FURRING IN THE LIGHT OF 16TH CENTURY SHIP DESIGN

A Thesis

by

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Abstract

"Build me straight, O worthy Master!
Stanch and strong, a goodly vessel,
That shall laugh at all disaster,
And with wave and whirlwind wrestle!

…And above them all, and strangest of all
Towered the Great Harry, **crank** and tall,
Whose picture was hanging on the wall,
With bows and stern raised high in air,
And balconies hanging here and there…"

The Building of the Ship by Henry Wadsworth Longfellow (1850)

Furring is a type of ship rebuilding method indicative of the late 16th century and early 17th century England. It was adopted as a remedial process to solve crank ships that were built too narrow and could not sail properly. Furring is not a familiar term used in the archaeological community because of the lack of evidence and substantial descriptive backing to understand it. Literature was not a prominent aspect of shipbuilding, and there were no archaeological remains found to show this rebuild method. That is until 2003, when a wreck was discovered in the Princes Channel. The *Princes Channel Wreck* (1574) is now the only known archaeological remains that show the practice of furring.

Looking closely at the ship remains and the historical sources defining the term furring, it is the hope, that this thesis will further clarify this discovery and possibly help in future discussions in interpretation and new discoveries of the same nature.

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I would also like to thank Dr. Ian Friel FSA and the Gresham College (and their lecture series) for his inspirational book *The Good Ship*, but also for his insightful lecture on September 29th 2009 about Elizabethan Merchant Ships and Shipbuilding, and particular attention and focus on the furring of the *Gresham Ship*.

Thank you to Wendy van Duivenvoorde, whose doctorate dissertation on the *Batavia* (1628) remains, clarified a lot for me. She, without hesitation answered my every (probably annoying) question about Dutch bottom-based construction.

And to Fred Hocker for his support and intellect on Dutch ship design and the continuous work he has contributed to the study of the *Vasa* (1628). The chance to work with both Fred and the 17th century Swedish Warship has taught me a lot in the construction and design of ships of this period.

I would also like to thank my professor and thesis advisor Dr. Jens Auer, who was part of the Wessex Archaeology team involved in the recovery of the only known archaeological ship remains, showing the practice of furring and who began the research into the ship repair method. Your passion towards the topic of furring on the *Princes Channel Wreck* is what motivated me and kept me writing.

And finally to my family, who have always inspired me to do what I love.

Dedication

I dedicate this to my left foot, for ‘supporting’ me through the tough times.

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Chapter 1: Introduction

Furring, is a type of ship rebuilding method indicative of the late 16th century and early 17th century England. It was adopted as a remedial process to solve crank ships that were built too narrow. The research into this rebuild method began when a 16th century shipwreck was discovered in the Prince Channel, Thames Estuary in 2003. The remains of the *Princes Channel Wreck* (1574) show distinguishing characteristics of the process of furring. Furring as defined by Sir Henry Mainwaring's *Seaman's Dictionary* is as follows:

"There are two kinds of furring: the one is after a ship is built, to lay on another plank upon the side of her, which is called plank upon plank. The other, which is more eminent and more properly furring, is to rip of the first planks and to put other timbers upon the first, and so to put on the planks upon these timbers. The occasion of it is to make a ship bear a better sail, for when a ship is too narrow and her bearing either not laid out enough or too low, then they must maker her broader and lay her bearing higher. They commonly fur some two or three strakes under water and as much above, according as the ship requires, more or less. I think in all the world there are not so many ships furred as are in England, and it is a pity that there is no order taken either for the punishing of those who build such ships or the preventing of it, for it is an infinite loss to the owners and an utter spoiling and disgrace to all ships that are so handled (Manwaring & Perrin 1922, 153)."

1.1 Aims and Objectives

The intention of this thesis is to gain more knowledge about the rebuild method called furring. In order to understand aspects of furring, the following chapters will try to understand the process by which furring is done on a ship, the reason why a ship needed to be furred, how it was furred, and whether a ship was furred during or after construction. These questions alone cannot be answered through the archaeological evidence of the *Princes Channel Wreck*,

and so a historical research based evaluation of furring will be looked at in order to understand these questions.

As indicated by Sir Henry Mainwaring, “there are not so many ships furred as are in England”. There have been thoughts and questions concerning an Iberian association along with Thomas Harriot’s *Scientific and Mathematical Papers*, which implies Spanish, French and Dutch involvements of furred ships. This thesis will focus on ships and the shipwrights of Elizabethan England during the late 16th century, however aspects of other countries will be looked at for comparison, such as the various translations of the term furring.

In summary the thesis will:

1. Investigate the potential purpose of furring a vessel.
2. Identify the motives and influences behind this “makeshift correction of poor ship design” and the possible methods of doing it (Shirley 1983, 100).
3. Apply the definition of ‘furring’ to the archaeological evidence of the *Princes Channel Wreck*.
4. Discuss the relevance of the investigation for maritime archaeology research.

The study of furring will shed light on a unique ship rebuild method of the 16th century, as well as bring a different understanding to the archaeological evidence. The *Princes Channel Wreck* is the only known archaeological evidence found with this particular rebuild. Furring is not a familiar term used in the archaeological community because of the lack of evidence and substantial backing to understand it. Looking closely at the ship remains and the historical sources defining it, it is the hope that this thesis will further clarify this discovery and possibly help in future discussions in interpretation and new discoveries of the same nature.

1.2 Literature Review

Research into the process of furring has been minute and studies that have been done on shipbuilding methods and repairs, culminate around this particular topic, but rarely focus on it directly. Furring, when made reference to in literature, has predominantly been included as second hand intelligence, conjoined into literature about general discussions, and as most researchers will admit, 'the sources are where you least expect them.' Nonetheless, the following section of this chapter will discuss the previous research on this topic, and whether they contribute significantly to pave the way to a better understanding about furring.

As mentioned above, the study of furring began with the discovery of archaeological remains. The *Princes Channel Wreck* brought to life, the concept of what furring looks like, as historians and archaeologists have only seen it through texts of manuscripts and definitions. Dr. Jens Auer and Antony Firth's interim report of the shipwreck published shortly after discovery, discusses in detail the construction of the ship. It is here the connection between furring and the archaeological remains were made. Mainwaring's definition was used to understand that connection.

The English Historical Review Vol. VII, of 1892, includes notes and documents pertaining to the royal navy under James I. In Oppenheim's chapter, he describes the developments in ship design and construction, and also the failures. The failures pertaining to Phineas Pett's ship, the *Prince Royal,* a case study that will be reviewed in this thesis. The failures pertaining also to the general standards of shipwrightry according to Captain George Waymouth who claims that, the methods of building resulted in no two ships being alike. And furthermore, the failures pertaining to the relationships between shipwrights and the supposed corrupt fraternity of shipbuilders, whose black listing methods of blaming constructors of causing crank-sided ships, produce an immense rift

between shipwrights but even more so, a greater demand for faster and more seaworthy ships.

Today, little research continues into the subject of furring. The end of the 16th century, the period in which furring is used, is a large aspect of history that is still unknown. In a time of scientific change, many methods of shipbuilding and ship repair were experimented and altered throughout England. Historians and archaeologists have touched on the shipwrights various attempts at solving problems in ship design, but furring is not one of them. It is however the conclusion of this section of the chapter, that the two sources that are mentioned, have and will significantly contribute to a better understanding of furring.

1.3 Source Review

Much of our knowledge about the design and construction of ships built during the 16th century is based on documentary and archaeological evidence. These will be the two primary areas discussed in this thesis. The documentary evidence will be in the form of both primary and secondary sources pertaining to the years around 1574, the dendrochronological date of the *Princes Channel Wreck*. The primary sources will include manuscripts of both a textual and iconographic context as well as published and unpublished works in autobiographies, seamen's dictionaries, treaties, and writer's of the time. The secondary sources will include texts concerning shipwrights, academics involved in the process of construction together with other relevant theses that have in part touched on the subject, and other publications regarding the historical context of 16th century shipbuilding. Although a fundamental majority of these texts have been published in the *Navy Records Society* and provide significant information on this particular subject, their detailed descriptions can only provide part of the evidence; the archaeological remains will be discussed in chapter 4.

Elizabeth Tebeaux wrote her thesis on the *Technical writing in English renaissance shipwrightery: breaching the shoals of orality* at Texas A&M University. Among the richly identified texts of the early 17th century, it was

pointed out how “Shipwrightery texts did not appear in English until the middle decades of the 17th century because shipwrightery was a closed discourse community, which shared knowledge via oral transmission (Teneaux 2008, 13).” Indeed this thesis could be entirely based in relationship to Tebeaux’s paper as a prime example of that, but the point here is, the textual sources that are available are publications and entries submitted at the beginning of the 17th century, and rarely in the 16th century. Indeed the Spanish Armada is note worthy news, but in a time when change was eminent, and the revolution of ships expanding both in size and design was at its birth, the lack of substantial literature is surprising.

It is nonetheless essential to demonstrate the familiarity of significant literature and relevant research at this time. As mentioned above, *The Navy Records Society* has published over 150 volumes of documents ranging from the 14th century up to the Second World War and is still in production today. Rare, and often hard to find, these published original documents hold the essential sources in British naval history and the expansion of naval power. Not to sound too cavalier, but almost all of the volumes pertaining to the 16th century and shortly thereafter, are relevant literature to this thesis and will be mentioned later on.

Sir Henry Mainwaring definition of ‘furring’ found in his Seaman’s Dictionary of the early 1600s, known as the *Nomenclator Navalis*, is one of the most vital literatures, explaining the process, purpose and even disadvantages to this type of ship repair. Ironically, throughout many other texts to be used, Mainwaring’s definition of furring is quoted regularly. Nathaniel Boteler’s (Butler) Dialogues take an interesting approach of discourse between an Admiral and a Captain. This means of briefing the head of the Board of Admiralty was intended to shed light on operations and life at sea in the Stuart Navy in 1634. Furring is mentioned among these dialogues, but appears to reproduce Mainwaring’s definition. Nonetheless, there are some additional notes inserted about a possible third method of furring a ship at the tumble-home.

In Captain John Smiths manuscript titled, *The Seaman's Grammar and Dictionary, explaining all the difficult terms in Navigation: and the practical Navigator and Gunner,* dating to 1627, the practice of furring is again referenced. Smith gives a similar explanation into the process of furring, like Boteler and Mainwaring but includes the reason to fur a ship when it is "crank-sided and will bear no sail (Smith 1627, 53)." This new reference denotes a further investigation into all ships found crank, and whether all crank-sided ships are furred, or if furring is simply one of many methods of repairing a ship.

The *Autobiography of Phineas Pett* is a manuscript in Pett's own writing, of his life between 1570 and 1638. Born into a famous family of shipwrights, Pett's story is that of immeasurable drama between his rival Matthew Baker and a subject of enquiry in 1608 and 1620 in relation to his contract to build the *Prince Royal*. Although this will be discussed in chapter 3, it is nonetheless essential to discuss the fact that many hypotheses have circulated around this enquiry, including the potential furring of the ship, and so an accumulation of literary sources, including Pett's autobiography will be discussed in order to understand the full situation of the enquiry, and the possible reasons for it.

The Sergison Papers, 1688-1702 draws on a limited selection of Charles Sergison's work, most notably a series of correspondence between the Navy Board and the Admiralty on the various aspects of naval administration, such as shipbuilding and the dockyards. And although the original manuscript touches on more aspects, such as the Spanish Succession, and that the correspondence relate to a much later period then the *Princes Channel Wreck*, it still provides significant information on the process of ship repair and the communication that occurred between various contacts in and out of the dockyards. While Merriman, the editor of this volume uses the instance of girdling and the twenty correspondence relating to a faulty design of the *Royal William* to illustrate a mutual antagonism, which hampered the naval administration of the day, it provides much more technical matters for methods of solving a crank ship.

Furring is referenced as a suggested method of solving this, rather then girdling, which was strongly opposed. Again this denotes further investigation into all ships found girdled and if girdling like furring is another method of repairing a ship.

Thomas Harriot's *Mathematical and Scientific Papers* holds a different description then Mainwaring's process of furring. In his manuscript there is immense discussion about rigging, ropes and sea charts in the style of rutters (navigational charts). Another thesis alone could be attributed to his one volume out of six, however John Shirley's book, *Thomas Harriot: A Biography* also has the definition of furring along with Harriot's accounts of conversations with Matthew Baker on his 'crude' tonnage calculations, transcribed from the manuscript.

Matthew Baker's manuscript shows iconographical and mathematical clues into the design intent of a shipwright during the 16th century. As the first English work on shipbuilding dating to 1570, it comprises of 165 annotated drawings, which as Tebeaux suggests, served as "mnemonics for the shipbuilders and perhaps for shipyard workers, many of whom might not have had more than rudimentary reading skills (Tebeaux 2008, 7)." Many of the drawings in Baker's manuscript depict hull forms in the shape of fish, humorously called, "Fish and Ships". Larrie D. Ferreiro's novel, *Ships and Science: The Birth of Naval Architecture in the Scientific Revolution, 1600-1800,* explains the use of diagrams of fish to "explain why the hulls of their ships were shaped with the broadest section forward and tapered aft, commonly cited as 'cod's head and mackerel's tail' (Ferreiro 2006, 123)." Ferreiro further explicates that, "this explanation did not describe the thought process that constructors went through to create a ship, but was used to justify the shapes that had been employed from the times of their ancestors (Ferreiro 2006, 123)." This would show evident in Baker's manuscript of dimensions, drawings and supposed mathematical methods of construction.

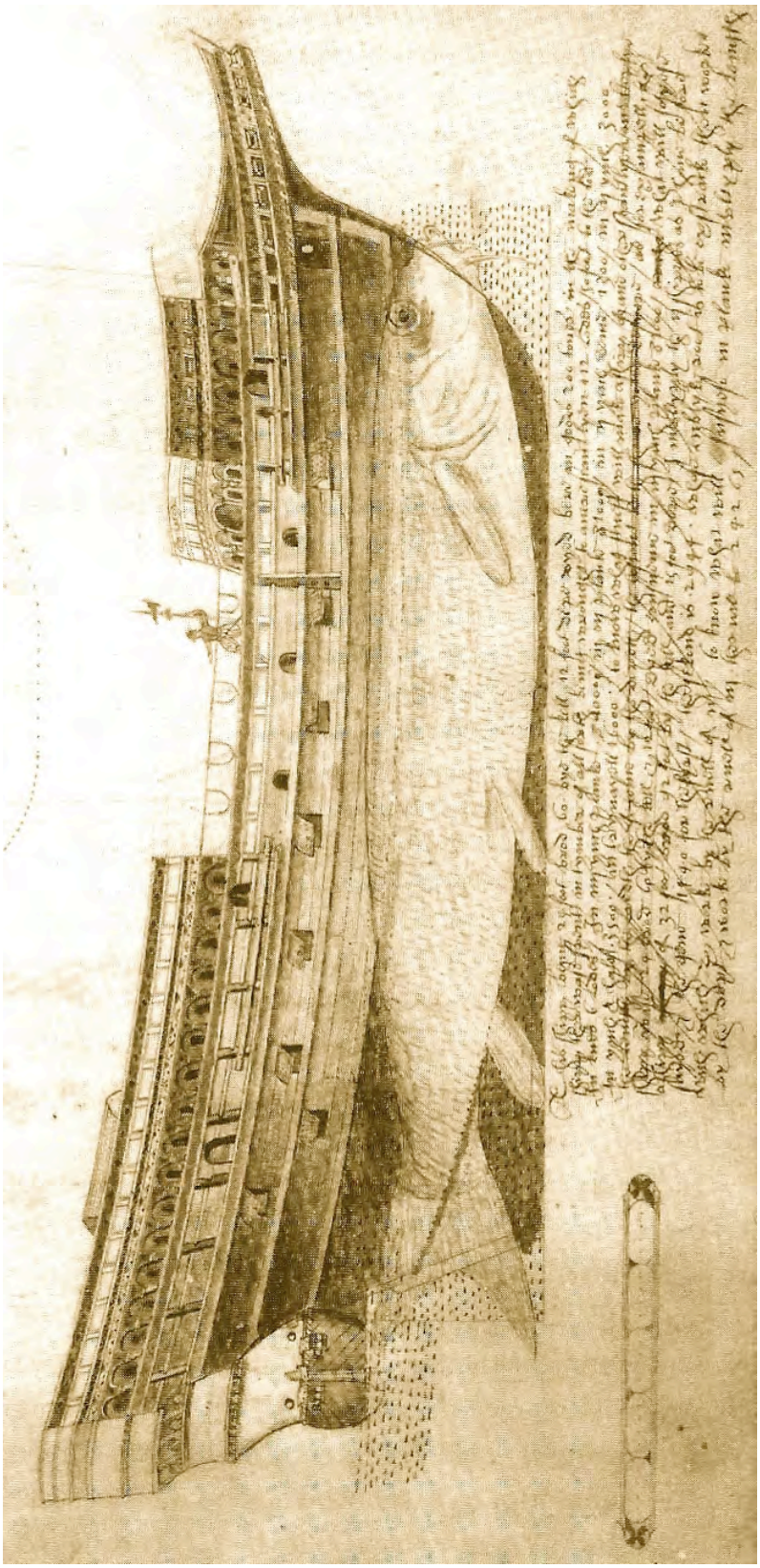


Figure 1: Hull form showing fish-like underwater body. *Fragments of Ancient Shipwrightry*, Baker (1570).

There are numorous other publications that will be included in this thesis, which give a more extensive background into the history of both the navy and merchant dockyards during the late 16th century and 17th century. These literary sources help with the providential understanding of how ship design transformed during the 16th and 17th centuries for better, and for worse, but do not in particular mention the process of furring.

1.4 Methodology

The archaeological remains bring substantial evidence to backing the textual support. "The historical past is substantially improved if they are supported by both documentary and historical evidence (Whylie 2002, 206)." This process of "analytical byplay" between documentary and archaeological data as Whylie explains, is a process of working "back and forth, from one to the other," and suggests that each in it's own can be used to extend the meaning of the other (Whylie 2002, 206). And that is essentially the hope of this thesis – to correlate between both archaeological data, that being the *Princes Channel Wreck* and the documentary data of shipwrights and scholars of the past.

The main bulk of this thesis will be dependent upon two of the above foundations. One is the archaeological remains of the *Princes Channel Wreck*; the other is a definition explaining a repair in the design of a ship, which will show to be one of the many forms of ship repair. By using Whylie's process of "analytical byplay," it may be possible to use both of them in conjunction with one another to not only understand the 'Five W's' (who, what, where, when, & why), but also the 'How'.

1.5 Standards (transcribing)

As there are only a few primary sources, the standards for transcribing them are fairly candid. Because Henry Mainwaring's definition of the process of furring has been edited and published into a secondary text, this thesis will try and follow the same guidelines of transcribing original texts into present day spellings. Thomas Harriot's style of writing is 16th century English cursive

calligraphy and varies in spelling and style throughout his manuscript. Rather then changing Harriot's spelling to present day English spelling of the words, this thesis will use his manuscript in conjunction with John Shirley's transcription of the definition. The reason for doing this is because in Harriot's definition of furring, past particular verbs are used, which may be misinterpreted if directly translated.

1.6 Definitions/ Terminology

The guidelines for definitions and terminology in this thesis will be set out by Sir Henry Mainwaring's *Seaman's Dictionary* (1644) in conjunction with the modern reference of *The Oxford Companion to Ships and the Sea* edited by Peter Kemp (1994). The combination of dictionaries will help both in the understanding of terms used, as well as the similarities and differences between the 17th century and present day understandings of them. This thesis will approach the concepts and terms of ship rebuilding with the awareness that readers may not understand them, and will attempt to define any terms used, throughout the course of the investigation.

Chapter 2: Furring

When the research into the hull design of the Princes Channels ship began, there were very few known descriptions of furring. The research for this thesis has uncovered, collated and documented, descriptions, definitions (many sources relating to the period from the end of the 16th century to the beginning of the 19th) and an understanding of what the process of furring is, as it pertains to ship re-fit methods.

As mentioned in chapter one, literary sources are limited for the 1500s and so many of the documentations and sources gathered for this thesis, come from later periods often describing 16th century shipbuilding, this may also include the definition of furring.

