A Global Forum for Naval Historical Scholarship

International Journal of Naval History

Volume 2 Number 3 December 2003
[Volume 3 Number 1 April 2004]

THE ROYAL NAVY, JOHN ERICSSON, AND THE CHALLENGES OF NEW TECHNOLOGY.

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John Ericsson and the Revolution in Naval Warfare 1850-1880

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Symposium, 14 November 2003

PROLOGUE:

In August 1837 a fifteen metre long boat the *Francis B. Ogden* steamed down the River Thames from Somerset House, near Waterloo Bridge to the steam engine factory of the Seaward Brothers at Limehouse. The vessel was towing the Admiralty barge, an elegant and ornate 18th century oared ceremonial craft. On board were a number of leading figures from the higher reaches of the Royal Navy's administration and policy-making body, the Admiralty. Admiral Sir Charles Adam, the First Sea Lord; Captain Sir William Symonds, Surveyor of the Navy; Captain Sir Edward Parry, Arctic explorer and Controller of Steam Machinery[1]; Captain Francis Beaufort, the Hydrographer of the Navy and other leading figures. The journey was completed at an unusually high speed, without accident.

After the return journey the First Sea Lord thanked Mr Ericsson for his trouble, and the Admiralty did no more. It was only later, and unofficially that Ericsson learned why his vessel had not secured a more positive result.[2] No official report of the trial was ever produced.[3] Symonds was convinced that any vessel powered at the stern would not steer, a view based on experience with paddle wheel ships that had been lengthened at the bow. He believed that Ericsson had covered this defect by towing the barge, but did not trouble to see the vessel proceed on her own. Ericsson's supporters then and now condemn Symonds' remarks as absurd, evidence of his reactionary opposition to steam power. In fact Symonds was quite correct. With the rudder placed ahead of the propeller Ericsson's vessel would not steer.

BUT there was second, unspoken and entirely different rationale for ignoring his remarkable vessel. Ericsson had no money to develop the prototype. His engineering partnership had failed, and within weeks he was locked up in the Fleet prison as a bankrupt debtor.[4] He had in effect asked the Royal Navy to fund the development of an entirely new technology, on the strength of a single demonstration by a river boat. He had no funds of his own to carry out fundamental research and development, and no significant sponsors. The Admiralty considered this work should be left to commercial concerns. They would only buy proven systems, not bright ideas and models.

Far from ignoring the propeller only a month later the Admiralty encouraged the development of the rival system of Francis Pettit Smith after a trial with a small boat off Dover. Smith's propeller had been adopted by a powerful consortium, which included bankers, engineers, naval officers and aristocrats. In marked contrast to the dismissive treatment accorded to Ericsson, the Smith Consortium was advised that a 200 ton vessel would be required to demonstrate their system at full scale. While Smith's boat, and his 200 ton ship the *Archimedes* were years behind Ericsson's craft in terms of concept, design and engineering, they had the support of a Joint Stock Company with a capital of £50,000. This secured their position with the Admiralty. Not that it secured them any benefit, after fifteen years of effort and expenditure the Company was bankrupt, and Smith was unemployed. Ericsson had been fortunate to escape the toils of this powerful machine.

THE SCREW PROPELLER:

Smith and Ericsson's deserved primacy in the history of the screw propeller reflects of their success in securing the funds required to develop and exploit the new technology, and not to any leap in design. Both men proposed and built flawed systems, and needed further funds to bring the system into practical use. Ericsson's propeller project was funded by Captain Robert Stockton of the United States Navy, in a private capacity. Stockton anticipated sales to the American Government and profitable employment on his Canal system. Smith's ideas were taken up on an altogether larger scale. In both cases profit was the motive. The only hope Ericsson had of making money from his propeller system, which was a concept, with a specific screw form, was to secure the intellectual property rights by taking out a Patent. This he had done, significantly some months after Pettit Smith who had the same aim. He also had to be prepared to engage in costly legal action to defend his rights. The Patent had exhausted his funds, and he had no hope of fighting Smith's consortium, either with a 200 ton ship or a court case. He was defeated by lack of money and support.

