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THE INTRODUCTION OF STEAM TECHNOLOGY IN THE FRENCH NAVY, 1818-1852

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NOTE

In this edition (2011) the original Introduction (pages 1-15) and Acknowledgements page have been replaced with a new Preface (pages ii-vii), and section headings have been added within the chapters and in the Table of Contents.

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PREFACE

In the first half of the nineteenth century, the French showed how a second class naval power could compete against a rival who had overwhelming naval superiority. In 1815, having been defeated in the Napoleonic Wars, France was hopelessly outnumbered at sea, with 71 ships of the line to 214 for Britain. By the mid-1850's she was still inferior in numbers of capital ships, but she had precipitated two war scares in England (in 1844 and 1852) and was being treated by the English as an equal in a major maritime undertaking, the Crimean War.

France met the English naval challenge to a large extent by aggressively acquiring the technology of the new industrial age and making innovative use of it. In doing so, she started what has become an important trend. In the 1880's, the U.S. Navy began to build its new fleet only after sending technical missions to Europe and importing some key technologies, notably the manufacture of large guns, armor, and steel. At the end of the nineteenth century, the Japanese navy got its start by acquiring technology from European firms and naval missions, then copying and improving it. The trend continues today: recently the American people were reminded of the importance of technology transfer by the revelation that the Soviet navy was making new, quieter propellers for its nuclear submarines with machinery and computer technology acquired from firms in Norway and Japan.

The technological advantage at the beginning of the nineteenth century lay with Britain. In the eighteenth century the English had begun to combine their engineering talent with large amounts of investment capital and an extensive trade network to generating a burgeoning industrial revolution. Their growing industries continuously demanded new technology and were numerous and strong enough to reward successful inventors with a large market. The Royal Navy often found itself in the fortunate position of being able to buy the latest technology on the domestic market without participating in the development process or paying development costs.

Technological development in most other countries during these years was much slower, inhibited by relatively small domestic markets and by strong English competition. Navies in these countries found that they could not rely on their national economies or on free market forces to generate a dependable domestic source of new technology and to sustain an adequate level of technological innovation. They did enjoy one opportunity, however. Early in the nineteenth century the English adopted an almost total free trade policy, and they not only allowed but even encouraged the export of their latest technology to anyone who would pay.

Almost immediately after the Napoleonic Wars, some key French naval leaders realized that, if the navy was to get new technology, it would have to do so on its own. They also perceived that steam propulsion, then still in its infancy, might

ultimately revolutionize naval warfare. In 1818, with the construction of two colonial steamers, _Voyageur_ and _Africain_, French naval officials took the first step in what became a concerted campaign to introduce steam technology into the French fleet and make it militarily significant. They encountered many problems, including inadequate naval budgets, the primitive state of French industry, French tariff policies, and opposition by elements within the navy. They persisted, however, and ultimately achieved a large degree of success. In 1843 the trials of the paddle frigate _Labrador_ demonstrated that French factories could build steam machinery as good as any built in England. In 1852 the trials of the fast steam battleship _Napoléon_ demonstrated that French engineers could be even more innovative than the English in using the new technology to enhance sea power.

To understand the process by which the French navy mastered steam technology, it is not essential to understand most of the mechanical details of steam engines and warships. It is useful, however, to understand the overall structure of sail and steam navies in this period. Sail navies were organized according to a rating structure--a graduated scale of ship classes in the fleet. At the top of the scale were the sailing ships of the line, ships with two or three covered gun batteries. (These are referred to here as battleships, for such was their function.) In the French navy in 1815 there were three types: a 120-gun three-decker, an 80-gun two-decker, and a 74-gun two-decker. Nearly all of these were built on standard plans developed during the 1780's

by a French naval constructor, Baron Sané. Below the battleships came the frigates, with one covered gun battery and a total of some forty or fifty guns. They were classified according to the caliber of their guns, although in 1815 nearly all frigates were of the 18-pounder type. Next came the largest corvettes, miniature frigates with covered gun batteries and up to thirty guns. Ships with covered gun batteries were regarded as the true combatant units of a navy, for use either in a fleet or as independent cruisers.

Navies also included smaller classes with all their guns in the open on the weather deck. These were used for cruising or for carrying messages. Because of this last mission, many of them and their steam successors were given the functional classification of "avisos" or advice-ships. The largest of these were open-battery corvettes with about twenty guns and three masts. They were followed by twenty- and ten-gun brigs, relatively standard types with two masts, and by a wide variety of types with less than ten guns. Sailing ships thus ranged from 120 guns to under ten guns, with the main types spaced along the scale at intervals of roughly ten guns.

The distinctive feature of the steam navy was the use of horsepower to classify ships. The steam navy eventually included a number of types which, in imitation of sailing ships, were called steam frigates, corvettes, and avisos. These types, however, were distinguished not by their configuration but by the power of their engines. The theoretical or "nominal" power of an

early steam engine was derived from a formula based to a large extent on the volume of the engine's cylinder. This formula assumed the use of low pressure steam (barely over one atmosphere). During the period discussed here, marine engines were practically all of the low-pressure type developed by Watt, generally with two cylinders working independently of each other to drive a common shaft. For these, nominal horsepower was a good indication of engine size, and therefore the size and military potential of the ship. In the French navy in the 1840's steam frigates varied from 650 to 450 horsepower, large corvettes from 400 to 320 horsepower, small corvettes from 300 to 220 horsepower, and large avisos from 200 to 160 horsepower.

These horsepower figures seem ludicrously low, but one must remember that these were still the early days of steam and that these engines were among the largest then in existence. At the conclusion of the period covered here, the largest steam engines ashore or afloat were barely 1,000 horsepower. The achievements of that day must be measured against contemporary efforts rather than the 280,000 horsepower of the largest modern aircraft carriers.

Studies like this are not completed without a lot of assistance and support. I would like to thank MM. J. Audouy, head of the French naval archives at the time this research was conducted, J.-P. Busson, then head of the French naval library and now head of the archives, and their assistants in the Service Historique de la Marine for introducing me to French naval records

and for making available to me much of the material used in this work. I would also like to thank the staffs of the Archives Nationales in Paris and the Public Record Office in London for providing much valuable material. Finally I offer my thanks and sincere appreciation to Professors William H. McNeill, Peter Novick, and F. Gregory Campbell of the University of Chicago for their assistance and guidance during the preparation of this work.

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CHAPTER I

THE NAVAL PROBLEM AFTER 1815 AND THE SEARCH FOR A CONVENTIONAL SOLUTION

Almost as soon as the Napoleonic Wars were over, the French navy began to make the policy decisions that would guide it in building its postwar fleet. It revised its strategic views on the types of naval wars that it should be prepared to fight, and it made a number of changes in the characteristics of the ships that were to fight those wars. It then embodied these decisions into a formal naval program, which remained the basis for French naval planning until steam technology entered the battle fleet in the 1850's.

The French navy emerged from the Napoleonic wars in 1815 convinced that France would never be the world's greatest naval power, at least not in the foreseeable future. This was clear from the determination with which the British had defended their lead during the war and the results at the end of it: 71 French ships of the line faced 214 British ones after the execution of the treaties of 1814.[1]

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[1] French figure valid for 1 January 1815 from Annales Maritimes et Coloniales (hereafter cited as Ann. Mar.), no. 10 (1819), p. 666; and Archives Nationales, Archives de la Marine, BB5-11. (Hereafter material from the French naval archives will

The problem for the French was thus how to be number two at sea--how to make seapower work to their advantage without having the world's largest navy. This problem is as difficult as it is important, and no generally satisfactory answer has ever been found. Efforts to resolve it have usually fallen in one of two categories: reliance on a new technological innovation (such as the submarine) to offset the opponent's numbers and strength in conventional forces, or redistribution of conventional forces geographically and numerically to concentrate against the opponent's weak points (as in the case of cruiser warfare against commerce). In 1815 no technological alternative to the sail line-of-battle ship was in sight, and the French navy thus concentrated in its immediate postwar planning on solutions using essentially conventional forces.

