David K Brown

BEFORE *the* IRONCLAD

WARSHIP DESIGN AND DEVELOPMENT 1815–1860

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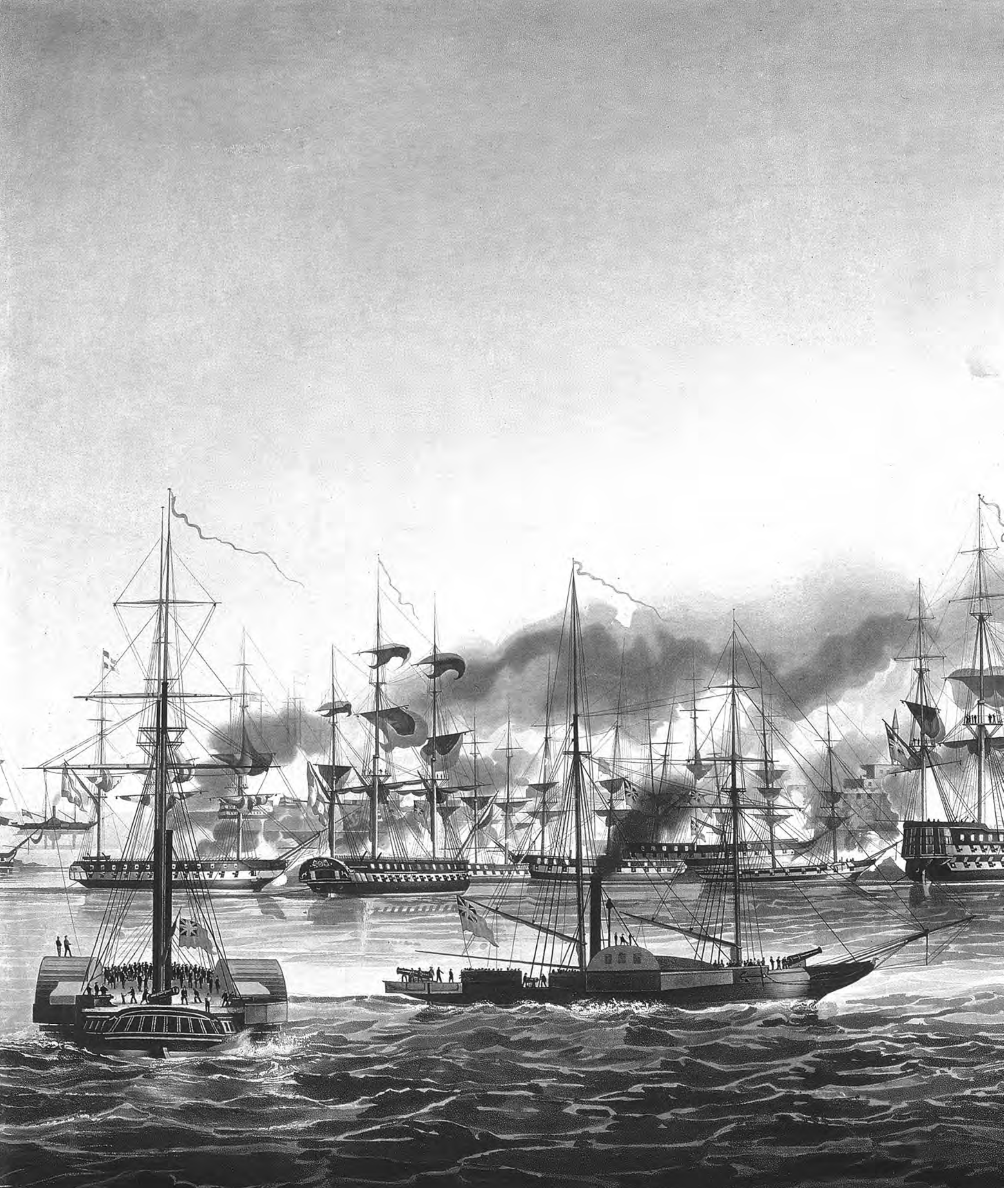

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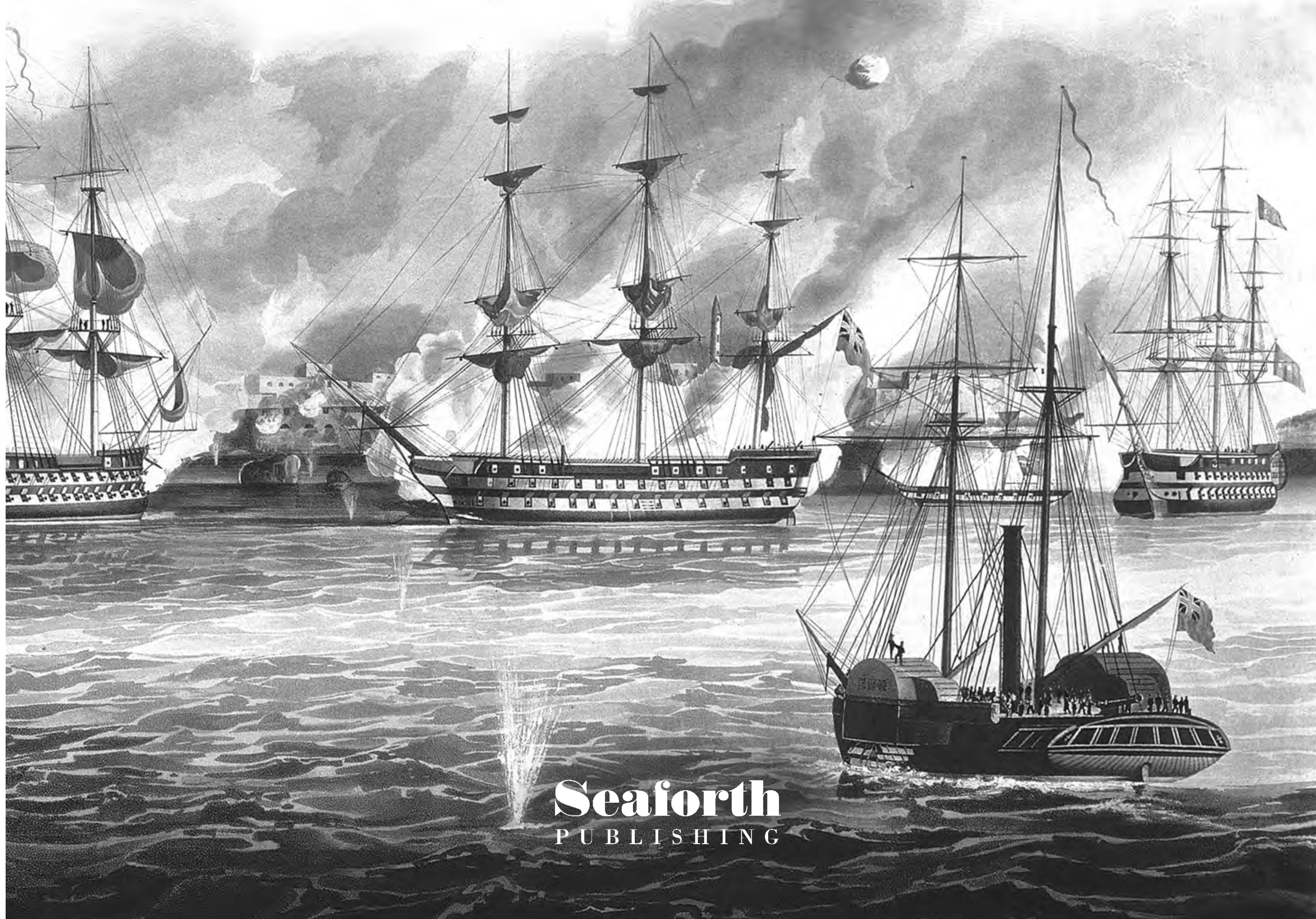

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Frontispiece:
This depiction of the bombardment of Acre (3 November 1840) shows a typical mixed fleet of the period. The principal ships of the line are the 72-gun *Benbow* and *Edinburgh*, both completed at the end of the Napoleonic war. However, the latter – here displaying Seppings's round stern – was to become one of the prototype steam battleship conversions. In the foreground are the paddle sloops *Vesuvius*, *Phoenix* and *Stromboli*, demonstrating their real value in naval warfare for the first time during this campaign. *(© National Maritime Museum neg 7019)*

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Introduction:
The Navy's Industrial Revolution

It will always be said of us with unabated reverence, 'They built ships of the line'. Take it all in all, a ship of the line is the most honourable thing that man, as a gregarious animal, has ever produced.

Ruskin, *Harbours of England*

IN THE NINETEENTH CENTURY, as now, the big warship was the most complicated and most expensive item in the defence budget. This book tells the story of the successive technical changes which led to the wooden ship of the line, first, vastly growing in size, then gaining in mobility through the power of steam and, finally, quite quickly being replaced by the iron-hulled, armoured battleship.

The first great change came when Robert Seppings used scientific method in the design of wooden hulls, an approach which led to a rapid growth in the line-of battle ship. The heavy and inefficient steam engine driving a paddle wheel was first introduced in auxiliaries to tow the sailing warship in calms or contrary winds. These paddle steamers soon grew, acquired an armament and became effective fighting ships themselves, though with some severe limitations.

The screw propeller overcame many of the problems

Virago towing the 110-gun *Queen* out of Grand Harbour, Malta, on 16 January 1844, demonstrating one of the earliest naval roles for steamers. *(© National Maritime Museum PY0891)*

Valorous. A second-class paddle frigate, the last major paddle fighting ship built for the Royal Navy. *(© National Maritime Museum neg 6845)*

of the paddler – and introduced a few new ones – and it could be fitted to many existing ships. Only a decade after the screw was proved, the Victory Review at the end of the Crimean War saw a fleet almost entirely consisting of wooden screw steamers.

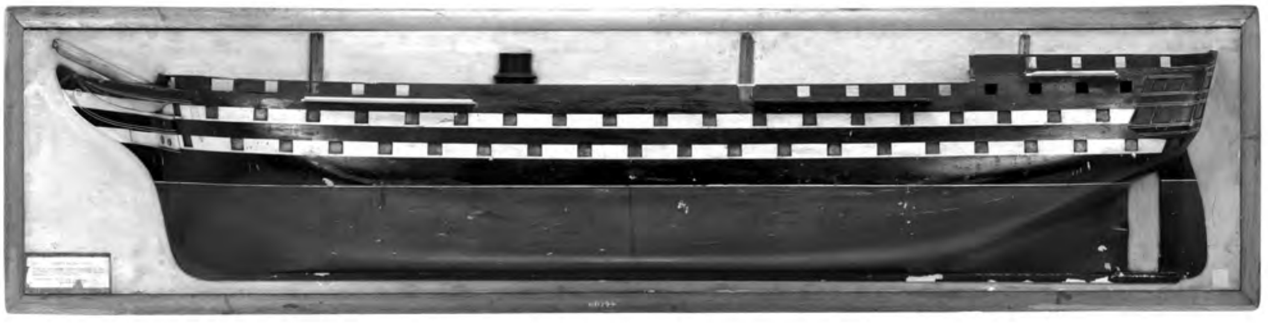
Heavy steam engines and the vibration from the early propellers required a strong and rigid hull which had to be made of iron. The first attempts at iron hulls were not successful, for wrought iron was not, and is not, a suitable material for warship construction. With the strong but brittle iron hull protected by armour, the way was open for the iron-hulled, armoured screw battleship *Warrior*. She was just as much the culmination of the developments of an earlier era as she was the prototype for the next generation and like most transitional designs was very soon obsolete herself.