Because there are many definitions of the term furring, this chapter, rather then listing them off one by one, will conduct an interrogative analysis of the term, adding in aspects of the definitions as they pertain to the subject. This will allow more clarity in the overall understanding of the term, as well as introduce aspects of furring that are relevant to the discussion. The reason for this, as previously mentioned, is due to the paraphrasing of other sources. Therefore, to avoid repetition, important extracts from each of them will be looked at.

2.1 So, What does furring mean?

The word ‘Fur’ comes from the French word ‘Fourrer,’ which was also associated with ‘Doubler’ (en termes de construction), which in English means to double or duplicate. ‘Fourrure’ in the feminine, means, ‘old canvas to service’, or a general name for service of plat, canvas, ropes, etc. The feminine often refers to fur clothing and to paintings on canvas. It’s modern form, ‘Fourrer’ means to stuff, but in nautical term is meant to add a lining, cover, or sheathe. The masculine however, would be ‘Soufflage,’ meaning sheathing or furring of a ship, doubling the ship, or covering her side with new wales and planks; the new planking of a ship, or giving her a new skin after the old planks are ripped off. The

shorter, ‘Souffler’ is sometimes referred to with the phrase, ‘Souffler les canons,’ meaning to scale the guns – ‘Scouffler un vaisseau’ (a ship), is to sheath a ship; to double a ship, when too crank, with new planks and wales (Dufief 1810, 46).

2.2 Who was using furring?

By looking at the similarity between fur and fourrer, there could be many suggestions as to its origin in both French and English. Fur in English could denote the metaphor of animal skin for example, to which one would layer to keep warm. However, that is not the purpose or intent of furring a ship. Nonetheless, this thesis is focused on the English furring, and so additional investigation into the origin of the ship refitting method, would prove useful in the understanding of furring overall.

It is clear by looking at various sources, even dictionaries of various languages, the word changes, but the meaning is the same; suggesting that the attempts of fixing a crank vessel by furring. It was a popular practice used by numerous European countries. It would indeed be worth further study in finding out which countries adopted this technique, and which country it originated from.

2.3 Where was furring being used?

By looking at the French word ‘Soufflage’, there have already been further nautical dictionaries from other countries found to have a word for furring. Perhaps the basis of new research should begin with the French term, rather then the English.

Language	**Word for ‘furring’**
English	‘Furring’ (Mainwaring & Perrin 1922)
French	‘Soufflage’ (Boyer 1764)
Spanish	‘Fórro’ (Newman & Baretti 1831)
Dutch	‘Tasse’ (Dufief 1810)

Sir Henry Mainwairing states in his definition of furring that, “I think in all the world there are not so many ships furred as are in England.” This could suggest that other countries did not need to rebuild this way as much, signifying perhaps that England had to fur ships more frequently due to failures in producing reliable ships. It may also suggest that furring was primarily an English rebuilding method.

Thomas Harriots explains in his manuscript that different shipbuilding traditions were adapted for the various geographical climates, allowing each country’s design and construction to vary. This could explain why perhaps the English shipbuilding tradition in particular succumbed to rebuilding ships after construction.

“… our English ships are intended to have such perfection, that (according to the intent of the builder) they hold burden with the Fleming; bearing with the Spaniard; going well with the French, &c … Every Nation aymeth at this: to have there ship go well and steer well. Which proceedith especially from the well weying of a ship fore & aft; for the Runne [that part of the ship’s bottom which rises from the keel and bilge and narrows toward the stern] and Tuck [the gathering of the ends of the bottom planks under the stern] … These are the chief propertypes of a ship in the sea. To go well; to steer well, and bear a good sail. As for the burthen that belongeth to the owners profit, which some to much affecting hath made us to have so many furred ships (Shirley 1983, 100).”

The English intention of acquiring as much knowledge about various countries shipbuilding methods could perhaps answer the questions (what caused cranked ships?). For when a shipwright adapted various methods of shipbuilding from other countries, there were compromises and repercussions in building such ships.

2.4 When was furring first documented?

Furring is a difficult method of ship refitting to research. It is incredibly hard to find sources that mention it at all: the method has only one archaeological example of its existence. That is why this thesis employs numerous definitions of the one word. It not only gives a general understanding of what shipwright's perceived of the method during the 16th century, which will show to be lacking in full understanding by some, but it also gives a rounder view of the actual process. Since no particular ships are mentioned in these definitions, nor accurate details and measurements of the process, only an overall analysis of the definitions in combination will bring to light the full understanding of what furring is exactly.

In English literature and sources of the 1500s and early 1600s many writers do not necessarily date their manuscripts or journals. Often times the date refers to the date of publication, and during that time manuscripts would be duplicated and copied, so to pass around as knowledge to various communities before surfacing as a published work. As Elizabeth Tebeaux from the University of Texas A&M describes, "only after 1640 in England did principles of ship design and construction begin to appear in print, and most of these combined navigation principles with concepts of shipbuilding and rigging (Tebeaux 2008, 14)." Tebeaux further explains that, "Shipbuilding 'texts', manuscript works prepared for use in shipyards […] were notebooks roughly penned and often highly technical (Tebeaux 2008, 5)."

During the early 1600s, the *Nomenclator Navalis* by Sir Henry Mainwaring had circulated the dockyards numerous times and according to Philip Barbour, who published Captain John Smith's exploits during that time, noted that Mainwaring "dedicated himself to writing a book for seamen that listed eight or nine nautical terms with hundreds of definitions." Many, including Smith have indicated that the earliest extent of Mainwaring's manuscript was written between February 1620 and February 1623. It is believed that during this time, a single

hand written copy was produced solely for the use of Sir George Villiers, 1st Duke of Buckingham, Right Honourable Marquis of Buckingham, Lord High Admiral of England, which was said to have been taken to sea with him on various expeditions, while the original was retained (Perrin 1922, 73). A more complete version of *Nomenclator Navalis* was thought to have surfaced around 1625, where nineteen years later it was finally published as *The Seaman's Dictionary*.

The Seaman's Dictionary, as it is more commonly known by historians and archaeologists today, appears to be one of the earliest English accounts describing the process of furring. This will be examined along with other dictionaries and sources that include the definition of furring. The publication date will also be looked at to indicate which of them was the first documentation of furring.

The most probable evidence of Mainwaring's dictionary being the first documented source is the fact that the majority of dictionaries and manuscripts defining the ship refitting process paraphrase Mainwaring's words. Some are reworded slightly; others include additional information on the subject. However, the basic knowledge of what furring was can be traced to Sir Henry Mainwaring's manuscript.

Mainwaring explains that furring is done by ripping, " … off the first planks and to put other timbers upon the first, and so to put on the planks upon these timbers. The occasion of it is to make a ship bear a better sail, for when a ship is too narrow and her bearing either not laid out enough or too low, then they must make her broader and lay her bearing higher. They commonly fur some two or three strakes under water and as much above, according as the ship requires, more or less (Manwaring & Perrin 1922, 153)."

This extract of Mainwaring's definition is used by other sources, which have actually stated or referenced it in their definition. It holds the majority of the desired description of the term, and it also explains the actual process that a ship

goes through to be furred, and why it is furred. After restating the above extract, some of the writer's add their own comments about the method, or simply rephrase into their own words. One wonders why they did not rephrase to begin with. It could be that the definition itself was so well written, that it was deemed unnecessary to change, or perhaps the understanding of the actual term, was not fathomed by the writer, who was accumulating their own terms for a seaman's dictionary. Nonetheless, the importance here is that those few that did write about furring, may have looked to Mainwaring's term for inspiration.

It is understandable that those who do not yet know what furring is exactly, or what it does to a ship, may perceive Mainwaring's definition as a bit confusing. The *Oxford Companion to Ships and the Sea*, published in 1994, gives another definition of furring, presumably somewhat cleaned up to modern understanding.

" … furring, is to rip off the first planks and to put other timbers upon the first, and so to put on the planks upon these timbers. The occasion of it is to make a ship bear a better sail, for when a ship is too narrow and her bearing either not laid out enough or too low, then they must make her broader and lay her bearing higher. They commonly fur some two or three strakes under water and as much above, according as the ship requires, more or less (Kemp 1994, 332)."

As may be noticed, there are no differences between Mainwaring's 16th century text, and the 20th century definition of the word. This is simply a method of misdirection of what is actually stated in the 1994 dictionary. Indeed Mainwaring's definition is quoted and referenced, but it is the overall text that helps the reader perceive what Mainwaring is trying to convey.

Tebeaux describes this as a sophisticated writing style in which writer's frequently used an oral style to convey terms and then launched into the description of how these objects were used. "One of the best example of the definition books is Sir Henry Mainwarings' *The Sea-Man's Dictionary*, which provides extended definitions of sea terms as well as derivative words (Tebeaux

2008, 14).” This does not confirm nor deny Mainwaring’s work to be the first documented source of furring, but it does indicate that the use of derivative words was necessary in order to define them.

Mainwaring’s oral style is quite unique from other definitions of furring, as it conveys a lot of emotion and personal opinion into the discussion. “… It is a pity that there is no order taken either for the punishing of those who build such ships or the preventing it (Manwaring & Perrin 1922, 153).” This aspect of the definition is not included in other writer’s works because it is Mainwaring’s oral style and each of the writer’s may wish to convey their opinions differently or not at all. It would seem quite irregular to publish a dictionary with such opinionated concerns over a type of ship refitting, but if it were not for Mainwaring’s fastidious descriptions, there would be no basis for understanding what furring did to a ship, and why it was considered, “an infinite loss to the owners and an utter spoiling and disgrace to all ships that are so handled (Mainwaring 1644, 153).” It gives a strong indication that furring was not a positive method of repairing a crank ship.

So not to leave readers in anticipation while trying to understand what the writer’s of the Oxford dictionary were trying to convey, the rest the text from the definition will be provided below.

“An old term in shipwrightry meaning to replank a vessel to give her more beam and freeboard […] Mainwaring’s strictures refer to errors in the original design of ships in that they were being built too narrow in beam and with insufficient freeboard to carry the amount of sail for which they were designed (Kemp 1994, 332).”

An extreme example of the paraphrasing of Mainwaring’s text can be found in Nathaniel Butler’s dictionary*, Boteler’s Dialogues* of which was first published in 1685, much later then Mainwaring. The reason this may be considered extreme is because of the introduction that E.G. Perrin, the editor of Bulter’s dictionary wrote to describe each section. Furring, found in the Fourth

Dialogue of Butler's dictionary describes similar phraseology to Mainwaring's. Perrin is very honest to point out that, "in its original form nothing but a crib from Mainwaring's Seaman's Dictionary […] that Butler does not openly acknowledge this would not be considered peculiar in that age […] but in process of copying from Mainwaring he has paraphrased his copy (either because he though it necessary to change some of the words to make the work his own, or from mere love of inversion), and thereby – to use a modern colloquialism – has given himself away; for it is abundantly clear after a study of original and copy that Butler was no Seaman, but one of the 'gentlemen captains,' and hardly knew stem from stern…(Perrin 1929, xxvi-xxvii)." Perrin goes even further to say that the majority of text that Butler extracted from Mainwaring's dictionary, was so inversed that the terms were literally lost in translation, however his definition of furring is understandable:

Furring "is performed by ripping off the planks, and putting second timbers upon the first timbers, and upon them again other planks. And all this is done to make a ship to bear a better sail (Perrin 1929, 92)."

Perrin concludes the fourth dialogue to be "of little independent value... (Perrin 1929, xxvi-xxvii)." This thesis will beg-to-differ in one aspect of Butler's definition describing another method of furring, which has not been found in any other definition of that time. This method, which will be mentioned in the next section, is to spike on pieces of timber along the main bends and wales to give a wall-raised ship form and more accurate buoyancy. Neither Mainwaring, nor any other writer mentions this method of furring.

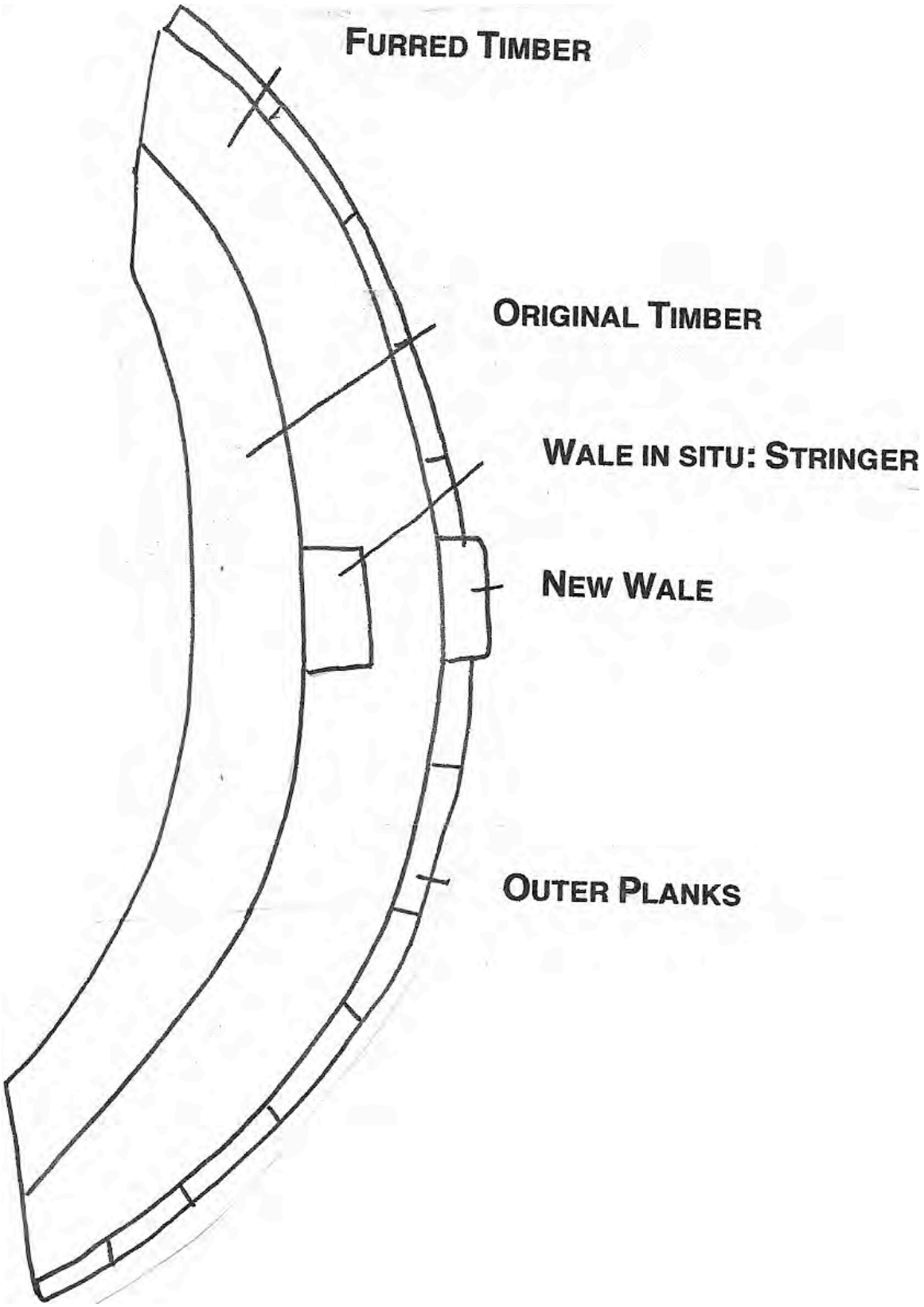


Figure 2: Frame Furring (Drawn by Cate Wagstaffe)

In *The Seaman's Grammars and Dictionary, explaining all the difficult terms in Navigation and the practical Navigator and Gunner: In two parts* (1627), Captain John Smith describes Furring in relation to a crank ship:

"If a ship be narrow, and her bearing either not laid out enough or too low, then you must make her broader and her bearing the higher by ripping off the planks two or three strakes under water, and as much above, and put on the Timbers upon the first, and then put on the planks upon those Timbers, this will make her bear a better sail, but it is an hindrance to her sailing, this is to be done when a ship is Crank-sided and will bear no sail, and is called furring (Smith, 53-53)."

Indeed Smith's work shows similarities to Mainwaring's in his definition of furring. However the curious aspect of Smith's work is the date the manuscript was published. Although there are accounts of the *Nomenclator Navalis* possibly circulating the dockyards in the late 1500s, this dictionary shows to be published seventeen years earlier. By looking at the two manuscripts, it is evident that Captain John Smith's definition is the first to be published, but again as indicated by both editors Everett Emerson and Philip Barbour, "Capt. Smith incorporated much of Mainwaring's material into his own tome "A Sea Grammar" which had a number of editions by 1699 (Barbour 1986, 91)." So it is clear that although there were various definitions of furring published prior to 1640, the circulations of these definitions surpass those dates and require more investigation into which of them began circulation first.

Although it may seem obvious that Mainwaring's definition of furring has been used more frequently then Smith's and Butlers, it is interesting to note that these three men have written and later published dictionaries comprising of nautical and seaman terms that can be flipped through like dictionaries of the 21st century. What is interesting is that these are educational platforms that were intended for public eye and knowledge about construction, design, rigging and navigation. From these three sources, it can be confirmed that Mainwaring is the

first documented dictionary providing the term and description of furring. However, as it may be suggested, dictionaries are far easier to come by, as they are duplicated and distributed in vast numbers. Bringing that into account, it maybe said in an overall analysis of when furring was first documented, that Mainwaring's definition might not have be the first after all.

It may be essential to go back to Tebeaux's point of roughly penned notebooks that observers in the dockyards used, as Matthew Bakers pictorial manuscript, for example, could, potentially be described as one of those technical masterpieces that was intended for personal use and was never published. Unpublished books and manuscripts are rare and one of a kind, this may suggest two things. First, that the writer's were using it for personal use, for example, a diary or journal, and so any personal writing about furring, would not be read easily by others. And second, if a manuscript or book is not published, it is not necessarily common knowledge, like a dictionary would be, so the discovery of such information about ship repair, would go unseen until discovery, or later publication.

Thomas Harriot's *Mathematical and Scientific Papers* comprise mostly of rutters, a form of recording nautical courses, anchorage, etc., as well as astronomical research. Within the several hundred pages or so, Harriot wrote various details about shipbuilding, rigging, divisions of loot between privateers, and of course the process of furring. This array of unsorted information was collected while he observed ship construction at the dockyards, and it would be considered a personal notebook in which he jotted down what ever he saw or thought interesting to note.

Harriots description of furring, unlike Mainwarings describes the process in which a ship is furred: "The furring of a ship is when she will not bear sail for want of breadth is to build her broader with outsides with timber and on the plumbs and thin board below and thicker upwards so far from below as is fit: and housing

it in upward to agree with the upper work by thinner boards again. Many merchant ships are fyne (found) to be furred (Harriot 1608, 33)."