The lessons of the war suggested the general direction that future French naval policy should follow. The main lesson was seen to be the futility of big fleet actions. Most of the encounters between French and British battle fleets in the war had been disasters for the French, and the crushing British superiority in numbers of line-of-battle ships at the end of the war was an additional deterrent to continued reliance on

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be cited by custodian: Archives Nationales, Paris (A.N.) or Archives du Service Historique de la Marine, Vincennes (A.M.), and the call number, which includes the prefix "Marine.") British figure, also for 1 January 1815, from William James, _The Naval History of Great Britain from the Declaration of War by France in 1793 to the Accession of George IV_, 6 vols. (London, 1837), vol. 6, abstract no. 23.

the battle line. However the results of the war did not suggest that France should carry this idea to its extreme and abolish the battle line altogether: France still had seventy-one battleships which, while no match for the English, were more than enough to overcome any other maritime power. In addition, the very existence of this expensive materiel, with the dockyards and stockpiles of supplies to support it, was a strong reason for its retention, for if these resources had been dispersed, most of their monetary value would have disappeared in sheer waste. A final argument against radical change was the condition of the French budget, which simply could not support the cost of scrapping one fleet and building another. Besides coping with economic crises after the war, the government had to pay a large indemnity to the Allies, who occupied parts of France until it was paid. Before this all other needs paled, and the navy budget was repeatedly slashed, until in 1819 it was inadequate even to prevent the deterioration of the existing materiel.[1]

The situation was not entirely unfavorable, however, for the events of the war also suggested a way out of the navy's dilemma. For most of the war the French battle line had been inactive, blockaded in port by superior British forces, but French frigates had frequently been able to evade the blockaders

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[1]Lieutenant de vaisseau Quérat, "Le Ministère Portal (29 décembre 1818-12 décembre 1821)" (Thesis, Ecole de Guerre Navale, 1936-37), pp. 5-9; Pierre-Barthélemy d'Albarèdes Portal, Mémoires du baron Portal, contenant ses plans d'organisation de la puissance navale de la France (Paris, 1846), pp. 31-33.

and achieve considerable success as commerce raiders. After Trafalgar, increased emphasis had been put on commerce raiding by frigates, and after the war this was regarded as one of the more successful campaigns undertaken by the Navy. Many felt that it would have been even more effective if it had been adopted at the beginning of the war instead of towards the end, and if the navy had not continued to pour much of its resources into construction of ships of the line, especially at Antwerp, right up to 1814. The results of the war suggested to many that frigates should have a greater part in future naval planning.

An additional advantage to frigates was that, in this category, the problem of British numerical superiority was not insurmountable. The Americans during the war of 1812 had shown how to overcome this problem--they did not try to compete in numbers, but built their frigates larger and stronger than the standard British (and French) models. Thus, while the latter carried 18-pounder guns, many of the American frigates carried 24-pounders, in hulls that were bigger and more solidly built than their European counterparts. The striking success of the American ships forced the British to order their frigate captains not to accept combat with American frigates, and to build a new class of 24-pounder frigates that could match the American ships. The French also wanted to be able to stand up to American frigates if need be, but their main interest in the new situation was the opportunity that it provided them in their competition with England, for instead of contending with a British lead of

over a hundred up-to-date frigates, they would be able to start afresh at a state of near equality with their rivals.

Postwar Programs, 1815-1820

For its day-to-day activities in the years immediately after the war, the navy set for itself only the most limited objectives: to protect French commerce and fisheries, to train at least some of its officers and men at sea, and to combat the deterioration of the ships laid up in reserve.[1] But even in this period of deepest austerity it began planning for the future. The first step was to learn as much as possible from its successful rival across the Channel. In the years immediately after the war, large numbers of Frenchmen visited England, and the Navy participated in the movement. The best known of the Navy's travelers was Charles Dupin, who, since graduating from the Ecole Polytechnique in 1803, had simultaneously pursued two careers, one as an officer in the Naval Construction Corps and one as a prominent theoretical scientist. Assigned by the Restoration government to take charge of construction work at the moribund Dunkirk dockyard, he got permission to make an extensive series of visits to England, in order to study the bases of British maritime strength, notably her navy, army, commerce and colonies. He and his compatriots studied practically every aspect of British life, but also brought back quantities of very specific technical naval information, on such matters as the new techniques of framing for ships, the new round sterns

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[1] Ann. Mar., no. 4 (1816), p. 442.

and full bows being fitted to British warships, machinery for making rigging and iron fittings for ships, steam engines for dredging harbors, and details on the new class of large British frigates.[1]

At the same time the Ministry of Marine began to tackle the problem of determining the size and shape of the fleet of the future. In August 1817 the minister appointed a commission of senior naval officers to study the problem, and it was decided to fix the size of the navy at fifty ships of the line and fifty frigates.[2] This already involved a change in the ratio between battleships and frigates, for at that time the navy had sixty-eight of the line and thirty-eight frigates afloat or building. In October 1817 a new minister presented to the cabinet a proposal for a secret ordinance to implement a long-range program based on a report by the head of the naval construction corps. Pointing out that at the present rate of decay the existing ships would disappear in ten years, he proposed building three of the line and four frigates each year, so as to have a fleet of thirty-eight of the line and sixty frigates in fourteen years.[3]

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[1] Ethel Jones, Les voyageurs français en Angleterre de 1815 à 1830 (Paris, 1930), pp. 140-145; Dossier of Charles Dupin, A.M., Marine CC7-779; Charles Dupin, Voyages dans la Grande Bretagne, entrepris relativement aux services publics de la guerre, de la marine et des ponts et chaussées depuis 1816, 6 vols., 2d ed. (Paris, 1825-26); Baron J.-M. Tupinier, Memoirs (written ca. 1848), Manuscript Collection, Bibliothèque de la Marine, Vincennes, p. 186.

[2] "Réponse à une note de Son Excellence, en date du 3 mai [1818]," 1 June 1818, A.N., Marine BB3-848.

[3] "Réponse;" Tupinier, Memoirs, pp. 180-181.

In his speech to the Chamber of Deputies on the navy budget for 1818, he estimated the cost of this program at 63 million francs, far above the 44 millions appropriated for 1817. However he argued that, in the long run, such an orderly program of maintenance and replacement would be more economical than allowing the navy to fall apart with a budget incapable even of keeping up with the rot in the reserve fleet, and then trying to rebuild it all at once in a panic when it was found to have disappeared.[1] Neither the government nor Parliament could accept the cost, but the program was used within the ministry for the next several years as a basis for naval planning.

The most important part of the new program was that relating to frigates. The minister not only increased the number of frigates relative to battleships, but specified that the first eight to be built would be of the large 24-pounder type, and that in the final fleet half were to be of this type and the other half of the traditional 18-pounder type.[2] Design work on the new frigates was already well advanced: the general characteristics for the ships were decided upon on 12 May 1817 and a competition was opened, in which the naval constructors in the five naval ports were invited to submit building plans. Three of these plans were accepted, and a ship was begun to each plan in the years 1819-20. Unfortunately the qualities of

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[1] _Ann. Mar._, no. 8 (1818), pp. 225-226; Quérat, "Ministère Portal," p. 16.

[2] "Réponse."

the new ships were ruined before they were begun, when on 13 July 1819 their armament was ordered increased from fifty to fifty-eight guns.[1]

Even such a simple matter as increasing the caliber of guns in frigates led to unexpected complications: in fact, it upset the whole system of ship construction in the French navy. Ships of the line were built according to a rigid system of classification that dated back to 1786, when it was decreed that the standard battleship would carry 74 guns: 28 36-pounders in the lower battery, 30 18-pounders in the upper battery, and 16 8-pounders (later partly replaced by carronades) on the forecastle and poop. They were also to be able to carry stores for eight to nine months, to permit long cruises overseas. In addition, since the best plan submitted in the design competition of 1786 was by Baron Sané, all subsequent 74's were to be built to the same plans. There were also to be a few three-deckers rated at 118 guns, to respond to the tendency of the British to favor that class, and also an intermediate class of 80 guns, similar to the 74 but with 24-pounders in the upper battery.

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[1]Tupinier, Memoirs, p. 191; Tupinier, "Observations sur les dimensions des vaisseaux de des frégates dans la marine française," Ann. Mar., no. 17 (1822), pp. 8-10. The increased armament was due to the decision to fill in the gap between the forecastle and poop on all large warships with a full deck and additional carronades. This continuous upper deck, plus the elimination of the extreme tumblehome of Sané's designs, became the most visible change in sailing warship design made during the Restoration. Less visible but just as important were the introduction of iron anchor chains and water casks and changes in the calibers of the ships' guns.

These 80's were the least expensive in proportion to the weight of their artillery of any of the three types, but could not carry as many stores as the 74. The 74 was to be the backbone of the fleet, with the 118 and the 80 being built in small numbers (also on plans by Sané) to provide strong points in the battle line for engagements in home waters.[1]

The problem with battleships was that in rough weather they had to close their lower battery ports to keep the water out, while this was often not necessary in frigates. This meant that in unfavorable seas the main armament of Sané's 74 would be reduced to the 18-pounders in the upper battery, which would be no match for the 24-pounders in the new frigates: in case of an action the 74's "safety would be compromised, as well as the honor of the flag."[2] The adoption of the new frigates meant that the old 74 had to go, and in 1819 the armament for future "74's" was fixed at 28 36-pounders in the lower battery, and 30 24-pounders in the upper battery, with 36 36-pounder carronades on the continuous upper deck bringing the total to 94 guns. This in turn raised problems of weight which were only partially offset by a six-inch increase in beam, and it was decided to develop a 30-pounder gun to replace the heavy 36-pounders.[3]

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[1] "Etat actuel de notre marine" (ca. 1789), A.N., Marine D1-4; Georges Lacour-Gayet, La marine militaire de la France sous le règne de Louis XVI (Paris, 1905), p. 563.

[2] Tupinier, "Observations," p. 30.

[3] Quérat, "Ministère Portal," pp. 18-20.