In the late 1830s the English Patent System was undergoing significant reform, making intellectual property rights defensible in court. Before 1830 protection had been limited, and was rarely accorded to intangibles. Thereafter the argument of public utility had seen the courts adopt a more favourable view, upholding nearly twice as many patents as hitherto. The development of specialist patent agents ensured that the specifications were more accurate, and helped to link innovators with capitalists. Only if a patent was defensible at law, and the patentee could afford to defend it, was there any value in the invention.[5] The introduction of the screw propeller into the Royal, and United States' navies would be dominated by the legal implications of patents.

STEAM and POWER

When Ericsson began work on steam it was the cutting edge technology of the age, and Britain was the dominant steam nation. James Watt had made the engine efficient, Richard Trevithick had made it portable, and Marc Brunel had done much to bring it into service for sea-going ships. The problem for all navies was that steam engines were heavy, unreliable and highly uneconomic. They applied their power to the water with paddle wheels, which were efficient propellers in a flat clam, on a river or a lake, but for ocean going purposes they posed an insuperable problem as every time the ship rolled the wheels either dug into the sea, or swung clear of the surface, making the ships forward motion resemble that of a crab. Only by setting fore and aft sails and using the wind to damp out the ships motion could the early paddlewheel ships navigate the oceans. This solution was acceptable for oceanic liner traffic, which had a fixed route, and needed to meet a timetable, at whatever cost.

However the problem for navies was very different, especially for the Royal Navy, which possessed a unique global reach, and had responsibilities to match. Just getting coal to the outer reaches of Empire was a monumental task. The Royal Navy needed ships that could steam for tactical purposes, battle, coast attack, towing and message carrying, but cruise under sail to preserve coal stocks and fragile machinery. Attempts to combine paddle wheels with heavy guns proved even more difficult, as the wheels filled half the broadside, and offered a large target to the enemy. Paddle wheel warships NEVER became the dominant element in naval warfare, they were auxiliaries in a sailing fleet, which provided firepower, strength, and endurance. The Royal Navy had been the first navy in the world to use steam for dredging, towing, mail packets and by the early 1830s, was building 1,000 ton paddle wheel warships.

The problems of the paddle wheel warship were well known by the mid 1830s, and intelligent officers were already looking for solutions.[6] Ultimately the screw propeller would answer all of their requirements, enabling the standard wooden sailing warship to be fitted for steam power without the loss of its broadside battery, or efficient sailing rig. The screw transformed steam from a primary power installed in auxiliary warships to an auxiliary power installed in front line warships.

Until the steam engine was rendered more efficient the best solution would be an auxiliary steam plant for entering and leaving harbour, or steaming into the wind, while relying on sail for the primary motion. A propeller placed below the water-line, keeping the broadside clear and capable of being disengaged while under sail would be far better than the paddle wheel, even if the performance was limited.

This was the situation when Ericsson and Pettit Smith developed their systems. Both men saw the Royal Navy as the ideal client for their work, having a large fleet, access to government funds and an existing need. The two men approached the problem in very different ways. Smith was a monomaniac, who spent years developing his idea with models because he lacked the engineering knowledge to solve them with theory. His 'Archimedean' screw reflected his origins as a classically educated man.

