probably survive to this effect, but the Admiralty Journal does not openly mention it. Either the change was well understood and all agreed that it was necessary (the only members of the Admiralty commission who could be expected to understand the matter were King Charles II, Prince Rupert, Sir Anthony Deane, and Sir John Tippets) or it had been seen earlier and so did not bring about the fierce resistance expected for something completely new. Evidence that it might have been known even earlier can be seen in two Navy Board models of the 1660s and 1670s, one of which no longer exists.

Before a final conclusion can be reached as to the reason for the introduction of the double frame, further archival research and the archaeological examination of at least some of the known Restoration era shipwrecks are necessary. This study has narrowed the date of the change to double frames to the second half of the 1670s.

NOTES

[1] The earlier issues of *Marriner's Mirror* remain a treasure trove for all those who have interest in the period. A huge debt is owed to Dr. R. C. Anderson for his contribution to the study of the 17th century ship.
[2] Frank Fox, *Great Ships: The Battlefleet of King Charles II* (London, 1980). For full listing of his works see the bibliography section.
[3] Riff Winfield, *The 50-Gun Ship* (London, 1997).
[4] See the Chapter on Navy Board models for discussion of the models as evidence and the controversy surrounding them.
[5] The best evidence for this is to be found in the Admiralty minutes published in J. Tanner, *Descriptive Catalogue of Naval Documtents in the Pepysian Library*, (Navy Records Society, 1903-1923), volume IV.
[6] J. D. Davis, *Tarpaulins and Gentlemen: The Officers and Men of the Restoration Navy* (Oxford, 1991) and "A Lover of the Sea and Skillful in Shipping": King Charles II and His Navy", *Royal Stuart Society* (Huntingdon, 1992); Sari Hornstein, *Restoration Navy and English Foreign trade 1674-1688* (Aldershott, 1991)
[7] Davies, "*A Lover of the Sea and Skillful in Shipping*", p. 1.
[8] William Sutherland, *The Shipbuilder's Assistant*, (London, 1711), p. 40.
[9] *Ibid.*, p. 159.
[10] William Sutherland, *Shipbuilding Unveil'd* (London, 1717), p. 120.
[11] In a personal conversation on May 27, 2001, Mr. Lavery told me that if he were to do it again, he would not use three futtocks and believes that she was framed with overlapping timbers. He did not specify whether he favors a one or two futtock frame.
[12] Brian Lavery, *Susan Constant, 1605* (Annapolis, 1988), p. 68.
[13] Brian Lavery, *Deane's Doctrine of Naval Architecture, 1670* (London, 1981), p.125.
[14] Peter Goodwin, *The Construction and Fitting of the English Man-of-War, 1650-1850* (Annapolis, 1987), p. 14.
[15] In a conversation that I had the pleasure of having with Mr. Goodwin in May 2001, he agreed that the description I quote is probably inaccurate. He agrees that scarph would not have meant letting one piece of timber into the other, but overlapping it and that the third futtock was not used until the later years of the century. In addition the copper bolts indeed are not mentioned in contemporary sources.
[16] Robin Piercy, personal communication, August, 1999.
[17] Colin Martin, "The *Dartmouth*, a British Frigate Wrecked off Mull, 1690," *International Journal of Nautical Archaeology* 7, No. 1 (1978).
[18] John Smith, *A Sea-grammar*, (London, 1627, Amsterdam, 1968 reprint), p.2.
[19] *Ibid.*, pp. 2-3.
[20] Henry Manwayring, *The Seaman's Dictionary* (1644, London, 1972 Menston reprint), p.88
[21] *Ibid.*, p.44.
[22] W. Salisbury, and R. C. Anderson, ed., *A Treatise on Shipbuilding and A Treatise on Rigging Written About 1620-1625* (London, 1958).
[23] *Ibid.*, p. 8.
[24] Richard Barker, "A Manuscript on Shipbuilding, *circa* 1600, Copied by Newton", *Mariner's Mirror*, vol. 80, No. 1(1994), pp. 16-29.
[25] *Ibid.*, p. 16.
[26] *Ibid.*, p. 20.
[27] Salisbury, *Treatise*, p. 2.
[28] *Ibid.*, p.2.