The decision on the new 74 was taken by a new minister of marine, Baron Pierre-Barthélemy Albarèdes Portal, who took office on 29 December 1818 and kept it until 12 December 1821. Portal, a Protestant and a prominent Bordeaux shipping merchant, was credited both by contemporaries and historians with the rebirth of the French navy. He deserves much of this credit, even though his program was largely a continuation of the work of the previous ministers as passed on to him by the permanent officials in the ministry.[1] Favored by the fact that the worst of the postwar economic crisis had passed and that the indemnity to the Allies had been paid off, Portal was able to present his program to the government and Parliament so skillfully that, even though the money could not immediately be provided, the principle of the need for adequate funding of the navy based on a rational program was soon generally accepted.

Portal adopted the figures of thirty-eight battleships and fifty frigates for the new fleet, with a total navy budget of 65 million francs per year for ten years needed to achieve and maintain it. These numbers were chosen, not with any absolute strategic scheme in mind, but as a compromise between the needs of the navy and the amount of money that could reasonably be hoped for. These computations were again made by the head of the Naval Construction Corps and other permanent officials in the ministry, and the results were, not surprisingly, very

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[1]Tupinier, Memoirs, p. 181.

close to the figures in the earlier programs. The only significant change was the reduction in the number of frigates from sixty to fifty, which Portal in his memoirs later regretted. The number of battleships was soon changed to forty.[1]

While the specific numbers of battleships and frigates may have been decided pragmatically, Portal did base them on a general view of the purpose of the navy, which he revealed most fully many years later in his memoirs. His program was inevitably directed against Britain, whose "power, deep-rooted hostility, constant competition for trade and political influence--in short her continued ill-will, more or less concealed," was the primary threat to France at sea.[2] This situation was aggravated by the results of the war, in which, while sweeping France from the seas, Britain had consolidated her hold on foreign markets and bases, and had built up the number of ships and men in her merchant marine, as well as the economic strength needed to maintain a large navy. Portal felt British economic strength was even more decisive than Britain's lead in men and materiel in putting her out of reach of direct French naval competition. However in building her position, Britain had made many enemies, and on this Portal based half of his program. He felt that Russia

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[1] Quérat, "Ministère Portal," pp. 16-18; Tupinier, Memoirs, p. 181; Portal, Mémoires, pp. 31-38, 242-243. See also A.M., Marine BB7-1 for information gathered at this time on the British and other navies by the Ministry of Foreign Affairs on Portal's request. This information seems to have arrived too late to have had much effect on the program.

[2] Portal, Mémoires, pp. 35-36.

and the United States feared British supremacy as much as did France, and felt that if France provided a strong nucleus fleet, these nations could be induced to ally with her in an emergency, at least diplomatically and perhaps militarily. Hence the need for a battle line which, while not by itself the equal of the British fleet, might be able to match it if joined by allied fleets, and which, even without allied support, would provide valuable support for French diplomacy.

However Portal's principal plan for maritime warfare did not rest on the battle line, for the war had impressed on him the "vanity" and futility of large fleet actions against Britain, even with allies. The battleships would be put to good use in attacking enemy convoys, defending French coasts and sea communications, driving off blockaders and perhaps in carrying out surprise attacks on the English coast to boost French morale. However the main effort of the French navy in a war with England, he felt, should be to attack the main source of English strength, and also her most vulnerable point: her seaborne trade; and for this the French navy would need a large force of strong frigates. Portal envisioned using these ships in an all-out attack on British trade, augmented by large numbers of privateers mobilized in an effort to "nationalize maritime war." Hence, in contrast to the old navy, Portal's navy was to have more frigates than battleships, and even among the battleships the smaller classes (74's and to some extent 80's), which

had the speed and cruising range of frigates, were to be favored over the lumbering three-deckers.[1]

Portal saw one more aspect of the post-1815 situation that he felt favored France: the fact that much of the world outside Europe was no longer under European domination. The United States had broken away from England, and all of South and Central America was in the process of breaking away from Spain. Portal felt this reduced the importance of seapower, since naval battles between European powers could no longer determine who would own these areas and control access to their products. It also reduced the importance of the remaining colonies, since their products were now available in ports not under European control. Hence a vast new field of activity had been opened up for French trade, and for the French navy, which would have to see to it that these newly opened areas were not again closed, either by other European powers or by local governments. The British had already adopted this system, even offering to open their colonies to foreign traders if France would do likewise, but the French feared that Britain would turn the system to her own advantage unless France maintained a strong presence overseas and continually asserted her rights. This mission would be carried out by small groups of warships stationed all over the world, and these station fleets would be composed of the same

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[1]Tupinier, "Observations," p. 5; Portal, Mémoires, pp. 36-38, 231, 235-239, 321-322; Quérat, "Ministère Portal," p. 5.

frigates and smaller cruising ships that would be used for commerce raiding in wartime.[1]

Portal presented his program to Parliament in 1819 with the budget for 1820, but in a particularly skillful way. Having decided with the permanent officials in the navy administration that France could afford 65 million francs for her navy, and that this would provide an adequate force, he first drew up his budget for that figure, and presented it as a model budget, which if repeated for ten years would produce a fleet of thirty-eight of the line and fifty frigates, all ready for immediate service, plus the necessary smaller ships, adequate reserves of materiel, and well-trained personnel. He then announced that for 1820 he was willing to compromise with the need for economy, and in a format parallel to that of the model budget, reduced his request for that year to 50 millions (an increase of 5 millions over the previous year), but in the process taking every opportunity to show how the reductions hurt the navy.[2] His master stroke, however, was his ultimatum: he showed that the fleet was deteriorating so fast that, if the navy budget continued to be limited to 45 millions, "the navy, after having

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[1]Portal, Mémoires, pp. 232-236, 242-243.

[2]France, Ministère de la Marine et des Colonies, Rapport au Roi, Budget de 1820, pp. 6-8. (Hereafter these Navy reports will be referred to as Budget, 1820 etc., it being understood that the reference is to the separately-printed report and not the budget itself; while reports of Parliamentary commissions on the budget will be indicated by references to Parliamentary documents.)

consumed an additional 500 millions, will have totally ceased to be by 1830." Hence, "we must either abandon the institution to save the expenditure, or augment the expenditure to save the institution."[1] These words, together with the political impossibility of giving up the navy and the steadily increasing ability of the economy to support it, caught the imagination of Parliament, and the principle of a 65 million franc navy budget was approved in the debate on the 1820 budget, even though it was not attained in fact until the budget for 1830.

Executing the Program of 1820

While Portal had succeeded in establishing a principle for the navy's relations with Parliament, events showed that he had done this before all the problems in the naval portion of his program had been worked out. The 1820's brought to light various discrepancies, technological and otherwise, in his program, which were at the bottom of most of the problems faced by the French navy during the remainder of the age of sail.

The first problems to appear were technological. It soon appeared that not all the problems raised by the installation of 24-pounder guns in frigates had been taken care of. To begin with, when the first of the new 24-pounder frigates, *Jeanne d'Arc*, went to sea on trials, she was found to be too small to carry her armament at either the designed speed or height above the water. Then the specifications for the new 74 were reexamined and found wanting: the ship would have a

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[1] *Budget, 1820*, pp. 3-5; *Ann. Mar.*, no. 10 (1819), pp. 666-670.

larger, less maneuverable hull than the old 80 while having fewer big guns in her batteries. Finally the naval commander at Toulon, following an ancient practice, received permission to "razee" an old 74. Razeeing involved removing the ship's upper battery, which in this case had begun to rot, leaving the ship as a powerful frigate with a battery of 36-pounder guns (her former lower battery). Her armament not only outclassed the 24-pounder frigates, but she also performed brilliantly on trials. It was clear that the rating structure for French warships would again have to be revised to take into account these new developments.[1]

The new system was provided in 1822 by Baron Jean-Marguerite Tupinier, who in doing so assumed the position he was to hold for the next twenty years as the most influential of the permanent officials in the ministry. At the time, Tupinier, after a distinguished career in the naval construction corps, was assistant and designated successor to the director of the most important department in the central administration, the Direction of Ports. (He succeeded to the directorship a year later, in 1823.) He was instructed to present to the minister the results of the trials of _Jeanne d'Arc_ and the razee (_Guerrière_), and he took the opportunity to develop the general principles on which he felt a new rating system should be based. He started by asking why _Guerrière_ was so superior in her seagoing qualities, both to the old 74 from which she had been

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[1] Tupinier, "Observations," pp. 3-4, 8-10, 29-31.

converted and to the new 24-pounder frigates. He concluded that the secret lay in the size of her hull, which was larger in proportion to the armament carried than normal practice in frigate construction called for. This ample hull, unencumbered by heavy upper works, not only gave the ship superior seakeeping qualities but also made her very fast and allowed her to stow ten months of stores, making her a peerless commerce raider. Tupinier felt that the 24-pounder frigate could be given similar qualities if her hull were increased in size by some 15 percent. As for the problem with the battleships, Tupinier made the obvious suggestion of abandoning the effort to improve the 74 and making Sané's 80, whose hull was better proportioned to carry the desired armament, the backbone of the new fleet.