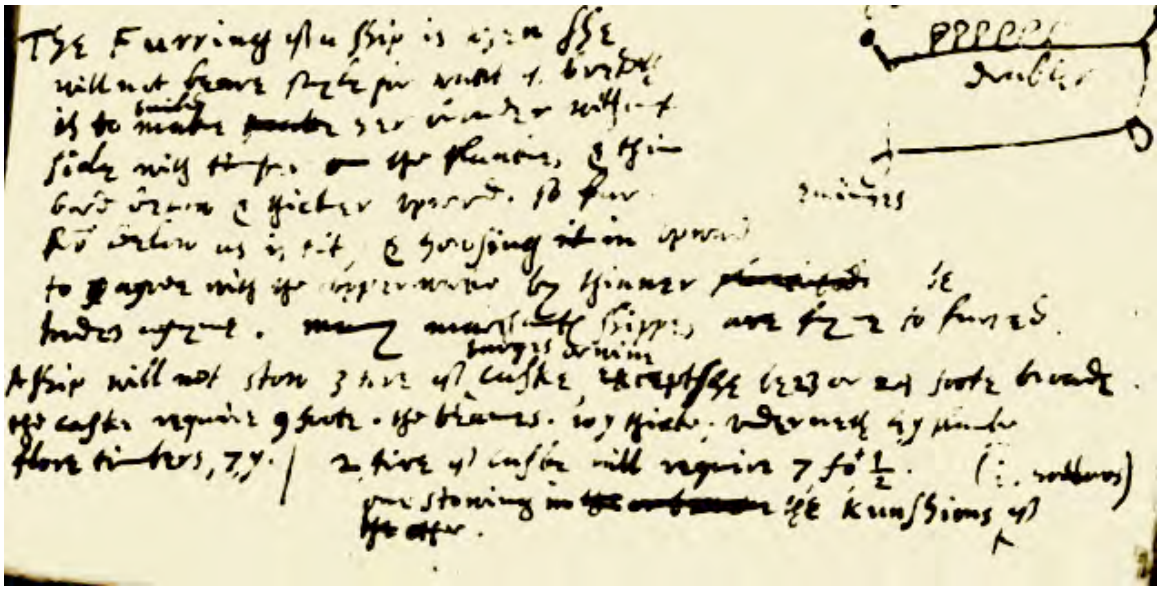


Figure 3: Thomas Harriot's definition of furring, *Scientific and Mathematical Papers* (1608-1610)

[John Shirley's transcription of the definition fyne/fayne = fine, may be misinterpreted. More likely the use of the word 'fine' in 16th century may well have been closely aligned with the irregular verb 'to find' (past participle 'found'). Harriot used the past participle, found, which can also be found in other literary evidence of the same period. For example: Sir Philip Sidney's (1554-1586) poem *Astrophel and Stella*, "Louing in trueth, and fayne in verse my loue to show, that she, deare Shee, might take som pleasure of my paine." If that is the case, then it is the second documented evidence that clearly shows that English ships, both merchant and naval, were furred.]

Harriot's manuscript, though not published, was written between the years 1608 and 1610. It is still not published to this day and is but one book out of six in which Harriot wrote through out his life. Even though Mainwaring's work has been rumoured to have circulated the dockyards anywhere from 1620 to 1625 as an unpublished work and later published in 1644, the earliest documented

account of its circulation is not known. Harriot's work would therefore appear to be the first documented account of furring.

In concluding this section, there have been many questions left unanswered. Out of the textual sources discovered, there has indeed been proof that Thomas Harriot's account of furring appears to be the oldest documentation. But, this is just an analysis of the documents that have been reviewed for this thesis. There are likely to be more sources published or unpublished that have not been discovered, which may hold more accurate details on furring, and there may be older accounts as well. The question of when furring was first documented will not only be subject to which countries used a particular rebuild method, but also the year ships themselves were being furred. Since the *Gresham Ship* was built around the year 1574, it is likely that manuscripts and dockyard notebooks existed during that time, which may hold information on furring. Whether those sources can be found, or still exist, would require further investigation into documentation of the late 16th century, which as this thesis has already stated, is a time in history when writing or documentation was not as necessary as sharing the knowledge orally.

2.5 Why was furring being used?

Furring is a method of ship repair, or to be more accurate, a method of rebuilding a ship after construction. The term 'rebuilt' can cause some confusion as it carries a different meaning in different periods. In the late 17th century and early 18th century a rebuilt ship was seen as a completely new ship, which adapted serviceable timbers from the original, and the name itself. Repair, or refits were considered 'great repairs' done to old ships.

In the 16th and 17th centuries however, a rebuild meant "replacement of decayed timbers, alteration of upper works, improvement of hull form or rigging, to bring the vessel's characteristics in line with current design (Nelson, 2001, 42)," and essentially the ship was still the same ship. The term rebuild in the 16th

century can be applied to the definition of a 'great repair' in the 18th century, which can cause confusion when discussing what was repaired, and what was rebuilt. (Nelson 2001, 42)

In 16th century rebuilds, "underwater lines could be altered by removing the planking and re-shaping the outside of the frames by packing with extra strips of timber called furring, or, if finer lines were required, by replacing individual frames or parts of frames (Nelson 2001, 42)." These rebuilds could change the speed and buoyancy of the hull and could effectively change the entire shape of the ship, but were still considered the same ship by the standard term. It is therefore imperative henceforth to use the correct term, that furring was a rebuild method and that the *Gresham Ship* was rebuilt.

In the Naval perspective, the reason for this confusing jargon was in fact meant to be a deceptive term. According to James A. Williamson who wrote *Sir John Hawkins: The Time and The Man (1970)*, explains that Elizabethan 'new-building' was created in the years leading up to the Spanish Armada to maintain the Navy at a fixed strength. Simply replacing old ships once they were worn out was more economical so that the old timbers that were retained on the new ship were still useful and not rotten. Williamson further says that, "the misleading continuity of the ships' names, and the retention of the phrase 'new-building' of such and such a vessel for what was really the construction of a quite different one (Williamson 1970, 343)".

Crank-sided ships

As mentioned above in the analysis of texts defining the term, furring was seen as a method created to fix a crank ship. But what exactly is a crank ship? The following section of this chapter will explain what a crank ship is and why furring was necessary to fix this problem. Furthermore, it is strongly believed that furring was simply one method of many intended to fix a crank ship, whether

rebuilding it, or repairing it. The other methods will be looked at along with the motivations behind having so many remedies.

In order to discuss what a crank ship is it is important to discuss what a crank ship meant to a 16th century shipwright. Instead of going into details about metacentre heights and scientific terms in shipbuilding, it maybe important to note that these terms did not exist until the late 1700s. To be as succinct as possible in a 16th century perspective, shipwright's knew that 'crank' and 'stiff' increased or decreased the roll of a ship. The ideal was in the middle – the metacentre, but this was not specifically understood as the metacentre, just simply, the 'Goldilocks Theory' of 'just right'. That is where the compromise or middle of buoyancy and gravity are correctly aligned or 'steady', in the perspective of a shipwright. "A ship, to be handy, steer well and fast under canvas, should be neither 'stiff', nor unduly 'crank' (Cusack-Smith 1886, 24)."

Crank, is a condition in which a ship becomes when it heels abnormally, and recovers slowly under the action of the wind. If a ship makes long slow rolls and takes it's time to resume a vertical position, it is called: crank, cranky, crank-sided, tender, or tender-sided. If the ship snaps back to its vertical position when heeled, it is called 'stiff.' Stiffness refers to a ships power to stand up to her canvas, and will offer great resistance to inclination from the upright, when under sail (Cusack-Smith 1886, 24). Although stiff is considered good in the case of many ships, there are extreme cases in which the vessel will be too stiff and resist the tendency to heel under wind pressure, and may cause damage to masts, rigging, and structure. According to Arthur Nelson, "most new Tudor ships were affected slightly on completion, one way or the other (Nelson 2001, 219)."

The reason why a ship may be crank cannot be summarized into one precise underlying cause, but rather anything that may affect the centre of buoyancy and the centre of gravity to each other – essentially anything that affects the ships stability.

The Stability of a ship will at any moment depend:

1. On her external form and proportions.
2. On her immediate comparative displacement and depth of immersion.
3. On the momentary distribution of her weights, as affecting the position of her 'centre of gravity' (Cusack-Smith 1886, 19).

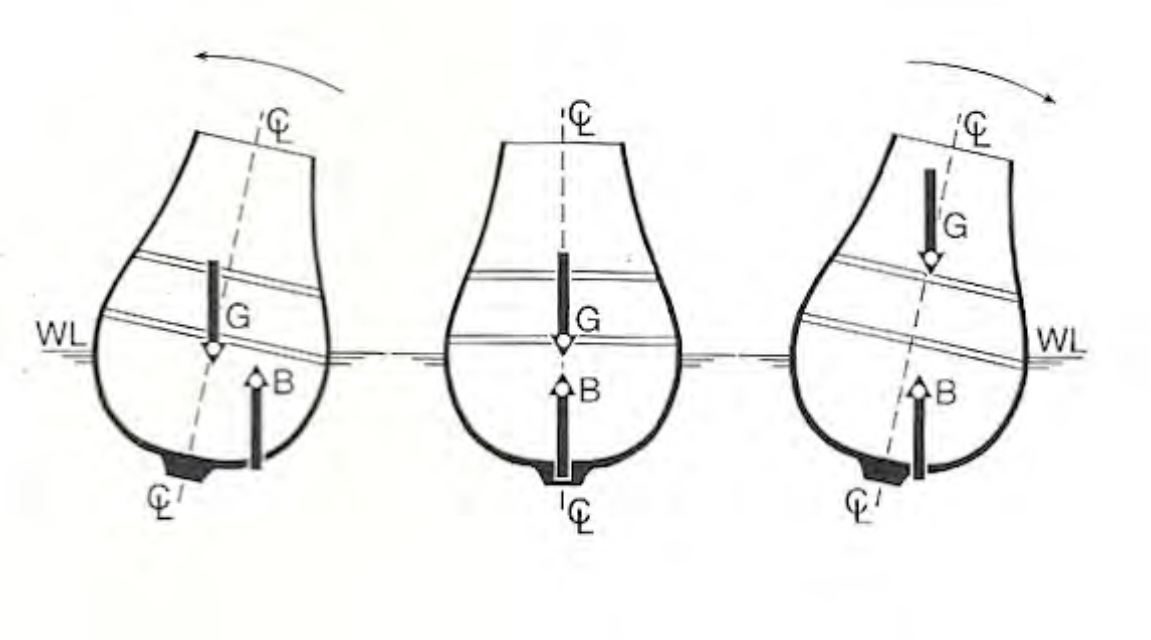
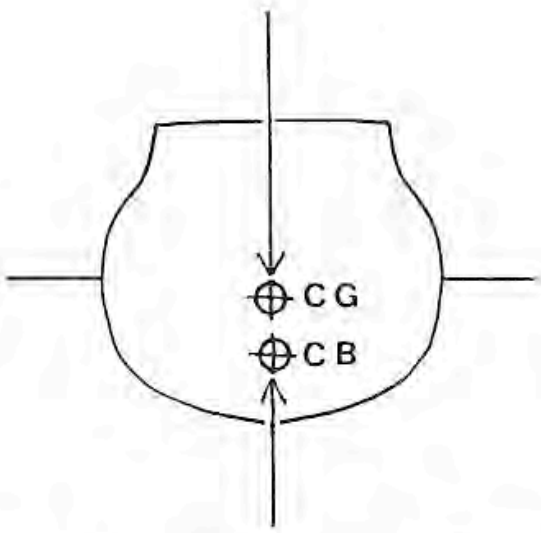


Figure 4: Stability is dependent on the position of two theoretical points: Centre of Buoyancy (B) and Centre of Gravity (G) (Nelson 2001, 219).

The summation of all the weights is an important aspect of the stability of a ship. Fixtures, fittings, masts, rigging, crew, ballast, etc., will have affect on a ships stability based on their individual moments about the centreline of the ship. These weights will act as a downward force on the vertical centreline (imagining a line drawn through the centre of the ship and the metacentre is the point in the middle). The centre of the submerged part of the hull, acts as an upward force on the vertical centreline, and so these two forces have to be balanced with the sea at the waterline of the ship when it is at rest.



Centre of gravity (CG) and centre of buoyancy (CB). The CG is the point where the gravitational mass of the ship may be theoretically considered to be concentrated. The CB lies in the centre of the volume of water displaced by the hull.

Figure 5: Seamanship in the Age of Sail, Harland 2009, 41

By looking at the various weights, distributions and contributing factors that may effect it's buoyancy, remedies can be attempted to solve what has affected the ships stability. In the case of the *Gresham Ship* (1574), furring was the chosen method to solve its crankness. Perhaps a look into various methods of solving a crank ship, will bring a fuller understanding into why furring was or wasn't the preferred method.

In the 16th century, many shipwrights built 'largely by eye, by flair or by rule of thumb' and as will be discussed in Chapter 3, this 'rule of thumb' has it's repercussions on the ships stability, often causing them to become "too high out of the water, crank, and cannot carry their canvas or work their guns in a seaway; that they will not steer, and sometimes, their sides are not of equal proportion the one to the other (Oppenheim 1892, 473)." John Shirley would later call rebuilding

and repairing of crank ships “a makeshift correction in poor ship design.” This, as many other writer’s, shipwrights, and scholars would agree, was caused by inaccuracy in building the ship.

When a ship was built, it’s launching was seen as a method of testing the ships stability, making sure it was sound and seaworthy. If a ship was found to be crank, it went through a sequential checklist, which either eliminated, or found causes, that would help determine its repair method. However as indicated by Arthur Nelson, a lot of times ships were seen as ‘sound’ and by age and decay of wood, would later become crank or tender-sided, requiring refitting and rebuilding. It is likely, however, that crank vessels of older age became so due to stability issues with the weights distributed on board. A crank ship that was built crank was a serious conditions caused by building the ship too narrow with insufficient freeboard. Other times however especially at the end of the 16th century, when larger ships were needed for defence, foreign trade, and longer voyages, more problems surfaced at the initial construction stage because of the unfamiliarity in concepts that inevitably affecting the design. For example the stability of a merchant ship used in calm domestic waters, would be substantially different from the same tonnage ship used in Atlantic voyages and armed to defend against pirates.

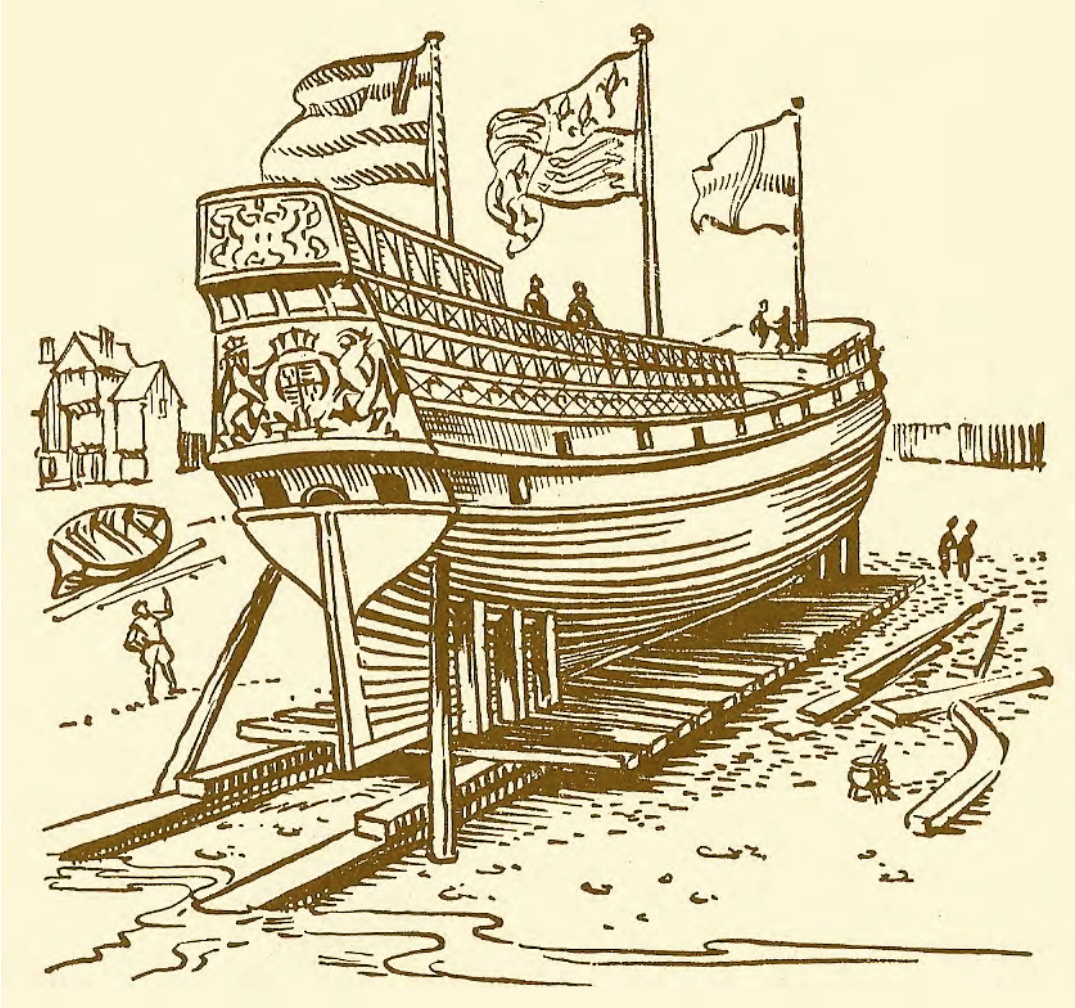


Figure 6: The launching of a ship in the 16th century was a way of testing a ships buoyancy (Robinson 1974, 45)

This thesis will argue that the essential reasons for various methods of fixing a crank ship were influenced by economic and political factors, which could impact the design. It is hard to draw a line between the merchant and navy dockyards without crossing over it to discuss shipbuilding methods. Most of the documents and correspondence were standardized in the royal dockyards, yet the *Gresham Ship* was a merchant vessel. With few sources describing the merchant dockyards process of construction and repair, naval correspondences will be used as a reference to that process.

A good argument would be to discuss the use of merchant ships for defence, as the *Gresham Ship* was an armed merchantman. The need to pursue

foreign trade, and to arm the civil vessels, which in their voyages the Royal Navy did not have enough ships to protect. Sir Westcott Abell says “all this in its turn led to the building of larger merchant vessels (Abell 1948, 29)”. So there is some correlating evidence that the political aspects of war affected the two dockyards equally. However, it is a logical assumption that the economical disadvantage of building those larger ships were that they required more money and time; as a small ship would cost far less and take less time to build or even repair. And so, the repercussions of such developments were already proving disadvantageous.

The economic aspect of shipbuilding would be a major factory in the deciding how a crank ship was refitted. This can demonstrate that either, merchant ship owners could not afford the most expensive or extreme method of fixing their crank vessel, or that the Navy dockyards had the time and expenses to practice the most effective method for the royal and military vessels. As this thesis describes the various methods, it will also look at the financial factors behind them.

Other repair methods

Minor repairs to a crank ship may include reducing the height of the mast, as the weight distributed above the centreline is too much and may cause it to roll or continually sit incorrectly in the water. By cutting an upper portion of the main mast, it reduces the weight, and the centre of gravity. Other options for repairing a crank ship included reducing or increasing specific weight distributions, depending on their moments about the centreline. In addition, a larger sail sheet for example, was considered minute in comparison to other methods, but it was cost effective to the merchants and sailors that could not afford bigger repairs like furring (Merriman 1949, 91).

Reducing the amount of guns on board can have a tremendous effect on the stability of a ship as well. They were considered one of the major causes of crank ships during the end of the 16th century and beginning of the 17th century.

As guns became a requirement for navy and merchant vessels, they were integrated into a ship after it's construction, there by effecting it's centre of buoyancy and adding immense weight above the waterline. One of the main reasons it was such a problem was because the guns were a new addition to a ship, and so the first tiers of guns were usually too high up the ships side to be on the main deck, surmising another method of repair by removing an entire deck from the ship to compensate for the stability and to keep the same amount of guns on board. The repairs and rebuilds during this time were centred on the amount of guns a ship could carry. If a ship was crank, quite possibly because of the weight and height of armament, different corrective methods were used to compensate. Once gun ports were being built into the construction of a ship, problems still surfaced as to a regularity of where exactly they should fit in the ship to maintain the stability (Nelson 2001, 42).

Ballast

The most popular and least expensive method of fixing a crank ship would be to add more ballast. Ballast, usually consisting of heavy materials like iron, lead, or most probably stone for the 16th century, was placed low in the hold to lower the centre of gravity and improve stability. In extreme cases like the Swedish Warship, *Vasa* (1628), there was no more room in the hold to distribute more ballast, which significantly weakened it's stability with the 64 guns sitting to high above the waterline. This caused the ship not to have enough weight below the centreline and far too much above. Some cases, in which ships were said to be too low in the water, were more often then not over weighted with ballast and had to have a quantity of it removed in order to steady the ship. This method was effective, but if a lot of ballast was necessary in order to fix a tender-sided vessel, as suggested by the repercussions of too many guns, it would cause the ship to sit very low in the water, decreasing her manoeuvrability and speed significantly. Another repercussion of adding a lot of ballast to correct the ship was the hold in

which the cargo was placed was substantially decreased with the ballast stones, leaving less room for actual cargo and goods to be placed on board.