[29] Barker, *A Manuscript*, pp.16-17.
[30] W. G. Perin, ed., *Autobiography of Phineas Pett* (London 1917), p. 60.
[31] W. Salisbury, "Framing of Ship Models," *Mariner's Mirror*, vol. 40, (1954) p. 156.
[32] Perin, *Autobiography*, p. 61.
[33] Frank Fox, *Distant Storm: The Four Days Battle of 1666* (Rotherfield, 1997), p. 62.
[34] R. C. Anderson, "Eighty–Gun Three-Deckers," *Mariner's Mirror*, vol. 4 (1914), pp. 203-206.
[35] R. C. Anderson, "A Collection of Shipbuilding Contracts," *Mariner's Mirror*, vol. 41 (1955), pp. 47-52.
[36] NMM, SPB/8.
[37] Lavery, *Deane's Doctrine*, p.116.
[38] PRO, SP 46/136, f. 227. Here is used the version published by Lavery in *Deane's Doctrine,* p.116-119.
[39] Letter is given in full in Frank Fox, "The English Naval Shipbuilding Programme of 1664," *Mariner's Mirror*, vol. 78 (1992), p. 287.
[40] Lavery, *Deane's Doctrine*, p. 29.
[41] R. C. Anderson, "The Framing of Models," *The Mariner's Mirror*, vol. 39 (1953), p. 139.
[42] William Baker, "More on the Framing of Models," *The Mariners' Mirror*, vol. 40 (1954) pp. 80-81.
[43] See Chapter 6 for discussion of her remains.
[44] Goodwin, *The Construction and Fitting,* pp. 231-233.
[45] The original contract is in PRO Adm. 106/3071.
[46] NMM, AND 31.
[47] J. Richard Steffy, personal communication, spring 1999.
[48] Apparently the original scantlings list for these ships has been found in the Public Record Office by Mr. Richard Endsor. I am indebted to Mr. Lavery for the news and to Dr. La Fevre for kindly confirming the information in a letter dated July 8, 2001.
[49] On *Britannia* alone more than 108 volumes of correspondence is surviving. In fact so much information has been uncovered by Dr La Fevre and his colleagues from the Anne Trust that a book on the 30 ships is being contemplated. I am indebted to Dr. La Fevre for sharing this information with me.
[50] NMM, SPB/28.
[51] I am obliged to Mr. Lavery for pointing this to me, personal communication, 29 May, 2001.
[52] PRO, ADM 106/3070.
[53] Winfield, *50-Gun Ship*, pp. 19,20, 23, 24 for tables of dimensions for fourth rates from the 1660s to 1680s.
[54] PRO, ADM 106/3070 and ADM 106/3071 contain a large number of contracts for third, fourth rates of 50 and 60 guns, sixth rates, fireships and even ketches. They date from 1689 to 1697.
[55] Laird Clowes, *History of the Royal Navy*, vol. 2, (London, 1901): Battle of Bantry Bay, Barfleur, Beachy Head orders of battle.
[56] PRO, Adm. 106/3071. Excerpts from the contract are published by Lavery in volume II of *Ship Of the Line* (London, 1984).
[57] PRO, ADM 106/3071 *Devonshire.*
[58] Letter published in Anderson, "Eighty Gun Three-Deckers", pp. 204-205.
[59] John Franklin, *Navy Board Ship Models 1650-1750* (London, 1989), p. 12.
[60] For a discussion of Keltridge's draughts see next chapter.
[61] PRO, ADM 106/3071, *Sunderland.*
[62] PRO, ADM 106/3070; ADM 106/3071; NMM SPB/8.
[63] NMM, SPB/8.
[64] PRO, ADM 106/3071 *Norwich.*
[65] J. Richard Steffy, *Wooden Shipbuilding and the Interpretation of Shipwrecks* (College Station, 1994), p. 269.
[66] Goodwin, *Construction and Fittings*, p. 13.
[67] NMM, SPB/8.
[68] PRO, ADM 106/3070, ADM 106/3071 and NMM, SPB/8.