By contrast Ericsson produced a remarkably modern system, a co-axial contra-rotating design that gave maximum power and excellent directional stability, in the same rapid and effective manner that he delivered all his projects. His all-round excellence as an engineer working in metals and steam, shone through the advanced prototype. Ericsson left no more explanation for his ideas than the motion of fish tails, but it is worth noting that many men had experimented with the idea, and that Samuel Owen had a screw propeller boat running in Stockholm harbour in 1815. Typically Ericsson did not carry on the existing line of development, which was essentially empirical, but developed his own solution.[7]

DIAGRAM

The co-axial drum contra-rotating multi-blade form may have been derived by twisting paddle wheels through 90 degrees, altering the angle of attack for the blades. Modern studies have shown that this system has significant advantages for very high power outputs.[8] Ericsson would have been more concerned by directional stability. Ericsson's Patent was taken out on 13 July 1836, six weeks after that of Pettit Smith. However, we must observe that both were for improved propellers, not an original invention. There had been at least five worthwhile 'inventions' of the screw propeller, for use with steam engines, before 1836. [9] He described his system as:

Two thin board hoops, or short cylinders, made to revolve in contrary directions round a common centre, each cylinder being also admitted entirely under the water at the stern of the boat, and furnished with a series of short spiral planes or plates – the plates of each series standing at an angle the exact converse of the angle given to those of the other series, and kept revolving by the power of a steam engine.

As the contemporary authority on the screw John Bourne admitted it was 'so complete in its mechanical details that, when tried, it was at once found to be efficient'. After years of haphazard, unregulated experiments Ericsson was the first engineer to design a system using science and logic. His great British contemporary Brunel would be the first to conduct truly scientific experiments to determine the propulsive efficiency of propellers. Significantly the propeller is shown aft of the rudder, where it could have little or no effect on steering.

After the patent had been proved, at considerable cost, Ericsson experimented with a model, and then built the 15 metre boat *Francis B Ogden,* named for the American Consul at Liverpool. The *Ogden* was launched in April 1837, and quickly proved she could steam at 10 knots, and tow small ships. In June *London Mechanics Magazine* revealed her design features to the world. The high-pressure fast running engine was typical of Ericsson, who stressed the small size, light weight and easy removal the propeller and the engines. This rather bulky first attempt to build an outboard motor was very clearly aimed at the auxiliary steam market.[10] His experience engineering fire pumps and railway locomotives was very important. Despite the near ideal specification, and the successful trial trip the Admiralty was not interested. The need that Ericsson addressed was real, and within fifteen years of his initial approach the Royal Navy had decided that all future warships would be screw propelled. Ericsson's work would play a key part in that decision.

MOTIVES:

In examining how the Admiralty responded to the screw propeller it has to be stressed that finance and politics were far more important than technological innovation. One of the perennial, irritating features of so much comment on the supposed 'failure' of the Royal Navy and the mercantile community to adopt steam and the various improvements in power and propulsion at the proper time is the conceit that Ericsson, Pettit Smith and others were attempting to 'interest' their fellow men in the new technology for the good of mankind.[11] In truth the engineering community wanted to sell these new ideas, for significant financial reward. Ericsson 's disgust at the failure of his design in Britain should be viewed in purely commercial terms. It is simply incredible to argue that commercial success was not his prime motive. His sense of outrage reflected his failure to secure financial support from the Admiralty, and the brief confinement in the debtors prison that followed, rather than concern for his fellow man. The prison term was particularly revealing. It demonstrated that Ericsson simply did not have access to the capital required to develop the screw. His system, whatever its merits needed Admiralty support, and was in consequence, doomed to fail. Similarly Smith, and the backers of the Ship Propeller Company, were not interested in science and experiment, but in the royalties and financial success they anticipated from the Patent of 1836. While the Admiralty demonstrated remarkable skill, or an incredible degree of luck, both in avoiding such entanglements, and securing proven technology for the country at a reasonable price, the mercantile community made relatively little use of the patented system. In truth the screw was of only limited value to the mercantile community before the development of compound engines and iron hulls. Only the world's navies could afford the cost of large wooden screw propelled ships, both the capital outlay and the alarming frequency of major repairs made them uneconomic.[12]

It should be recalled that any number of speculators and cranks were also trying to lighten both private owners and the Government of funds, making caution essential. Filtering out the 'cranks' before they troubled the Admiralty was one of the main tasks for Captain Parry the Controller of Steam.[13] The Admiralty preferred to work with a small number of large and reliable contractors. For the screw propeller this role would be filled by the Ship Propeller Company, not the lone engineer. Significant support for this view can be drawn from Ericsson's success in demonstrating and selling to the Royal Navy an electric sounding machine, the precursor of Sonar.[14] When he had a product ready for market, the Royal Navy was interested.