These major changes in the ships of the Navy took place in little more than a generation and yet all too often 'the Admiralty' of 1815–60 is portrayed as reactionary, opposed to all change. There was indeed a proper conservatism which was seen as a reluctance to render valueless by unnecessary change the investment already made in the world's largest fleet. The initiation of change could safely be left to others, since Britain's industrial might could quickly and easily retake any temporary lead elsewhere. The quotation below comes from Sir Baldwin Walker's case for the radical introduction of the *Warrior* at the end of the era, but is implicit in much of what had gone before.

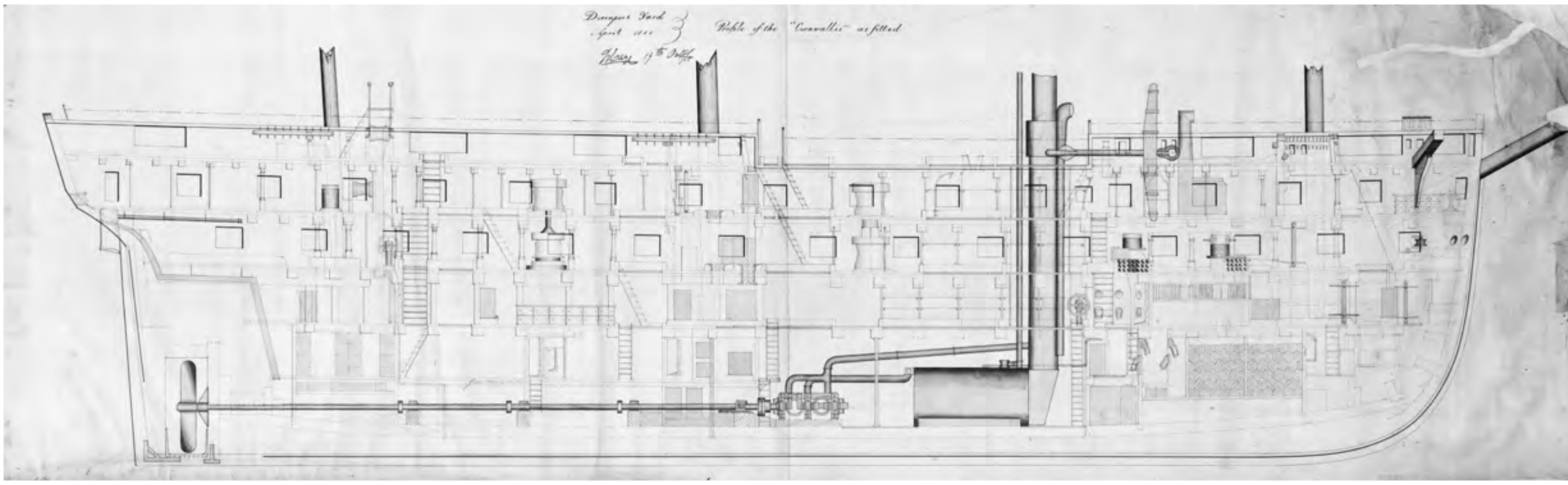
> Although I have frequently stated that it is not to the interest of Great Britain – possessing as she does so large a navy – to adopt any important change in the construction of ships of war which might have the effect of rendering necessary the introduction of a new class of very costly vessels, until such a course is forced upon her by the adoption by foreign powers of formidable ships of a novel character requiring similar ships to cope with them, yet it then becomes a matter not only of expediency, but of absolute necessity…

One often reads that the design of a particular early-nineteenth-century warship was copied from another, usually in the context that British ships were copies of foreign prizes. While there is some truth in such statements, they ignore other more important factors. On a more general level, it is true that the French first developed the big two-decker and the Royal Navy followed.

Designers of the period attached undue importance to the lines of the ship; indeed, the lines were William



Official half-model of *Duncan*, the final development of Edye's brilliant design of *Agamemnon* and the only one of the class completed as an unarmoured ship. *(© National Maritime Museum L0818)*



Admiralty profile draught of the *Cornwallis*, as converted to a screw 'blockship' or Steam Guard Ship. Beginning in 1845, this programme was the first to apply steam propulsion to ships of the line. *(© National Maritime Museum J2677)*

Symonds's only claim to be a designer, as he left the structure to his very able deputy, John Edye. In fact, as discussed later, the shape of the ship was so constrained by the need to provide buoyancy at the ends that all forms were far removed from the hydrodynamic ideal, and the small differences between rival designs can have had no effect on performance. In structural design the British were far in the lead, thanks to Seppings. He was the first to understand fully the nature of the loading on a ship at sea and he developed a light and durable structural style to meet these loads. It is wrong to say that *Ganges* was a copy of the captured French *Franklin* (HMS *Canopus*) merely because Seppings used the French lines; the shape of the bow and stern and the structural style were more important, and were all Seppings's.

Admiral Sir Baldwin Walker in the uniform of the Turkish navy in which he served from 1838 to 1845. He later became a distinguished Surveyor of the Navy from 1848 to 1861. *(© National Maritime Museum neg 9572)*

The notion of a reactionary Admiralty is so deeply entrenched that it is essential to quote at some length from contemporary reports and documents which demonstrate a determination to seek the whole truth and an ability to appreciate future potential, as well as to warn of immediate difficulties. After all, it has well been said, 'Of what use is a newborn baby?'

For this reason, prominence has been given to the trials of such ships as the HEICoS (Honourable East Indian Company Ship) *Nemesis*, the first iron warship; of *Archimedes* and *Rattler*, the early screw ships; of the 'blockships', the first steam battleships, and the full-scale tests of armour. The only significant opportunity for these ships to be proved in action was during the Crimean War, whose technical aspects are discussed in some depth. It was the first naval war in which fleets of steamships were deployed, and the first in which significant use was made of shells, mines, armour and other modern systems. The effects of this war were important, too, for the merchant navy, as steamships increased rapidly in numbers due to favourable charter rates. However, despite novel production methods, the war led to the collapse of the shipbuilding industry on the Thames, due mainly to wage inflation.

Some of this new technology was created within the Admiralty service, such as Seppings's structural scheme and George Airy's work on correcting the deviation of compasses in iron hulls which alone made iron seagoing ships possible. Much more was developed in industry, but it will be shown that the Admiralty was usually among the leaders in the utilisation of such inventions.

All too often it is forgotten that an organisation such as the Admiralty is not an impersonal and homogeneous entity, but consists of a number of all-too-human individuals, widely differing in their outlook, united only in their dedication to the cause of the Navy. To all these people the well-being of the Navy mattered and there were a few cases in which technical differences crossed the border into very bitter personal feuds. Some of the people involved were both innovators and highly competent (and these qualities are not the same); others were less so, but from 1815 to 1860 the Admiralty was blessed with many outstanding servants.

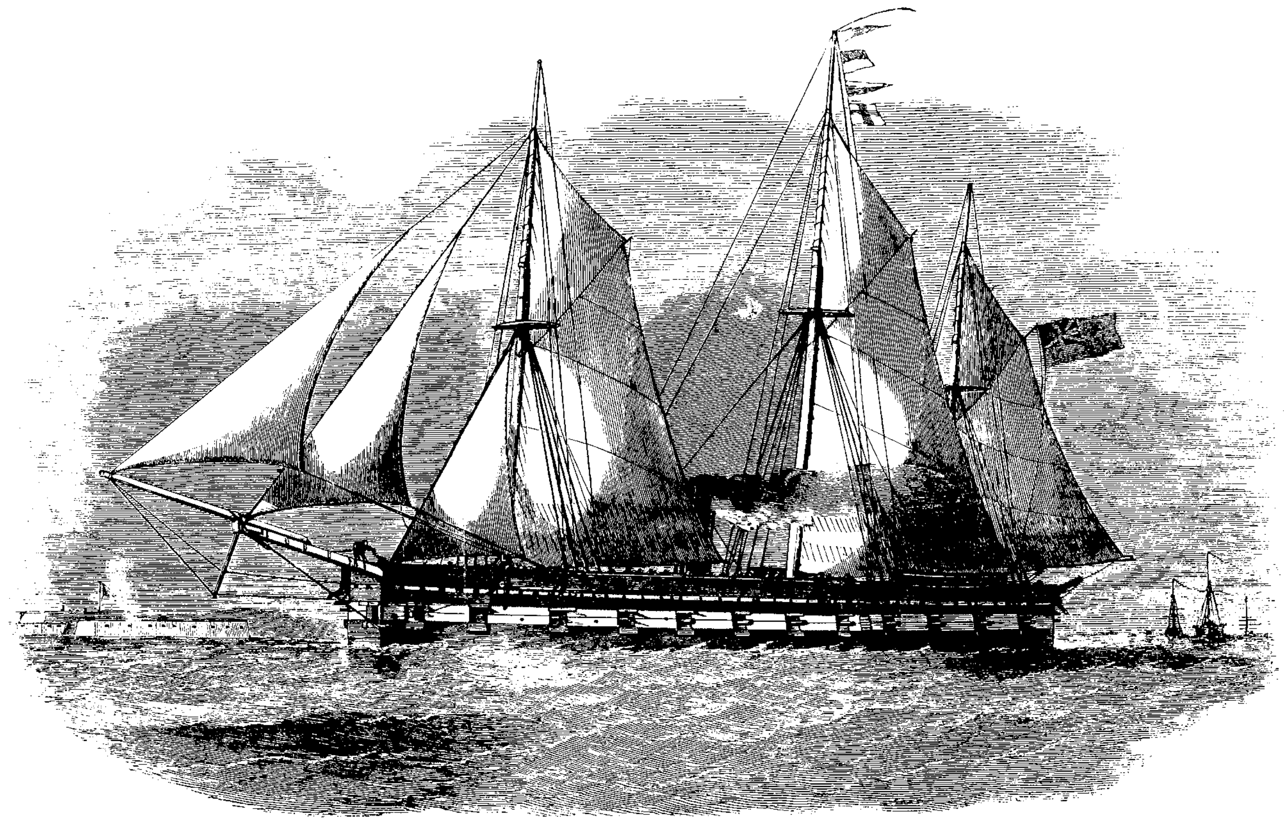
The first iron warship to see service was the *Nemesis*, belonging to the Honourable East India Company. She is in action here against Chinese war junks on 7 January 1841. *(© National Maritime Museum PY8893)*

Among the politicians, Sidney Herbert and Henry Corry stand out. Corry seems to have been a leader in the complex dealing which led to the blockships completing as seagoing battleships rather than as semi-mobile batteries. Later, he was one of those who recognised the need for *Warrior* to be an iron ship. For many years the senior civil servant (Second Secretary) was John Barrow, an early advocate of steamships, whose advice helped Smith greatly in winning acceptance for his screw propeller.

Admirals Cockburn and Baldwin Walker were most prominent among naval officers, but perhaps even more impressive is the way that time and time again an officer, often undistinguished, would be called on to report on a new type of ship, engine or weapon, and would produce a balanced and comprehensive report which stands up to the penetrating scrutiny of hindsight. The seaman officer was not the reactionary so often portrayed. In particular, the Board of Admiralty maintained a wise balance between innovation and well-tried practice in using resources which were very limited.