[69] PRO, ADM 106/3071.
[70] On contemporary draughts see Chapter IV.
[71] PRO, ADM 106/3070 and 106/3071.
[72] *Ibid.*
[73] NMM, SPB/8.
[74] Lavery, *Line of Battle.*
[75] PRO, ADM 106/3070 and ADM 106/3071.
[76] NMM, SPB/8.
[77] *Ibid.*
[78] *Ibid.*
[79] Sutherland, *Shipbuilder's Assistant,* p. 38.
[80] *Ibid.*, p.38.
[81] *Ibid.*, p. 40.
[82] *Ibid.*, p.44.
[83] *Ibid.*, p. 40.
[84] *Ibid.*, p. 26.
[85] *Ibid.*, p. 26.
[86] Brian Lavery, The 30 Ships of 1677, Part III: The Two-Deckers, *Model Shipwright* 35, (1980) pp. 45-46.
[87] *Ibid.*, p. 47.
[88] Personal Communication with Mr. J. Richard Steffy.
[89] National Maritime Museum Ship Draught Room.
[90] Lavery, *Ship of the Line*, vol. II.
[91] For a more detailed study of her remains see the next chapter.
[92] Lavery, *Deane's Doctrine*, p. 16.
[93] A microfilm of the notebook is located at the NMM, but the library staff was unable to locate it in three days in May, 2001.
[94] Fox, *Great Ships*, p. 193.
[95] Personal observations.
[96] David Wray, Bomb Vessels: Their Development and Use, Part I, 1682-1700, *Model Shipwright* 19, (1977), p. 243.
[97] Anderson, "The Framing of Models," p. 139.
[98] Baker, "More on the Framing of Models," pp. 80-81.
[99] Manwayring, England, 1972 .
[100] Anonymous, *L'Album de Colbert* (Omega, 1988).
[101] Baker, "More on the Framing," pp. 80-81.
[102] W. Salisbury, "The Framing of Models," *Mariner's Mirror* vol. 40, (1954), pp. 156-157.
[103] *Ibid.*
[104] See below.
[105] Perrin, *The Autobiography*, pp. 31-32.
[106] *Ibid.*, p. 60.
[107] *Ibid.*, p. 156.
[108] Salisbury, "Framing of Models," pp. 156-157.
[109] Robert Latham and William Mathews, eds., *The Diary of Samuel Pepys*, vol. 3, (London, 1970-1983), p. 149.
[110] *Ibid.*, p. 208.
[111] Franklin, p. 180.
[112] *Ibid.*, pp. 10-11.
[113] Grant H. Walker, "The Rogers Collection: Collecting the Dockyard Models," *Nautical Research Journal*, vol. 44, No. 2, (1999), p. 86, Plate 16.
[114] Franklin, p. 11.
[115] *Ibid.*, pp. 143-147.

[116] *Ibid.*, p. 70-71.
[117] NMM, model number SLR 0405.
[118] Franklin, p. 64.
[119] Fox, *Great Ships*, p. 133.
[120] *Ibid.*
[121] Franklin, p. 111.
[122] *Ibid.*, p. 143.
[123] *Ibid.*, p. 143.
[124] *Ibid.*, p. 11.
[125] See Chapter III of this study.
[126] Franklin, p.12, fig. 7.
[127] See Chapter IV of this study.
[128] Fox, *Great Ships*, p. 75-77.
[129] Salisbury, "The Framing of Models," p. 157.
[130] Fox, *Great Ships*, p. 76.
[131] Franklin, p. 70.
[132] For these notes on model SLR 0368 I am indebted to Mr. Lavery who not only kindly arranged for me to view the model, but also shared with me his views on the dating. Here I have quoted him almost verbatim.
[133] Anderson, "The Framing of Models," p. 139.
[134] Franklin, p. 150.
[135]Henry Culver, *Vessels of the Seventeenth Century Ships* (New York, 1926).
[136] Hobart Holly, "*Sparrow-Hawk* A Seventeenth century Vessel in Twentieth-Century America," *American Neptune*, vol. 13, (1953), pp. 51- 64.
[137] Mr. Jonathan Adams believes it likely that the vessel remains are indeed from the early seventeenth century. Personal communication.
[138] Holly, p. 56.
[139] In conversation, Mr. Adams confirmed that no fastenings exist between the futtocks and the floors.
[140] Jon Adams, *Sea Venture:* A Second Interim Report, *International Journal of Nautical Archaeology* vol. 11, No. 4, (1985), pp. 333-347.
[141] Fox, *Distant Storm*, p. 355.
[142] Colin J. Martin, "The Cromwellian Shipwreck off Duart Point, Mull: an Interim Report", *International Journal of Nautical Archaeology* vol. 24, No. 1, (1995), pp. 15-32.
[143] Martin, "*The* Dartmouth", pp. 29-57.
[144] A. Eames, The King's Pinnace, The *Swan*, *The Mariner's Mirror*, vol. 47, (1961), pp. 49-55.
[145] Colin Martin, The Duart Point Wreck, *Scotish Diver*, March, (1995), pp. 36-37.
[146] Valerie Fenwick, and Alison Gale, *Historic Shipwrecks* (Stroud, 1999).
[147] *Ibid.*, pp. 99-100.
[148] Martin, *The* Dartmouth, p.46.
[149] *Ibid.*, In reality there is plenty of evidence to determine that chock scarphs (or also called anchor chocks) were used by 1689 at the latest. See Chapter III.
[150] *Ibid.*, p. 47.
[151] *Ibid.*, p. 53.
[152] Sir John Knox Laughton, ed., *The Naval Miscellany* (Navy Records Society vol. XL, repr. 1984), p.147
[153] Jerome Hall, *A Seventeenth-Century Northern European Merchant Shipwreck in Monte Christi Bay, Dominican Republic*, Ph. D. Dissertation, (Texas A&M University, 1996).
[154] *Ibid.*, p. 63.
[155] Frank Fox, Hired Men-of-War, 1664-1667, *The Mariner's Mirror*, vol. 84, (1998), p. 14.
[156] Edward Bushnelle, *The Complete Shipbuilder* (London, 1669) In his work he describes the lofting of a frame and is clear from his text that the frame was to have two futtocks and was to overlap.
[157] Hall, p. 75.