TRIUMPH IN AMERICA:

After the failure of his screw propeller project with the Admiralty, and a spell in debtors prison Ericsson was persuaded by Commodore Robert Stockton to take his talents to the United States. The iron screw propeller ship *Robert F. Stockton* built at Birkenhead was demonstrated in London in January 1839, and sailed to America in April. Ericsson followed at the end of the year.[15] He would earn a fortune and undying fame American service. However, the Royal Navy had not heard the last of him.

For all the favourable press notices and demonstrations the *Stockton* was flawed. She would to answer the helm when placed in service on the Delaware River, and had to be rebuilt, emerging as the *New Jersey* with her rudder abaft the propellers, in the location that Smith had patented.[16] Sir William Symonds had been quite correct. Ericsson's United States propeller patent of 1838 was for an installation above the stern, driving the propeller after of the rudder. It was clearly an 'outboard' or detachable concept.[17] Once the propeller had been placed ahead of the rudder, and simplified Ericsson developed twin shaft installations that avoided cutting into the sternpost, and quickly dominated the American market.[18] In Britain his system, promoted by Ogden and the Laird shipyard was less successful.[19]

The *Princeton* was built using Ericsson's engineering design and a native hull form. She has always been touted as the world's first purpose built screw propeller warship, but that is incorrect. The Admiralty project engineered by Isambard Kingdom Brunel and F P Smith was launched and entered service earlier. Ericsson's hagiographer's claim priority by dismissing the *Rattler* as a conversion, and this inaccuracy is accepted by others wishing to show the Royal Navy as backward or reactionary.[20] Although she used timber collected for a paddle wheel sloop, this ship had not been laid down, and no timber had been converted. Under Brunel's direction the *Rattler* was given a very good engineering installation, which outlasted and out performed Ericsson's. Her propeller cold be lifted clear of the water, for more efficient sailing. She also proved to be a highly successful test platform, achieving a speed of 12 knots, 1/3 higher than the *Princeton* and providing a wealth of carefully recorded data to guide future developments.[21]

More significantly still, by using the team of Smith and Brunel the Royal Navy limited development costs, and kept the rewards to the patent holders very low. Even if Ericsson had been given the opportunity to carry on his work the Admiralty would have kept a very close watch on his costs, he would not have made his fortune from the Royal Navy. No one did, it was simply too professional and well-organised to let such a thing happen.[22]

THE PROPELLER NAVY:

The initial success of the *Princeton* attracted attention at the Admiralty, and the Royal Navy kept watch on her. As an American 'first' her achievements were boosted by all manner of spurious claims, implying she was the first warship to be primarily a steamer, and that she had won a race with the powerful British paddle wheel Atlantic liner *Great Western.* In fact *Princeton* was an eight knot auxiliary steamship[23], while the liner made twelve to fourteen knots. Far more significant than speed was the *Princeton's* all round excellence as a design. She was, like her British contemporary, the *Rattler* the answer to the big problem of combining steam and sail in a wooden warship. Her unique feature was the machinery, which had been designed to be placed below the waterline, safe from enemy fire. The funnel could be lowered, and all aspects of the engineering design bore the hall-marks of genius.[24] From the beginning of his career in steam engineering Ericsson had used his design and engineering talent to produce compact, lightweight power plants, be they for railways or ships. He had always recognised the need to keep the machinery below the waterline. In the 1820s, it was a key feature of his machinery in the Arctic vessel *Victory*. By the time he designed *Princeton* this line of thought had produced engines half the weight of the typical English designs, and taking up far less space.[25]