Within the service, there were many outstanding engineers. In this writer's opinion, Thomas Lloyd, engineer-in-chief at the time of *Warrior*, was one of the great engineers of the century, possessing a breadth of vision matched only by Marc, Isambard and Henry Brunel, George and Robert Stephenson, and a very few others. Isaac Watts, designer of some of the largest wooden ships ever built and then responsible for their successor, the *Warrior*, must rank only a little behind. These men were supported by a number of distinguished naval architects such as Fincham, the Langs, Edye, Large, Morgan, Creuze and, of course, Seppings. With a few exceptions, all these Admiralty constructors were graduates or staff of the first School of Naval Architecture, opened at Portsmouth in 1811. Almost accidentally, the final success of the graduates of this school has become an underlying theme of this book.

By 1860, the majority of master shipwrights in the Royal Dockyards were also graduates of this school. The role of the master shipwright, his background and status, is often misunderstood. They were the managing directors of the largest industrial concerns in the country, usually of middle-class background, well educated and from whose ranks would be chosen the Surveyor who was usually knighted as, indeed, were some master shipwrights. They were certainly not mere uneducated craftsmen. The most promising young men rose rapidly through the junior ranks, and as assistant masters would be given a chance to show their managerial skills in a small yard. If successful, a larger yard and promotion to the well-paid rank of master would follow. In the nineteenth century career development was less formal than it is today; knowing the right people



Thunder. A wooden-hulled, armoured battery of the Crimean War.

counted – and still does – so that reality was not as simple as that sketched above.

There were many more who made major contributions, such as Thomas Blomefield on gun-making, John Hay on the fouling of iron ships and Airy, the Astronomer Royal, whose work on compass correction made the seagoing iron ship possible. Airy also made studies into the efficiency of steam engines, justifying the Admiralty's choice of manufacturers, outstanding among whom were Penn and Maudslay.

The Admiralty deserved great credit for the way in which the transition from *Victory* to *Warrior* was handled. Looking back, one can see only a very few aspects in which they could have moved a little faster, and even fewer in which they moved too fast. They had some excellent engineers within the service, and were quite willing to work with the great men outside the service.

Sources

There are few readily available and reliable books covering the technical aspects of the period and not many on more general topics. For the political and economic background, Bartlett is invaluable. Lavery deals well with the sailing ship, as does Lambert with the steam battleship. Fincham, a master shipwright, is the only contemporary writer of history to be of much value, and he is reliable only when writing of his own experience. There is no good history of marine engines nor of gunnery (*pace* the various works quoted). This is a history of ships themselves and cannot adequately cover engines or guns, though their implications for the ship designer must be mentioned. The major sources are the searching Parliamentary Enquiries of the day.

Acknowledgements

Above all, I must thank the late George Osbon, who showed me the way ahead some sixteen years ago and gave me so much statistical data. Then, too, the staffs of various libraries: the Naval Library (particularly Miss V Francis), the PRO, Ship Department and A E W Haslar. Dr Tom Wright of the Science Museum and his colleague Joe Roome, Dr N A M Rodger, PRO, and David Brown, my namesake, Naval Historical Branch, have given most valuable assistance, as have Cdr Trevor Shaw PhD, Terry Davis and David Lyon. Steve Roberts and John Campbell have not only made the result of their own studies available to me but have been friendly but searching critics. Thanks are due also to Robert Gardiner, whose suggestion that *Warrior* be included brought the whole story into focus; and to the many others, too numerous to mention, who have contributed.

Finally, my thanks to my former secretaries, Sheila and Edwina, and to my wife Avis for their help and forbearance.

David K Brown, RCNC
1989

Publisher's note

Since the above was written, there have been a number of significant publications in this area: indeed, *Before the Ironclad* might be seen as the work that encouraged, if not inspired, a more positive interpretation of the Royal Navy in this period. The ships are now covered in great detail in *The Sail and Steam Navy List* by David Lyon and Rif Winfield, and the 1817-1863 volume of Winfield's *British Warships in the Age of Sail* series. Andrew Lambert's pioneering work *Battleships in Transition* was followed by a far larger study entitled *The Last Sailing Battlefleet: Maintaining Naval Mastery 1815-1850* and two books on the Crimean War, as well as a monograph on HMS *Warrior*. Professor Lambert also contributed the section on Brunel, HMS *Rattler* and the introduction of the screw propeller into the Royal Navy to *Brunel's Ships* with Denis Griffiths and Fred Walker. A broad account of the period is *Steam, Politics & Patronage: The Transformation of the Royal Navy 1815-54* by Basil Greenhill and Ann Giffard.

Steam at Sea by Denis Griffiths filled the need for a good general history of marine engineering, but there is still no satisfactory history of guns and gunnery in the first half of the nineteenth century.

Illustrations

In the first edition D K Brown wrote:

> These present some special difficulties in that photography had been barely invented during the period covered, and illustrated journals were not common until well into the period. Only in the Crimean War did illustrations become common and hence that chapter is much more generously decorated than others. Originals are hard to find and copies of copies lose their quality. However, thanks to individuals, museums, etc (listed below), I hope that something of the quality of this forgotten fleet is presented.
>
> I am particularly grateful to the Trustees of the Science Museum for permission to use many of their photographs, especially those of their beautiful models of marine engines.

After his death in 2008 the author's picture collection was dispersed, so it was necessary for the publishers to reconsider the illustration of the book. Fortunately, the vast collections of the National Maritime Museum were able to supply many of the original illustrations, but in higher-quality formats that benefit from modern digital technology. Furthermore, the cooperation of the Museum made it possible to include additional images from parts of the collections – like the original draughts – which were almost impossible to access when the book was first written. In this context, the publishers would like to extend special thanks to Jeremy Michell, Andrew Choong and the staff of the Museum's Brass Foundry outstation, and Emma Lefley and her colleagues in the Picture Library.

We are also happy to acknowledge specific help from William Mowll, Dr Stephen S Roberts, and from Major Grant Walker of the Beverley R Robinson Collection, US Naval Academy Museum.

Some terms used

Displacement The actual weight of the ship and its equipment. By Archimedes' principle, weight equals buoyancy and buoyancy is the weight of the water displaced by the underwater hull when floating.

Entrance The forward part of the underwater hull, up to the largest section.

Horsepower A very difficult subject, covered in full in Appendix 1, but in brief:
NHP (nominal horsepower) was a measure of the geometry of the engine and bore little relation to the real power. Modern convention is to use lower case letters for horsepower and this has been adopted except for NHP where capitals are used to make it clear that it is not power.
ihp (indicated horsepower).The power available in the steam, not all of which could be used to drive the propeller.
shp (shaft horsepower). The power put into the screw.

Line-of-battle ship The usual contemporary abbreviation was 'liner', which is used here, as well as 'battleship'.

Run The after part of the underwater form.

Tonnage Given in 'builder's measurement' (bm) or, from the mid-1830s, strictly 'builder's old measurement', since a new definition of tonnage was introduced for merchant ships; it was rarely used for warships. It was a measurement of volume, given by

$$\frac{(LB - \tfrac{2}{3}B) \text{ x } B/2}{94}$$

Trials Trial speeds quoted were generally the average of several runs over a measured distance in opposite directions. This procedure eliminated the effect of tide, but not necessarily that of wind. With care, the procedures then in use should give a speed, *on the day*, accurate to about ¼ knot; the three decimal places often quoted are an arithmetical quirk of the averaging process and should be forgotten. Methods to correct for the effects of fouling, which could be several knots, or for changes in displacement, did not exist. The Admiralty published very detailed tables of the trials results of screw ships; data for paddle ships are less abundant and much less reliable.

One Victory 1793–1815

DURING THE REVOLUTIONARY and Napoleonic wars the Royal Navy achieved the most overwhelming series of victories in the history of naval warfare. The main fleets of France, Spain, Denmark and The Netherlands were captured or destroyed – in some cases more than once – and there were innumerable successes in single-ship actions. After Trafalgar, the British battlefleet was not seriously challenged. These repeated victories gave the Royal Navy an arrogant self-confidence which helped it greatly to win against the odds, even as recently as the Second World War.

Written in the form of a scoreboard, the results of this war at sea seem almost incredible. The figures in Table 1.1 are inevitably imprecise, since some older or smaller ships had only a marginal claim to be classed as line-of-battle ships, and it is not always clear whether individual losses were due to damage in action at sea, bad weather, military action against a port, or a combination of causes.

In summary, in fighting at sea, the Royal Navy lost five battleships and sixteen frigates, and the enemy navies lost some 92 battleships and 172 frigates. It should be noted that only about 20 per cent of losses in action involved the destruction of the enemy by fire or flood. The wooden fighting ship was hard to sink by cannon fire; for example, take the well-documented case of *Impregnable* at Algiers in 1816. She was struck by 268 shot, of which fifty hit below the lower deck, including three 68pdr balls below the waterline, yet she was able to sail to Gibraltar for repairs.[2] The large number of captured ships helped augment the output of hard-pressed British building yards.

Table 1.1 **British and Enemy Losses 1793–1815**

		At sea		Port	
		Captured	*Destroyed*	*Captured*	*Destroyed*
Royal Navy	Line of battle	5			
	Frigates	16			
France	Line of battle	46	10	13	10
	Frigates	110	25	15	4
Netherlands	Line of battle	8	10	3	1
	Frigates	8	1	5	1
Spain	Line of battle	17	2	3	1
	Frigates	16	3	1	2
Denmark	Line of battle	1	17		
	Frigates	1	8		
Turkey	Line of battle	1			
	Frigates	1	4		
Russia	Line of battle	1			
USA	Frigates	3			
All enemy	Line of battle	79	13	43	14
	Frigates	139	33	29	7

Notes

1. Figures from James, *The Naval History of Great Britain*.[1]
2. Line-of-battle ships under sixty guns ignored.
3. Ships which ran ashore in battle and were then destroyed count as destroyed at sea.
4. Ships scuttled in port to avoid capture are listed as destroyed in port.

Table 1.2 **Accidental Losses**

		Wreck	*Founder*	*Fire*	*Total*
Royal Navy	Line of battle	15	3	8	26
	Frigates	59	3		62
France	Line of battle	6	4	1	11
	Frigates	10	1	1	12
Netherlands	Line of battle	1			1
	Frigates	1			1

Considering the relative number of ships at sea, the figures in Table 1.2 demonstrate the superb seamanship of the Royal Navy, the result of long years at sea and a strict discipline. It is worth noting that five of the liners lost were the old and unsatisfactory 64-gun ships, a high proportion of such vessels (it is possible that they had less efficient officers). The number of vessels lost by fire suggests that the improvements made after the war to magazine safety were long overdue.

The British success in battle was primarily due to leadership and to seamanship. Sea officers had learnt much from the War of American Independence and had polished their skills in the opening years of the new war. On the other hand, the majority of the French officers of the old navy were killed or deposed in the Revolution. The high rate of fire maintained by British gun crews was another important factor in victory. In part, the ability to fire at least three rounds as against two from the French was a result of training, but it also owed much to the technology of British gunfounders, an aspect discussed later.

The overall superiority of the Royal Navy in battle, due to gunnery and seamanship, is clear from Table 1 and it seems unlikely that the ships themselves were inferior to those of the enemy. It is strange, therefore, that virtually all British writers insist that British-built ships were poor in comparison with those built in other countries. Naval officers and the new generation of professional naval architects were in agreement on the virtues of foreign, and in particular, French ships. British designs were said to be smaller and slower, with cramped gun decks too close to the waterline. Their designers

The battle of Algiers, 1816. Like much naval warfare of the period 1815–1860, this action involved ships attacking forts, usually successfully. *(© National Maritime Museum BHC0617)*

were said to be mere tradesmen with none of the science of French naval architects.