[158] The term "first futtocks" are used in this work, simply because it was used by Hall. No trace of second futtocks has actually survived on the seabed.
[159] Hall, p. 75.
[160] *Ibid.*, p. 77.
[161] Sheila A. Clifford, *An Analysis of the Port Royal Shipwreck and its Role in the Maritime History of Seventeenth-Century Port Royal, Jamaica*, MA thesis, (Texas A&M University, 1993).
[162] Clifford, p. 82.
[163] *Ibid.*, p. 89.
[164] *Ibid.*, p.90.
[165] *Ibid.*, p.90.
[166] *Ibid.*, p. 90.
[167] *Ibid.*, p. 107.
[168] *Ibid.*, p. 97.
[169] A. J. Hoving, *Nicolaes Witsens Scheeps-bouw-konst Open Gestelt* (Franeker, 1997), p. 44.
[170] A. J. Hoving, *The Ships of Abel Tasman* (Hilversum, 2000), p.56.
[171] Fox, *Great Ships*, and *Mirror of Empire, Praise of Ships and the Sea.*
[172] Fox, *Distant Thunder, Four Days Battle.* p. 40.
[173] A. J. Hoving, "17th century Dutch Shipbuilding," *Model Shipwright* vol. 58, p.
[174] Rolfe Hoeckel, *Risse von Schiffen des 16 und 17 Jahrhunderts* (Bielefeld, 1977).
[175] Richard Unger, *Dutch Shipbuilding before 1800* (Amsterdam, 1978). Bjorn Landstrom, *Regalskeppet Vasa* (Stockholm, 1980). For comments on these two works see Hoving "A 17th – century Dutch *Pinas"*, *International Journal of Nautical Archaeology*, vol. 17, No. 3 (1988), p. 217.
[176] Herman Keting, *De Prins Willem* (Bussum, 1979).
[177] Hoving, *The Ships*, p. 102.
[178] Heinrich Winter, *Der Hallaendischer Zweidecker von 1660/1670* (Rostock, 1985).
[179] G. C. Dik, *De Zeven Provincien* (Franeker, 1993).
[180] For a full list of Mr. Hoving's publications used in this study see the bibliography.
[181] Hoving, "A 17th- century Dutch 134-foot *pinas"*, Part I, p. 216.
[182] Cornelisz van Yk, *Nederlansche Scheepsbouwkonst Opengestelt* (Amsterdam 1697), pp. 69-70.
[183] Nicolaes Witsen, *Architectura Navalis et Regimen Nauticum* (Amsterdam, 1691), p. 110 and van Yk p. 53.
[184] Witsen, p. 104.
[185] *Ibid.*,p. 94, The actual statement is that two ships built by two men would not be quite the same.
[186] *Ibid.*, p. 111.
[187] *Ibid.*, p. 105
[188] *Ibid.*, p. 169.
[189] *Ibid.*, p. 169 and associated plate.
[190] Hoving, *Nicolaes Witsens...*, pp. 102-103.
[191] Witsen, p. 170 and associated plate.
[192] *Ibid.*, p. 170.
[193] Hoving, *Nicolaes Witsens...*, pp. 102-103.
[194] Hoving, "Away from the Draughting Board," *Model Shpiwright*, vol. 69 (1989), pp. 43-51.
[195] Yet, see the photo sequences in Hoving's *The Ships of Abel Tasman*. The figures seem more logical. pp. 58-64.
[196] Witsen, p. 106-107.
[197] *Ibid.*, p. 112.
[198] *Ibid.*
[199] *Ibid.*,.
[200] Fox, *Distant Storm....*
[201] *Ibid.*, p. 135.
[202] *Ibid.*, p. 137.
[203] Lavery, *Deane's Doctrine*, scantlings table.