However Tupinier did not stop there, but went on to examine the navy's rating structure as a whole. He noted that there would be a big gap between the 24-pounder frigates and the 36-pounder razees, and also a gap between the 118-gun three-decker (which he proposed keeping unchanged) and his new 80. No other nation had filled these gaps, but Tupinier proposed that, just as the United States had taken the technological lead at sea with her jump to 24-pounders, France should now take it with another jump. The means to do this quickly was at hand, for the navy had nearly completed development of a 30-pounder gun as an intermediate caliber between the 24 and the 36-pounder. Tupinier therefore proposed adding two new rates to the navy: a battleship with 30-pounders in the upper battery, and a 30-pounder

frigate. The hulls of the former would be built from the keel up as razeed three-deckers, hopefully being as superior to these as Guerrière was to the 74, and the latter were to be midway in size between Guerrière and Tupinier's 24-pounder frigate.[1]

The rationale behind these proposals became somewhat clouded when, during the deliberations on his report, Tupinier proposed an additional innovation: arming all the battleships in the fleet with the same caliber gun: 30-pounders, of varying lengths and weights depending on their position in the ships. While it might have seemed that there was now no reason to build Tupinier's intermediate class of battleship, the ship was retained, probably due to the anticipated benefits from her large hull; and in the end only one class was deleted, the 36-pounder frigate, since the 36-pounder gun was to be eliminated from the fleet altogether. This caused some debate as to whether Tupinier's 30-gun frigate should be built on his plans or on those of the razees--after some experimentation the former was decided upon. After extensive study by boards of naval officers in the ports and at Paris, Tupinier's system was formally adopted as the standard for the new navy in a royal ordinance signed on 10 March 1824, which also gave legal sanction to Portal's fleet of forty battleships and fifty frigates. In its final form the

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[1] Tupinier, "Observations"; Tupinier, Memoirs, pp. 191-193; A. Mazères, Notice sur M. le baron Tupinier (Paris, 1842), pp. 14-15.

system called for four rates of battleships: the three-decker of 120 guns, Tupinier's intermediate class with 100 guns, the successor to Sané's 80 which now carried 90 guns, and a handful of 74's (now 82's), restored to the program for use in shallow water. The three classes of frigates: 30-pounder, 24-pounder and the old 18-pounder, were still distinguished by their artillery--the system of a uniform armament of 30-pounders was extended to them in the 1830's.[1]

All this detail seems rather trivial a hundred and fifty years later, but in fact it represents a significant escalation in naval strength brought about in peacetime by the upsetting of the technological balance between classes of ships that had prevailed through most of the period of the revolutionary and Napoleonic wars. The remarkable thing is that, with the decree of 1824, the escalation stopped. This indicated in part that Tupinier had in fact restored the equilibrium between the different classes of ships, by producing roughly equal intervals of size, strength and cost between them, and also showed that this equilibrium was not challenged from outside: the British built

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[1] Ann. Mar., no. 59 (1836), pp. 55-61; Tupinier, "Observations," pp. 55-61. On frigate design see Director of Ports to Minister of Marine (hereafter Ports to Minister), 6 May 1823, A.M., Marine 7DD1-48; Commandant de la Marine, Toulon, to Minister, 30 August 1823, A.M., Marine 7DD1-9; France, Marine, Conseil des Travaux (hereafter C.T.), 22 March 1824, A.M., Marine BB8-1106 and 1110. The plans for the 100-gun battleship (nominally drawn by Sané) and the 30-pounder frigate were approved by the Council of Works on 13 May 1824, along with those for a 20-gun war-brig also proposed by Tupinier: C.T., 13 May 1824, A.M., Marine BB8-1106 and 1110.

equivalents of Tupinier's 100-gun battleship, but avoided any further innovations in ship design and even failed to match the larger classes of French frigates. The new equilibrium was expensive, however, for the new ship types were larger and more expensive than the old, putting new pressures on the budget that Portal had not anticipated.

Other problems soon became apparent with Portal's program. A general inspection of the reserve fleet, initiated by Portal, found that decay in these ships was even more rapid than feared, and that more money than planned would have to be spent on repairs to keep them afloat.[1] In 1825 the estimated lifespan of a large ship was downgraded from fourteen years to twelve, based on actual experience since the war. This was only partly offset by the discovery that work spent on repairs was as effective in extending the life of the fleet as work spent on new construction: Portal had thought it was only half as effective.[2] Another problem was revealed during the French intervention in Spain in 1823, when the navy found it needed many smaller ships (small brigs, schooners, etc.) than Portal had allowed: these, plus the corvettes and larger brigs used on overseas stations took both money and men that had been

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[1] Budget, 1821, pp. 8-9; Budget, 1823, p. 11; Quérat, "Ministère Portal," p. 25.

[2] Budget, 1827, pp. 18-20; France, Ministère de la Marine et des Colonies, Budget de 1827, Développements relatifs aux dépenses du matériel de la flotte, pp. 120, 123, 135-137 (Report usually bound with Budget, 1827); Budget, 1820, p. 21n.

allocated to large ships. The demand for small ships became chronic, and was a continual drain on both the French and British budgets. The same was later true for steamers, which had not even been mentioned in Portal's model budget.[1] The most serious problem was that Portal had called for forty battleships and fifty frigates always ready for sea, but had not made any allowance for ships under repair. In 1825 it was estimated that a quarter of the total number of battleships in the navy and a sixth of its frigates would necessarily be under repair at any one time, due to the rate of deterioration and the capacities of the dockyards. To allow for an orderly repair program and still have the desired number of ships ready for action, the total number of ships on the navy list would have to be raised to fifty-three battleships and sixty frigates, all of which would consume maintenance funds.[2] There were additional strains placed on the navy budget during the 1820's that were not related to materiel, resulting especially from the extensive personnel reforms and pay increases necessitated by the return to a prolonged period of peace, and from the need to keep many more ships in commission on foreign stations and on special diplomatic missions than originally anticipated.

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[1] _Budget, 1822_, p. 18; _Budget, 1825_, p. 16; _Budget, 1826_, p. 18; _Budget, 1828_, p. 5.

[2] _Budget, 1827_, p. 18; France, Marine, _Développements_, pp. 120-121.

All these problems indicated that, despite the assurances of successive ministers, a budget of 65 million francs would not be enough to support Portal's program as initially conceived. The situation was made even worse by the fact that, until 1830, the navy budget remained well below the 65 millions required by Portal's plan: the average budget between 1826 and 1829 was 57 million, although actual expenditures were higher. These shortages hurt material the most, for personnel and operational requirements were relatively inflexible. As early as 1820 it was seen that the building rate planned by Portal--starting six big ships each year and completing them in three--could not be maintained, and the budget for 1821 included plans to increase the number of building ways, and hence the number of ships building at any one time, from the eighteen required by Portal's system to thirty, equal to one-third of the active fleet. Portal, who was still minister, did not particularly regret this necessity, for he pointed out that it could be turned to the navy's benefit. Later reports expanded on this theme, indicating that experience showed that a ship began to rot as soon as it was launched, and that ships decayed faster if laid up in reserve than if actively used. In contrast, ships allowed to remain on the building ways, if properly ventilated and covered by a protective shed, would last almost indefinitely without decaying, and in addition would have a longer service life after launching because their timbers would be better

seasoned. In short, a reserve fleet maintained complete on the ways would cost practically nothing.[1]

It was this realization that provided the answer to the navy's budgetary problem and which brought Portal's program, somewhat modified, back within reach. In the budget of 1827 the minister approved the increase of the overall size of the fleet to fifty-three battleships and sixty frigates, and during the following year Tupinier worked out and implemented the remainder of the system, which was approved without alterations by the minister in the report on the 1828 budget. The number of ships ready for action was to remain at forty battleships and fifty frigates, but no less than half of these were to be kept essentially complete on the ways until they were needed, supplemented by more (eventually fixed at thirteen battleships and sixteen frigates) at less advanced stages of construction. When the 1828 budget was compiled the navy had only thirteen battleships and ten frigates on the ways, and during the next several years the navy made a great effort to acquire additional building ways and bring the number of ships on them up to the level of the program.[2]

The flaw in this system was quickly seen by the navy. A ship on the building ways could not, in fact, be immediately

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[1] Budget, 1820, pp. 39-40; Budget, 1821, p. 20; Budget, 1827, p. 19.

[2] Budget, 1828, pp. 6, 16-19; Budget, 1829, p. 22; Tupinier, Memoirs, p. 225.

available for use, for her rigging could be fitted and her guns and stores put aboard only after launch. In addition, part of the hull planking would have to be left off to allow proper ventilation and prevent decay. This meant that, after a ship on the ways was called for, the dockyard would have to do the last twelfth of her construction, launch her, fit her out, and, perhaps the most difficult, man her. Under ideal circumstances this would take two months for one ship. In 1828 the minister acknowledged that it was more economical to leave ships on the ways, but warned that if the navy went too far in this direction and war came, "we would find ourselves entirely unarmed and unable to act during a period of time which, in such cases, is always too long." Therefore, in planning the budget for 1829, he increased the afloat portion of the fleet to two-thirds, which he felt was the best compromise between the number of men available and the resources of the budget.[1] However the navy was unable to maintain this level, and in the period of austerity after the July Revolution it fell back to the original plan of having half of the fleet afloat and half on the ways. This remained the basis of French naval planning until the proportion was again changed in 1846.