More extreme cases of crank ships required the increase of beam. This allowed the upward force on the centreline to be lifted, giving the ship more buoyancy underwater. Increasing the beam required the rebuilding of a ship, as alterations of the hull form and upper works were necessary to make the ship become stable (Nelson 2001, 42).

Interestingly enough, when a ships hull was reshaped or altered, it was not only the hull that was adjusted, but also the masts, yards sails, and rigging, which were altered and enlarged. The problem in this was having too much weight acting as a downward force on the centreline. Like a scale, it has to be balanced on both ends to be steady and equal. So in order to adjust the upward force (the submerged hull), the downward force must be adjusted slightly as well. This will not be seen on archaeological remains today, as masts, sails and rigging are very rarely preserved. (Merriman 1949, 103)

Girdling

More permanently, key structural methods were utilized to solve this crank or tender issue. Girdling was seen as a popular method of fixing extreme cases of tender-sided vessels. Like furring it required doubling, but of extra planks fastened to the outside of the hull at the widest breath of the frames. It was considerably faster to do and cheaper then furring, which required the ripping off of all the planks, added the extra frames on top and then reassembling the planks again. For girdling, it was unnecessary to disassemble any part of the ships hull structure. Many documented sources use the two terms of girdling and furring interchangeably, but girdling was seen as a different method from furring, intended to solve the same problem. ‘Girdle’ comes from the word ‘belt,’ which sits around the waist. The same idea of a garment belt on a common sailor could

be applied to a ship, by placing a belt of timbers around her belly at the waterline, giving her more breadth measurement and so increasing stability.

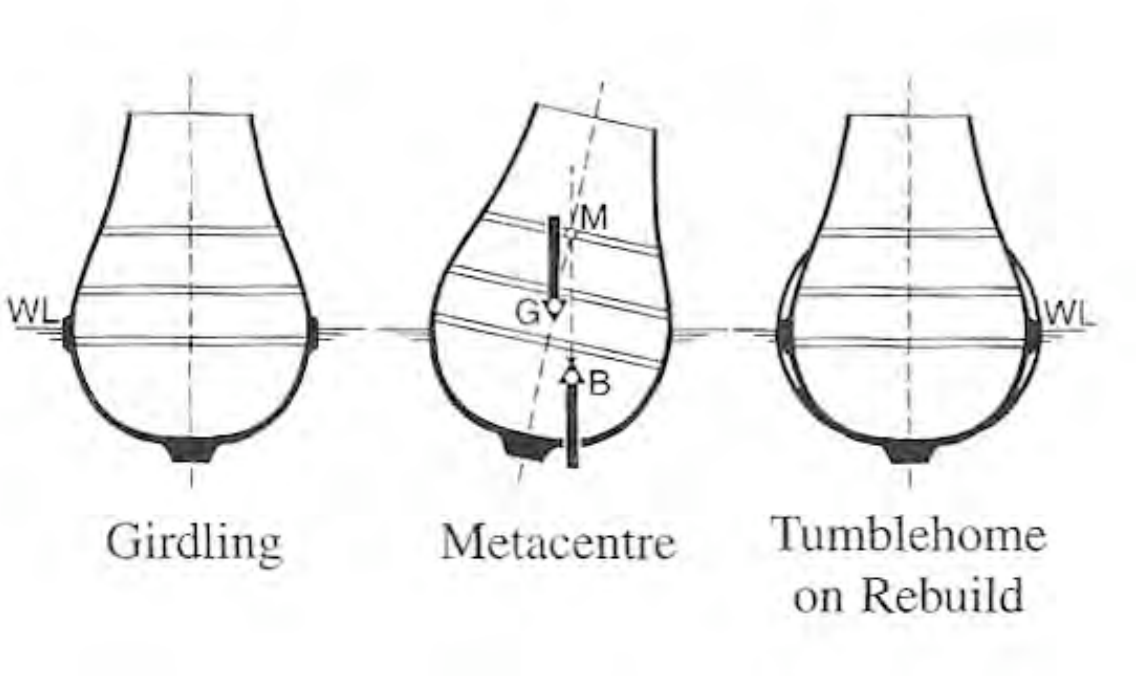


Figure 7: Girdling was a permanent repair method that consisted of extra timbers fastened outside the hull at the widest breadth of the frames, increasing the beam measurement, lifting B and giving more buoyancy (Nelson 2001, 220).

2.6 Case Study #1: *HMS Royal William*

In the late 17th century, a "long and contentious" series of correspondences between the Navy Board and the Admiralty on the various aspects of naval administration shows the process that the Chatham dockyard went through to determine a crank ships remedy. If a vessel was found to be crank-sided, it's owner or captain would submit a letter to the Navy Board in which he would describe the problems that have caused his ship to bear no sail. If the evidence was compelling and the ship was indeed found to be crank, a decision was then made as to the remedial process.

Exerts from the twenty correspondences will be looked at to possibly determine how the *Royal William* was found to be crank, and why girdling was

the method of repair chosen. It is interesting to note however that through out these correspondences, strong objects to the ship being girdling were expressed due to time restraints, lack of sawn fir and oak timbers available for the service, dockyards being full, and the said ship being seen as either too crank or not crank enough for the requirements asked by the Earl Of Danby, Rear Admiral of the Blue Squadron in her Majesties Fleet.

No. 27, Admiralty to Navy Board, January 26, 1693/4:

Gentlemen,

The Earl Of Danby, Rear Admiral of the Blue Squadron of their Majesties Fleet, having laid before this Board several reasons for a girdling of the *Royal William*, we send you herewith a copy of the same desire and direct you forthwith to consider thereof, and to report to us your opinion whether it is proper to be done, and if so, whether it can be completed [in] time enough for her going to sea with the Fleet.

[Endorsed]: - Reasons given for the necessity for girdling their Majesties' ship *Royal William*.

(I) Her foundation not being sufficient for her upper works 'twill be such an addition as will make her carry sail enough to work her, whereas she is now not able to do it.

(II) 'twill cause her to be more floaty and for that reason carry her guns better.

(III) That it will make her a more circular body and consequently work much better.

(IV) That she will sail better, because her straight side being made circular she will carry a great deal less dead water.

(V) That it will make her almost shot-proof between wind and water and consequently not in so much danger of being sunk. (Meriman 1949, 87-88)

This exert from the beginning of the series of correspondences indicates the presence of a standardization in the dockyards. To submit a list of problems with ones ship demonstrates not only what is wrong with the ship specifically, but also what methods of repair can be drawn on to solve them. In the case of the *Royal*

William, it was first suggested by the writer's of the very first letter in the series that the ship should be girdled.

The correspondences following continue to talk about the time restraints and conditions in which the ship should be girdled. When a ship is girdled, there is no consistency at this point as to how much wood is applied. This may vary significantly depending on the issues with the ships buoyancy. Calculations can then be made as to how much wood is required.

First. The difference in gravity between sea-water and fir timber of equal bulk.

Secondly, the difference between the squares of the half breadth of the ship now, and the same with the addition of the girdling proposed.

For the First: a cub. foot of sea water is held to be 64lbs. weight. A cub. foot of fir timber do 34lbs. weight. Therefore every solid foot of wood will bear in salt water 30lbs more than its own weight and not otherwise.

Which granted:- In a girdling containing 12 strakes 14" broad, 8" thick: Wrought in proportion from the midships fore and aft by due method of calculations, will float about 12 tons of dead weight and will bear up no more of the whole weight of the ship than 12 tons of cask might do fixed to the same body under water. (Meriman 1949, 89-90)

Intermediately through the correspondences, furring is mentioned as a preferred method, which would evidently solve the problems of the *Royal William*. "… this is humbly to lay before you a copy thereof, whereby your Honours will be informed that it is their opinion a girdling may be well laid and substantially fastened on her, but will not finish so well as [to] the furring (*sic*) as on those that are not doubled, and that the undertaking of the said work at this time of the day (if there were no other argument against it) would break all their measures and not only delay the said ship but cast the Duke irrecoverably behindhand (Merriman 1949, 92)." It is evident from this correspondent that furring was not the chosen method of fixing the *Royal William*, because a lot more time would be required to fur the ship, however it was seen as a permanent method that would

no doubt fix the problems mentioned in the very first correspondent, but the Duke was strenuously concerned for the ships completion in time for the fleets departure.

Furthermore, March 4th of 1693 (one of the last correspondences in the series), an extract from the Navy Board Minutes was taken. The transcript is an interesting aspect to the process of refitting the ship, as it appears to be a series of questions to three of the officers who serve on board the *Royal William.* These questions were asked pertaining to the first letter sent, describing the conditions in which the ship was crank. It appears, the investigation behind this transcript was intended to find out how crank-sided the ship was, and how long she had become so.

The Boatswain, Carpenter and Gunner… who being called in were asked: -

(I) How the ship bore sail the last year. To which they answered that she carried sail as well as most of the other great ships, and her guns as high from the water.

(II) How she wrought, and particularly in staying and wearing. To which they answered that she missed staying sometimes, but others (and particularly the *London*) did so too. That she was a little unruly coming up, but it blew hard, so that it was not to be wondered at. When she would not bear up in the Downs, there was a flood tide, her head to the eastward, the wind S.W. and but 12 or 13 inches by the stern.

(III) How she sailed with regard to other ships with the same sail aboard. To which they answered that she sailed heavy, and not altogether so well as she did the year before.

(IV) What draught of water she had. They answered twenty-three feet eight inches when Sir Cloudisley Shovell was in her, and about twenty-three feet last year.

(V) What quantity of ballast was aboard her. They answered: - about four hundred tons.

(VI) How she sailed at the latter end of the year when it was supposed she might be lightened. They answered – much the same as before, the cask being filled with water as fast as it was emptied, so that she was not lightened.

(VII) Whether she was tender when Sir Clowd: Shovell was in her in the year 1692. They answered that they had very little trial of her that year, and that is she was a little tender they resumed it proceeded from her being so deep, though they had little reason to judge she was so, more than that in Rye Bay, lying thwart the tide in a storm of wind, the water flapt *(sic)* in at her lower ports, from whence they imagine that report chiefly arose.

(VIII) What guns she had on board. They answered – one hundred and six, and that six of them, of 14 cwt. each, were upon the poop and four in the forecastle, two of which were of 32 cwt. each and the other two of 20 cwt. each.

(IX) Who was the pilot that brought her about from the Downs last year. They answered – one Cheeseman of Rotherhithe. (Meriman 1949, 100).

Upon completion of the questions, the writer of the minutes continues to express his motivation behind the inquiry, suggesting that five or six hundred yards of canvas had been taken out of the *Royal Williams* sails the previous year. By inquiring upon these three officers, the truth could affirm this and that the ship was not crank, however in actuality only eight yards were taken out. It was then confirmed that the ship was indeed crank and that she was to be girdled with eight-inch stuff.

It was suggested in one of the correspondences that the *Royal William* may have already been doubled, but it did not stress in detail what sort of doubling it may have been. It is possible that some attempt at temporarily expanding the beam was put in place, which would have required annual repairs to be kept in working condition. Under the last section, No. 27 (s), objections were noted, trying to prove that girdling and enlarging the ships masts and sails would not answer the expectations that the Earl of Danby expected for it. The objections, of which appear in different hand writing then the others and are assumed to be

written by a Edmund Dummer – Surveyor of the Navy, suggesting reasons why girdling was a bad idea.

The idea in girdling the *Royal William* was to give her a greater breadth in the midships, to make her more circular, and to make her move faster through the water. According to Dummer's objections, the ship was probably crank-sided as suggested, meaning she did not sit vertically in the water. However, other circumstances such as her 'not bearing sail' and her hull sitting to low in the water which slowed her down significantly, were not caused by her crankness, but from extenuating circumstances that caused her to appear to need girdling. The reasons he gave, where that there were less sheets in the sail then the previous year and that there was too much ballast. By simply solving these problems, girdling would not be required.

Dummer goes further to suggest what would happen if "a very good ship" were to be girdled, and the repercussions of doing so. The *Royal William* was believed to be doubled, although the correspondence themselves do not explain in detail what kind of doubling was used. According to Dummers objections, the ship was "chocked out 6" of a side with dead wood". This can either mean the ship was previously girdled, of which Dummer repeatedly uses the phrase, "former girdling", or perhaps it was the third method of furring of which pieces of loose timbers were assembled to and around the turn of the bilge. Dummer says that by having this 'former girdling' in place, the new girdling would weigh the ship down significantly and render her more crank (by overpowering her body below) then she was already. Dummer also explains that in the process of girdling a ship, long bolts are fasten all along the ship creating holes which must be bored and would add to the multitude that are already there. These long bolts "as going almost quite through the whole work, will add so great a weight as I verily believed will sink her as much, if more, than her girdling will lift her." This suggests that by girdling the ship, it would counteract what was desired and would only further crank and weigh the ship down.

Dummer also presents an interesting statement in which he says, “it is experimentally found that the thickest part of a ship first rots, and consequently that prodigious thickness this ships side will be when a girdling is added to her former doubling will inevitably occasion a very speedy decay of all the timbers, planks and trenails contained within it (Meriman 1949, 102).”

Edmund Dummer writes these objections to prove the first complaints of the crank-sided *Royal William* to be groundless, and that the notions of her problems stated in the first correspondent were in fact false. His sharp vocabulary directs attention to the repairs of crank vessels as being ‘present evils’ that should be remedied, explaining that the present service done to the ship, whether she be girdled or furred for that matter, should not have been done.

This thesis will argue in favour of Dummer’s objections in that the circumstances surrounding the girdling of the *Royal William* were acted in haste. In accordance with the ship departing with the fleet, perhaps a few steps in the process were skipped, and as mentioned above in the correspondences themselves, “the safest and surest method to make this ship properly useful is to do with her, as with weights on a scale, to remove from the one to the other till the balance is more even (Meriman 1949, 91).” It would appear that scaling the ship, did not take precedence over her departure time and if steps were taken, as Dummer implies, the ship may have been remedied and girdling would not have been needed.

The letters in the series stop there, raising questions as to how effective the girdling was upon completion, and whether the *Royal William* should have been furred, as previously suggested or simply adjusted to suit a more accurate balance of weights and sails. It would appear that furring was not needed and that they only resulted in girdling to avoid time taken to adjust the stability. Brian Laveny would later write that, “very few ships were girdled after the *Royal William* (Laveny 2000, 61).” Possibly because the whole situation surrounding the *Royal*

William's demand for girdling was seen as a mutual antagonism that hampered the naval administration, or the grounds for her complaints were false, not only causing a rift between the Navy Board and the Admiralty, but also between what should be done to a ship found crank.

Brian Laveny explains that "very few ships below the Third Rate were treated in this way", which raises questions as to the procedures taken in the merchant dockyards. If there was no standardization, perhaps an argument can be made for the fact that ships were being girdled (and furred) without proper understanding of what was causing the tender-sidedness and that merchant dockyards may have experienced the same problems.

Furring, mentioned only briefly in the correspondents as an alternative method to girdling, was seen here as a time consuming, money spending method which would be adapted if either the ship was extremely crank and required a vigorous reshaping of the hull, or if time was available for the pursuit of a permanent solution to a ships stability shortcomings.

Although the above discussion on girdling the *Royal William* seems untoward in respect to the theme of this thesis on furring in the 16th century, it demonstrates a comparative analysis of how a crank ship was (possibly) fixed. The same process could arguably be applied to furring a ship, though with considerable awareness of the fact that furring was a rebuild method that required much more time, money and work. It can still bring immense insight into the procedures that were taken when repairing and rebuilding a ship.

Plank-upon-plank furring

In Mainwaring's definition, there are two types of furring described. One of them has already been mentioned, as it was the particular method chosen to rebuild the *Gresham Ship*. The other one "is after a ship is built, to lay on another plank upon the sides of her, which is called plank upon plank (Mainwaring & Perrin 1922, 153)." The confusion between girdling and furring is evident here, as

girdling requires the doubling of the planks. In the case of the plank-upon-plank furring, doubling of the planks is also required. So why the two names for the same method? What is the difference between girdling and plank-on-plank furring? And furthermore, what is double planking in relation to girdling and plank-on-plank furring?

In fact, as previously mentioned, girdling only requires the doubling of a strip of planks around the belly or waterline of a ship. How big that strip is, is dependent of how tender the sides of the ship are. Plank-upon-plank furring would suggest the doubling of planks not just around the waterline of the ship. As indicated in the *Royal William*, calculations were surmised in order to determine how much weight these doubled planks would have on the ship. It would not be a grand assumption in presuming plank-upon-plank furring had a much heavier effect, significantly weighing a ship down; the more additions to the upper works and hull shape, the more weight acting on the centre of gravity and centre of buoyancy.

The majority of texts and sources describing furring, focus mainly on the frame-upon-frame furring method. If plank-upon-plank furring is mentioned, it was copied from Mainwaring's dictionary. Out of the sources pertaining to furring (Thomas Harriot, John Smith, Nathaniel Butler, Sir Henry Mainwairing, and texts acquired from modern day sources such as Peter Kemp's Oxford Companion), only one particular source has originally identified what plank-upon-plank furring is: Mainwairing. This would be surprising to point out, as Thomas Harriots manuscript has been indicated as the oldest source, however Harriot only mentions furring to be a double framing method. Butler mentions plank-on-plank furring but acquires his knowledge of the method from Mainwairings manuscript. Smith primarily mentions frame furring in relation to crank-sided vessels, and the modern day Oxford Companion, copies from Mainwairing's text again. What does this suggest?

It could indicate that plank-on-plank furring was indeed a method that did exist near the end of the 16th century and beginning of the 17 century, but perhaps became obsolete through the years, as money and resources were focused on more effective and quicker ways of solving crank vessels, such as girdling. There is also the suggestion that perhaps plank-on-plank furring was not an English method of fixing a crank ship, and that these ships receiving the treatment, were likely influenced by other countries techniques. Indeed one argument may be that furring could have been a French adaption of solving tender-sided vessels.

It raises the question, stated above, what are the differences between girdling a ship and plank-on-plank furring. It may also be further expanded into double planking and other forms of hull modification. The similarities between these could perhaps highlight an understanding into why plank-on-plank furring is rarely mentioned, and why these terms are used interchangeably.

Schematics of each process would clearly explain the difference between how much more wood was needed to turn a girdled ship into a plank-on-plank furred ship. These are not currently known to be available, however, by using reasonable understanding, an argument can be made. This thesis will argue that girdling, plank-on-plank furring, and double planking, are not the same methods of correcting crank ships. The following evidence should support this argument.

Plank-upon-plank furring was suggested as a repair method in an archaeological discovery. In 1628, the Dutch East India Company (Vereenigde Oost-Indische Compagnie, VOC) built the *Batavia*, a 24 cast iron gunned vessel. The famous story surrounding the *Batavia's* surmise on 4 June 1629 is based on a mutiny and massacre that occurred among the 320 survivors of the wreck. It's importance to the discussion of girdling and plank-on-plank furring, centres around the *Batavia's* hull construction and design. According to Patrick E. Baker

and Jeremy N. Green's article on the *Recording techniques used during the excavation of the Batavia,* the ship was found to have plank-on-plank furring.

The discussion arose when details on the general underwater recording systems for the timbers were explained, in that the difficulty in accurately cataloguing the various timbers amounted to a layering system in order to code each timber. The confusion would lay in the fact that the *Batavia* is believed to not only have double planking in the furring kind, but also thin skin on top, as well as sheathing; an array of layers which no doubt needed coding in order to understand the structure and layout of the remains *in situ*.

Although the article is persuasive in it's argument for plank-on-plank furring, it does not mention any measurements or calculations of these doubled planks. Research today on the remains of the ship have concluded that the *Batavia* was in no way plank-on-plank furred.