The reality of Ericsson's position was made clear when a large gun, built by Stockton in imitation of one that Ericsson had commissioned for the ship burst, killing the Secretary of State and the Secretary of the Navy. Having spent the past months denying Ericsson any credit for the ship Stockton suddenly remembered that it was all Ericsson's work, and ensured the engineer was not paid for his efforts.[26] This led to a fifteen year break in relations between the engineer and the American Navy, which constructed a series of pathetic vessels in an attempt to circumvent Ericsson's American Patent.[27] Ericsson went to law, and won his case in 1853, but Congress refused the appropriate the money to pay him.[28] These were years of growing commercial success, Ericsson's propeller becoming dominant in the United States, particularly on the Great Lakes, and he had been able to indulge his more ambitious design for a hot air engine.

While Ericsson secured a new and profitable market in the New World his patent rights and designs were promoted in Europe by his fellow countryman and long term backer Count Rosen.[29] Rosen approached the Royal Navy in 1842 to have Ericsson's simplified screw tried in the tender *Bee*.[30] In 1843 he secured an order from the French

Navy to install Ericsson designed machinery in their first screw warship, the *Pomone*. After watching as the Ericsson propeller took over in the New World, investigating reports of the *Princeton/Great Western* race, obtaining a copy of Commodore Stockton's secret report[31] and investigating whether the propeller was of Ericsson or Smith design, the Royal Navy followed suit in 1844 with the Ericsson designed machinery installed in the frigate *Amphion*.[32] Both French and British warships were designed to have their machinery below the waterline, Ericsson's unique selling point. The development of the direct acting horizontal engine 'driven' by Ericsson, brought the first generation of screw steam warships to maturity. The design was developed by British marine engineers into the power-plant that propelled the screw fleet of the1850s. This may have been a more important contribution than pioneering the screw propeller, because once the engine could be stowed away below the waterline the British were prepared to adopt the screw as the prime mover of the entire Navy.

This decision followed exhaustive trials with the *Rattler* and a number of other ships of all sizes, including the Ericsson engineered *Amphion* and battleships. Having employed a legal expert to watch the situation the Admiralty carefully avoided paying for any more of the Patented applications than was absolutely essential, and strung out any decision on the system to weaken the bargaining position of Pettit Smith and his backers. It had hoped that the patent rights would expire, and contested their renewal. Ericsson's British patent was renewed for another five years in 1850, with a reversion in favour of the Admiralty. In preparing the case the Admiralty found they had no record of the 1837 trial by the *Francis B.Ogden*.[33] When Smith's patent was also renewed, in both cases on the grounds that the patentees had not gained sufficient reward from their innovation, the

Admiralty was ready. In September 1851 five identified patent holders were forced to agree to share a single reward of £20,000 for the surrender of all their rights to the Admiralty. The final instalment was paid in 1852.[34] Far from ignoring the propeller the Admiralty had used their dominant position as the largest potential customer for screw propelled wooden ships to manipulate the patent system to throw all of the development costs onto the patentees and avoid paying them when the system was finally ready for service.

LATER PROJECTS:

John Ericsson's second major contribution to warship development, the *Monitor* was in part the long matured revenge of a man who harboured hatreds for decades. He would teach those proud British Admirals a thing or two.

In fact he had nothing to teach them. The alternative British turret concept of Captain Cowper Coles, already undergoing trials before the American Civil War broke out was based on an entirely different principle. Coles had designed a conical armoured gunhouse, and on showing his sketches to Brunel had been given the throw-away line, that he should put a railway turntable under it. This produced Coles's system in which the weight of the turret was carried on a wide roller path, rather than Ericsson's central spindle. This made the British turret easier to operate, less liable to jam and more secure in action than Ericsson's concept.[35] However, Ericsson's system was more complete, for it came with mechanical gun carriages, already attempted on *Princeton* which would transform the ability of warships to use the heavier artillery being developed to penetrate armour. Little wonder the British never lost interest in Ericsson's work. During the Civil

War the Royal Navy made great efforts to collect information on the new technologies being used, both from eye-witnesses, and covert sources. In this way plans of Ericsson's monitors were obtained. The British were not overly interested in the armoured turret ships, which they judged inferior to their own productions, but they were fascinated by torpedo warfare.