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The major policy decisions made by the French navy after the Napoleonic Wars thus fell in the decade between 1817 and 1827. The navy first decided that the fleet of line-of-battle

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[1] _Budget, 1829_, pp. 23-26; _Budget, 1830_, pp. 16-18.

ships should not be abandoned despite its failure during the wars: a battle fleet might prove valuable in a diplomatic or military alliance against England, and it would allow France to maintain her rank as the world's second largest naval power, even though it would not begin to approach in size the British battle fleet. To compensate for British superiority in battleships, the French navy decided to place more emphasis than before on commerce raiding by large frigates: a large number of frigates was included in the new fleet, and a new type of frigate with 24-pounder guns was developed. The technical problems caused by the creation of this new type of ship were resolved in 1822 by Baron Tupinier, who established the characteristics of what were to remain the standard classes of French warships for the next thirty years. Finally, in 1820 a minister of marine, Baron Portal, incorporated these decisions into a formal program which balanced the navy's needs against its budgetary resources and stated that the French navy should always have ready for action forty battleships and fifty frigates. This program had to be modified later in the 1820's due to complications not foreseen when it was drafted, but these modifications did not change the basic principle of a balanced fleet in which an intelligent combination of conventional sailing battleships and frigates would offset the supremacy in numbers of ships of the British navy. This principle, along with the standard fleet of forty battleships and fifty frigates, remained the basis of all French naval planning until steam technology entered the battle fleet in the 1850's.

CHAPTER II

STEAM: THE EXPERIMENTAL PERIOD, 1818-1830

The naval program decided upon by the French navy during the 1820's was probably the best one that could have been developed in the face of British naval supremacy using conventional naval forces, since there was no chance that the French could match the British in numbers of ships. But it could not guarantee success in a naval war with England, since it did not provide the only sure means to such success: superior strength. Superior strength could, however, be achieved not only by superior numbers but also by superior technology, and some Frenchmen hoped that new technological inventions might eventually permit the French navy to compensate for the British superiority in conventional forces. One such invention was just beginning to make its appearance--steam propulsion for ships.

The French navy came into contact with steam technology for the first time in 1818, and from then to 1830 used it primarily on an experimental basis, first in the colonies and then in its own ports. During its experiments the navy discovered that for some services, such as ascending rivers or

towing sailing ships in and out of port, steamers were all but indispensable. By 1830 steamers had a secure place in the navy, although their functions were still very limited. However the navy also discovered that neither the industrial facilities nor the technological knowledge needed to build steamers existed in France. During the 1820's it became more and more directly involved in the process of developing these resources, to the point where, by 1830, it had established its own steam engine factory and imported an example of the latest type of British engine, both to fill its own needs and to serve as models for future French industrial and technological growth.

As of 1815 there was hardly any precedent in France for the use of steam to propel ships, and indeed practical steamers were only a very recent phenomenon anywhere. The idea traditionally goes back to Jonathan Hulls in England in 1736, but it only became a practical, paying proposition in America in 1807 with Robert Fulton's Clermont and in England in 1812 with Henry Bell's Comet. While experiments with steam propulsion had been carried out in France by Jacques C. Périer in 1775 and the Marquis Claude de Jouffroy in 1781, these efforts had failed and the idea was not pursued in France.[1] Only in 1816, two years before the first navy ships were ordered, did France see her first practical steamer. In that year Pierre Andriel and

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[1] K. T. Rowland, Steam at Sea: A History of Steam Navigation (New York, 1970), pp. 12-19.

Lieutenant-General Pajol formed a company for the use of "steam pumps and the inexhaustible motors that they perpetually put into operation" for "accelerated navigation" on the Seine.[1] The company purchased a steamer in England: Margery, built in 1813 with an engine of only 14 horsepower, which they renamed Elise. Under the command of Andriel she sailed from London on 9 March 1816, and after being delayed at Newhaven by bad weather, crossed the Channel in twenty hours in heavy seas under steam alone on 17-18 March. She then ascended the Seine and arrived at Paris on 29 March. The Moniteur reported on 30 March that "steam, by means unknown to us, causes two wheels placed on the sides of the boat to move, propelling the boat upriver."[2] The ship then returned to Rouen and began a regular service between that city and Elbeuf, a round trip of three and a half hours. However she failed to make a profit and soon returned to England and resumed her old name.[3] Pajol experimented with at least two

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[1] Félix Rivet, La navigation à vapeur sur la Saône et le Rhône, 1783-1863 (Paris, 1962), p. 4.

[2] A. Anthiaume, Le navire: Sa propulsion en France et principalement chez les normands (Fécamp, 1924), p. 220; Ann. Mar., no. 4 (1816), p. 323.

[3] Alternatively, it is claimed that British records on Margery closed in October 1816 and that her timbers reportedly could be seen on the banks of the Seine as late as 1888. W. A. Baker and Tre Tryckare, The Engine Powered Vessel: From Paddle-wheeler to Nuclear Ship (New York, 1965), p. 15. The drawings of Elise and Charles Philippe in this book are similar to drawings in the papers of the naval constructor J.-B.-A. Pironneau, A.M., Marine JJ-324.

more steamers as tugs on the Seine before going out of business, while Andriel went to Naples, received a monopoly of steam navigation in that kingdom in January 1817, and established one of the pioneer steam lines in the Mediterranean.[1] During 1816 Jouffroy had also attempted to revive his experiment of 1781, but his Charles Philippe incorporated none of the technical advances made since then by Watt and others and was unsuccessful.

Jouffroy's failure and that of Pajol left France once again without any steamers.[2] The gap was soon filled by an enterprising American whose success was as complete as the failure of his predecessors. Edward Church, who had met Fulton in 1810 and absorbed his ideas, came to France in 1817 as American consul to Lorient, and with the help of the American consul at Bordeaux, who was also his brother-in-law, started a steamer service on the Garonne in 1818. He quickly expanded his service to other towns in the area, and by 1822 had six boats in service.[3] In 1820 he sent a seventh ship, Triton, along the coast all the way to Le Havre, and the American consul there used her to start

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[1] Hubert Giraud, Les origines et l'évolution de la navigation à vapeur à Marseille (1829-1900) (Marseilles, 1929), p. 10; Anthiaume, Propulsion, pp. 218-220; J. Gilbert, Essai sur l'art de la navigation par la vapeur (Paris, 1820), pp. 16-18; Jean-Pierre Busson, "Quelques aspects des débuts de la construction navale et de la navigation à vapeur, particulièrement à Rouen et au Havre de 1816 à 1828," in Les origines de la navigation à vapeur, ed., Michel Mollat (Paris, 1970), p. 30.

[2] Rivet, Saône, p. 64; Gilbert, Essai, pp. 20, 56.

[3] Ann. Mar., no. 16 (1822), p. 206.

a regular service between Le Havre and Honfleur. On her way north, Triton had been the first steamer to call at Nantes, where in 1822 yet another American consul, joined by his colleague at Bordeaux, was to start the first steam service on the Loire. (A monopoly of steam navigation on the Loire had been granted to a Frenchman in 1816 but without any practical results.)[1] Thus in a few years, Church and his colleagues brought steam navigation to three major areas of France, where they were quickly followed by French competitors.[2]

However the spread of steamers in France was not matched by the spread of the ability to build them. The hulls were easy to procure: those for the Bordeaux and Nantes steamers were built in those cities and, except for two early hulls built at Le Havre (perhaps for Pajol), those for the earliest ships on the Seine were probably built at Rouen.[3] The problem was the steam engines: while there was a steam engine industry in France, it

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[1] A. Anthiaume, Le navire: Sa construction au Havre pendant le XIXe siècle (Paris, 1925), p. 16: H. Redeuillh, "Un des premiers bateaux à vapeur construits en France: Le Triton," in Actes du LXXXIe Congrès National des Sociétés Savantes, Rouen-Caen, 1956, Section d'histoire moderne et contemporaine (Paris, 1956), p. 821.

[2] Rivet, Saône, pp. 65-67, 96-102; Gilbert, Essai, p. 56; Busson, "Débuts," p. 37.

[3] Félix Libaudière, Les origines de l'industrie nantaise au XIXe siècle: La navigation à vapeur, 1822-1825 (Nantes, 1909), pp. 13-14, 20-22; France, Archives Nationales, Section Outre-Mer (former archives of Ministry of Colonies, Rue Oudinot, hereafter cited as A.C.), Martinique 143-1284.

was very limited, since out of all the engines in France in 1815, it is estimated that half were built in one factory: the Périer works at Chaillot, near Paris.[1] There is no evidence that any of the early steamers in France (except perhaps those of Jouffroy and Pajol, which were failures) received French engines, while a number are known to have received British-made engines, including the six in service at Bordeaux in 1822 and the first steamer at Nantes, Loire. Reliable engines were already easily available in England; and the Americans and their first French competitors brought certainly some and probably all of their engines there.[2] The lack of a sound steam engine industry was one of the main problems faced by advocates of steam navigation in France.