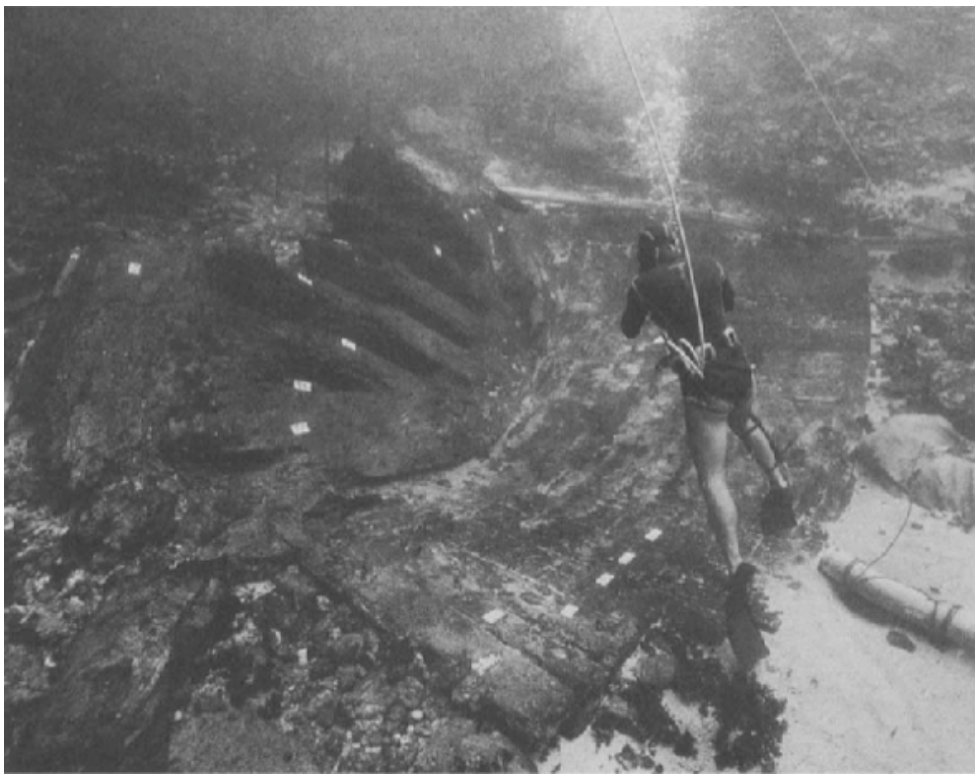


Figure 8: Batavia site (Baker and Green, 143)

The *Batavia* is an example of two construction processes. First, is that the double planking was part of it's original construction, which is confirmed by the fact that her last voyage was also her maiden voyage. There was no time for post-launch repair. Furthermore, this is also proven by the fact that the ship was not old enough for reinforcement on the hull, as rebuilding and furring would be applied shortly after the construction. Secondly, the double planking is what is known as sacrificial planking or more commonly referred to English documents of this period as sheathing, a protective rather then a corrective layer. In addition, a third layer of thin fir or sheathing was placed on top of the doubled planks to ensure full protection of the hull. When the sheathing wore away, it could easily be replaced without the worry of damage to the other layers of planks. Girdling and furring are alterations done to the original structure, where as double planking, in the Dutch tradition, would emphasise doubling during the construction process rather than after (Hocker 2004, 83).

The reason why *Batavia* was not plank-on-plank furred is that it was built in the VOC tradition, in which double planking was incorporated into the original construction. Wendy van Duivenvoorde describes this as a bottom-based construction method characteristic of 16th and early 17th century Dutch shipbuilding. It incorporates two thick layers of oak hull planking below its waterline, which could very easily be mistaken for girdling or plank-on-plank furring, as they also require two thick layers of planking. For the VOC, the intent of double planking was not post-construction repairs, but a pre-construction focus on the ship's strength and waterproofing. This allowed more protection against teredo molluscs (shipworms) and other exterior factors that may weaken a wooden hull. On top of the two layers of planking, other layers were added consisting of pine sheathing, oak ceiling planking, and an inner pine floor that protected the lower sections of the hull. The combined thickness of the double planking was 18cm, which would rule out both the methods of girdling and plank-on-plank furring as well, as the planks used would have to be much thicker than

that used for sheathing. This “double-dutch solution” was initiated for the reason of longer voyages into environments that may require more protection on the hull (van Duivenvoorde 2009, 67).

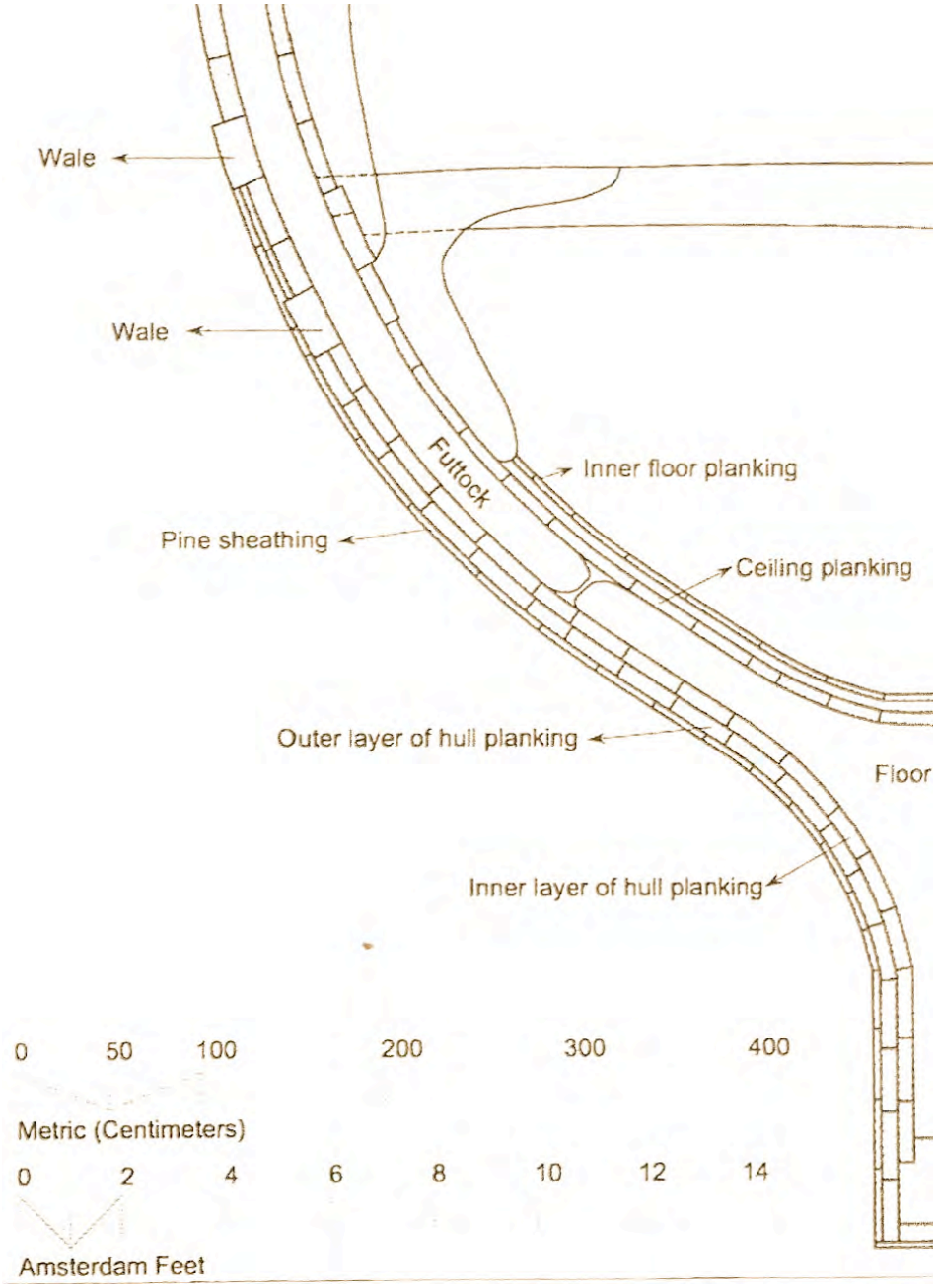


Figure 9: Batavia’s bottom-based hull construction: layers of planking and frame timbers, a VOC tradition and not plank-upon-plank furring (van Duivenvoorde 2009, 64).

This misuse, of the terminology has caused historians and archaeologists to use terms such as ‘double planking’ in a colloquial sense, which only further damages the understanding of what it actually is, and what it does to a ship. By using groupings and classifications such as double planking and furring (of which there are three kinds), there can be ‘ambiguous intertwinement’, which will cause further confusion. One archaeologist may be able to explain perfectly, the concepts of doubling planking in the Dutch tradition, but may not be able to accurately perceive the purpose of girdling or plank-on-plank furring in the English fashion. (Maarleveld 1995, 3)

In John Hawkins voyages he uses the term double planking, but in two different contexts. He talks about the sacrificial planking required to sheath a ship and that some ships are “so eaten, that the most of their planks under water have been like honey combs, and especially those betwixt wind and water (Hawkins, 203)”. He continues to say “another manner is used with double planks, as thick without as within, after the manner of furring; which is little better then that with lead.” Hawkins explains four different kinds of sacrificial planking, which includes double planking and furring [plank-on-plank] as similar methods to a form of sheathing against shipworm (Williamson 1970, 203).

Perhaps the jardon-ridden terms for classifications have dated back to the 16th century with people like Hawkins and have never fully been understood as being one precise definition, as the editors of Sir Henry Mainwairing’s first volume succumb to while identifying girdling and furring. The mistake, or perhaps unidentified differences between them, has required quite a lot of additional interpretation for this thesis, as many sources would term furring as girdling and vice versa. Perhaps in identifying which furring out of the possible three methods they were referring to, is the issue. If plank-on-plank furring was mistakenly used as a definition of girdling, the comparison may be understandable, as they both require the doubling of planks externally. But if frame-on-frame furring is mistakenly used as a definition for girdling, then the comparison is lost – as they

cannot accurately be used to mean the same thing because effectively one is horizontal and the other vertical.

To illustrate this, in Sir Henry Mainwaring's first volume, there is a catalogue of defected ships, which required either the rebuilding or repair of them. The Mary Rose of 1623 (not to be mistaken for Henry VIII's flagship built in 1509) was on the list and described as: "Tender sided, hard of steering, and said a slug of a sail. She hath been **furred and girdled**, and lengthened abaft with a false post and false keel (Manwaring 1920, 157)". It would be very unconventional and extremely expensive to give a ship a double dose of rebuilding. To girdle and to fur a ship raises many questions. What kind of furring do they refer too? If, as this thesis has suggested, a plank-on-plank furring was used, then perhaps the editor did not know which double planking was used and forwent the conclusion of using both girdling and plank-on-plank furring. If however, the ship was frame furred and girdling, it would seem an overly extensive process to use two methods internally and externally, in solving the same problem of her tender-sidedness. (If this was the case, then it was one seriously messed up ship.)

Third method of furring

A third method of furring has been indentified, however this method can only be found in one source, and that is Nathaniel Butler's dictionary. Along with plank-upon-plank furring, there is no record of this type of furring being used on a ship, nor in other sources to indicate it's popularity and particular function or outcome on a ship. It may be possible that furring is an incorrect term used for this type of repair. Nonetheless, there has been no further definitions found to explain this type of furring more fully, only the following text from Butler's dictionary can explain what it is:

"To which end also, especially if the ship be anything wall-raised, that is, raised out straight up, they use to spike on some thin timbers or narrow thick planks all

alongst her main bends and wales; which adds somewhat towards her better bearing though not much (Perrin 1929, 92)."

When Butler uses the term 'wall-raised' he is referring the former term of 'wall-reared', which in later 18th and 19th century dictionaries is called 'wall-sided'. Wall-reared is also defined in the *Boteler's Dialogues*:

"*Admiral*: What mean you when you say a ship is wall-reared?
Captain: Of this I spoke somewhat formerly, and even now I made mention of a ship being housed-in (after she is past the breadth of her bearing, she is brought in too narrow to her upper works, and this is called pinched-in as well as housed-in – today referred to as tumble-home), in her upperworks; quite contrary to which when a ship is built over-right or directly up, after she comes to her bearing, she is said to be wall-reared; the which thought it be unsightly, and as the sea phrase is, not shipshapen, yet it causeth a ship to be very roomy that is large within board, and withal makes her a wholesome ship (when a ship will hull, try, and ride well) in the sea, especially if her bearing be well laid out (Perrin 1929, 96)."

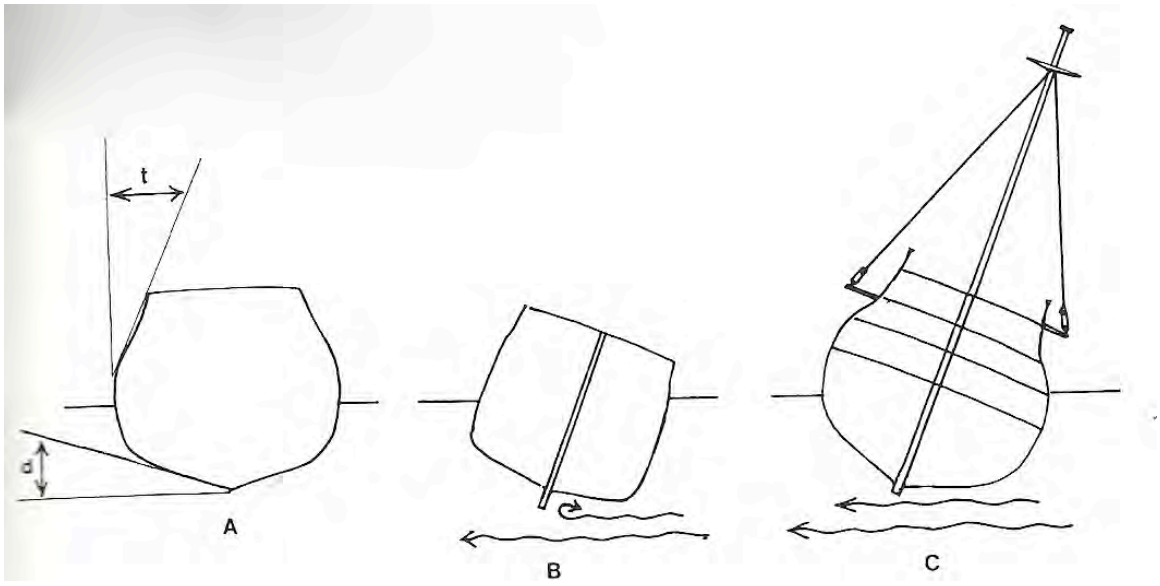


Figure 10: (A) shows deadrise (d) and tumblehome (t). (B) shows fairly flat floors and little tumblehome (wall-reared). (C) shows a warship hull with greater deadrise and much tumblehome/pinched-in/housed-in. (Harland 2009, 45)

When a ship is constructed, its hull is built with a very pronounced tumble-home, making the width of the upper deck considerably less than that of the main and lower decks. A tumble-home is “the amount by which the two sides of a ship are brought in towards the centreline after reaching their maximum beam (Kemp 1994, 896).”

From what Butler describes, some ships may have been built without a pronounced tumble-home, or “not laid out” enough, causing them to be perpendicular to the surface of the water, like a wall. If that was the case, then perhaps this third method of furring was introduced as a cheaper method of furring or girdling (could potential be either one). By spiking on timbers and planks of various thicknesses and various locations where the tumble-home should be pronounced. According to Peter Kemp’s dictionary, warships required a tumble-home to accommodate the main and lower deck guns “which were much larger than those mounted on the upper gundeck and needed more space for the gun crews to work them (Kemp 1994, 896).” Ergo, if the ship was ‘wall-sided’, a much less stable situation could result, especially with the guns, if in the run-out position, “hanging over the seas, as it were (Harland 2009, 44).”

According to Butler, this ‘furring’ process of spiking on timbers may have added to the ships better bearing slightly, but not to the desired effect. This may simply indicate that using this method to widen a ship really was the “you get what you pay for” method, a dirt-cheap form of girdling.

It is curious that furring is a term meant to describe three different methods of rebuilding and repair. Other methods such a girdling and sheathing are terms that define one method. (Although it may be argued today that girdling and sheathing were seen as the same thing in the late 18th century). Most dictionaries and sources defining the term furring regularly refer to frame furring and not the other two. This suggests that ‘furring’ may also be a term subjected to colloquial inversion, which simply means ‘to fur’ as the above section describing its French

translation means ‘doubling’. This could perhaps signify why three types of timber doubling are called the same thing. The fact that Mainwaring and his avid followers, including Smith (*The Seaman’s Grammars and Dictionary, explaining all the difficult terms in Navigation and the practical Navigator and Gunner: In two parts*, 1627), and Butler (*Boteler’s Dialogues,* 1685) refer to the second method of furring by stating, “the other, which is more eminent and more properly furring… (Mainwaring 1644, 153),” clearly suggests that out of the three types of furring, frame-on-frame is the most correctly suited to the definition. Obviously this raises questions about the other two. Are they indeed furring, or perhaps one was the earliest derivation of girdling, and the other a cheap cost-effective method that died out of service. Either way, according to Butler, all three methods of repairing a crank ship are called furring.

This chapter shows a mere fraction of the knowledge about furring through the insight of other repair and rebuild methods. By looking at methods such as girdling and double planking, a clearer picture emerges about the differe processes that occurred both pre and post construction in ship refitting. This will include the Navy dockyard standardization in the later years of the 17th century, as well as the problems that arose when a perfectly good ship was to be girdled or even furred. What is more surprising is the aspect of the misuse or misinterpreted vocabulary in English society in the 16th century as well as present day research on the subject. This has shown that ship repairs and rebuilds during this period are misconstrued areas under discussion in English history and archaeology, that would be more fully understood by standardizing the definitions of the terms to describe it. By looking at when manuscripts were first published or not published at all, and looking at the definitions themselves, it is clear that any further discussion on this subject, may have to go back to the beginning for clarification. However, in understanding where terms originated from and where methods of repair originated from, perhaps the beginning is not so far away. The question then asked could be, why the discrepancy and confusion of terms and

definitions? Perhaps, it began in the beginning and was never fully understood. Each shipwright defined repairs and rebuilds based on their regularity in their industry or dockyard. In the next chapter, shipwrights will be looked at, in light of the misunderstandings of the late 16th and early 17th century shipbuilding fraternity, who used these terms.

Chapter 3: The doubling standard

This chapter's main focus is to understand how and when shipwrightry changed from art to science. This thesis will argue that there was indeed an artistic rather then scientific approach to the building of carvel ships, which in turn led to the repairs and rebuilds seen in the previous chapter.

The word *science*, which will be used throughout this chapter, should not be interpreted as the science of today, nor of the scientific principles seen in the 18th century with shipwrights like Fredrick Chapman. The science this chapter will discuss, relates more to the geometric principles seen in its infancy at the beginning of the 16th century. And although Phineas Pett and Matthew Baker may be perceived to know geometric principles, one as much as the other, this following chapter will provide a case study in which Phineas Pett ventured from the simple geometric understandings that Baker was using, into a more pure geometry of ship design.

HMS Prince Royal, built in 1609-1610 by Phineas Pett at Woolwich became the subject of an enquiry in which accusations were placed on how the ship was built. This was the first major ship built by Phineas, although he had completed a rebuild on HMS Merhonour (1612-1615), which was originally built by Matthew Baker in 1590. One shipwright re-building another shipwrights ship could be contentious in itself, as it could quite possibly account for the tension and rivalry that Baker and Pett constantly had.

Various documented sources have looked at some of the problems that may have surfaced during the enquiry. The issue with this is that there are so many hypothesis as to what was actually wrong, that it is unclear what was the true cause and what was if perhaps just speculation. Accusations directed at Pett included: furring the ship, girdling the ship, using unseasoned timber to construct her, using rotten wood to construct her, and cutting entire decks off the ship to solve problems already being observed during the first stages of the construction.

Another theory that historians have suggested, is that there was nothing wrong with the ship at all, simply jealous shipwright rivals who invented the accusations to destroy Petts successful career. If the last one is the case, it would again pose interesting questions as to why furring was seen as such a bad method of repairing a ship, as here it was clearly being used as a blacklisting method. It also displays a cruel and competitive aspect behind shipwright's motives and influences in the shipbuilding fraternity. All these aspects will be touched on in the following pages of this chapter and will continually demonstrate the art behind shipbuilding during this time and the developments that ushered science (as in geometric principles) into the equation of ship design.