There are innumerable accounts by officers of the RN, accepted by historians such as James[3] and Brenton,[4] and by later writers, extolling the merits of captured ships and few indeed put a different viewpoint. By 1816 one-ninth of the battleships in commission were prizes, as were about a ninth of smaller vessels. A large proportion of British-built ships were based, to some extent, on the designs of captured enemy vessels.

Actual evidence in support of these views is less easy to come by. One may use the subjective impressions of ships' captains and officers, but even today such evidence is considered unreliable because of the strong emotional bond between a captain and his ship. Unless she breaks his heart, a captain will always swear that his present ship is the best ever. Admiral Nelson, during the brief period in which the *San Joseph* was his flagship, told Lord Spencer that she was the finest ship in the world, yet he had never been to sea in her at that time. Brenton, too, commends the *San Joseph* in his book:

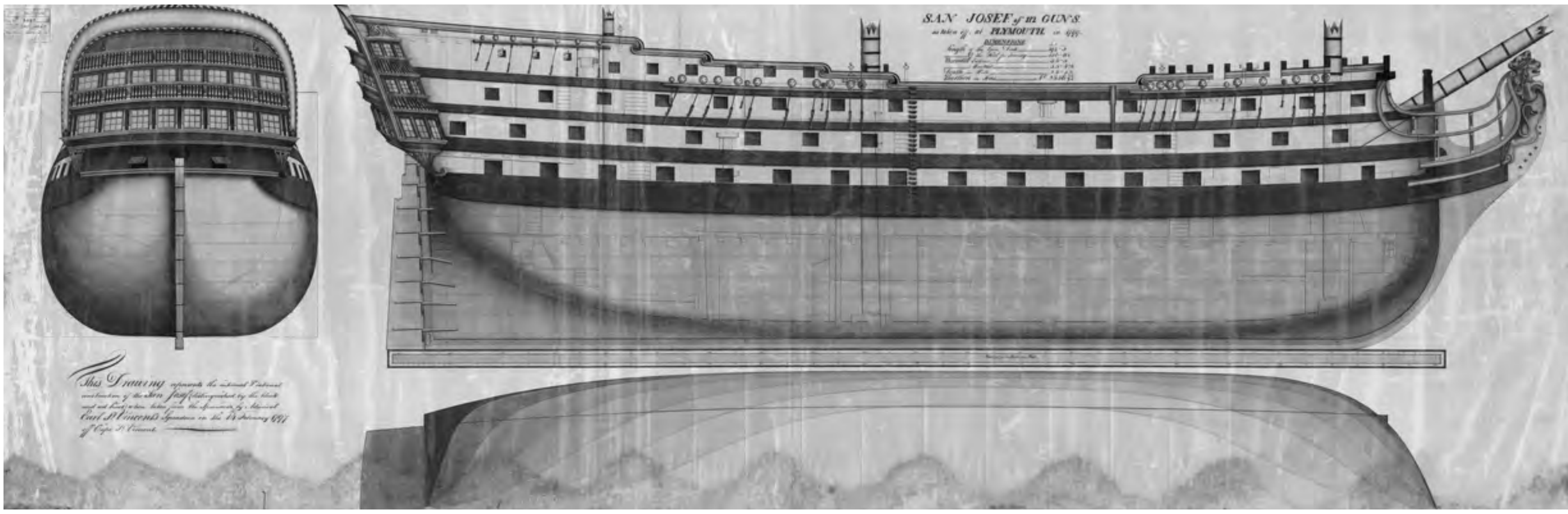
> The *San Joseph*, of 112 guns, taken in the battle off Cape St Vincent in 1797, was long admired in the British Navy, uniting all the superior qualities of a ship of the line with the sailing of the fastest frigate: her lower deck ports were higher out of the water with all her sea stores in than was ever known in any other ship of the line; she could carry her guns run out when few British ships would have ventured to open a port; she stowed 500 tons of water and we had nothing that compared with her as a ship of war.[5]

San Joseph may have been a fine ship, but English builders, who were not in any way reluctant to copy the best of foreign designs, chose *Victory* as the model for the smaller three-deckers.

Before considering such allegations in detail it is necessary to set out the desirable qualities of a warship. British resources of all kinds were limited, yet the Royal Navy had to provide several large fleets, as well as smaller squadrons worldwide. The enemy could bide his time and strike in one area only, a difference summed up today by comparing a sea *command* navy with a sea *denial* navy.

Britain was short of building slips and of shipwrights; timber was increasingly difficult to obtain, as were naval stores such as hemp. Seamen, too, were scarce and all these problems forced the Admiralty and Navy Boards

1. W James, *The Naval History of Great Britain 1793–1820*, London (1822).
2. Ibid.
3. Ibid.
4. E Brenton, *Naval History of Great Britain*, London (1823).
5. Ibid.



San Josef. This captured Spanish three-decker was much praised by naval officers but did not influence British ship design. *(© National Maritime Museum J1945)*

to build the smallest ships with the minimum capability to do the job. As Sir Robert Seppings was to say in 1830:

> It is a fact which cannot be controverted, that in point of experience, whether considered in respect of building and first equipment or in reference to the subsequent wear and tear of the hulls of ships and their stores, the smaller they are to carry the number of guns prescribed and to secure the necessary seagoing qualities, the more advantageous they will be to the country. [6]

The 'rate' of a ship depended on the number of guns it carried and it is obvious that a bigger ship would carry a set number of guns more effectively, would be more seaworthy, and hence would be considered superior. Later in the century, displacement was the base line for comparison and the 'best ship' was the one carrying most guns on a given tonnage.

The first paper read to the Society for the Improvement of Naval Architecture in 1791 was, unfortunately, anonymous but contained a reasoned critique of British design.[7] The author (possibly Captain Sir John Warren) suggested that British ships were at a disadvantage when 'sailing by the wind' and in the angle of heel produced by the wind. Both these problems related to lack of stability affecting mainly the smaller three-deckers and the 64-gun ship, already obsolete by 1815. The bigger frigates (1791) of thirty-six and thirty-eight guns were 'admirable ships'.

A limited study of contemporary French writing suggests that they had a different view of the performance of their ships vis-à-vis those of the Royal Navy. M Bouvet, writing of French ships, says:

> They have never, by any chance, taken or preserved any advantage over their adversaries, or succeeded in eluding or flying from a disastrous engagement. Our ships of all rates, whether in company or alone, have rarely escaped pursuit of those of the enemy that have fallen in with them while cruising … The fault may in great measure be attributed to the French ships being too sharp and constricted at their extremities; they are not what is termed good sea-boats; this peculiarity, which has been imagined to lead to superiority in point of swiftness, has produced a contrary effect, at least in rough seas.[8]

The most common allegation by British writers against British designs is that they were slower than those of all other navies. Direct evidence on relative speed is both hard to find and hard to interpret. Study of James's history has identified only fifty-eight chases in which it is clear that one ship, or groups of ships, was faster than its opponent. It must be noted that these fifty-eight chases almost all led to an engagement and there must have been many inconclusive pursuits. However, the number identified is sufficient and probably sufficiently unbiased to give meaningful results. This evidence is examined in detail by the author elsewhere.[9]

Table 1.3 **Comparison of Ships in Chase**

Frigates and above				
Faster ship		*Slower ship*		
Built in	*Manned by*	*Built in*	*Manned by*	*Number*
Britain	Britain	France	France	40
France	France	Britain	Britain	6
France	Britain	France	France	8
Spain	Britain	Britain	France	1
Britain	Britain	Denmark	Denmark	1
Britain	Britain	Russia & Sweden	Russia & Sweden	1

The problem of comparing the performance of two or more groups of ships of different designs with crews of different ability and under very different conditions of sea state is not easy (Table 1.3). There will always be two different categories of influence at work: the systematic advantage of better seamanship, skill in trimming ballast and rig and of better hull design, as against the random effects of fouling and the strength and direction of both wind and sea. The latter effect was clearly shown on 26 July 1798 when HMS *Brilliant* was being caught by the French ship *Vertu* but, when the wind changed, *Brilliant* proved the faster.

6. R Seppings, letter to *United Services Journal*, vol 1 (1830).

7. Anon, 'Remarks on the forms and proportions of ships'. *Collection of papers on naval architecture, European Magazine*, London (1800).

8. M Bouvet, quoted by 'Nauticas' Veritas', *Naval and Military Magazine*, vol III (1828).

9. D K Brown, 'Speed of sailing warships', 'Empires at war and peace', Conference, Portsmouth (1988).

Table 1.4 **Relative Speed of British-Manned Ships**

Built in	*Won*	*Lost*
Britain	42	6
Abroad	10	0

Some further insight can be gained by comparing the performance of British-manned ships, built at home or abroad (Table 1.4). This table suggests that there was a slightly greater chance of foreign-built ships winning a chase, but any such advantage was small and swamped by random effects.

From the mid-eighteenth century onwards, captains of British ships were required by the Navy Board to report on the sailing qualities of their ships, answering a standard list of questions.[10] The key questions concerned the maximum speed attained with different wind speeds and directions during a whole commission. Such reports provide a somewhat more objective assessment of a prize than that given in the moment of victory.