[204] *Ibid.*, p. 138.
[205] Hoving, "A 17th –century Dutch *Pinas"*, p. 216 and also van Yk pp. 69-70.
[206] van Yk, p. 53.
[207] *Ibid.*, p. 55.
[208] *Ibid.*, p. 60.
[209] *Ibid.*, p. 68.
[210] *Ibid.*, p. 68.
[211] *Ibid.*, p. 69.
[212] *Ibid.*, p. 76.
[213] *Ibid.*, p. 78.
[214] *Ibid.*, p. 78.
[215] *Ibid.*, p. 78.
[216] *Ibid.*, p. 78.
[217] *Ibid.*, p. 79.
[218] *Ibid.*, p. 147.
[219] *Ibid.*, p. 149.
[220] *Ibid.*, p. 153.
[221] Hoving, "A 17th –century Dutch *Pinaas,"* p. 216.
[222] van Yk, p. 70.
[223] *Ibid.*, p. 73.
[224] Anonymous, *L'Album de Colbert*, notes, p. 1.
[225] *L'Album de Colbert*, notes p. 2.
[226] *L'Album de Colbert*, notes, p. 3.
[227] Fox, *Great Ships*, p. 123
[228] The document is transcribed in Jean Boudriot, *The History of the French Frigate* (Rotherfield 1993), An English translation., p. 57.
[229] Personal observations at the Conservation Laboratory at Texas A&M University.
[230] Norman C. Owen, "HMS *Hazardous* wrecked 1706. Pre-disturbance Survey Report 1987," *International Journal Nauitcal Archaeology* 17 No. 4, (1988), p. 285.
[231] *Ibid.*, p. 291.
[232] Norman C. Owen, "*Hazardous* 1990-1991 Interim Report," *International Journal of Nautical Archaeology* 20, No. 4, (1991), pp. 325-334.
[233] *Ibid.*, p. 327.
[234] *Ibid.*, p. 327.
[235] *Ibid.*, p. 328.
[236] Sutherland, *The Ship-Builder's Assistant.*
[237] The pattern on the Kiten wreck was double frames with two singles in between. The length on which this pattern was observed was more than 2 meters.
[238] Personal communication with Taras Pevny. His work on the drawings of *La Belle* has led him to believe that diagonals were becoming important in the design process, moving away from the traditional arc-based methods.
[239] R. C. Anderson, "Danish Shipbuilding," *Mariner's Mirror*, vol. 18, (1932), p. 81.
[240] *Ibid.*
[241] The Danish foot was about 10% longer than the English, so the described ship was a substantial vessel.
[242] Anderson, "Danish Shipbuilding," p. 84.
[243] Anderson, "Dutch Shipbuilding, 1664," *Mariner's Mirror*, Vol. 14, (1928), pp. 158-161.
[244] Anderson, "Danish Shipbuilding," p.85.
[245] Carl Olof Cederlund, "The *Wasa* as product of Dutch Shipbuilding" in Arne Bang-Andersen, Basil Greenhill and Egil Harald Grude ed., *The North Sea A Highway of Economic and Cultura, Exchange* (London, 1985).
[246] *Ibid.*, pp. 20-21, fig. 11.