The development of steam navigation, even in its most embryonic state, aroused the interest of the French navy. Among the innovators in steam propulsion and those who wrote about it,

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[1] Jacques Payen, Capital et machine à vapeur au XVIIIe siècle: Les frères Périer et l'introduction en France de la machine à vapeur de Watt (Paris, 1969), p. 228.

[2] Of the Bordeaux steamers, Ingénieur (1819) had engines by Fawcett of Liverpool, while the first of the Nantes steamers, Loire, also had engines from Liverpool and two of the pioneers on the Seine, Aaron Manby and Génie du Commerce (1820) had engines built by Manby in Birmingham prior to his move to France. Church established a shipyard at La Seyne near Marseille in 1818, but I have been unable to trace any steamers or engines to this yard. Rivet, Saône, p. 63; Anthiaume, Construction, p. 54; Gilbert, Essai, p. 56; Louis Brindeau, Les premiers bateaux à vapeur au Havre (Le Havre, 1901), pp. 10-12; Tourasse and F.-N. Mellet, Essai sur les bateaux à vapeur appliqués à la navigation intérieure et maritime de l'Europe (Paris, 1828-29), pp. 16-22, 126; A.C., Martinique 143-1284.

there were already some who claimed for it direct military value. Of these the most persuasive was Fulton, due to his reputation and to the fact that he actually built his war steamer. This, a steam floating battery usually referred to as _Fulton_ or _Fulton the First_, was well known to the French navy, for she had been visited by French naval officers as early as 1815 during her trials.[1] She was described in the official _Annales Maritimes_ of 1816 as a combination of all imaginable means of destruction in a hull that, due to its stout construction, was invulnerable to enemy shot. Among the more exotic features listed (mostly imaginary) were her ability to spray enemy decks with torrents of boiling water and to repel boarders with jets of flame. The article indicated that in case of war similar steam floating batteries and gunboats might be found necessary for the defense of French coasts and ports.[2]

Other writers suggested that steam could provide valuable support to the traditional sail navy. One noted that steam engines on barges had already proved useful for dredging channels, and suggested that such craft, with the addition of steam propulsion, would be useful for military ports, particularly Dunkirk and Bayonne. The same author also proposed using steamers to tow warships in and out of the major naval ports, especially Rochefort,

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[1]Howard I. Chapelle, "Fulton's 'Steam Battery': Blockship and Catamaran," _United States National Museum Bulletin_, no. 240 (1964), p. 144.

[2]_Ann. Mar._, no. 4 (1816), p. 319.

where the approaches were particularly difficult. He also recommended careful study of Fulton's floating battery.[1] But the navy's first two steamers were built to meet an additional need which had only recently arisen: colonial service.

Colonial Steamers: Senegal

The colonies that France recovered in 1815 were but a pathetic remnant of the empire that she had won and lost in the preceding three centuries. They consisted of a few islands in the Caribbean, North Atlantic and Indian Ocean, a stretch of jungle on the northern coast of South America (French Guiana), a trading post on the west coast of Africa (Senegal) and scattered small trading posts in India. Despite the insignificance of these colonies, the French did not hesitate to reoccupy them after the war, and throughout the Restoration the ministry of marine and colonies regularly reminded the king and Parliament of their importance. The ministry argued that only the colonies could offer France markets that would always be open to French trade and that would be regulated by French commercial laws, thus freeing French commerce from the hazards that beset it everywhere else: political instability which could at any time close foreign markets, fluctuations in the commercial and tariff policies of foreign governments, and competition from foreign traders, especially the British. They also contributed to French national strength, encouraging through guaranteed markets the development of French industry and a strong merchant marine,

[1] Gilbert, Essai, pp. 22, 41-44.

while freeing France from the tribute paid to foreigners for tropical goods which could be grown in the colonies. Finally, as distant outposts which were an integral part of the French kingdom, they were an important political and military link between France and the world outside Europe. They provided ports of call and safe havens for French merchant shipping, and bases of operations (points d'appui) for French warships. In short, the colonies were "advanced posts for French military, agricultural, commercial and political interests, which extend and strengthen the chain of relations between France and the rest of the world."[1]

France faced, however, serious problems in reestablishing her colonies, among which perhaps the most severe were lack of money and lack of manpower. If metropolitan France had been impoverished by the last years of the war, the colonial economies had been utterly ruined by the blockade and the British occupation. Frenchmen showed little interest in migrating to the colonies, and the peace settlement of 1815, in endorsing the abolition of the slave trade, threatened the main labor supply of the colonies, negro slaves. When the Restoration government drew up its postwar plans for the colonies, it placed first on the list economic development, primarily through the cultivation of tropical crops needed in France, in order to help both the

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[1] Budget, 1820, p. 60; Budget, 1822, pp. 40-41; Budget, 1823, p. 25; Budget, 1826, pp. 29-30; Budget, 1827, pp. 58-59; Budget, 1828, p. 80; Budget, 1829, p. 83.

colonists and the metropolitan budget. To make up for the lack of manpower, they called on science to help identify and develop profitable crops, and on technology to help cultivate and process them. Tropical plants were collected and studied in botanical gardens in nearly all of the colonies, while labor-saving devices such as plows, cotton gins, and steam engines for processing sugar and cutting wood, were sent out to the colonists on generous payment terms, with the intention that they would be used as prototypes and serve as models for locally produced copies. The government encouraged the invention of new machinery in France through the _Société d'encouragement pour l'industrie nationale_ and in the colonies through the award of gold medals to planters, and in addition it bought and sent out British machinery that looked promising.[1]

It did not take long to recognize that steam navigation could be of great use in the colonies, where communication across great distances was a major problem. Experience in Europe and especially on the Mississippi River in the United States showed that steam could open up rivers that were difficult to navigate under sail, and that it could also provide communications between isolated posts on a long coastline (such as in French Guiana, where the winds were unfavorable for sailing craft), as well as locally within a harbor. Admittedly, there were special problems in getting steamers out to the colonies

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[1] _Budget, 1820_, p. 64; _Budget, 1822_, pp. 45-47; _Budget, 1824_, p. 33; _Budget, 1825_, p. 36; _Budget, 1827_, pp. 56-57.

and supporting them there, but special needs for steamers soon arose that made these problems seem insignificant.

The first call for steamers came as part of the most ambitious colonial effort of the Restoration: the reoccupation of Senegal. In the old French empire of the eighteenth century, Senegal had been a relatively insignificant colony, useful only as a base for procuring slaves and gum from the interior of Africa. It was dealt a severe blow when one of its two occupations, the slave trade, was outlawed in 1815, but the 1815 settlement also left it as one of only two French colonies with any territorial expanse, and it became the focus of the effort of the Restoration government to develop the empire as a source of supply for colonial crops.[1] In 1816 an expedition was sent out under Colonel Julien-Désiré Schmaltz to retake possession of Senegal from the British, who had captured it during the war. His instructions, dated 18 May 1816, also ordered him to report on the possibility of cultivating colonial crops in Senegal by means of free labor, and to indicate the means necessary to set up such a system.[2] He was delayed by the shipwreck of his flagship, _Méduse_, but duly assumed control of the colony and submitted

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[1] Eugène Saulnier, _Une compagnie à privilège au XIXe siècle: La Compagnie de Galam au Sénégal_ (Paris, 1921), pp. 17-19.

[2] Minister of Marine (hereafter Minister) to Schmaltz, 31 December 1818, A.C., Sénégal I-6; C. Schefer, comp., _Instructions générales données de 1763 a 1870 aux gouverneurs et ordonnateurs des établissements français en Afrique occidentale_, 2 vols. (Paris, 1921-27), 1:227-312.

his report on 8 July 1817, following which he was recalled to Paris to explain his plan and help prepare its execution. The "political and moral" aim of his plan as accepted was "gradually to introduce among the blacks of Senegal a civilization based on Voluntary Work, on crops more productive than those that the natives are presently cultivating, on education, and on the maintenance of peace in the region." The system would be made to work by creating among the natives "new needs and desires" for French goods hitherto unknown to them (encouraging them to grow the crops that the French wanted and opening new markets for France) and in part by the presence of 700 Europeans in three posts along the river, plus 500 at Gorée and Saint Louis on the coast, which would overawe the pacified natives and protect them against their marauding Moorish neighbors. Fast, reliable communications on the river between these posts was essential to the security of the project, and to guarantee these communications Schmaltz proposed using two steamers.[1] The government approved his project on 18 May 1818, including the dispatch before the end of the year of two expeditions to Senegal, and it immediately began procuring a long list of equipment, including the steamers.[2]

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[1]Minister to Schmaltz, 31 December 1818, A.C., Sénégal I-6.

[2]Ibid.; Minister to Schmaltz, 25 May 1818, A.C., Sénégal I-5; Saulnier, Compagnie du Galam, p. 20.