3.1 Early 16th century motivations and innovations

During the 16th century, England saw dramatic changes in the design and construction of ships. The catalyst for such a change began with the carvel or frame first ship, which England adopted as the main construction method, replacing the clinker-built ships that were produced with a shell-first construction. Clinker ships were seen as slower vessels in the water due to the friction caused by the added surface area and were more difficult to repair and harder to install gun ports. Implementing the carvel-built tradition was a faster and more efficient method for the needs of the navy. However the ability to change from clinker to carvel was not an easy transformation for the English shipwrights, especially as the demand for larger gunned ships grew, the shipwrights now gained their knowledge of construction from captured vessels and observing other countries developments. The only solution was to hire foreign carpenters and in some cases foreign or foreign trained shipwrights into the dockyards to help with the constructions and repairs (Steffy 2006, 142).

Frame-first construction opened a whole new world for shipwrights, as they could more easily alter the shape of the vessels unlike the clinker-construction. The U-shaped stern frames could allow guns to be mounted closer

to the water and could allow fore and aft castles to be integrated. Gun ports could also be cut into the hull and covered with lids for protection. Inevitably, all these additions became more standardized and streamlined in the Elizabethan age. It was a time when hull design became the more significant characteristic, as carvel-built ships were the established construction method. All the methods adapted to carvels were being changed to suit the design of a ship and certainly to suit the military expectations of using ships in conflict.

War was the other driving factor behind the development of ships (the first being economical factors discussed in Chapter 2), as John Hawkins suggested placing more deck guns on the broadside to eliminate the need for boarding and hand-to-hand combat, which in turn lead to more streamlining of the ships for stability and manoeuvrability in battle. This eliminated a lot of the elements seen in the beginning of the 16th century and introduced new ship types, such as the galleon. These changes resulted in shipwrights building sleeker and faster ships. It also led to standardizations in measurement while building, so ships could be adapted to the same principles (Howard 1979, 89).

3.2 Ship Design and Shipwrights

The problems that occurred in ship design during the 16th century were caused by the greater demand for larger and faster ships. This was not just for the navy's agenda but merchant trade and transportation as well. Elizabeth Tebeaux's discussion on the 'closed discoursed community' of shipwrights emphasises this problem, in that the knowledge in ship construction and design was being shared from father to son, teacher to apprentice. Shipwrights were taught largely "by eye, by flair or by rule of thumb (Abell 1948, 30)". Their teachers were shipwrights who worked on either smaller carvel ships, or clinker-built ships, and so there knowledge was only relative to what they had learnt.

Figure 11: Shipwrights drawing, *Fragments of Ancient Shipwrightry*, Baker (1586)

Now, an avant-garde age had come where ships had to be built twice the size of their predecessors. It would be a challenge alone to look down the length of a large ship, using the rule of thumb method to see if it was accurately and equally built. Sir Westcott Abell illustrates that a shipwright's perception during this time, of making a ship faster and more manoeuvrable, was based on the idea of making the ship narrower. "There seems perhaps an instinct that the narrow ship passed more easily through the water, whereas in the past 30 years it had been proved that breadth alone does no detract from easy travel because draught of water is also a factor (Abell 1948, 53)." Narrow ships lead to crank ships, which in turn lead to furred ships.

The matter of 'eye' and judgement was nearly impossible if the shipwright could not see the entire ship while looking at it head-on, which is where Captain George Waymouth's famous quote, "no two ships alike" comes from (Oppenheim 1892, 473). If a shipwright wanted to build two ships identical in construction and

design, they would in fact be very different, because of the current shipbuilding standards. These standards were limited to oral knowledge, rather then sketches and models of a ship pre-construction. "… an English shipwright of the period learnt his **art** of building and repairing ships primarily through practical training and experience gained on an apprenticeship, in contrast to French naval architects whose education was grounded on **science**, above all, mathematics… (Fox 2007, 1)."

To continue on the artistic direction of shipbuilding, it was somewhat becoming apparent in the late 16th century that art alone could not create the large ships in demand. Isaac Taylor's novel entitled *The Ship* written in 1844 explains this new understanding into why science was imperative in the building of a ship.

"Much is done, and done excellently, by practical men, who, having from their youth been accustomed to shape this or that, become expert in the doing of it, and can make all the points in their machinery match the greatest nicety. But these men are often destitute of science their skill is chiefly *art*, attained by practice, and as long as this answers its end, all is well. If, however, inconveniences are to obviated or improvements to be made, then *science* is absolutely necessary. A mere practical man may, by natural sagacity, give a shrewd guess at the cause of failure, in any specific instance, and contrive the means of avoiding it, but still this may be *only* a guess, and it may, or may not be a good one; if it suffice for the purpose, he yet can hardly tell why it does so. When science can be brought to bear upon such a difficulty, it is more than possible that the real cause maybe discerned, and the remedy infallibly pointed out. Mathematical skill has, therefore, become of essential importance in modern ship building in discovering the best shape for a body moving in water, and liable to the influence of violent winds and tempestuous waves. (Taylor 1844, 93)"

The *Royal William* is a perfect example of this, as Edmund Dummer, Surveyor of the Navy from 1692-1699 enquired into the ships crankness using theoretical and deductive reasoning. The ship was indeed crank but for reasons the owners, who sailed and worked the ship, could not understand. The ideas

behind girdling or furring the ship (to which they chose to girdle) were based on the general assumptions that girdling and furring were remedies that solved crank ships. Whether this particular ship required such a serious repair to fix a minute problem that according to Edmund Dummer, could have been solved through the readjustment of weights and sail, was beyond the comprehension of the men who did not know the ships actual problems when they themselves should have known best.

3.3 Establishing science and mathematics

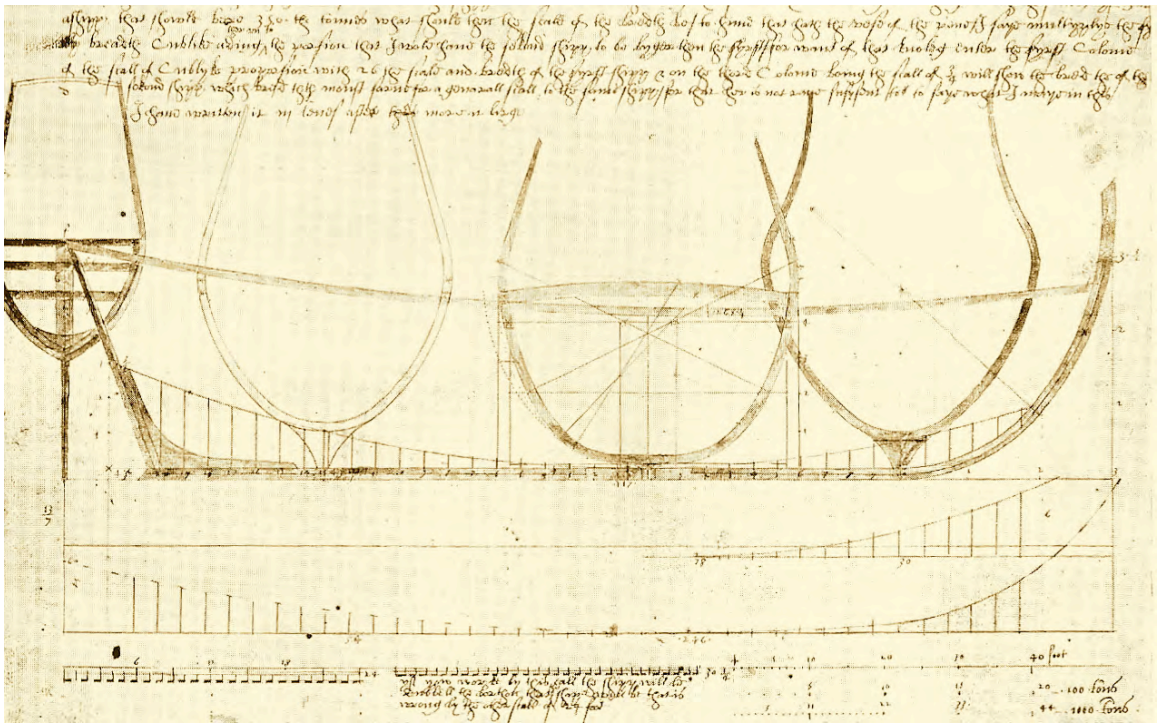


Figure 12: Sheer draught for building, *Fragments of Ancient Shipwrightry*, Baker (1586).

It wasn't until Matthew Baker that the ideas of design and construction became more uniform or even put to paper for that matter. In 1582, he surmised the method of measuring the tonnage of ships (the inside room or space in terms of the number of Bordeaux casks that could be stowed on board). "Length of the keel (leaving out the falsepost), the greatest Breadth within the plank, the Depth from that breadth to upper edge of keel, multiplying these together and dividing by one hundred (Dirk: Pepys Diary, 2010)." This allowed shipwrights to form the

tonnage calculation of a ship before it was built, instead of doing post construction measurements. This new mathematical equation brought an understanding to building ships, that there could be a pre-determined idea of the size and possible shape, but there were still many problems that had not been solved through Baker's calculations.

Thomas Harriot's *Scientific and Mathematical Papers* discuss in detail his criticism of Baker and his practices by considering the way in which Baker computed the tonnage of his vessel:

"It is knowne by experience that a ship whose depth .10. foote, bredth .20., length .50. by the keele - is of burden a 100 tone. Mr. Baker makes this rule & findes it little more or lesse then truth otherwise tried. He makes a solid nomber of 10. 20. & 50.; & then devides it by a hundred. The quotient is the tonnes of burden (in ye hold) as I take it. The sayd length bredth & depth must be in feet for this rule. Ffor tonnes & tonnage of the Kinges ships he multiplyes as before but deuides by 70. & the quotient is counted her tonnage. By these rules the Tonnage of shipps is measured for the King. Tonnes & tonnage is what a ship doth carry of ordinance master sayles * yards together with that which she carry in hold. (Shirley 1983, 101/ Harriot 1608, 41)"

John Shirley (*Thomas Harriot: A Biography,* 1983*)* continues the discussion about Harriots reactions to Baker's calculations, expressing that his calculations, "are much too crude for serious use (Shirley 1983, 102)". According to Gregory Robinson in *Elizabethan Ship*, Baker based his measurements and calculations on the ship *Ascension.* The ship measured 54 feet on the keel, 24 feet broad inside the plank, and 12 feet depth in hold from her breadth to the top of the keel. Multiplying all three measurements together gave 15,552. Dividing that by 100 gave 155.52, which was the assumed tonnage. Baker originally used divisors of 97.2 (which would have made the tonnage 160) but for the sake of convenience, later changed it to an even 100.

Tonnages were always rounded to the nearest 10, which would seem logically more convenient, however according to Robinson, Matthew Baker

always “measured outside the plank for breadth, and to the bottom of the keel for depth. These alterations would have made a ship appear to be 20 tons in the 100 larger (Robinson 1974, 54)”. Robinson explains that shipwrights were paid by the tons when they sold ships to the king, which could suggest the increase of as much as 20 or 30% in shipyards. It would be very difficult to verify the tonnage of a ship, suggesting further that shipwrights may have been dishonest when working with Baker’s calculations.

This insight has raised questions as to Baker’s initial intension in using the equation, as Harriot expresses a more accurate result by dividing the ‘solid number’ or cubic feet of the parallelepiped by 3 and multiplying the result by 64 (the number of pounds in each cubic foot of water displaced by the vessel). John Shirley says, a “greater accuracy could be obtained by simply determining the volume of the vessel’s displacement – a feat which should easily be within the capabilities of the Queen’s shipbuilder (Shirley, 102)”. Harriot’s recommendation for measuring displacement was not thought highly by Baker, and the changes were never made.

Both Harriot and Baker strove to improve the state of English shipwrightry, with significant contributions to English ship design. They also introduced the first ideas behind geometric principles and mathematics in shipbuilding. Phineas Pett would later draw on these new perceptions of pre-determined ship designs by creating a model of the *Prince Royal* in order to present his envision to the King’s son, Prince Henry. “This idea of making a scale model of the design before starting to build the ship was the first instance of what became the custom for large or novel vessels (Abell 1948, 42).” The ideas of creating a ship with fuller lines underwater to carry both its burden and guns was steadily becoming a standard that every shipwright tried to achieve. Phineas Pett’s ship, demonstrated the most impressive symbol of this trend.

3.4 Case Study #2: The *Prince Royal*

Figure 13: The Prince Royal (1610), *British Warships in the Age of Sail 1603-1714: Design, Construction, Careers and Fates* (Winfield, 3)

There are many conjectures and theories around the *Prince Royal* and its subject of enquiry in 1608 and 1621, to which Phineas Pett was accused of incorrectly and poorly building the ship. The reason this particular case study is significant to the subject of furring, is that furring was believed to have been one of the accusations suggested in the enquiry. And although it will be unavoidably pointed out as a false claim, it will demonstrate and perhaps bring to light why furring is rarely seen in historical records and was not a highly sought after rebuild method, as Mainwaring has described.

To mention furring, is to suggest incompetence, and therefore furring is never stated and impossible to find. To suggest that furring was needed to build a ship was by its very definition, a design of incompetence, which Mainwaring strenuously objectifies in his definition. “It is a pity that there is no order taken either for the punishing of those who build such ships or the preventing of it (Manwaring & Perrin 1922, 153).” Well, perhaps that statement proves true, as the subject of enquiry into the construction of the *Prince Royal* was seen more as a red herring for the problems of overall ship design and of the jealous shipwrights, who could not fathom the idea of a ill-qualified novice shipwright managing to design such a great ship.

Phineas Pett was born in 1570, which would make him an unlikely candidate for the building of the *Gresham Ship*, though he was indeed brilliant for his age and excelled through school, graduating at the age of twenty with a M.A. degree. In 1592 Pett wanted to obtain service with Matthew Baker, but was denied and became a carpenter for two years. Over the next several years, Pett spent time with Baker learning a great deal of knowledge, which helped him to eventually become an assistant to the master shipwright in 1602 and Master of the Shipwrights Company in 1607 following Baker. In the same year, Pett made a model of a ship for Prince Henry and presented it to the king. King James was unsure of this model and asked Pett if he could “build the great ship in all points like the same (Abell 1948, 42).” By October 1608, the keel was laid for the *Prince Royal* to be built. (Abell 1948, 41-43).

During this time, the King had begun an enquiry into the corrupt manner of the Navy Office on 8 May 1609. According to Sir Westcott Abell, there was great increase in abuse, deceit, and fraud charged against the officers and workers within the Navy. Pett was among those blamed for his actions when he was keeper of timber and stores at Chatham. Some historians have suggested that this is how the accusations of unseasoned and substandard timbers were placed on the *Prince Royal*; in that Pett did not take better care to exam the timbers in

his own store. It appears that Master shipwrights inflated their costs and diverted timber and materials to their private yards, and it was believed that because Pett held the position of 'favourite shipbuilder' he exploited the resources even more so (Abell 1948, 42). According to A.P. McGowan, editor of *The Jacobean Commissions of Enquiry 1608 and 1618* (1971), the Kings "whole attitude throughout the proceedings made it perfectly clear that no fault would be found with Pett (McGowan 1971, xv)." Perhaps by having such high-up connections, the King ignored evidence of the ship being (possibly) furred, and believed in Pett's defence more then others (McGowan 1971, xv).

Because of such a serious enquiry, there were many questions asked as to Pett's fitness for the task of building such a large ship. He had no previous experience in building large vessels and many other shipwrights believed that he had not yet learned the craft. Pett's persistence in seeking favour at court was seen as an offset to his lack of knowledge and although he gained the kings favour, his fellows did not like him (Perrin 1918, 71).

As the enquiry carried on, the *Prince Royal* was brought into the debates. "The foremost villain was the builder of the *Prince Royal*, Phineas Pett (McGowan 1971, xv)." Now it is in this aspect of both the enquiry and of Pett's reputation that the various accusations were laid about the *Prince Royal* already being ill built. It would be interesting to note that later in Pett's life, the same circumstances were brought against him when he was commissioned to build the *Sovereign of the Seas* (1637), suggesting that perhaps the accusations were nothing more then complaints against Pett being the chosen shipwright for the job.

According to Phineas Pett's autobiography, edited by W.G. Perrin, Matthew Baker was brought to the Navy Commission to answer questions in regards to Pett's fitness to build the *Prince Royal*. Baker was asked how much the ship would cost, to which he stated £7,000 when in fact the overall cost was

twice as much at £20,000. £1309 of that was spent along on decoration and carving. Baker was then asked about the timbers used to build the *Prince Royal*. He told the Commission that Pett had used substandard wood that was "badly chosen" for the ship. Baker was finally asked whether Pett was fit for such a task, to which he replied that Pett was not, and that the only ship he had ever built was of a mere 120 tons and had to be furred shortly after (Perrin 1918, 71-72).

Only one of the above accusations Baker made was true. The enquiry had found fault with the working of the wood. The frame-bend of the completed ribs were found to have been worked incorrectly. The futtocks did not have enough scarf for the floor timbers, (The floor timbers and the futtocks make up a complete frame, to which overlapped one another for additional strength), the treenails were fastened to the planking both inside and out, and the timber itself was substandard and not in working condition.

"Baker, and perhaps some of the others, must have been chosen on the governmental principle of setting personal enemies to inspect each other's performances, seeing that he had not long before stated on oath that he thought both Petts 'simple' and quite unfit to be entrusted with the production of a large ship. Pett, naturally, had little love for Baker, although he had years before attempted to be friendly with the veteran, ascribing all his knowledge of his **art** (Oppenheim 1892, 487)."

McGowan states that there was "ample opportunity for the shipwrights … to inspect the great new ship. Their comments produced such tales of scandalous mismanagement and shoddy workmanship (McGowan 1971, xv)." McGowan says further that some of the shipwrights "were openly envious and jealous of Pett's favoured position … declaring the Prince Royal to be built of timber in some parts rotten and in others green and unseasoned (McGowan 1971, xv)."

The Shipwrights that had made these complaints were from various dockyards in England. Among them were Matthew Baker, John Bright, Edward Stevens and George Waymouth, of which Pett had confrontations with (Oppenheim 1892, 487). It is suggested by historians that Matthew Baker headed this fraternity of shipwrights and that he made up the accusations of furring the *Prince Royal* because Pett had misused Baker's calculations. In Baker's answers to the Navy Commission, he spoke only in hatred and false claims, the allegation of furring being one of them (Perrin 1918, 71). In reality, Pett introduced modifications to Baker's calculations, such as the width of the floor and shape of the beam; Pett had not in fact furred the ship to widen the beam. It could perhaps be suggested that Baker's real motives behind these accusations were to get back at Pett for repairing a ship of his, by furring it, or for pure jealousy of Pett's uncanny success (Abell, 1948, 43).

Matthew Baker, while acting as witness for the Navy Commission, stated further that Pett had only repaired a 223-ton ship that was in worse condition after Pett had completed it. "…so that with his first repairing and furring up them he doubts not but it doth appear by the accounts that his workmanship with stuff was more chargeable than a new ship of that burthen might have been new-built for; which are enough to persuade any man that he cannot be sufficient to perform the building of so great a ship, when he hath performed the reparation of a small ship so ill, as of a good ship he made a bad (McGowan 1971, 231)." This account of Baker's, not only suggests that Pett furred a ship, but that he poorly furred it. If furring was seen as a bad method of repairing a ship, which would no doubt discredited a shipwright, then surely furring a ship, badly, was seen as even worse.

After the shipwrights had visited the *Prince Royal,* Phineas Pett had made changes, which Abell says, "seemed to show his weakness in **art** and the imperfection of the mould (Mould being used as the name for the transverse shape) (Abell 1948, 43)". It was found near the end of the ships construction

however that Pett in fact made very little changes to the mould, perhaps to get the rival shipwrights off his back about his new improvements to the ship design.

William Laird Clower's novel, *Royal Navy: A History from the earliest Times to 1900* (1996), refers to a man by the name of 'Stow', who speaks about the *Prince Royal* shortly after it's construction. In Stow's account, he explains that the *Prince Royal* is "double built, and is most sumptuously adorned, within and without, with all manner of curious carving, painting, and rich gilding (Clower 1996, 5)." Clower explains that the term 'double built' refers to 'double planking'. "All the bulkheads were also double bolted with iron. Both these features (double planked and double bolted) were innovations (Clower, 1996, 5)."