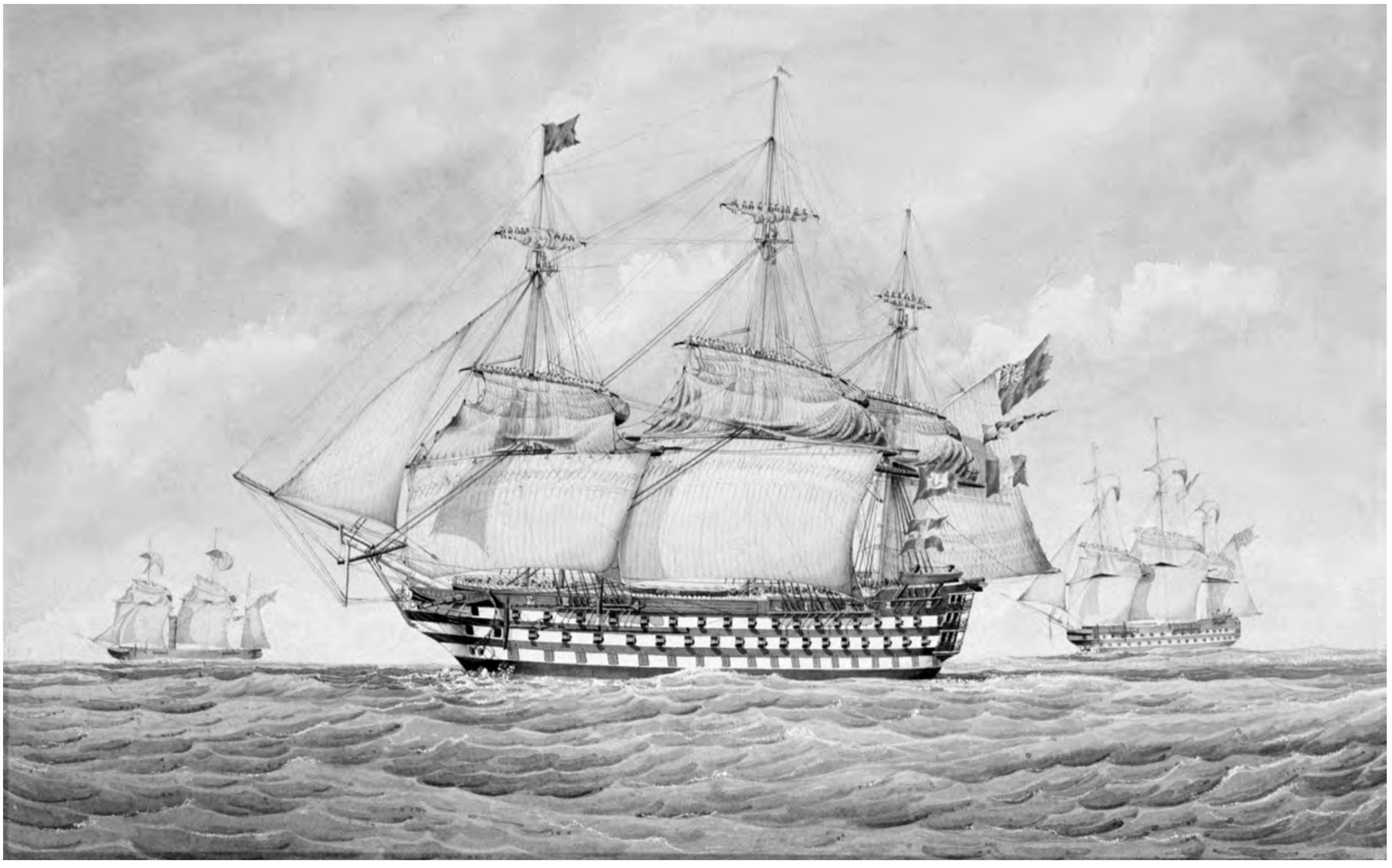
Fouling affected all ships but it is not clear that they were affected equally. Copper sheathing was tried in the Royal Navy in 1763, and by 1782 all problems had been overcome and some three hundred British ships were sheathed. During the War of American Independence this usually gave British ships a speed advantage of up to 1½ knots.[11] By 1793 all navies were using copper sheathing and, if it was in good condition, no one ship would have had an advantage. However, due to shortages, the French used very thin copper, which was easily damaged or eroded, leading to rapid growth of fouling on the unprotected areas. Even when the copper was sound, it would form a green patina after about a year in seawater and lose much of its anti-fouling properties. British ships on blockade duty, long out of dock, did suffer from such fouling and would be slow in comparison with ships fresh out of dock. It is thought that French dockyards were so dilatory that their navy reaped little benefit. Overall, the effect of fouling is seen as random, making difficult the comparison between forms.[12]

It was also suggested, notably by the new generation of naval architects, that French forms were faster because of their superior understanding of hydrodynamics. The drag of hulls of the size, shape and speed of nineteenth-century warships was primarily due to viscosity, a topic almost totally ignored by the science of the day. Since a fluid lacking viscosity produces no drag at all, scientists from Isaac Newton onwards fudged the answer by considering flow over the fore body only. This incorrect assumption led them to direct their attention to the form of the entrance and the shape of the midship section, contrary to the empirical knowledge that the shape of the run was

10. B Lavery, *Ship of the Line*, vol I (Appendix XI), London (1983); see also n9.

11. R J B Knight, 'The introduction of copper sheathing into the RN 1779–86', *Mariner's Mirror*, vol 49 (1963).

12. Brown, op cit.



Hibernia. A 110-gun ship designed by Henslow and launched in 1804. Reconstructed in 1819–1825, she was highly regarded and enjoyed a long career – seen here at sea in the 1840s. *(© National Maritime Museum PW5999)* vital to good performance. It is no wonder that the master shipwrights were unimpressed by such science.

Morgan made a very careful analysis of the characteristics of hull forms from many navies in *Papers on Naval Architecture* in 1826.[13] His tables show little difference between the proportions of rival designers. There was, perhaps, a tendency for British ships to be marginally narrower than most, which would lead to slightly greater heel in a strong wind. Morgan appreciated that, once a ship heels, its underwater form is unsymmetrical, always increasing the drag, and usually causing the ship to fall away to leeward as well as bringing the gunports nearer the water.

Like his contemporaries, Morgan believed that the shape of the midship section had a major influence on sailing. Today, it is clear that the section shape could have had no influence on speed and little on rolling. Section shape could have affected the ability to hold a course, but the effect must have been very small within the practical limits of the shape.

The effect of an extreme and certainly quite impractical change of shape has been examined by G S Baker, superintendent of the Froude Ship Tank.[14] He compared the resistance of the *Victory* with that of a 'modern' sailing ship of the same displacement but 69ft longer and 12½ft narrower. This dramatic change in form led to a reduction in resistance of some 30 per cent, which would lead to a 1–1½-knot advantage to the longer ship. In comparison, the very small differences between ships of rival navies can have had no observable effect.

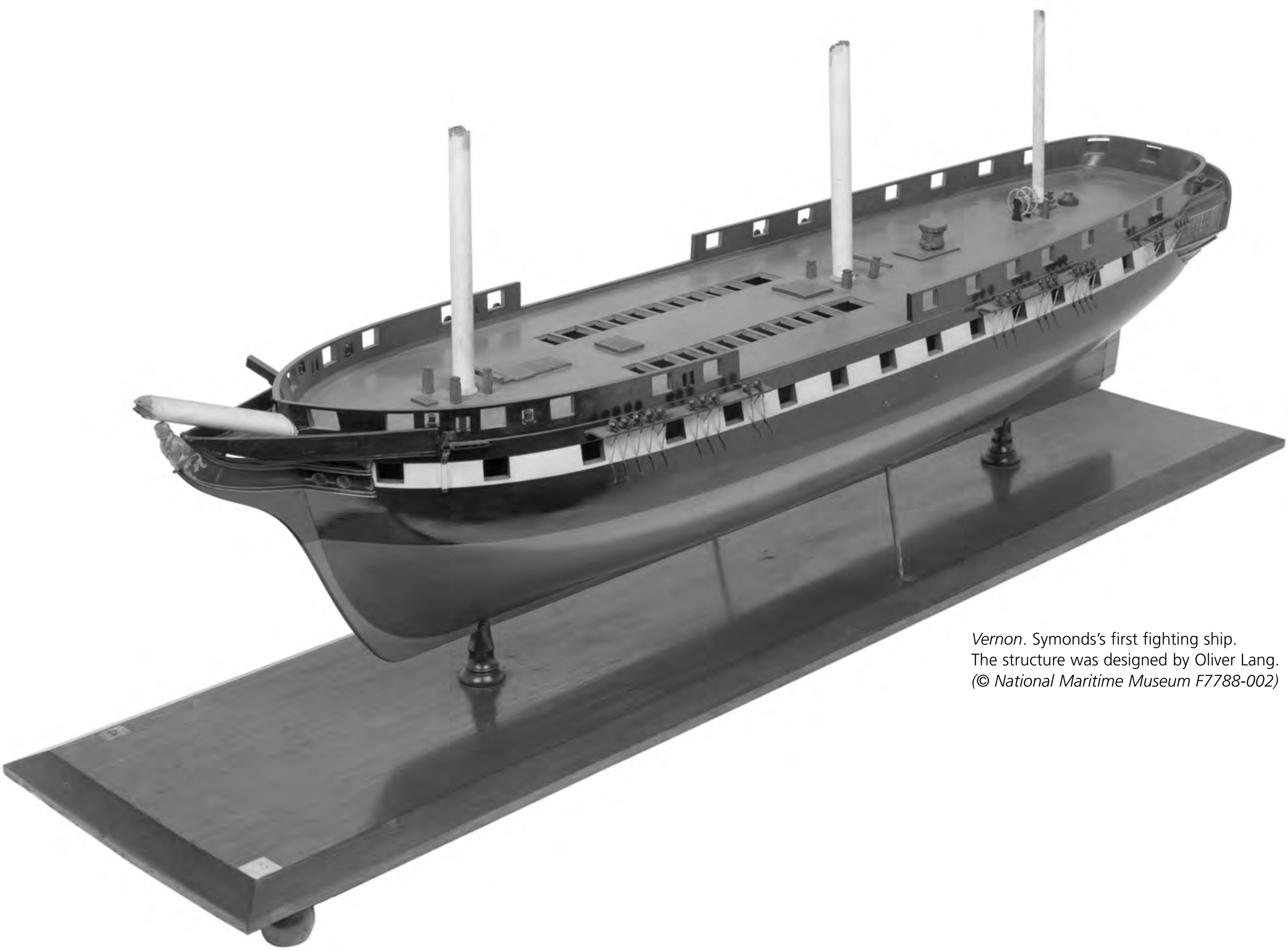
In fact, the hull form of the wooden warship of all navies was dominated by the problem of keeping the load on the hull down to a level which could be accepted by the structure.[15] The side planking was not effectively joined at the seams or at the ends of the planks and could move under load. Such relative movement led to the whole hull bending, an effect known as 'hogging' or 'breaking the sheer'. In order to reduce the loading due to the sea to an acceptable level, it was necessary to arrange that the buoyancy at any section along the length was roughly equal to the weight of that section. In particular, the weight of the heavy bow and stern chasers had to be supported by full underwater sections, very different from the fine ends which would be selected by a modern naval architect. The hull form of warships was so far from the ideal that small differences in shape can have had no measurable effect.

The evidence that there was little difference in hull

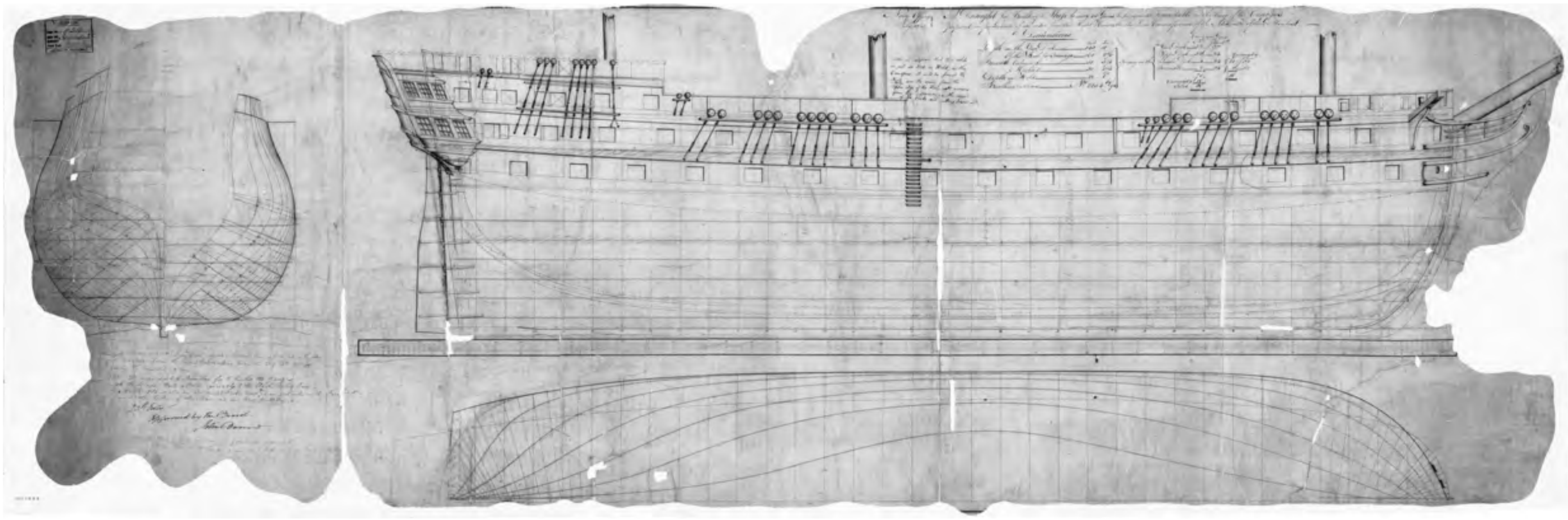
13. W Morgan, 'Brief sketch of the progress of naval architecture', *Papers on Naval Architecture*, vol I, London (1826).