The first of the expeditions sailed from Lorient on 7 July 1818. It was only a small exploratory one, consisting of the navy brig Argus, whose function was to ascend the Senegal River and reestablish a French presence at the proposed advance post at Bakel in Galam. She was to stay there for a year, gathering information on the area and preparing a base for larger expeditions to follow. The brig began her trip upriver on 17 August, accompanied by two ships of the colonial government, which was anxious to forestall the British who were active in the area, and a trading vessel from Saint Louis, which was to reopen what in the previous century had been a prosperous trade between the upper part of the river and the coast.[1]

Meanwhile in France lack of funds forced the postponement from October 1818 to early 1819 of part of the main expedition, with the men and supplies for the two settlements downriver from Galam. Schmaltz was also informed that the steamers would not be ready to participate in the initial establishment of the two posts, and his logistics plan as revised on 14 September included two old hulks, fitted with artillery and strong bulwarks, which would protect the posts until the steamers arrived.[2] The main expedition finally arrived in Senegal in

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[1] A.N., Marine BB4-404; Minister to Schmaltz, 31 December 1818, A.C., Sénégal I-6; Saulnier, Compagnie du Galam, pp. 23, 29, 43; Paul Marty, "L'établissement des français dans le Haut Sénégal, 1817-1822," Revue de l'histoire des colonies françaises 13 (1925):63-68.

[2] Schmaltz to Director of Colonies, 9 August 1818, and Minister to Schmaltz, 22 September 1818, A.C., Sénégal I-5.

April 1819 with Schmaltz, 600 men, and supplies for the river posts. It was hoped that the steamers would follow in time for the relief trip to Galam, scheduled for June.

The importance of the steamers was underscored by the fate of the Argus expedition. Short on supplies and unsure of the friendship of the natives, it was hanging on precariously at Galam under the command of two very junior officers, having lost both its commander and its geographer to disease. Schmaltz attributed these losses principally to the fact that the ship had taken no less than seventy-four days to ascend the river. This made him appreciate more than ever "how indispensable the steamers are for the forthcoming expedition. Their shallow draft will permit sending them on the first flood crest of the river. The state of affairs at Galam . . . makes me regard it as most important to send them from Saint Louis during the first days of July."[1]

But Schmaltz was destined for repeated disappointments regarding his steamers. On 2 June he acknowledged receipt of a letter dated 20 April from the Ministry stating that they would not arrive before 20 August or be ready for use before the end of September. "It would be difficult under present circumstances," he wrote, "to hear news more likely to upset our plans. After having made the treaties that remove all obstacle to the execution of the plan of colonization, it is urgent that we act

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[1]Schmaltz to Minister, 10 April 1819, A.C. Sénégal I-6.

without losing time to consolidate the establishment at Galam and to complete this initial effort with an expedition capable of giving the people along the river a true idea of our strength. This delay upsets all my calculations . . . here I am, stopped for lack of my primary means of execution."[1] Schmaltz faced a dilemma: it was out of the question to abandon Galam, but he could not bring himself to send a large garrison up by conventional means, fearing the effects on the enterprise, both in the colony and in France, of a long transit under sail and the mortality that might result from it. Hence he decided to send only one ship with a few men and the most indispensable supplies, and count on the promises of the minister to deliver the steamers in time for them to make the trip before low water made the river impassable towards the end of the year.

He was not happy with this solution, however, and shortly before the relief vessel sailed at the end of July, he wrote to the minister again deploring the absence of the steamers. "I was counting on them, and their sudden appearance on the river would have spared us many half measures. The trip would have been made by them with Promptitude and Safety, and I find myself obliged to send a colonial ship which is far from offering me the same guarantees. . . ."[2]

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[1]Ibid.

[2]Schmaltz to Minister, 10 July 1819, A.C., Sénégal I-6.

But September arrived, and instead of bringing the steamers it brought another letter from the ministry saying that the first steamer would not arrive before mid, and perhaps late October. Schmaltz now found himself in serious trouble, for the relief expedition could no longer be delayed--in fact it soon developed that he had not left enough time to send it to Galam in sailing craft. The expedition was hastily formed and left St. Louis on 18 September, but was turned back short of its destination by low water and went into winter quarters on 19 November at one of the posts on the lower river, Dagana. Schmaltz again complained of the lack of the steamers, which would have permitted him to spare the Galam relief force the hazards of a long and difficult trip in small vessels devoid of any conveniences. In addition, he felt that their mere appearance on the river would have made an impression on the natives sufficient to eliminate the need to negotiate with riverine tribes for the passage of the relief expedition, and to prevent the incursions against riverine allies of the French by their Moorish neighbors. At least they would have permitted a more prompt response to these attacks.[1]

By this time Paris was fed up with Schmaltz's complaints about the steamers. The minister wrote him in December, "You have complained bitterly and repeatedly about the delay in the

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[1] Schmaltz to Minister, 4 September 1819, A.C., Sénégal I-6; Saulnier, Compagnie du Galam, p. 45; Marty, "Haut Sénégal," pp. 94-97.

arrival of the steamers that you were to have received before the end of June 1819. My regrets in this matter preceded yours--it was a question of the first ships of this type to be built in France for such a purpose. We were unable to avoid much groping about, and despite the continual efforts of my department to obtain a better result, only one of the two ships was able to depart on 16 October last--the other will only be able to sail in several days."[1]

The problems faced by the Navy in producing the ships were truly monumental, for they were among the first to be built in France, being preceded only by those of Jouffroy, Church and Pajol; and were very likely the first successful ones entirely built (hull and engines) in France. They were certainly the first to be built by or for the government, which was careful to search out the best talent in France for the project. It secured the services of Pajol's chief engineer, Clement-Marie Lebreton, a former officer in the naval constructors' corps who had taken his post with Pajol with the approval of the Navy after being prematurely put on the retired list by the Restoration government and who, following Pajol's financial collapse, sought reintegration into the navy.[2] He was ordered to design the hulls for the two steamers, which were ordered on 31 August 1818 to be built at the navy yard at Lorient. For

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[1] Minister to Schmaltz, 20 December 1819, A.C., Sénégal I-6.

[2] Busson, "Débuts," p. 36.

the engines, the navy went to the French company with the most experience, the Périer firm at Chaillot. This factory had been inactive during the last years of the war, but was bought in February 1818 by Antoine Scipion Périer (no relation to the founder, J.-C. Périer) and put under the direction of Humphrey Edwards, an English engineer. The Navy contracted with Périer on 8 September 1818 for an engine of 32 horsepower for each ship, at a total cost of 67,500 francs.[1]

The hulls were launched on 8 and 24 February 1819, were named respectively Africain and Voyageur, and were ready except for their engines in June (Voyageur) and July 1819, already well behind schedule. At least one set of engines arrived at Lorient in July in the navy transport Pourvoyeur, and Voyageur was rushed to completion: she was commissioned on 10 July, left the dockyard on 22 August, and ran her definitive machinery trials in Lorient harbor on 23 September with satisfactory results.[2] She sailed for Senegal under the command of Lieutenant Auguste Louvrier and escorted by brig Silène on 16 October and arrived in Senegal on 1 November. She did not use her engine during the passage--instead her paddle wheels were stowed on deck and she made the trip under sail.[3] Africain

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[1] Busson, "Débuts," p. 36; Payen, Périer, pp. 23, 40, 225-227; note by Inspecteur Général du Génie Maritime (hereafter cited as Insp. Génie), 28 August 1824, A.C., Sénégal XVI-43.

[2] Gilbert, Essai, p. 57; A.N., Marine BB5-13.

[3] Insp. Génie note of 15 October 1823, A.C., Sénégal XVI-43.

was only taken in hand after *Voyageur* was completed: she began to receive her engines on 26 September, was commissioned on 1 January 1820 and ran trials on 24 January. She sailed for Senegal on 1 March but was turned back by bad weather, and finally arrived in Senegal on 12 May, eleven months after Schmaltz had wanted her.

The dates show how limited was the navy's ability to build steamers at this time. The initial problem was probably late delivery of the engines from Périer: small hulls like these could have been ready for their engines within a few weeks of launch if the engines had been on hand. The delay to *Africain* indicates that either Périer could only build one set of engines at a time, or that Lebreton and the navy engineers at Lorient could only install and adjust one at a time. Even so the achievement was substantial--the ships' machinery functioned well on their arrival in the colony, and the future was to show that meeting construction schedules when new technology was involved was a very difficult undertaking.

Schmaltz was delighted finally to get *Voyageur*. He wrote to the ministry three days after her arrival that she had suffered some damage during the trip out, but that he hoped that it would prove to be minor and that she would soon be ready to render important services.[1] He at once put the ship to work

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[1] Schmaltz to Minister, 3 November 1819, A.C., Sénégal I-6.

carrying supplies to the relief force at Dagana, where a caravan was being readied to carry the material the rest of the way to Galam since the river was now too low for the steamer. Schmaltz wrote from Dagana on 3 December that "the steamer Voyageur, which has succeeded completely, arrived in spite of continuously adverse currents and winds in fifty-two hours from Saint Louis to Dagana. . . . The success of this vessel made me feel more deeply than ever how valuable the two steamers that I requested would have been if it had been possible to get them to me in time."[1] Time was now working against Schmaltz, for as early as May 1819 he had signed treaties with some tribes on the right bank of the river, and he was now being inexorably drawn into the endemic warfare between these tribes and the Moorish tribes on the left bank. By February 1820 the latter had succeeded in forming a coalition against the French and their allies, blocking the land route to Galam and forcing Schmaltz to take drastic action. He used Voyageur first to carry him to Podor for a last effort at negotiations, and then sent her back to Saint Louis to raise relief forces for Dagana and get them there before the enemy could mount an attack. This she did despite being slowed down by contrary winds. He then sent her on a diversionary raid which he hoped would draw the enemy away from Dagana and force them to return to their own territory. Two

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[1] Schmaltz to Director of Colonies, 3 December 1819, A.C., Sénégal I-6.

shell guns were added to her armament, and her commander, Lieutenant Louvrier, then took her upriver beyond Podor and bombarded two villages which contained many of the enemy chiefs, part of their army and all their supplies. The raid had the desired effect of sowing panic among the native forces, which burned the villages and retired into the interior, ending the immediate threat to the French posts.