The accusations of the *Prince Royal* being furred and girdling, as mentioned in chapter 2, can quite possibly be incorporated into Stow's claim of the ship being double planked. When Stow explains the doubling of the ship, he also says that it was an innovation – suggesting that it was a good method adopted to a ship, however it is unclear whether Stow like John Hawkins, refered to double planking as a sacraficial planking, or as a repair method incorporated into the ships design, post construction. It is possible that Stow, like Hawkins, misused the term, but the shipwrights that examined the ship made no claims about the ship being double planked, unless referring to the accusation of furring. The interesting aspect of this insightful source, is that Stow claims that the ship was double planked as a possitive feedback to the ships grandeur. Baker, Bright, Stevens and Waymouth were using furring, as a negative connotation to the ships design process.

It would be interesting to point out that in a Gresham College lecture given by Ian Friel on 'Elizabethan Ships and Shipbuilding', Friel stated that there were approximately "forty-five shipwrights appraising ships for the High Court of Admiralty between 1579 and 1590," and although this dates quite a few years before the enquiry on the *Prince Royal*, Friel also noted that out of those forty-five

shipwrights, only fourteen could sign their names." This would indicate not only a problem in the geometric principles of shipbuilding for the shipwrights that could not write their own name, let alone calculate the tonnage of a ship, but also the structure of class among the shipwrights that would have dramatically effected the dynamics in the dockyards. Although Pett came from a long line of intellectual shipwrights, he was considered of lower class to other shipwrights such as Matthew Baker, Richard Chapman, William Burrell, and other well-known shipwrights. Pett managed to find his way into higher company and to gain recognition this way, but he was still seen to other shipwrights, as ill qualified.

Phineas Pett may have indeed been weak in the art of shipbuilding, but a step ahead of other shipwrights when it came to furthering the developments of predetermined design. And while calling it science through out this chapter, it is important to recognize that it was science in it's infancy. Indeed the real scientific aspects of shipbuilding would be seen in the 18th century with shipwrights like Fredrick Chapman. The universal ideas of what science is today, involve experimentation, testing, dissecting frogs and taking things apart to understand their components, of which Pett did not do (well, maybe he dissected frogs). Pett did however move from the rule of thumb to a more repeatable and accurate process that could reproduce the lines of a ship. Therefore, this is indeed a step beyond pure art, and beyond Captain George Waymouth's quote, of "no two ships (being) alike (Oppenheim 1892, 473)."

Many archaeologists and historians will argue that it was Matthew Baker and not Phineas Pett that introduced the ideas of preconceived ship design. However, "the tone of Baker's manuscript indicated that he was describing accepted methods rather than radically new ideas (Hocker, 2004, 82)." Pett's involvement in the advancement of ship design was taking those accepted methods and applying radically new ideas. This thesis is not trying to argue that Baker played no part in the scientific developments of ship design, only that he played the part of a 16th century shipwright and Pett, the part of a 17th century

shipwright, each contributing significant advancements to a "pre-determined formulation of a ship's structure and configuration" in their time. "The process has its beginning…before construction…by its nature it is conceptual and its key is predetermination (Barker 1988, 61)." Both men possessed a predetermination in ship design.

Phineas Pett took initiative in sweeping aside Matthew Bakers principles in shipbuilding, which was the cause for so much controversy over the *Prince Royal.* And although the *Prince Royal* was never found to be crank or furred, it did 'raise a hell of a storm' to which brought to light just how competitive the shipwrights were in their building of ships. This case study shows the clash of two generations of naval architects, the old generation still striving on the art of shipbuilding, and the new generation introducing science into shipbuilding. It is a shame that such a great ship was used as a red herring in the politics of shipwrightry.

The *Prince Royal* never had any strenuous duties after the Navy Commission enquiry that lasted more then a decade, It was eventually rebuilt in 1641 at a cost of nearly £20,000 due (only) to it's substandard timber. There were no claims of the ship needing repairs because it was crank (Abell 1948, 43).

Pre-*Prince Royal*

Historians have studied the mystery behind how an ill-qualified novice shipwright managed to design the *Prince Royal*. It is now believed that Phineas Pett did not originally create the ship, but copied the idea of it from another ship, where he later built a model of it and presented it to the king. The *Tre Kroner* (Three Crowns) was a flagship of the Danish fleet that sailed into London in 1606, carrying on board Christian IV. According to N.A.M. Rodger, the technical credit of the *Prince Royal* belongs to the Scottish shipwright David Balfour, who built the *Tre Kroner*. It is believed that Balfour trained in England at an early age and adapted the "distinctive English 'whole-moulding' design technique, which

was quite unlike the methods used elsewhere … notwithstanding the jealousy with which English shipwrights guarded their secrets from foreigners (Rodger 1998, 387)."

Figure 14 The Prince Royal, Pepys's Navy: Ships, Men and Warfare 1649-1689 (Davies 2008, 46)

To carry the heavy weight of the guns, Balfour used a more fuller hull form, to which Pett copied for the *Prince Royal*. It is these fuller lines in which shipwrights such as Baker criticized in the enquiry. However, they were right in the fact that the *Prince Royal* was perhaps "incapable of the nimble manoeuvres necessary for Elizabethan gunnery tactics, and right too that Pett's dishonest dealings over timber would limit her life, but they failed to see that the fine hull forms of the late Elizabethan warships were overloaded with their existing guns, and could not support any growth in armament (Rodger 1998, 387)".

The *Prince Royal* was brought into the subject of enquiry because of its builder Phineas Pett. Although problems were seen in the design of the ship, it would not be unfair to say that the majority of ships during the Elizabethan era were less then perfect, certainly if compared to the *Prince Royal*. Indeed the problems that culminated around the end of the 16th century were more to do with ways of solving problems of crank vessels, which were no doubt caused by the overloading of guns on fine hull formed ships. In Pett's attempt at solving these faults with the *Prince Royal*, to support the weight of armament, he underwent immense pressure from his peers and the Navy Commission, but successful defeated the claims made about the ship being furred.

Without doubt, the profession of shipbuilding in the 16th century was an art. Most shipwrights were illiterate and the 'eye' was the key for decisions in appropriate timber choice, of length, breadth, and depth of measurement. Phineas Pett did not follow the rules of art, and although historians have argued that Matthew Baker took the first steps from art to science, his pictorial manuscript *Fragments of Ancient English Shipwrightry* (1570) was in fact far from the reality of practical shipbuilding. Shipbuilding was without scientific knowledge of displacement, and so ships that were crank ships, were a normal end result.

In the 16th century, as indicated by Ian Friel, the number of shipwrights who were illiterate and therefore with limitations of scientific knowledge, show that the writings of Baker, Pett, Hawkins, Dean, Burrell and later Chapmen and L'Hoste form the base of our historical and political history; as history is written by those who can write.

This thesis will argue the possibility that Sir Henry Mainwaring's commentary on furring could be applied to the *Prince Royal* in that it was "a pity that there [was] no order taken either for the punishing of those who build such ships or the preventing of it," as furring was one of the accusations used. Mainwaring's quote does not necessarily indicate that it was a furred ship that

was a pity, but the fact that a poorly build ship need to be furred. The fact that it was a false claim in the enquiry only proves further that furring was not a rebuild method that shipwrights wanted to make publically aware. It was a sign of incompetence for a shipwright to mess up in the process of designing and constructing a ship. Furring solved the problems seen in this time, but the political propaganda that circulated during the 16th and early 17th century, converted the dockyards into nests of intrigue. This is why furring is rarely stated, and impossible to find. Perhaps, by looking at archaeological evidence of furring, the blacklisting repair method can be more closely looked at, as the literature will no more.

Chapter 4: The Gresham Ship

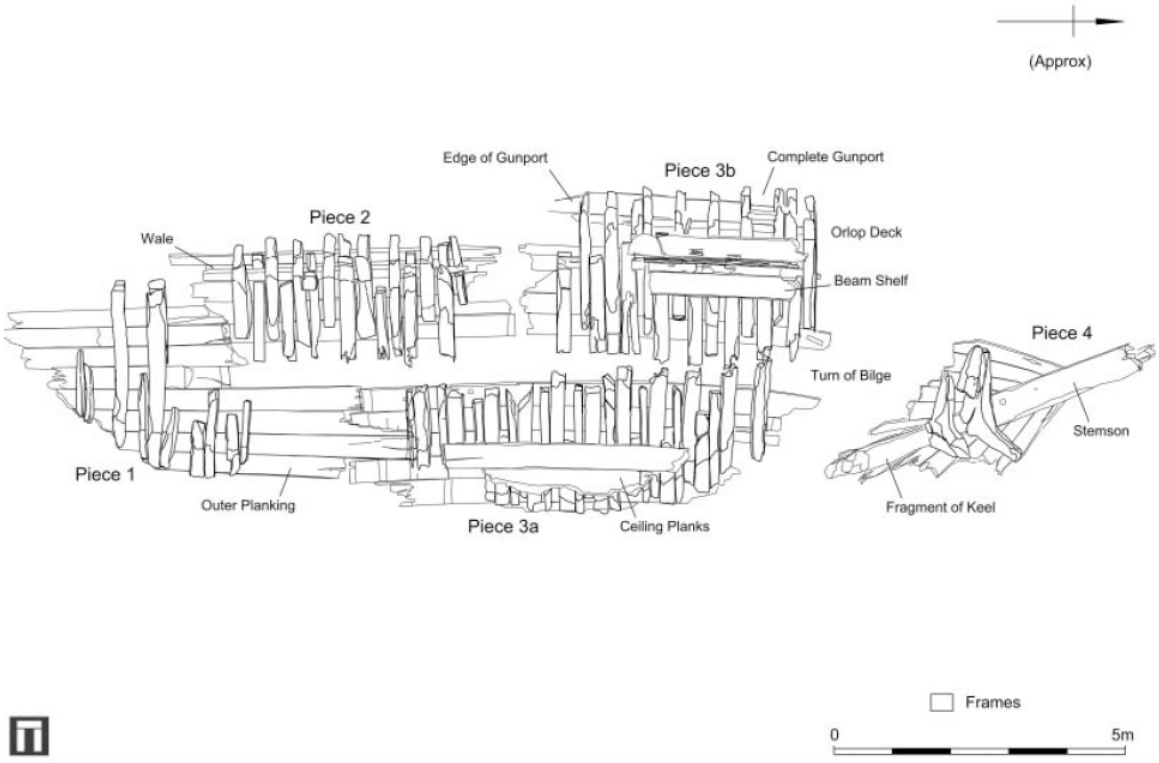


Figure 15: An overview of the preserved hull sections of the *Princes Wreck Channel*, drawn by Kitty Brandon, Wessex Archaeology, (Auer & Firth, 227)

The following sections of this chapter will describe an actual archaeological wreck that shows the repair method of furring. The definitions of furring, as provided by Sir Henry Mainwairing (1644), Thomas Harriot (1608-1610), Nathaniel Butler (1685), and John Smith (1699) will also be applied to the archaeological remains, which will bring a fuller understanding into the past three chapters of this thesis. The remains today of the *Princes Channel Wreck* (1574) are now broken into five different sections, which together form only 20% of the entire hull of the ship. As mentioned in chapter 2 regarding mast, sails and rigging, which are often adjusted when a ship is furred, there are no remains, so the description of what still remains today will be subject to a limited discussion. It is nonetheless important to approach this case study by looking at the overall concept of the ship as one wreck, rather then five different pieces.

This chapter will also discuss the design and construction of the ship by focusing on the preserved sections of the hull that show furred characteristics. This will include specific features of the remains such as the wale that remained *in situ* during the rebuilding stage and became a structural stringer for the furred frames, the original outer planking of which were placed back on the ship after rebuilding her, the orlop that also shows modifications for the new additions of timbers, as well as other distinguishing features.

Many aspects of the *Princes Channel Wreck* that show modifications and adjustments from the rebuilding are not aspects testified in historical record nor any of the sources obtained for this thesis. The definitions do not hold enough information to coincide with the remains and not all the remains can be explained through the definitions. By looking at the new features not yet discussed in this thesis in combination with those that have been, furring in light of 16th century ship design may be more fully understood.

4.1 Case Study #3 – The *Princes Channel Wreck* or *Gresham Ship*

There has been debate as to the preliminary naming of the wreck. It was found in Princes Channel at the mouth of the Thames Estuary. This prompted it's initial naming to be the *'Princes Channel Wreck'*. The debate surfaced when a single gun was found baring the insignia of a grasshopper, the motif of Sir Thomas Gresham, founder of the Royal Exchange (1519-1579).

Figure 16: Sir Thomas Gresham's grasshopper motif on the barrel of gun, (http://www.wessexarch.co.uk/projects/marine/thameswreck/gresham.html)

Because the grasshopper motif was a significant step forward in learning more about the wreck, many archaeologists and historians prefer the name '*Gresham Ship'*. In order to avoid further confusion, this thesis will use the two names, but in different contexts. '*Princes Channel Wreck*' will refer to the archaeological wreckage and what remains today of the ship. The other name, '*Gresham Ship'* will be used when discussing the ship itself as a whole, pertaining particularly to its context in the 16th century. Although the gun was identified as being made by Sir Thomas Gresham, it is not affiliated to the actual man, as guns in the 16th century were traded and reused numerous times by other ships and countries. Perhaps a closer look into the discovery of the wreck will bring to light why there are two names for the same ship.

4.2 The *Princes Channel Wrecks* discovery

In 2003 the Port of London Authority discovered the ship during a standard surveying operation of the Princes Channel in the Thames Estuary. Because the channel provides a main route for ships to enter the Thames, dredging is required to remove obstructions that pose hazards and impede navigation during low tides. Upon initial discovery, Port of London Authority divers inspected the

ship and believed it to be a wooden Thames barge. This resulted in an immediate wreck removal procedure and while removing pieces of the wooden remains; a gun and anchor were discovered. Once the (Thomas Gresham) gun was revealed, archaeologists from Wessex Archaeology were brought in to investigate the wreck, which culminated in the recovery and recording of artefacts and structural remains of considerable importance. In the subsequent months following the discovery, Port of London Authority discovered further remains, which were grabbed and lifted for removal. Wessex Archaeology was commissioned to carry out remedial recording of the materials that were brought up.

Wessex Archaeology recorded as much as possible, with the limited time constraints of removing the wreck to clear the channel for busy traffic. Recording was done in drawings, descriptions and photographs of each piece of timber. A total station was employed to record all five pieces recovered, which proved difficult to do, as the doubled frames concealed much of the inner construction of the ship. Today research into the hull remains of the *Princes Channel Wreck* is primarily based on the recordings and drawings that Wessex Archaeology did in 2004. The wreck now sits in the estuarine lake Horsea Island near Portsmouth. The saline water of the lake should have allowed the timbers of the ship to stabilize while being studied, however today much of the ship is eroded. (Auer, Firth 2007, 222-224)

Because of the urgent situation in excavating and lifting the wreck for preservation, it was not disassembled. This has always been a popular debate between archaeologists, whether to disassemble a wreck in order to learn more about it or to preserve and study the ship, as is. The question of disassembly has been suggested for other famous ships of the 16th and 17th century, such as the *Mary Rose* (1509) and the *Vasa* (1628), which are larger vessels containing more preserved remains. It is this thesis's belief that because there are only 20% remains of the *Princes Channel Wreck*, it would be more beneficial to

disassemble the remains and learn more about the construction techniques and more so to learn about the furring in closer detail. It is unfortunate that the *Princes Channel Wreck* has eroded and that the remains of the deck construction no longer exist. If there were ever an opportunity to study archaeological remains of a furred ship, now would be the time.

4.3 Potential 1846 salvage operation on the *Princes Channel Wreck*

Considering that the potential provenance of the ship is an armed merchantman of the 16th century, the artefactual evidence is limited. It is speculated however that in 1846, a salvage operation took place by divers, possibly to retrieve cargo and guns. This was documented in the *Whitstable Shipping and Mercantile Gazette* of 2 May 1846. It stated that divers from Whitstable "salvaged six guns, tin, iron and lead from a wreck on the Girdler Sand, which is immediately adjacent to Princes Channel (Auer & Firth 2007, 234)".

It was further reported in the *Journal of the British Archaeological Association* that Elizabethan artefacts found in the wreck included personal items such as a leather shoe, a knife and a silk doublet. The guns recovered were described as being of a 'very ancient date'. The cargo, consisting of iron and lead bars and lead and tin ingots, was also mentioned and that 2,700 tin ingots were lifted along with iron bars, lead pigs and red lead in casks.

The location of the said wreck was not identified, however the depth was said to be four fathoms, which as Dr. Jens Auer has said, "7.4m at low water, is consistent with the depth of the wreck site in Princes Channel (Auer & Firth 2007, 234)". Dr. Auer further clarifies that even though there is no actual evidence of the salvage of 1846 taking place on the *Prince Channel Wreck* in particular, the extenuating circumstances of similar artefacts and locations make it quite likely. Furthermore the likeliness of the salvage taking place on the *Prince Channel Wreck* would explain the relatively small amounts of cargo found as well as a

rope that was found enfolded around the lifting rings of a wrought iron gun, suggesting that at some stage an attempt of salvage did occur.

University College London is currently studying the remains of the artefacts found on board the ship, while the University of Southern Denmark has focused its Maritime Archaeology Program on the hull remains. The following sections of this chapter will discuss the *Princes Channel Wreck* hull remains that show significant details and can shed light on the process of furring.

4.4 Was the *Gresham Ship* furred during or after the construction process?

In order to understand features of the *Princes Channel Wreck* that pertain to furring, comparisons will be made to both the two case studies talked about in this thesis of the *Royal William* (1670) and the *Prince Royal* (1610), as well as the definitions of furring that explain certain aspects of the process of furring.

While studying the remains, archaeologists were unsure whether the *Gresham Ship* was furred during the construction process or shortly after. This is understandable, as the dendrochronological date of the furred timbers; match the date of the original timbers of around 1574.

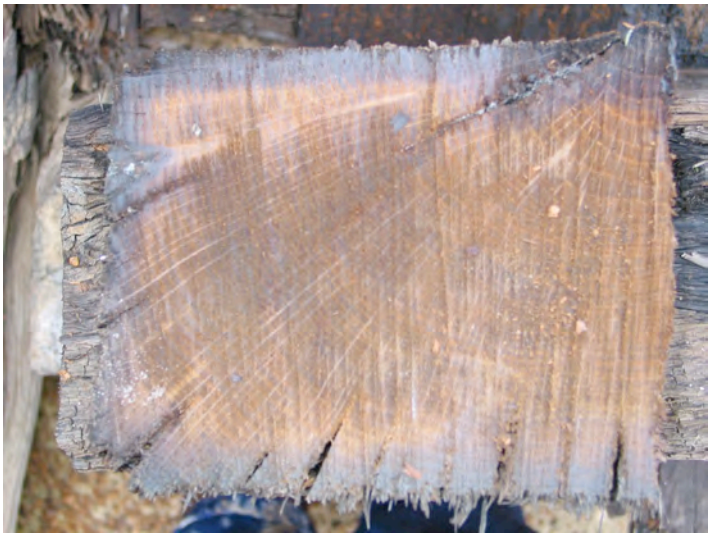


Figure 17 Dendrochronological sample of timber taken from the *Princes Channel Wreck,* dating to around 1574 ((Photographed by Wessex Archaeology).

In looking at the two previous case studies in this thesis, there can been some debate into that theory. Phineas Pett was accused of furring the *Prince Royal* during the construction process to fix the problems that the other shipwrights had pointed out regarding the moulded shape of the frames and the fact that the floor was too wide. The claims that her depth was too great and her side too upright caused the shipwrights to believe that 'she must be tender sided and not able to bear sail'. However, the accusations of the *Prince Royal* being furred were proven false and she was not furred during or after the construction process.

The relevance of the *Prince Royal* to the dendrochronological dating of the *Princes Channel Wreck* is that Phineas Pett was the storekeeper for timber in the dockyard, as the enquiry was focused on the theft of such timbers that were placed into the private dockyards of shipwrights. Timber during the 16th century was cut and placed in these storage buildings in the dockyards to be used to build and repair the vessels. If a ship was build and found to be crank, the same timber, from the same year of cutting, would still be in storage in the buildings, and so any repairs done after construction, would show the same dendrochronological date of the original components of the ship (Rodger 1998, 376).