14. G S Baker, 'Development of the hull form of merchant vessels' (8th Andrew Laing lecture), *Transactions, North East Coast Institution of Engineers and Shipbuilders*, vol LIV (1937).

15. J F Coates, 'Hogging and breaking of frame built wooden ships', *Mariner's Mirror*, vol 71 (1985).



Vernon. Symonds's first fighting ship. The structure was designed by Oliver Lang. *(© National Maritime Museum F7788-002)*



Formidable. This draught for an 84-gun ship of 1815 is annotated 'on the lines of the *Canopus*', a French prize, but the design was later altered to include Seppings's structural improvements and his round stern. *(© National Maritime Museum J2310)*

form or in speed between different national styles seems conclusive. One must ask why the almost unanimous British view was to the contrary. First, there was the excitement of the chase which always leads the hunter – and perhaps even more, the hunted – to exaggerate. In this case there was an even better reason to praise the qualities of a capture, since prize money depended on the value of the ship which had been taken. Naval architects, too, had reason to support the myth of French superiority. They wished for more attention to be given to the scientific study of their subject and it was convenient to attribute the apparent superiority of enemy ships to their superior science. True or false, the Admiralty acted in several ways to remedy what they perceived as British inferiority.

For many years the Admiralty, the Navy Board and the master shipwrights had used the lines of some captured French ships as the basis for new British designs. This practice was by no means universal; the big three-deckers owed little to foreign influence and Slade's *Victory* was seen as a form worth copying well into the nineteenth century. The big two-deck Second Rates were a French speciality and the form, but not the structure, of such ships was usually based on *Canopus*. Third Rates had a more mixed ancestry, with some French input, much modified by the surveyors.[16] French influence was more closely seen in the form of frigates. The two most numerous classes of Fifth Rate were based on the *Presidente* captured in 1806 and the *Leda* in 1782. It is surprising that the 44-gun *Presidente* was chosen as a model since she was caught after a twelve-hour chase by the 18-gun brigantine *Despatch*, a vessel not well regarded for speed. Despite the ease with which both these ships were caught, they were highly praised for their sailing qualities and their lines were used for large classes of RN ships. (*Leda*, incidentally, was similarly prized in the French navy, large numbers of this Sane design being built well into the nineteenth century.)

There were real, if small, differences between the design philosophies of the two rival navies. Gardiner has summed up the practical consequences of the French philosophy as follows:[17]

a. Light construction which may have given a slight advantage in speed when new. However, lack of strength led to rapid distortion of the hull, causing a loss of speed.
b. A high speed in optimum conditions, usually on one point of sailing only.
c. Less stability at large angles of heel and hence able to carry less sail in high winds but able to 'ghost' in light breezes.
d. Relatively leewardly.
e. Lower firepower than British ships of the same size.

It will be seen later that these differences persisted at least until 1830. It should be emphasised that the foregoing remarks are not intended to show that British ships were 'better' than their French equivalents, but merely different to a very small degree. To sum up, the words of Sir Phillip Watts, who designed much of the First World War fleet, seem appropriate. 'They were weather-beaten craft, often in poor repair, but they did their work with extraordinary persistence.'[18]

The firepower of RN ships was enhanced by the high rate of fire which they could achieve. To a considerable extent, this rate was due to the skill of British gunfounders and, in particular, to Thomas Blomefield.[19] He was appointed Inspector of Artillery and Superintendent of the Royal Brass Foundry in 1780, with the rank of major, where he remained until his death as a general in 1822.

During the War of American Independence attempts had been made to achieve a higher rate of fire but too many guns had cracked or burst. Blomefield introduced new methods of testing (proof), better instruments for inspection and required a more exact adherence to contracts. In addition, he redesigned the guns for greater strength. Progress was slow but steady and, by about 1796, British iron guns were reliable and could be fired faster than those made elsewhere. Indeed, British guns were highly valued abroad and sought energetically. Initially, his insistence on getting everything right led to a shortage of guns, but as new contractors appeared to accept his challenge this problem was soon remedied.

16. Lavery, op cit.
17. R Gardiner, 'Frigate design in the 18th century', *Warship* 9, 10 and 12 (1984).
18. P Watts, 'Ships of the RN as they existed at the time of Trafalgar', *Trans INA*, vol 47, Pt 11 (1905).
19. H A Baker, *The Crisis in Naval Ordnance,* National Maritime Museum, Monograph 56, London (1983).

Two Science, Seppings and the School

THE FRENCH DEVELOPMENT of the theory of naval architecture owed much to an initiative by Jean Baptiste Colbert, Minister of Marine to Louis XIV. In 1681 he summoned many of the leading scientists of France to a conference in Paris, where the problems of warship design were outlined to them and their help invited in finding solutions. The Academy of Science encouraged these studies by offering prizes for the best papers submitted on naval architecture. By the end of the seventeenth century papers had been published on the theory of sails, manoeuvring, etc. In 1697 Paul Hoste, Professor of Mathematics at the Royal Seminary at Toulon, wrote that unless the fundamentals of naval construction were fully understood, design would continue to be a process of trial and error.

During the eighteenth century many books were published of increasing value to the profession. The most famous is Bouguer's *Traité du Navire* (1746), but there were other important works from Euler, Jorge Juan and Chapman. The state of naval architecture at the end of the century was summarised in Chapman's works, discussed later.

The only British contribution to theory, but a most valuable one, was that by George Attwood on the stability of ships at large angles of heel, presented in two papers to the Royal Society in 1796 and 1798. However, the length and difficulty of the calculations required for a direct solution of Attwood's equations meant that they could not be used in ship design until Barnes produced a simplified method some seventy years later.

It was left to a bookseller named Sewell to take the initiative in raising the standard of naval architecture in Britain.[1] In visits to naval ports he had heard much talk of the inferiority of British warship designs, and he set aside the covers of the *European Magazine*, which he published, for correspondence on the subject.

As a result of the interest aroused, Sewell called a meeting at the Crown and Anchor in the Strand on 14 April 1791 which led to the formation of the Society for the Improvement of Naval Architecture. By June the Duke of Clarence, himself a naval officer and later King William IV, had agreed to become president of the society, which had a distinguished membership including the Earl of Stanhope (a naval innovator of note), Lord Mulgrave (First Lord), Sir Joseph Banks (President of the Royal Society), Admiral Sir Charles Middleton (a former controller, later Lord Barham) and Sir Charles Knowles (a hydrodynamicist). The vice president was Captain Sir John Warren, distinguished both for his intellect and his fighting record. By the following year some 270 had paid their subscription of two guineas (£2 2s).

The principal object of the society was stated to be 'the improvement of naval architecture in all its branches'. The society intended to offer awards of up to £100 for work on the theory of floating bodies and their resistance to motion, to obtain plans of various ships and calculate their capacity, position of the centre of gravity, tonnage, etc. The society also intended to carry out its own experimental work.

The papers of the society were published by Sewell in 1800 and it can be seen how well they lived up to their aim of studying all branches of the subject.[2] The first paper was by an anonymous naval officer (possibly Warren himself), entitled 'Remarks on forms and proportion'. As well as the general comparisons of British and foreign ships quoted in the previous chapter, it discussed problems of stability and described how de Romme had measured the metacentric height of the *Scipio* in 1779 by running out the guns on one side only and then moving the crew across to the low side. Finding the stability inadequate, de Romme had the ship girdled, adding a foot each side to the beam.

The author then describes how he carried out three similar inclining experiments, moving fourteen guns, each weighing 3 tons, through 3ft and measuring the heel. From this he was able to deduce the metacentric height (see Table 2.1). He found that the *Bombay Castle* was stiff enough, perhaps even a little too stiff, while the other two needed more ballast to improve their stability. The full theory of the inclining experiment was given by Chapman in the same volume.

Table 2.1 **Metacentric Heights**

Ship	*Displacement (tons)*	*Metacentric height (ft)*
Formidable	3,150	3.42
Barfleur	3,360	3.77
Bombay Castle	2,700	4.47

A lengthy paper by Gabriel Snodgrass, discussed later, gave his views on the strength of wooden ships, and Attwood's classic work was republished. More practical articles covered the curing of beef, stowage of drinking water and life saving, and Clerk's well-known book on tactics was reviewed.

The most famous work by the society was the series of model tests on the stability and resistance of various forms carried out by Colonel Beaufoy, a member of the council. Between 1793 and 1798 he completed some 1,700 successful runs in Greenland Dock, London. These tests and their results are described in Appendix 2,

1. A W Johns, 'An account of the Society for the Improvement of Naval Architecture', *Trans INA*, vol 52 (1910).

2. Anon, 'Remarks on the forms and properties of ships', *Collection of papers on naval architecture (European Magazine)*, London (1800).

but it is clear that Beaufoy was close to a solution to the problem of estimating resistance of full-size ships, finally solved by William Froude some seventy years later. In particular, he appreciated the importance of friction, neglected by most previous workers.

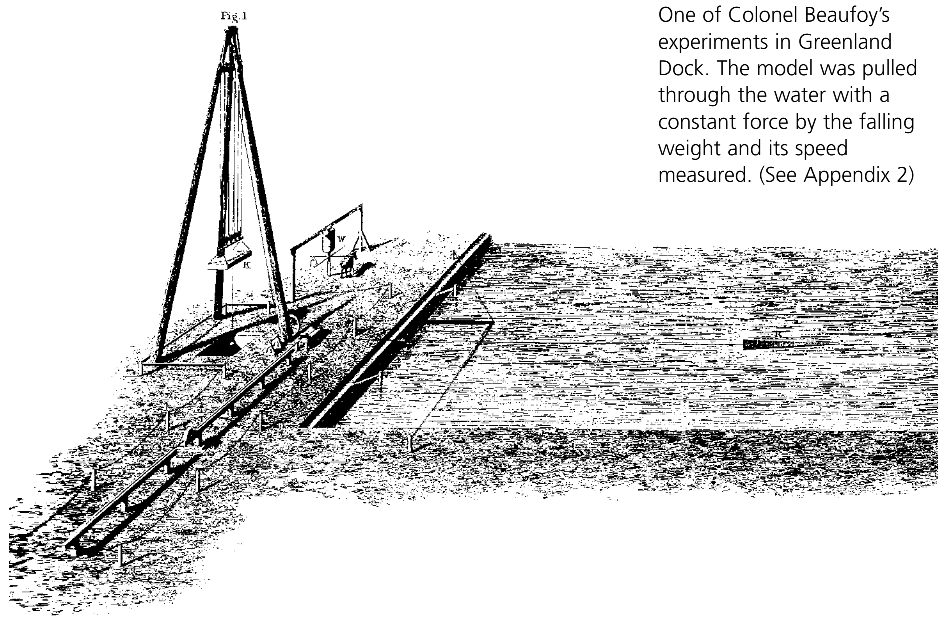
The society came to an end in about 1799, but it had a lasting effect on the progress of warship design in Britain. In particular, Lord Barham had come to believe in the need for a better-educated class of naval constructors within the Admiralty service. He had probably noticed that few, if any, Admiralty naval architects belonged to the society. It is, however, interesting to note that many years later Morgan, a product of Lord Barham's new school and an outstanding man, was to dismiss the society as 'amateurs'.[3] Although he admitted that a few of the papers were valuable, he dismissed others as 'totally devoid of scientific knowledge' and saw Beaufoy's work as inferior to that of the Royal Academy of Paris. Though there is an element of truth in his comments, similar criticism could be levelled at his own *Papers on Naval Architecture*. There was undoubtedly considerable ill-feeling between the society and the Admiralty constructors.