[247] Christian Lemee, *A Ship-Cemetery on the site of the B&W*, p. 4, unpublished paper.
[248] Christian Lemee, *Renaessanceskibe pa Christianshavn* (Saertyk fra Nationalmuseets Arbejdsmark 1997), p. 16, fig. 6.
[249] Lemee, *A Ship-Cemetery*, p. 4.
[250] Lemee, *Renaessanceskibe*, pp. 20-21, fig. 11.
[251] *Ibid.*, p.16, fig. 6.
[252] Hoving, *The Ships of Abel Tasman*, p. 58.
[253] Lemee, *A Ship-Cemetery*, p. 5.
[254] *Ibid.*, p. 26, fig.16.
[255] Lemee, *A Ship-Cemetery et supra*, p. 1.
[256] *Danske Orlogskibbe.*
[257] Cederlund, "The *Wasa* ... ", etc., p. 172.
[258] Fox, *Great Ships*, p. 132.
[259] *Ibid.*
[260] *Ibid.*, p. 133.
[261] *Ibid.*, p. 133.
[262] Hoving, "Away from the Drawing Board".
[263] Sutherland, William, *The Ship-Builder's Assistant* (London, 1711).
[264] Fox, Frank, *Great Ships*, p. 133.
[265] Frederick af Chapman, *Architectura Navalis Mercatoria* (Stockholm, 1769).
[266] Sutherland, *Ship-building Unveil'd*, (London, 1717), scantlings tables, pp. 36-37.
[267] Admiralty Journal, 5 May 1677. J. R. Tanner, ed., *A Descriptive Catalog of the Naval Manuscripts in the Pepysian Library at Magdalene College, Cambridge*, vol. IV, (Navy Records Society, 1922,) p. 415.
[268] *Ibid.*, p. xii.
[269] *Ibid.*, p. 434.
[270] *Ibid.*, June 9, 1677, p. 442.
[271] *Ibid.*, July 10, 1677, p. 471.
[272] *Ibid.*, July 10, 1677, p. 472.
[273] *Ibid.*, July 14, 1677, p. 475.
[274] Sarri Hornstein, *Restoration Navy and English Foreign Trade 1674-1688* (Alderschott, 1991), chapter 1.
[275] Samuel Pepys, *Memoirs of the Royal Navy* (London, 1688), p. 61.
[276] Tanner, August 3, 1678, p. 595.
[277] *Ibid.*, April 19, 1676, p. 662.
[278] *Ibid.*, July 3, 1674, p. 54,.
[279] *Ibid.*, February 6, 1675-76, p. 276.
[280] *Ibid.*, May 12, 1677, p. 422.
[281] *Ibid.*, May 12, 1677, p. 423.
[282] *Ibid.*, July 7, 1677, p. 468.
[283] *Ibid.*, July 21, 1677, p. 481.
[284] For the attempts to force the Royal will on the recalcitrant Pepys on this subject see pages 423,428, 430, 463, 487 in Tanner, *Catalogue,* vol. IV.
[285] For a general overview of the Third Anglo-Dutch War see the introduction to R.C. Anderson ed., *Journals and Narratives of the Third Dutch War* (Navy Records Society, 1946).
[286] Sutherland, *The Shipbuilders Assistant*, p. 43.
[287] Peter Goodwin, personal communication.
[288] David Howard, *The Voyage of the Armada* (New York, 1982), p. 209.

REFERENCES

Manuscript Sources

National Maritime Museum (NMM), Greenwich, United Kingdom,
Draught Room, William Keltridge Drawings
NMM, AND 31, William Keltridge Notebook, c.1675
NMM, SPB/8 Shipbuilding Contracts
NMM, SPB/28 Edward Battine, *Proportions for Ships with Directions for drawing and Deleniating Ships Bodies*, 1686

Public Record Office (PRO), London, United Kingdom

ADM 106/3070, Contracts for:

Newarke, 3rd rate
Cornwall, 3rd rate
Norfolke, 3rd rate
Colchester and *Romney*, 4th rates
Mary Galley, 4th rate
Penzance, 6th rate
Swan 6th rate
Faulcon, 6th rate
Griffin, fireship
Phaeton, fireship
Vulcan, fireship
Fox, fireship
Phenix, fireship
Unidentified, ketch
Scarborough and *Harpe,* ketches

ADM 106/3071, Contracts for:

Spragge's Contract for four frigates
Hind, ketch
Biddeford, 6th rate
Seahorse, 6th rate
Harwich and *Pendennis*, 4th rates
Sunderland, 4th rate
Unidentified 60-gun ship, 4th rate
Norwich, 4th rate

3 unidentified 50-gun 4th rates
2 unidentified 60-gun 4th rates
Devonshire, 3rd rate

Printed Sources

Adams, Jon, "*Sea Venture*: A Second Interim Report," *International Journal of Nautical Archaeology (IJNA)* 11, no. 4, (1985): 333-347.

Anderson, R. C., "A Collection of Shipbuilding Contracts," *Mariner's Mirror*, 41, (1955): 47-52.
_____"Danish Shipbuilding," *Mariner's Mirror*, 18, (1932): 81.
_____"Dutch Shipbuilding, 1664," *Mariner's Mirror*, 14, (1928): 158-161.
_____"Eighty –Gun Three-Deckers," *Mariner's Mirror*, 4, (1914): 203-206.
_____"The Framing of Models," *Mariner's Mirror,* 39, (1953): 139.
_____ ed., *Journals and Narratives of the Third Dutch War*. London, 1946.

Baker, William A., "More on the Framing of Models," *Mariner's Mirror,* 40, (1954): 80-81.

Barker, Richard, "A Manuscript on Shipbuilding, *circa* 1600, Copied by Newton," *Mariner's Mirror*, 80 (1992): 16-29.

Boudriot, Jean, *The History of the French Frigate*. Rotherfield, 1993, An English translation.

Bushnell, Edmund, *The Complete Ship-Wrigh.* London, 1669.