After the Civil War Ericsson's great project was a self-propelled controlled torpedo, ancestor of the modern wire-guided weapon. This was his response to the British development of the turret warship concept, the battleship *Devastation* which had the range and power to attack New York.[36] Between 1870 and the mid 1880s his compressed air powered 8 meter long weapon. Not content with a major breakthrough in weapon design, the first example of a projectile with mid course guidance, Ericsson also designed and, at his own expense built a torpedo boat, calling her *Destroyer* two decades before the term came into common usage.[37] Despite official encouragement in America there was no money to support his work, and the ship was eventually sold to Peru, only to be embargoed by the war with Chile. The idea was to protect the American coast against hostile ironclads, a type the far-sighted Ericsson had already condemned as 'torpedo-food'. Despite successful demonstrations the United States Navy could not secure Congressional funds, and he kept the Royal Navy informed of his progress throughout. In 1881 the Ordnance Committee reported that Ericsson used gunpowder to fire the torpedo out of the submerged tube, and that he planned to fit the warhead with 250 lbs of dynamite. He had not yet fired a live round.[38] Later Lieutenant Gladstone was sent to New York, and his report was so favourable that a submarine gun and four torpedoes were bought for further trials in Britain.

On July 22nd 1886 the weapon was tested at Portsmouth. At a range of 100 meters the first weapon ran straight, and destroyed the target. A second trial on August 19th ended in failure, when the submarine gun was blown to pieces by the torpedo warhead. It emerged that the trials officer had replaced Ericsson's fuse with a British type, but that was the last Royal Navy contact with the remarkable Mr Ericsson. Typically he responded to their polite rejection with a stinging rebuke on the institutional failure of the Admiralty to see the future, as demonstrated by his experience with the screw propeller. It was unfair, and did no good, but it was as much a part of the man as his engineering genius.[39] The ship was eventually sold to Brazil in 1891, but by then Ericsson was dead, and his torpedo had been overtaken by the more sedate development of the Whitehead design.

CONCLUSION:

John Ericsson was a remarkable man. He travelled to find fame and fortune, and he ended up with both, but along the way he knew failure and disappointment. His contribution to the development of the modern warship, and methods of design and construction, was unique. He changed the nature of war at sea by adapting steam power to the existing warship type, and went on to design a warship entirely divorced from the age of sail. Ericsson, like Smith depended on his backers. The two men share primacy in the propeller story because they found the financial support necessary to develop the concept into a useful propeller. The unique point in Ericsson's role is that he designed and engineered two vital modern systems, while in Britain it required three men to match his contribution, Smith and Coles thought up the systems, but only Isambard Kingdom

Brunel could engineer them to the same standard as Ericsson. There is no finer tribute for a 19th century engineer than to be placed in such company.

The propeller, the turret, the mechanical gun carriage and the torpedo were critical developments that transformed the nature of war at sea in a period of astonishing technical change. In all four cases John Ericsson conceived and engineered successful prototypes and production versions. That others also came up with similar ideas is not to be wondered at, these devices were answers to real problems. Ericsson's designs were invariably better than anyone else produced before trials and development, but he was regularly overtaken by more dedicated, single minded men of limited vision, men like Pettit Smith and Coles, because they were prepared to put up with slights and reverses of an innovators life with more equanimity, and a more even temper than the volcanic Ericsson. He was, in the final estimate, a towering genius with a flawed personality and a limited capability for human relationships. His personal life was an awkward inconvenience, abandoning his son, wife, friends and family, giving up social life and pursuing vendettas with remarkable determination across the decades.