The work of Sir Robert Seppings

Many of the critics of the supposed lack of science in British design are themselves lacking in understanding of scientific method and confuse science with mathematics. Scientific method involves setting out a general explanation of cause and effect and then testing the application of the new theory. Viewed in this light, British work on the design of structures was original, scientific and useful.

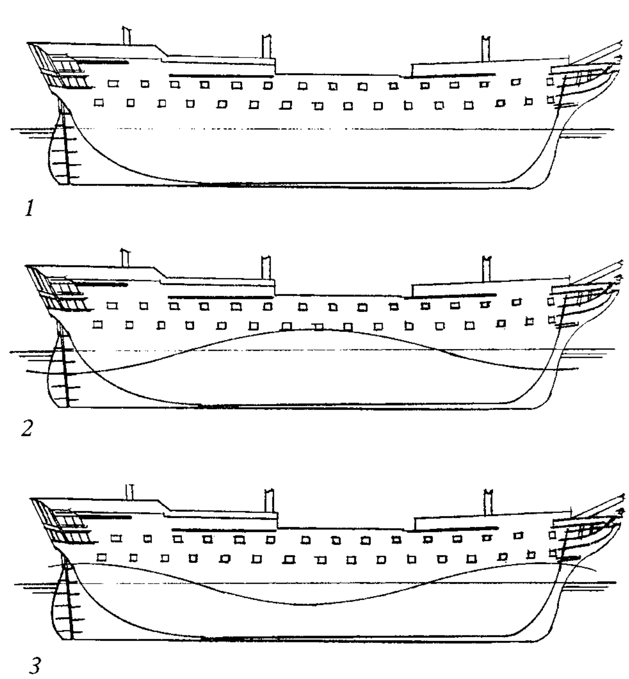
With few exceptions, wooden warships up to the end of the Napoleonic wars had a structure of transverse frames covered with longitudinal planking. Seppings described such a structure as like a five-bar gate without the diagonal member, in that there was little resistance to prevent the planks sliding past each other, turning rectangular bays into lozenges. Such movement in the side planking of a ship caused what is referred to as hogging, or breaking the sheer. The ends of the ship would droop and the seams would slip and open, leading to a further weakening of the structure as the damaged joints filled with water, causing rapid rotting of the wood.[4] The widely-held belief at the time that the flexibility of a wooden ship made it better able to resist the force of the sea is totally fallacious. Study of hogging can be confusing, since hogging in the context of a modern steel ship is a somewhat different phenomenon in which the whole ship bends as a homogeneous beam.[5]

The nature of the problem was beginning to be understood towards the end of the eighteenth century and attempts were made in several countries to introduce the diagonal members in the side needed to resist shearing forces.[6] Several French and Spanish experimental ships were captured by the Royal Navy and found to be no more rigid than were traditional structures. During the wars, Gabriel Snodgrass joined the Admiralty from the East India Company, where he had been chief surveyor. His prime task was to make emergency repairs to ships whose structure had already failed. In many of the ships that he had to repair, the transverse sections had distorted, which he cured by diagonals in that plane. His short-term cure for lack of sheer stiffness in the planking was to add further thick planks on the outside. This provided a bigger area of caulking which helped, by friction, to prevent relative movement. Snodgrass's structural philosophy is clearly expressed in a letter of 1796, republished by the Society for the Improvement of Naval Architecture, and shows that he was well aware of the loads which are imposed on a ship in a seaway and of the disposition of structure needed to resist them.[7]



One of Colonel Beaufoy's experiments in Greenland Dock. The model was pulled through the water with a constant force by the falling weight and its speed measured. (See Appendix 2)

3. W Morgan, 'Brief sketch of the progress of naval architecture', *Papers on Naval Architecture*, vol 1, London (1827).
4. J F Coates, 'Hogging or "breaking" of frame built wooden ships', *Mariner's Mirror*, vol 71, Part 4 (1895).
5. J E Gordon, *The New Science of Strong Materials*, London (1968).
6. D K Brown, 'The structural improvements to wooden ships instigated by R Seppings', *The Naval Architect*, Pt 5 (1985).
7. G Snodgrass, letter to H Dundas, printed in *Collection of papers on naval architecture*, London (1800).



Loading in a seaway

1. When the ship is floating in still water, the weight of guns, hull structure and supports for the sails at the bow and stern will be greater than the support provided by the buoyancy of these narrower sections. The ends will drop, distorting the sides. This is known as 'hogging'.

2. Buoyancy of the ends is further reduced and hogging strains are increased.

3. With wave crests at the ends and a trough amidships the buoyancy is increased at the ends and reduced amidships. The ends tend to rise and the middle drops, a condition known as 'sagging', which caused few problems to the wooden warship.

Sir Robert Seppings (1767–1840), Surveyor of the Navy from 1813 to 1832. *(© National Maritime Museum BHC3019)*

A fuller understanding of the problem came with the work of Robert Seppings (1767–1840).[8] He was the son of a cattle dealer in Fakenham, Norfolk, who, through the influence of his uncle, a retired naval captain, was accepted as an apprentice by the master shipwright J Henslow, at Plymouth. His apprenticeship was completed in 1789 and he rose rapidly through the ranks of shipwright, quarterman and foreman, becoming assistant to the master shipwright at Plymouth Dock in 1797. The master shipwright was the equivalent of the managing director of a Royal Dockyard and would usually take a keen interest in the career of a young man whom he had accepted as his personal apprentice. Seppings does not seem to have had much formal mathematical teaching, but his work demonstrates a keen mind, well-trained in clear presentation.

In 1803 he received a gold medal for his work to improve the docking of ships, and the following year he became master shipwright at Chatham. In that position he was able to develop and prove a new system of ship construction, which also made possible the dramatic increase in size of the last generation of wooden warships. His work was also directed towards the use of smaller lengths of timber and reducing the need for grown timbers which were becoming difficult to obtain.

His system of ship construction grew steadily and quite quickly into a comprehensive whole. The Navy Board wrote to Seppings at Chatham on 26 February 1805 suggesting the use of Snodgrass's methods in repairs to the 74-gun ship *Kent*.[9] Seppings felt that such methods were inadequate, and proposed instead to use diagonal braces on the side in the form of Xs, probably at a shallow angle, claiming reduction in the use of timber, greater strength and a straighter ship. In 1806 the Navy Board gave approval for Seppings to try his ideas on a 74-gun ship and on a frigate. The *Warspite* was a stage in the development, but the full diagonal truss system was first fitted to *Tremendous* in her repairs of 1810, and the *Albion* of 1811 was the culmination of Seppings's structural plan.

There were four elements in the final system:

a. The diagonal trussed frames which are the most conspicuous and best-known features of Seppings's construction.
b. The spaces between the bottom timbers were filled in solid and the ceiling caulked.
c. The beams were connected to the frames using continuous shelf pieces and waterways in place of knees (the French had used a similar scheme for some years).
d. Diagonal deck planking.[10]

John Barrow, Second Secretary to the Board of Admiralty, called a meeting of eminent scientists on 24 November 1811 to consider Seppings's work. They were already aware that breakage measurements taken the previous year during the undocking of *Tremendous* had shown practically no deflection. It is probable that this meeting led to two mathematical studies into Seppings's design. The first was by Thomas Young in England, the second by Charles Dupin in France. Napoleon had been informed of the discussion of 24 November within a few days and invited Dupin to comment.

Young's work largely confirmed the soundness of Seppings's views but, as Wright has shown, the mathematics used by Young was tortuous, hard to follow and not always correct. He seems to have concentrated on bending moments rather than the more relevant shearing forces. It is unlikely that this study added to the Board's understanding of Seppings and must have reinforced the shipwrights' suspicion of the value of mathematics.[11]

Seppings presented a paper to the Royal Society in 1814, as a result of which he was elected as a Fellow.[12] His paper was followed by one from Young which was seen by some as suggesting that Seppings had developed his system from earlier work by others and that the arrangement of the diagonals was not entirely correct. It is true that the idea of diagonal stiffening to prevent shear deflection had been tried before, unsuccessfully; the difference was that Seppings's arrangement worked well.

The diagonal trusses should have been arranged to take the load in compression rather than in tension, but with the short lengths involved there was little practical difference. In later developments of his system Seppings reversed the slope of his diagonals. It was suggested by his critics, and still repeated, that Seppings's construction was heavy, but this was true only when the trusses were added to an existing ship. A new ship, designed to his system, should have been stronger and lighter;

8. T Wright, 'Thomas Young and Robert Seppings. The science of ship construction in the early 19th century', joint meeting of the Royal Institution and the Society for Nautical Research, Science Museum (1981).
9. Ibid.
10. J Fincham, *A History of Naval Architecture* (1851, reprinted London 1979).
11. D K Brown, 'Speed of sailing warships' (Annex 7), 'Empires at war and peace'. Conference, Portsmouth (1988). Note: Sir R Baker made the point well in a private letter in 1981. Mathematics was introduced into design (rightly) but one of its side effects was the idea still alive that mathematics and calculation could 'get it right'.
12. R Seppings, 'A new principle of constructing ships of war', *Phil Trans*, vol 54 (1814), 285.

Seppings claimed a saving of 180 tons in the building of a 74-gun ship.

Seppings wrote another paper in 1815, rebutting Young's insinuations of plagiarism. This paper was not published, but much of its content was used by Barrow in an article to the *Quarterly Review* strongly defending Seppings.[13] Dupin joined in with a well-reasoned paper to the Royal Society in 1816, generally supporting Seppings and criticising Young's mathematics.[14] The English summary of this paper was prepared by Young and is misleading.[15]

Seppings's next paper was in 1817, and is of interest for its description of a trial on the old Danish 74-gun ship *Justitia* just before she was broken up.[16] Temporary diagonal members were fitted to her in dock and the breakage measured on undocking and again twenty-four hours later. The diagonals were then removed and the breakage remeasured. It was found that the stiffening reduced breakage from 2ft 3in to 1ft 2in initially, which increased only by ⅜in over twenty-four hours. Removal of the trusses increased the breakage to 2ft. In this paper, Seppings explicitly denied that his ideas were derived from others, though he acknowledged that a study of drawings of the bridge at Schaffhausen had helped.

Seppings's last paper in 1820 dealt with a modified scheme for merchant ships, in which iron straps were used for the diagonal members to increase internal stowage. This was an adaptation of the scheme which he had already introduced into frigates and which can still be seen in the *Unicorn* (currently undergoing restoration at Dundee). There seems to have been little use of this system in merchant ships, though Brunel did use it for the *Great Western*, with acknowledgement.[17]

There can be little doubt that Seppings's work was novel and based on a rational understanding of the problem. His work was continued and developed in the 1830s when Lang and Edye extended the use of iron diagonals to line-of-battle ships, enabling a vast increase in size. His other improvements will be discussed in the next chapter.