Cederlund, Carl Olof, *The* Wasa *as product of Dutch Shipbuilding* in Arne Bang-Andersen, Basil Greenhill and Egil Harald Grude ed., *The North Sea A Highway of Economic and Cultural, Exchange*. London, 1985.

Clifford, Sheila, *An Analysis of the Port Royal Shipwreck and its Role in the Maritime History of Seventeenth-Century Port Royal, Jamaica*, MA thesis. Texas A&M University, 1993.

Culver, Henry, *Vessels of the Seventeenth Century Ships.* New York, 1926.

Davies, J. D. ""A Lover of the Sea and Skillful in Shipping": King Charles II and His Navy". Huntingdon, 1992.
_____*Tarpaulins and Gentlemen: The Officers and Men of the Restoration Navy.* Oxford, 1991.

Dik, G. C. *De Zeven Provincien.* Franeker, 1993.

Eames, A., "The King's Pinnace, The *Swan," Mariner's Mirror*, 47 (1961): 49-55.

Fenwick, Valerie and Alison Gale, *Historic Shipwrecks.* Stroud, 1999.

Fox, Frank*Distant Storm: The Four Days Battle of 1666.* Rotherfield, 1997.
_____*Great Ships*: *The Battlefleet of King Charles II.* London, 1980.
_____"The English Naval Shipbuilding Programme of 1664," *Mariner's Mirror*, 78 (1992): 277-292.
_____"Hired Men-of-War, 1664-1667," *Mariner's Mirror*, 84 (1998): 13-25, 52-172.
_____"More on the *Royal Katherine," Model Shipwright*, 50 (1972): 128-131.

Franklin, John, *Navy Board Ship Models 1650-1750* .London, 1989.

Goodwin, Peter, *The Construction and Fitting of the English Man-of-War, 1650-1850* Annapolis, 1987.

Hall, Jerome *A Seventeenth-Century Northern European Merchant Shipwreck in Monte Christi Bay, Dominican Republic.* Ph. D. Dissertation, Texas A&M University, 1996.

Hoeckel, Rolfe. *Risse von Schiffen des 16 und 17 Jahrhunderts.* Bielefeld, 1977.

Holly, Hobart "*Sparrow-Hawk* A Seventeenth Century Vessel in Twentieth-Century

America," *American Neptune*, 13 (1953): 51- 64.

Hornstein, Sari *Restoration Navy and English Foreign trade 1674-1688.* Aldershott, 1991.

Hoving, A, "Away from the Drawing Board, Part I," *Model Shpiwright*, 69 (1989): 43-51.
_____ "Away from the Drawing Board, Part II," *Model Shipwright,* 71 (1990): 47-49.
_____ "Dutch 17th century Shipbuilding," *Model Shipwright,* 58 (1986): 28-36.
_____ *"Heemskerck* (1638), Abel Tasman's War Yacht," *Model Shipwright*, 86(1993): 18-29.
_____ *Nicolaes Witsens Scheeps-bouw-konst Open Gestelt.* Franeker, 1997.
_____ "A Pinasship of 134 feet," *Models Shipwright,* 58 (1986): 39-51.
_____ "A 17th- century Dutch 134-foot *pinas*, Part I," *IJNA,* 17, no. 3 (1988).
_____ "The Fluit," *Nautical Research Journal*, 42, no.1 (1997): 24-35.
_____ *The Ships of Abel Tasman.* Hilversum, 2000.
_____ "Stern Carvings," *Model Shipwright*, 78 (1991): 49-54.

Howard, David, *The Voyage of the Armada.* New York, 1982.

Ketting, Herman, *De Prins Willem.* Bussum, 1979.

Kruger, Kurt, "A Navy Board Model in Vienna," *Model Shipwright*, 73 (1986): 35-42.
_____ "50-Gun Fourth Rate (c. 1692)," *Model Shipwright*, 81 (1994): 46-52.

Landstrom, Bjorn, *Regalskeppet Vasa.* Stockholm, 1980.

Latham, Robert and William Mathews, eds., *The Diary of Samuel Pepys*, vol. 3. London, 1970-1983.

Laughton, Sir John Knox, ed., *The Naval Miscellany*, vol. XL, reprinted. London, 1984.

Lavery,Brian, *Deane's Doctrine of Naval Architecture, 1670.* London, 1981.
_____ *Ship of the Line*, vol. II .London, 1984.
_____"The 30 Ships of 1677, Part I," *Models Shipwright*, 33 (1980): 54-61.
_____"The 30 Ships of 1677, Part II," *Model Shipwright*, 34 (1980): 2-9.
_____"The 30 Ships of 1677, Part III," *Model Shipwrigh*t, 35 (1981): 42-48.
_____*Susan Constant, 1605.* Annapolis, 1988.