POSTSCRIPT:

Ericsson's story is also part of an enduring myth. It is assumed that the world's navies were reactionary, or at best unduly conservative in their handling of technical change in the nineteenth century. This, it has been argued, was symptomatic of large hierarchically structured bureaucracies opposed to change in any area, from uniform regulations to weapons procurement. This view is reflected in the work of historians of the liberal progressive school for whom conservatism in technology, as in politics, is the mark of an unthinking and bigoted reactionary. They contend that, had the world's navies been more adventurous, technical progress would have been more rapid, and more economical. As the largest, and among the best documented, navies the Royal Navy has often been criticised for technological conservatism throughout the long nineteenth century (1815 - 1914). This line has been adopted in studies of the introduction of steam power, iron ships, the screw propeller, armour plate, turrets, and a number of other important new systems.

Existing accounts treat the introduction of new technologies as a purely technical issue, isolated from politics, finance, strategy, tactics, and naval administration. For too long the underlying assumptions about progress and the engineers who pioneered new systems have been based on self-serving contemporary pamphlet literature and hagiographies. By failing to question the underlying assumptions of this literature subsequent generations have done a grave disservice to the memories of hard-working, professional men. The core argument is that a 'conservative' bureaucracy either misunderstood or deliberately opposed each new manifestation of progress. This line of attack was soon repeated in biographies and general histories. Perhaps the first, and most influential renditions of this 'critical' version appeared in Isambard Kingdom Brunel Junior's biography of his father, which appeared in 1870. Brunel junior largely created the genre, by linking his father with other engineers and inventors of the era. He based his case on Brunel's favourite anecdote about the introduction of the screw propeller and the 'adverse influence which had been exerted in some departments of the Admiralty to prevent the successful issue of these experiments'.[40] While this version was perpetuated in the standard modern life[41] it finds no support in Brunel's own archive.[42] If the engineer was the nineteenth century ‘hero’ he needed a dragon to slay, and navies, the bigger the better, were ideal. They were big, impersonal bodies against which lone engineers could strive, and were too powerful to make their ultimate defeat problematic.

When John Ericsson received his valedictory biography his brief relationship with the Royal Navy was portrayed in equally bleak terms.[43] Even before this version appeared the liberal progressivist version, in which the Admiralty was the source of all obstruction, had been adopted by the standard history of the Royal Navy.[44] It would be followed in the standard account of the development of marine engineering.[45] These accounts all assume that anyone but a fool, and a peculiarly conservative fool at that, would have seen the merits of the propeller from the beginning, and pressed for its’ immediate adoption. They ignore the key questions that surrounded the process. These were financial, technical, political, tactical and strategic. When they have been addressed it is possible to see the propeller in a wider context, providing an altogether more complex chain of events.

The Admiralty was not dragged, reluctantly, into the propeller. It was well aware of what was happening from the beginning, maintained a careful watching brief, intervened in particular experiments to great effect, forced the private sector to conduct almost all the fundamental research and early practical trials, without adequate recompense, and then intervened in the process at a decisive moment, just as the technology matured, to clear up all the patent rights and build the world’s first all steam fleet. Far from the reactionary image created by the engineers and their hagiographers, the most common complaint of contemporaries was that they had been ‘defrauded’, and that the Admiralty would only deal with people it could ‘bully or defraud’.[46]

Without the financial support of the Ship Propeller Company the screw would not have been adopted so quickly, similarly without Stockton Ericsson would have abandoned his project, turning his fertile mind to other areas just as he had the field of locomotives after the failure at Rainhill. Financial support was critical to the success of nineteenth century innovation and invention. Backers were vital to cover cost of basic development and early trials in return they hoped to make money. They would be disappointed.