The School of Naval Architecture

As a result of the general belief in the inferiority of British design, Lord Barham, on becoming First Lord, set up a commission 'to enquire into and revise the civil affairs of the Admiralty'. This commission produced a voluminous series of reports between 1803 and 1808 in which they expressed their concern over the low standard of education of dockyard officers and their fears that this standard might fall even further.[18] Prior to 1801, the master shipwright and his assistant were each allowed to take five premium apprentices. This scheme attracted the sons of well-off parents who had already received a primary education. Working with dockyard senior officers, they received a sound training in both

13. J Barrow (unsigned), Art VII *Quarterly Review,* vol XII, No XXIV (1815), 460.

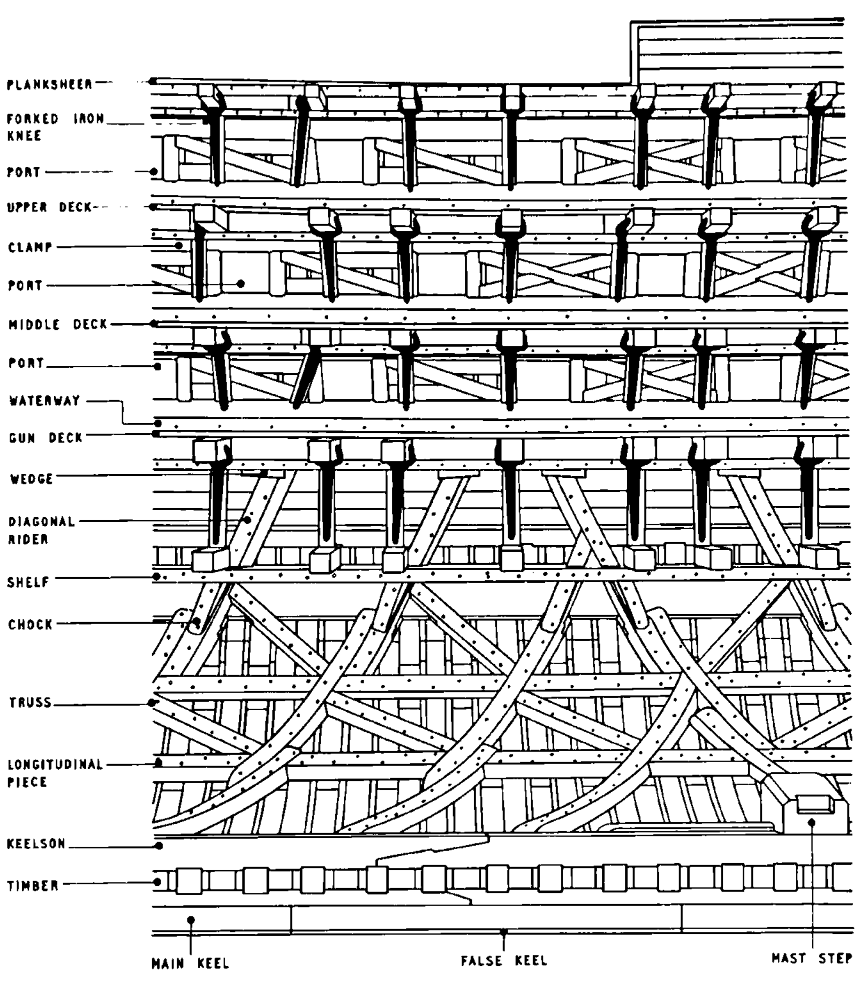
14. C Dupin, 'De la structure des vaisseaux anglais considérée dans ce dernier perfectionnement', *Phil Trans*, vol 54 (1817), 86.

15. Wright, op cit.

16. R Seppings, 'On the great strength given to ships of war by the application of diagonal braces', *Phil Trans*, vol 154 (1817), 1.

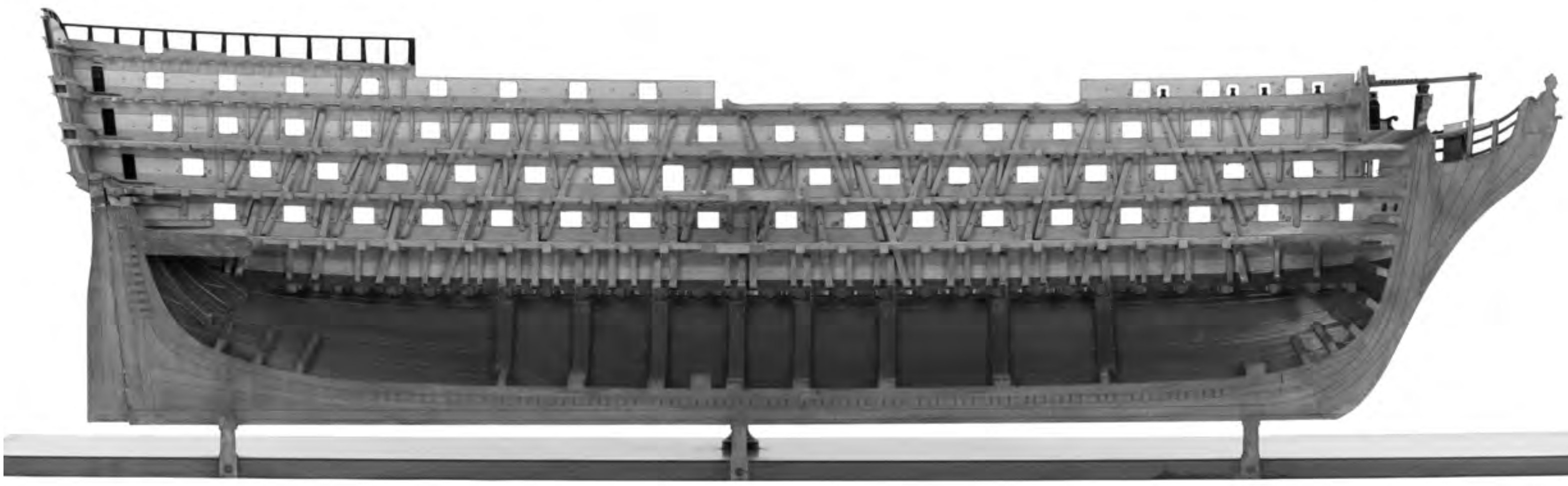
17. D Griffiths, *Brunel's Great Western,* Wellingborough (1985).

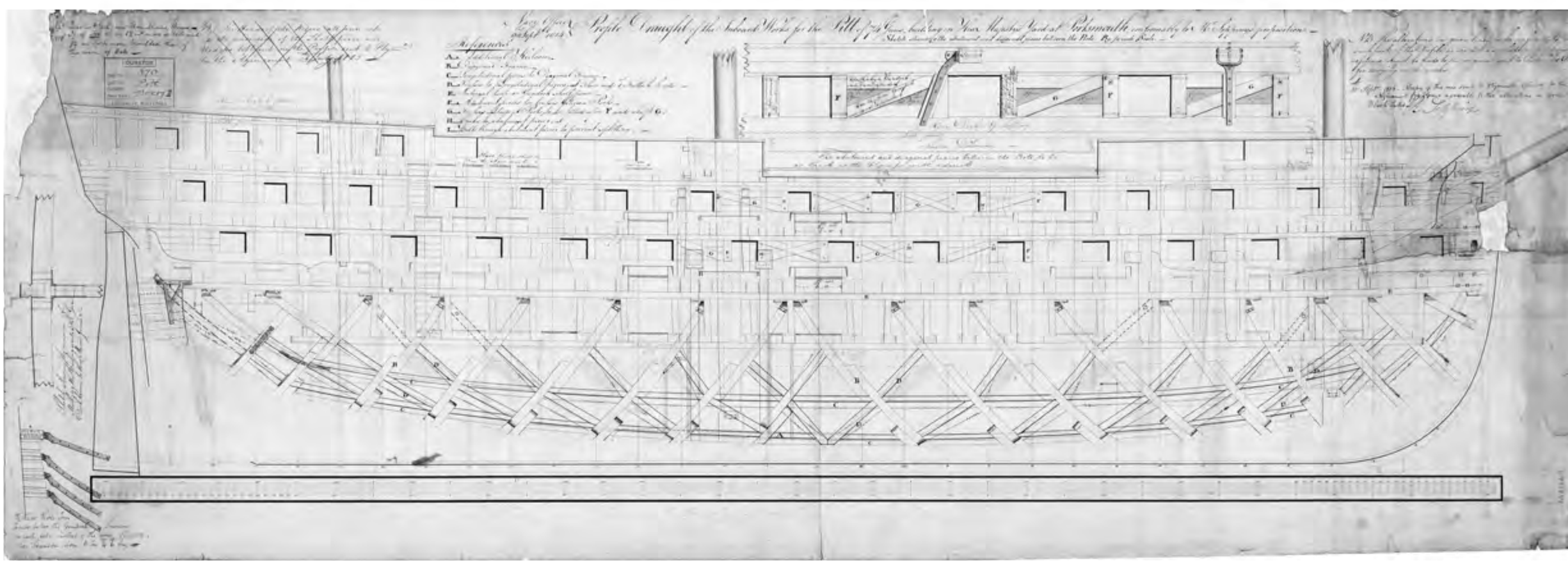
18. Third report of the Commissioners for Revising and Digesting the Civil Affairs of H M Navy, London (1808).



Left: Seppings' diagonal braced hull construction, definition of terms. *(Science Museum)*

Right: Photo of model. *(Science Museum)*





Top: A model of typical internal structure before Seppings. The heavy diagonal riders in the topsides were a clumsy, and largely unsuccessful, attempt to offset the effects of hogging. *(© National Maritime Museum L3214-001)*

Above: One of the first profile draughts to show Seppings's structural innovations, for the 74-gun *Pitt* of 1814. *(© National Maritime Museum J2722)*

the theory and practice of shipbuilding and were well placed for rapid promotion when they finished their training. This system produced many good senior officers, eg Slade (who designed the *Victory*), Seppings and many others, but there was a suspicion, probably unjustified, that their advancement owed more to corruption than merit. Though no such case was proved, the suspicion was such that premium apprentices were abolished by Lord St Vincent as part of his drive against corruption in 1801. Somewhat similar schemes for quartermen (chargehands) and foremen were abolished in 1802 and 1804.

The new apprenticeship scheme was not such as to attract bright young men or to give any prospect of producing suitable senior officers. There was no entry examination; the only qualifications required were a medical certificate and a minimum height of 4ft 8in. It was found that this class of apprentice was incapable of learning the geometrical complexity of mould loft work and they were described as a lazy and insubordinate bunch.

The Commission of Revision in their third and eighth reports made some specific recommendations on the education of shipwright apprentices and on the conduct of the school:

a. There should be two classes of apprentice, the 'ordinary' who would normally become tradesmen and the 'superior' destined for more senior posts.
b. The superior class should form a school attached to the RN College at Portsmouth which had been founded as the Naval Academy in 1773. The course would last for seven years with theoretical studies in the morning and practical shipbuilding in the afternoon. The final year was to be spent at sea.
c. Entrance to the school was to be by competitive examination conducted by the professor and three senior dockyard officers. There was to be no system of nomination or patronage and apprentices entered into the ordinary class could compete for places at the school.
d. There were to be twelve students in the first entry and, in the following years, four would be admitted, bringing the school up to a total of twenty-four, a number which it was believed would provide the required number of senior men.
e. Students would be paid £60 per annum in their first year, rising to £140 in the last two years. Of this, £8 per annum would be deducted to pay the professor.
f. Progress would be monitored by annual examinations and, on successful completion of the course, the graduates would be employed as assistants to foremen in