Lemee, Christian, *A Ship-Cemetery on the site of the B&W*, unpublished paper.
_____ *Renaessanceskibe pa Christianshavn.* Saertyk fra Nationalmuseets Arbejdsmark, 1997.

Manwayring, Henry, *The Seaman's Dictionary*, 1644. Reprinted, London, 1972.

Martin, Colin, "The Cromwellian Shipwreck off Duart Point, Mull: an Interim Report," *IJNA,* 24, No. 1 (1995): 15-32.
_____"The *Dartmouth*, a British Frigate Wrecked off Mull, 1690," *IJNA*, 7, no. 1 (1978): 29-57.
_____"The Duart Wreck," *Scotish Diver*, (March, 1995).

McGowen, P., ed., *The Jacobean Commission of Enquiry 1608-1618.* London 1971.

Owen, Norman, "*Hazardous* 1990-1991 Interim Report," *IJNA,* 20, no. 4 (1991): 325-334.
_____"HMS *Hazardous* wrecked 1706. Pre-disturbance Survey Report 1987," *IJNA* vol. 17, no. 4 (1988): 285-293.

Pepys, Samuel, *Memoirs of the Royal Navy.* London, 1688.

Perin, W. G., ed., *Autobiography of Phineas Pett.* London, 1917.

Ralamb, Ake Classon, *Skepps byggerij eller Adelig Oefnings Tionde Tom.*Stockholm, 1691.

Salisbury, William, "The Framing of Models", *Mariner's Mirror* 40 (1954): 156-157.

Salisbury, William and R. C. Anderson, ed., *A Treatise on Shipbuilding and A Treatise on Rigging Written About 1620-1625.* London, 1958.

Smith, John, *A Sea-grammar.* London, 1627. Reprinted Amsterdam, 1968.

Sutherland, William *The Ship-Builder's Assistant.* London, 1711. Facsimile reprint Rotherfield, 1989.
_____*Shipbuilding Unveil'd.* London, 1717.

Tanner, J. R., ed., *A Descriptive Catalog of the Naval Manuscripts in the Pepysian Library at Magdalene College, Cambridge,* vol. IV. London, 1922.

Unger, Richard, *Dutch Shipbuilding before 1800.* Amsterdam, 1978.

van Yk, Cornelisz, *Nederlansche Scheepsbouwkonst Opengestelt.* Amsterdam, 1697.

Walker, Grant H., "The Rogers Collection: Collecting the Dockyard Models," *Nautical Research Journal*, 44, no. 2 (June, 1999): 75-88.

Winfield, Riff, *The 50-Gun Ship*. London, 1997.

Winter, Heinrich, *Der Hallaendischer Zweidecker von 1660/1670.* Rostock, 1985.

Witsen, Nicolaes, *Architectura Navalis et Regimen Nauticum.* Amsterdam, 1691.

VITA

NAME Kroum Nickolaev Batchvarov

ADDRESS 4200 Scotland #58
Houston, TX 77007
kroum@earthlink.net

EDUCATION

1997-2002 M.A. in Anthropology, Nautical Archaeology Program, Texas A&M University, College Station, TX.

1990-1994 B.A., Political Science, Park College, Parkville, MO

PROFESSIONAL EXPERIENCE

1999-present Project Director, Bulgarian Black Sea Project, Bulgaria: Kiten Shipwreck Excavation

1999 Archaeologist, Tektas Burnu Shipwreck Excavation, Turkey

1998 Archaeologist, Lake Champlain Maritime Museum, Vermont. Projects include:
Barn Rock Harbour canal barge recording
Pipe Stove Wreck, survey and hull recording

PUBLICATIONS

An Archaeological trip to Bulgaria, *INA Quarterly* 26.3, 1999

The First Black Sea Shipwreck Excavation: Kiten, Bulgaria, *INA Quarterly* 28.1, 2001

Тайните на един потънал кораб, *АзБуки*, volume 9.3, 2001, pp. 22-23. Newsletter of the Bulgarian Ministry of Culture. With Kalin Porozhanov and Kalin Dimitrov

"Урдовиза 2000" - Съвместна Българо-Американска Подводна Археологическа Експедиция, *Archaeological Surveys and Excavations 1999-2000*, Proceedings, of the XL National Archaeological Conference, Sofia, 2001. With Kalin Porozhanov, Hristina Angelova and Kalin Dimitrov