The self-serving, politically naïve and technologically determinist accounts left by nineteenth century engineers, who wished to portray themselves as high minded servants of humanity, have been taken at face value for too long. By contrast the Admiralty was technologically dynamic, and adopted a professional approach to the management of change, which it handled with great skill between 1815 and 1914. There were a few spectacular examples of failure, notably the loss of HMS *Captain* in 1870, but this was caused by the politicians overriding or ignoring their professional advisors. France, by contrast, started four technology based arms races, and lost every one within five years. Because the Royal Navy was central to British Strategy the Admiralty had to be certain that it could meet its commitments, it could not afford to take any risks with the core capability, the battlefleet. Britain won the naval races because it had long term finance, a superior industrial base and greater political commitment. The role of the Admiralty was to ensure that the fleet remained modern and effective on a reasonable budget. It was remarkably successful. It required tremendous political skill, technical knowledge and professional insight to pick a consistent and effective path through the tortuous channel of nineteenth century warship development, between the Scylla of profligate waste and the Charybdis of reactionary obscurantism. By exploiting the best minds in the field the Royal Navy managed to steer a successful course. No-one did more to push those developments than John Ericsson. Ericsson might not have made his fortune from the Royal Navy, but he was not ignored.

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[1] Parry A. *Parry of the Arctic, 1790-1855*. London 1963 pp.197-209 esp. p.203

[2] The only eyewitness account of this event comes from a lecture given by Ericsson's friend and lawyer John O. Sargent in Boston in 1843. This is highly partial, and in view of the subsequent success of the system in the United States, took the character of a triumphal condemnation of Admiralty reaction, without mentioning the Smith project. Preble, G H *History of Steam Navigation*.Philadelphia 1883 pp.153-5.

[3] Admiralty – Parry 18.11.1850: ADM 12/528.

[4] Church, W C. *Life of Ericsson.* 1907 New York, Vol. I p.89.
White, R. *Yankee from Sweden.* New York 1960. pp.49-50.

[5] Dutton, H.I. *The Patent System and Inventive Activity in the Industrial Revolution 1750-1852*. Manchester 1984 esp. pp. 69, 72, 78-80, 86, 93-4.

[6] Brown, D.K. *Before the Ironclad: the development of ship design, propulsion and armament in the Royal Navy, 1815 - 1860*. London 1990 p.99

[7] Bourne, J. *A Treatise on the Screw Propeller.* London 1855 2nd Edition. Bourne was a promoter of Pettit Smith. His encyclopaedic study details every known system. for Ericsson see pp.29-30 & 89-91.

[8] Excell, J. 'Reinventing the propeller' *Design Engineering* 11.7.2003. It has been used on torpedoes for many years, and is also common on submarines.

[9] Petty, W.M. 'The Introduction of the Screw Propeller' Unpub. University of London MA Thesis 1969 The work of Stevens, Owen and Ressel failed from the inadequacy of contemporary engine and boiler technology. Ressel's effort, as might be expected in the Austria of Metternich, was brought to a premature end by the secret police. Wilson's valuable work with hand cranked screws, which anticipated the correct position for the propeller, was never linked to an engine, while Marc Brunel did not realise the idea was sufficiently novel to be worth patenting

[10] *London Mechanics Magazine* June, 1837: in Taggart, R,. *Marine Propulsion: Principles and Evolution.* Houston Texas 1969 p.121. See he American patent of 1838 for the most complete demonstration of this approach.

[11] Hewish, J. *The Indefatigable Mr. Woodcroft; the legacy of invention.* London 1979

[12] Royal Navy Chief Constructor John Edye Evidence to the Parliamentary Committee on Naval Estimates *Parliamentary Papers* 1847-48 Vol. XXI p.186: see Lambert, A. D. *Battleships in Transition..* London 1884 p.55 et seq.

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[14] Friendly, A. *Beaufort of the Admiralty*. New York 1977 p.296.,

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