Figure 18 Trenails that were left *in situ* during the re-planking stage (Photographed by Wessex Archaeology).

Other aspects that may indicate that the *Gresham Ship* was furred after construction show that when the planks were removed for the addition of doubled frames, the trenails were cut. According to Nathaniel Butler, "ripping off the planks, and putting second timbers upon the first timbers, and upon them again other planks", could suggest that new planks were placed on the ship after it was furred. This was most probably due to the aspects discussed in the case study of the *Royal William*, in which Edmond Dummer suggests girdling to be a bad idea, for the bolts and trenails that were placed in the ship would cause more weight and holes to be caulked, then were required. In furring a ship, shipwrights wanted the least amount of holes to caulk, as it may require repairs in the future. Furred ships were very hard to repair if leaks or problems within the furred frames occurred. It would require either the removal of all the furred frames to fix the problem, or the hope that such problems were not severe enough to affect the ship significantly (Merriman 1949, 93).

Figure 19 Outer planks with new wales and original planks (Photographed by Wessex Archaeology).

The *Gresham Ship* did not acquire new planks, as indicated by the cut trenails, trenail holes, and the new trenails that were placed near the old ones. This would strongly indicate that the ship was furred after construction and then had the same planks re-applied to the hull. There could however be debates concerning this, as the planks may have been ripped off during the construction phase and then replaced, but it would seem far to much work to remove the planks and reapply them, or to caulk all the holes that were created in the process. It is more likely that the *Gresham Ship* underwent sea-trials during it's first launching and was then found to be crank and required furring, and so the furring of the ship commenced shortly after the construction process.

4.5 The Double Frames

Figure 20: Original and furred frames of the *Prince Channel Wreck* (Photographed by Wessex Archaeology).

The furred timbers, of which sit on top of the original timbers, are doubled from the turn of the bilge upwards and narrow from their fuller moulded dimensions to c.50mm. According to Thomas Harriot, the timbers were “thin bord below & thicker upward so far from below as is fit”. This tapering was made so that the shape of the doubled frames could agree with the upper works. By making them in such a way, this allowed the bilge to be widened, but could also allow the smooth re-application of the planks. Interestingly, all the double frames rest on a single plank triangular in sections. This plank seems to fill the gap between the heel of the doubled timbers and the surface of the first futtock. According to Abell, at one point the ends between the parts were joined by a wedge-piece called a ‘shock’ “shaped like a triangle and worked on the inside of the frame.” Although it allowed a smoother surface for the re-planking of the hull and could add a little more strength to the frames, they were prone to decay and

in later times the ends were made square and were fitted close with the dowel at the middle to prevent sideways movement (Abell 1948, 88).

Figure 21 floor timbers, filling frames, first futtock with furred timber as well as triangular plank near original planks can be seen (Photographed by Wessex Archaeology).

4.6 Not mentioned in definitions

At the same level of the orlop (the lowest deck on a ship) there are chocks that have been inserted between the original frames and the furred frames. This aspect of furring a ship is not mentioned in any of the definitions of furring, however according to John Walters, of *Fenchurch-buildings, Architect and Engineer; for certain improvements in the construction and fastening of the frame-timbers and Bends of Ships or Vessels, whether Building or under repair* (1816), if a vessel is constructed with spaces between the frame, chocks are inserted for better stiffening of the whole hull. This would make sense, as a crank ships remedy is to be stiffened and the chocks inserted between the frames would add to that desired goal, acting as hull braces or “strutting pieces of timber

scantling tailed in between frame and frame, acting as arches, in the direction of the said brace (Walter 1816, 529)". The furred timbers could perhaps be interpreted as the braces for the original timbers. The chocks were placed in intervals to shape and achieve the moulded dimensions and add to the furred timbers intent of stiffening the *Gresham Ship* through the remedial process.

Figure 22 Chocks that have been placed between each frame (Photographed by Wessex Archaeology).

Figure 23: Elements of the orlop deck construction (Photographed by Wessex Archaeology).

Other orlop features, which are significant to discuss, as archaeological remains of this period scarcely provide such insight, are the deck's construction, which sits below the preserved gunport. There are aspects missing, such as the deck beams and planks, which show recesses where they once use to rest on the shelf clamp. These may have been disturbed during the excavation, or decayed during the ships some 400-year sleep in the channel. The beam-shelf, half-beam clamp (or carling), and part of the waterway still remain, of which indicate reinforcement of lodging knees instead of hanging knees, which would have been fixed horizontally between the forward side of the beam and the ship's side. These knees would have been fashioned into a right angle to provide strengthening and support at the points of intersection of the timbers. All these elements were intended to add structural strength to the deck construction.

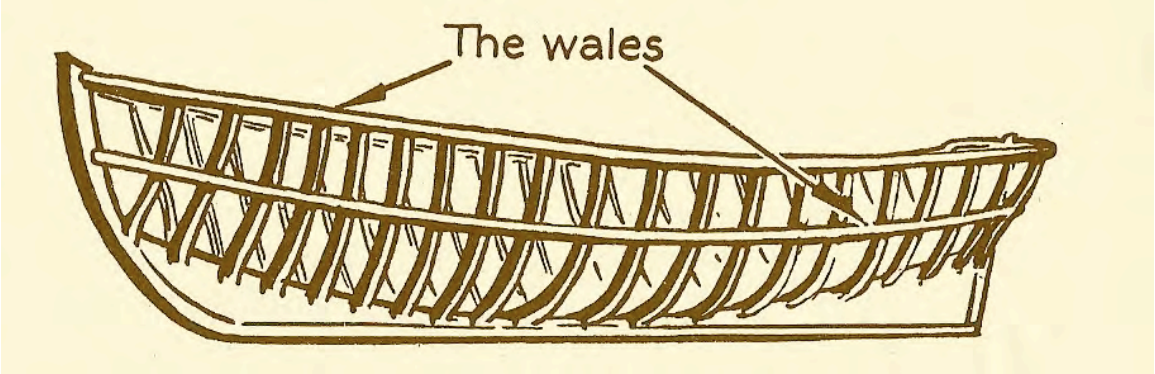


Figure 24: The wales on a ship (Robinson 1974, 42)

Another aspect of the *Gresham Ship's* furring that has not been mentioned in the dictionaries, are the wales. The wales are an extra thickness of wood bolted to the sides of a ship in positions where protection is needed (Kemp, 923). The importance of the wales on the *Gresham Ship*, are that when the outer planks were removed for the doubled frames to be added, the wales remained. This would have added significant structural support for the original frames, and because the wale remained *in situ* during the furring process, the furred timbers were cut to fit on top of the wale, allowing the wale to serve as a stringer to increase longitudinal strength.

Figure 25 The wale remained *in situ* as a structural stringer (Photographed by Wessex Archaeology)

Another aspect of the '*Gresham Ship'* that was modified during the furring process is the stem rabbet. The stempost assembly is unique in that many other archaeological finds from the 16th century, no longer have stem or stern pieces preserved. If another ship from the 1500s was identified as being furred, it is possible that the stem will not be preserved enough to shed light on furring like the *Princes Channel Wreck* does.

Figure 26: The stempost and rabbet of the *Prince Channel Wreck.* (Photographed by Wessex Archaeology)

There are distinguishing tool marks and cut treenails (like the planks that were re-applied), which show that the angle of the rabbet was modified. The lowest plank on a ship is known as the 'garboard-strake'. It "butts on the main keel, in which a rabbet (or groove) is cut to take the edge of the plank (Abell 1948, 34)". With the furred timbers placed on top of the original timbers (and the wale that has now become a stringer), the rabbet would have to be adjusted to

compensate for the increase in width from its original position in order to re-plank the hull. Filling pieces were also inserted around the rabbet to change the angle and accommodate the hood ends of the planks (the planks no longer exist today), which would have changed shape on top of the furred timbers.

Figure 27 Furring requires more then just the removal of planks and adding additional frames and timbers (Photographed by Wessex Archaeology).

The adjustments of all these aspects of a ship are remarkable to see in archaeology, as the definitions do not explain as much detail. The definitions make it seem quite easy, in that the planks were removed, the additional frames were added on top of the original ones, and then the planks were put back on. That is the general knowledge of the descriptions Smith, Butler, Harriot and Mainwairing provide. By looking at the archaeological remains, it is clear that more work was taken into the furring of a ship, and it is understandable that such a process was considered a major rebuild. The furring the *Gresham Ship* resulted in the vessel gaining about 1 foot in width on each side. That would seem

incredibly minute considering the huge process that took place in order to add a foot to the width of the ship.

Although there are only 20% remains of the *Princes Channel Wreck,* the features that show to have been modified for the ships furring, shed immense insight into more then what historians and archaeologists know today. With further study of the remains, it is likely that more features will be discovered that show modifications of the rebuilding process.

Chapter 5: Discussion and concluding remarks

The aim of this thesis was to understand the process of furring, why a ship needed to be furred, how it was furred, and whether a ship was furred during or after construction. By looking into case studies of ships from the 16th and 17th centuries, it has become apparent that there are very limited historical documents that mention furring. Moreover a number of those documents that have referenced furring have misinterpreted what furring is. This thesis has however reached its goal of learning more about furring in light of 16th century and 17th century ship design by investigating the potential purpose of furring a ship.

Although this thesis wanted to focus on a 16th century aspect of furring, the 17th century provided more documentation on ship construction and rebuilding. The *Royal William* (1670) was not furred, but there were many suggestions made in correspondences between the Navy Board and Admiralty that she should have been furred to permanently solve the problems described. The ships rebuilding process was recorded in 20 detailed letters, demonstrating that furring was scene as a more appropriate method of fixing the ship. That is why the *Royal William* became relevant to the discussion of this thesis, as it discussed the standardizations of fixing crank ships.

As to the *Prince Royal* (1610), furring was scene as a red herring during the beginning of the 17th century, not long after the construction of the *Gresham Ship* (1574). The political aspects of shipwright rivalry coincided with the repair methods that each shipwright adapted to their ships. Furring was seen as a method of fixing a shipwright's incompetence, which could suggest why there were no documents in the 16th century found to have accurately described a particular ship being furred. (Who wants to admit their failure?)

The final case study in this thesis was an archaeological example of a furred ship, which still raises many questions into the process of furring. It would be curious to point out however, that if the *Princes Channel Wreck* had not been

discovered in 2003, the knowledge on furring, and indeed this thesis, would most probably be limited to Mainwaring's definition.

5.1 Further maritime archaeological research

There are still many aspects of furring unknown. The origin of furring for example is a subject that could not be discussed, as this thesis's focus was on English ship repairs of the 16th century. Perhaps further study into other countries that adopted the technique of furring, such as France, whose direct translation of furring means 'to double', may hold more information about the process and of the origin of such a repair.

Thomas Harriot's manuscript of *Scientific and Mathematical Papers* (1609) appears to be the oldest source describing the process of furring a ship, however Harriot's work is unpublished. This raises many questions into whether more unpublished manuscripts and documents of the 16th and early 17th centuries describe furring, with (possibly) more detail. The study of dictionaries has been the main focus of this thesis, as they are published and are easier to find. Manuscripts and personal notebooks will probably hold more detail into actual features of a ship that are modified for furring, like the discussion in chapter 4 on the *Princes Channel Wreck* remains. Furthermore, the dictionaries as described in this thesis, date primarily to the early 1600s, this could be because publication in the 1500s was not prominent or that indeed dictionaries circulated the dockyards within this time and were only later published. It would be fascinating to see manuscripts from the 16th century that describe shipbuilding and ship repair in more detail.

Lastly, the 'colloquial terms' in naval history has become an unavoidable problem for both archaeologists and historians. To inaccurately describe girdling or furring as the same repair method is only one of the mistakes seen. Perhaps a standardization in terms in necessary, but of course that has never been easy, as even English speaking countries around the world use different terms to describe

components on a ship (ex. a carling and a half-beam clamp are the same thing). Nonetheless, there should be more consideration and research taken into terms like furring and girdling so that they are not used interchangeably, as they are clearly different methods of repair.

Awareness of Case Study #3

The *Princes Channel Wreck* is a very rare archaeological find as it is the only 'known' archaeological example of the practice of furring. Its insight into this thesis has allowed a better understanding of not only the process of furring a ship, but also the aspects of shipbuilding during the 16th century. The case studies in this thesis have focused on navy warships, as naval records were more prominent then merchant records both during and after the Spanish Armada. The *Princes Channel Wreck's* remains can provide a detailed study into the "sourcing and working of timber, to shipyard practices, and to broader questions of the influence of different building traditions in Atlantic Europe at a time of change (Auer & Firth 2007, 234-235)".

Awareness of other furred shipwrecks

The *Princes Channel Wreck* was initially thought to have been a Thames barge. It was not until a 16th century gun was discovered that archaeologists believed the wreck to be of historical importance, and only after it's excavation and recovery was furring identified. It is possible that other wrecks around the United Kingdom and aboard have also been misidentified. The *Batavia* (1628) is the other extreme of this, in that she was believed to have been plank-upon-plank furred, but under further study was found to have been double-planked in a Dutch tradition. Perhaps shipwrecks from both the 16th and 17th century warrant a re-examination to determine if they are furred.

Furring is a result of the confluence of concepts in art and science of shipbuilding, driven by the demands of commerce (merchant navy) and/or war (royal navy). The transition from using eye of judgement to mathematics, geometric principles and scientific pre-determined form caused many shipwrights to build crank ships that needed to be furred. This would suggest that Mainwaring was right when he said, “In all the world there are not so many ships furred as are in England … for it is an infinite loss to the owners and an utter spoiling and disgrace to all ships that are so handled (Manwaring & Perrin 1922, 153).”

Glossary of Terms
(As illustrated in Richard Steffy's Ship and Boat terms)

Ballast: Heavy material, such as iron, lead, or stone, placed low in the hold to lower the centre of gravity and improve stability

Beam: A timber mounted athwart ships to support decks and provide lateral strength; large beams were sometimes called *baulks*. See also **Breadth**.

Bilge: The area of the hull's bottom on which it would rest if grounded; generally, the outer end of the floor. When used in the plural, especially in contemporary documents, **bilges** refers to the various cavities between the frames in the floor of the hold where bilge water tends to collect.

Breadth: The width of a hull; sometimes called **beam**, which is technically the length of the main beam.

Butt: The lateral end of a hull plank or timber.

Carling: Fore-and-aft deck timbers set between the deck beams to stiffen them and support the ledges.

Carvel-built: Planked so that the seams were smooth, or aligned, as opposed to **clinker-built**. Northern European scholars reserve "carvel-built" for frame-first forms of construction; thus, the flush-laid bottom planks of a cog are not described as "carvel" laid planks.

Caulk: To drive oakum, moss, animal hair, or other fibrous material into the seams of planking and cover it with pitch to make the seams watertight.

Chock: An angular block or wedge used to fill out areas between timbers or to separate them; chocks were used to fill out deadwoods and head knees, separate frames and futtocks, etc.

Clamp: A thick ceiling strake used to provide longitudinal strength or support deck beams; clamps were often located directly opposite the wales and acted as internal wales; a clamp that supported a deck beam was called a *shelf clamp*.

Depth of hold: The distance between either the bottom of the main deck or the bottom of its beams and the limber boards, measured at the midship frame.

Double planking: A VOC tradition of adding two layers of *sheathing* or *sacrificial planking* to a hull during construction.

Dowel: A cylindrical piece of wood (of constant diameter) used to align two members by being sunk into each.

Draft: The depth to which a hull is immersed; also, a drawing or plan.

Filling piece: A single timber or block used to fill out an area, such as the side of a gunport where it did not coincide with a frame, or in the spaced between frames to maintain rigidity.

Fine lines: A descriptive term applied to a vessel with a sharp entrance and a narrow hull.

Frame: A transverse timber, or line or assembly of timbers, that describe the body shape of a vessel and to which the planking and ceiling were fastened. Frames were sometimes called **timbers**.

Freeboard: The distance between the waterline and upper deck.

Furring: a rebuild method intended to solve tender-sided vessels. Methods include plank-upon-plank furring, frame furring, and adding sparse timbers along the ship externally.

Garboard strake: The strake of planking next to the keel; the lowest plank. Also, the lowest side strake of a flat-bottomed hull.

Girdling: a repair method of adding a belt of timbers around the belly of a ship for additional strength and stability to a crank ship.

Gundeck: The deck where the guns were located; larger ships had as many as three gundecks (a three-decker), called the lower, middle and upper gundecks.

Keel: The main longitudinal timber of most hulls, upon which the frames, deadwoods, and ends of the hull were mounted; the backbone of the hull.

Knee: An angular piece of timber used to reinforce the junction of two surfaces of different planes; usually made from the crotch of a tree where two large branches intersected, or where a branch or root joined the trunk. See also **lodging knee**.

Ledge: A short beam set between and parallel to the deck beams to provide intermediate support of the deck; the ends of ledges were supported by **carlings**, **clamps**, or **lodging knees**.

Lines: The various shapes of a hull; expressed graphically, a set of geometric projections usually arranged in three views, hat illustrates the shape of a vessel's hull.

Lodging knee: A horizontal, angular timber used to reinforce two perpendicular beams or the junction of a beam and the side of the hull.

Metacentre: The intersection of a vertical line drawn through the center of gravity of a vessel when it is stable with a vertical line drawn through its center of buoyancy when the vessel is heeled.

Mold: A pattern used to determine the shapes of frames and other compass timbers. Molds were usually made from thin, flexible pieces of wood. See also **whole moulding**.

Narrowing line: A curved line on the half-breadth drawing of a hull, designating the curve of maximum breadth or the ends of the floor timbers through the length

of the hull. The former was called the *maximum breadth line*; the latter was known as the *breadth of the floor line*.

Orlop deck: The lowest deck of a large ship

Planking: The outer lining, or shell, of a hull.

Rabbet: A groove or cut made in a piece of timber in such a way that the edges of another piece could be fit into it to make a tight joint. Generally, the term refers to the grooves cut into the sides of the keel, stem and sternpost, into which the garboards and hooding ends of the outer planking were seated.

Sacrificial planking: A layer of planks added to the outside of ship to protect against shipworm.

Sheathing: A thin covering of metal or wood, to protect hulls from marine life or fouling, or to stabilize and protect surface material applied for that purpose. Sheathing was most commonly used in the form of copper, lead, zinc, or allow sheets… also known as *sacrificial planking*.

Shipwright: A master craftsman skilled in the construction and repair of ships. In many instances, the person in charge of a ship's construction, including the supervision of carpenters and other personnel, control of expenditure and schedules, and acquisition of materials. Probably in many more areas and periods than have been documented, the term designated a formal title, such as the shipwrights to the English monarchs, or a level of expertise qualifying admission to a guild or association.

Stem: A vertical or upward curving timber or assembly of timbers, scarfed to the keel or central plank at its lower end, into which the two sides of the bow ere joined.

Strake: A continuous line of planks, running from bow to stern

Stringer: A general term describing the longitudinal timbers fixed to the inside surfaces of the frames; the ceiling, other than the common ceiling.

Timbers: In general context, all wooden hull members; specifically, those members that formed the frames of a hull.

Trenail: A round or muilt-sided piece of hardwood, driven through planks and timbers to connect them.

Tumblehome: The inward curvature of a vessel's upper sides as they rose from the point of maximum breadth to the bulwarks. Tumblehome reduces topside weight and improved stability. Also called *pinched-in* or *housed-in.*

Turn of the bilge: The outboard part of the lower hull where the bottom curves toward the side.

Wale: A thick strake of planking, or a belt of thick planking strakes, located along the side of a vessel for the purpose of girdling and stiffening the outer hull.

Wall-sided: The figure of a ship's side when, instead of being incurvated, so as to become gradually narrower towards the upper part, it is nearly perpendicular to the surface of the water, like a wall. In shipbuilding, this was formerly called wall-reared. Also called *wall-raised.*

Waterway: A timber or gutter along the side of a deck whose purpose was to prevent the deck water from running down between the frames and to divert it to the scuppers.

Whole moulding: A Process to determine the transverse shapes of hulls by means of one or more standard moulds, which were shifted as necessary to produce fair shapes without the use of compasses and complex drafting methods. The process was not as precise as determining individual hull shapes from lines drawings or with compasses and scale, and it was usually limited to the production of small craft after the seventeenth or early eighteenth century.

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