Unfortunately for Schmaltz, Voyageur's raid also alarmed the government in Paris, for it revealed beyond any doubt that force would be needed to establish and maintain the colony in the form planned by Schmaltz.[1] Paris had begun to have doubts as early as mid-1819 when Schmaltz proposed some major changes to his plan, involving extensive French settlement in the interior, and reported his first treaties with the natives. The government reminded him that the original plan had relied on nothing more formal than friendly persuasion and the workings of a cash economy to establish French influence, while Schmaltz now seemed to be moving in the direction of formal political agreements, which would inevitably lead to wars and the imposition of French domination by force. Parliament and the government were both upset over the moral and financial implications of such a policy, fearing that "we would apply to Senegal the system followed by the English in India,"[2] and they cut Schmaltz's

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[1] "Rapport au Conseil des Ministres," May 1820, A.C., Sénégal I-6.

[2] Minister to Schmaltz, 13 September 1819, A.C., Sénégal I-6.

budget, denied his request for additional troops, and enjoined him to rely for his safety on the friendship of the natives, the 500 to 600 Europeans already in Senegal, the two steamers, and the existing posts at Galam and Dagana.[1] They also sent out an investigative commission which arrived in the colony three days after Voyageur and rode up to Dagana in her.[2] Events thereafter, climaxed by Voyageur's raid, appeared to have confirmed the government's worst fears, and in July 1820 Schmaltz was recalled. This was the end of French efforts during the Restoration to extend their control in Senegal: for the remainder of the decade they made extensive efforts to grow tropical crops in the areas already held, but even these efforts were ended by the July Monarchy in 1830, reducing the colony once again to its former status as a simple trading post.

The end of Schmaltz's plan, however, did not mean the end for steamers in Senegal, for, once introduced, they had been found to be indispensable. Sail simply could not provide the regularity of communications along the river or the protection for traders (who in 1820 set up a private company for trade with Galam) that the steamers gave. Africain's captain reported in 1822 that even the temporary suppression of the steamers on the river would have serious consequences:

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[1] Ibid.; Minister to Schmaltz, 18 May 1820, A.C., Sénégal I-6.

[2] Marty, "Haut Sénégal," p. 98.

> We have found that these ships inspire terror among the natives, who are today convinced that their attacks on them are useless. Also, the trip [to Galam], which no longer encounters any obstacles, will certainly suffer delay and perhaps losses if it is tried next year without this escort. Moreover these trips, which no longer arouse much concern among those designated to relieve the post at Bakel, will become as fearful as they were before the arrival of the steamers because everyone knows today that the safety of Europeans depends on the speed of the trip.[1]

For the rest of the century there would always be at least one government steamer in the colony, while efforts would be made to have at least two.

However this intensive use of the new technology brought with it some problems. The colonial government soon began to notice that every time it sent *Africain* or *Voyageur* out, they were a little slower than before in spite of all the efforts of their commanders to force more speed out of them. In addition, mechanical breakdowns became more frequent, forcing the ships to proceed under sail or tie up to trees on the river bank until repairs could be made. In October 1822 the captain of *Africain* reported that his boilers were in such bad shape that they would have to be replaced before the ship could make another trip to Galam, and the colony estimated that *Voyageur* could only make one more trip before her boilers too gave out.

Other problems also came to light regarding the ships themselves. Their hulls were essentially conventional sailing

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[1] Commanding Officer *Africain* to Governor Senegal, 25 October 1822, and Director of Colonies to Minister of Marine, 8 March 1823, A.C., Sénégal XVI-43.

brig hulls, and their commanders complained that these were not suited for use on the river: they were too heavy for their engines, and their high sides caused loss of both speed and maneuverability due to wind resistance. In addition their accommodations were not suited for the tropics due to inadequate ventilation. Finally, Voyageur's hull had warped, causing her paddle wheels and parts of her machinery to rub against the hull timbers.[1]

These two problems, maintenance of the machinery and design of the ships for the specific needs of the colonies, were the main ones faced as successive generations of steamers were sent out to Senegal. The ministry was quick to find in the reports on Africain and Voyageur the reason for their machinery problems: their boiler furnaces had not been cleaned since the ships had left France, and a thick layer of soot had become baked on the metal surfaces, blocking the transfer of heat to the water and weakening the boilers. Poor operating practices compounded the problem. At first, when the ships had been running well, their machinery had been operated by the builder of the ships, Lebreton, but since then the efforts of the ships' captains to increase speed by burning more fuel and forcing the machinery had simply accelerated its deterioration.[2] Thereafter

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[1]Commandant Senegal Flotilla to Governor Senegal, 30 September 1823, A.C., Sénégal XVI-43.

[2]Insp. Génie note, 17 February 1823, A.C., Sénégal XVI-43.

the navy tried, often with considerable difficulty, to see to it that a qualified engineer was always on duty with the ships in Senegal to operate and maintain the machinery.

The problems in designing the ships were also not easily overcome. The colony and the ministry agreed that new boilers should be sent out for _Africain_, so as to have at least one steamer again available in a short time.[1] As for _Voyageur_, it was agreed that she should be sent back to France and a smaller ship built to replace her incorporating lessons learned with the first two ships. However there was disagreement on the characteristics of the replacement. The colony asked for a small, fast river steamer like those in use on the Gironde, claiming that it would cost no more than a new set of boilers for _Voyageur_. The ministry responded that the problem could not be answered so easily: ships like those in commercial use in France cost three times as much as the colony thought, and would be useless in Senegal as they carried only a one day supply of coal and no cargo.[2] The ship would have to be specially designed and built for colonial use, and on 18 October 1824 the minister directed the naval constructor Jean-Baptiste Marestier,

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[1]Director of Colonies to Minister, 8 March 1823 and 25 March 1823, A.C., Sénégal XVI-43.

[2]Commandant Senegal Flotilla to Governor Senegal, 30 September 1823; Director of Colonies to Minister, 31 October and 11 December 1823; Insp. Génie notes of 15 October and 15 November 1823; A.C., Sénégal XVI-43. _Voyageur_ was in fact kept in the colony and only her machinery was sent back to France.

who was already building three steamers for the navy, to build a reduced edition of these for Senegal. Marestier was unable to provide adequate coal capacity without exceeding the maximum length allowed by the colony, and the ship that resulted, Serpent, was necessarily a compromise between the need of colonial steamers for maneuverability and endurance. This problem was only eliminated in the 1840's with the introduction of iron hulls, which finally made fully satisfactory colonial steamers technologically feasible.

Colonial Steamers: French Guiana

Even with these limitations, the early steamers had important advantages, and other French colonies soon discovered a need for them. Postwar plans also called for developing the only other French colony with significant land area, French Guiana. Here the main problem was the climate and the lack of an indigenous population that could be put to work on plantations, and the development plans therefore concentrated on attracting immigrants from all parts of the world, including India, the United States and France, and establishing them in settlements in the highlands where it was hoped that the climate would permit them to survive.[1] New technology was used wherever possible here as in Senegal and the other colonies, and the original allocation of funds in the 1820 budget for the development of Guiana included a steam engine for the processing of sugar and "purchase and maintenance of a steamer." In allocating the

[1] Budget, 1820, pp. 53, 57; Budget, 1821, p. 31.

funds the ministry noted that steam navigation "would be extremely useful there, not only for ascending the rivers more easily, but also for communications along the seacoast, where the currents are always contrary for ships traveling from north to south, and where the winds are also contrary for them during the greater part of the year. The model steamer which would be sent to the colony would be used advantageously there by the government, would provide services for private individuals, and would offer an example which the latter would proceed to imitate on their own account," by investing in additional steamers.[1] The main problems were the price tag (190,000 francs out of a total of 500,000 for the year) and the fact that the government had no well-defined settlement plan for Guiana as it did for Senegal. The result was that the funds were reallocated during the year, and the steamer was dropped in December 1820 despite the fact that its estimated cost had fallen to 120,000 francs. Instead the governor of Guiana was invited to raise funds for the ship by public subscription or to encourage formation of a private company to build and operate it.[2]

In sending this advice the government based its hopes on what was happening in Martinique. There an American,

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[1] "Apperçu [sic] de l'emploi d'une somme de 500,000 francs demandée aux Chambres pour service colonial extraordinaire de la Guyane française, Exercise 1820," undated, A.C., Guyane F1-09; Budget, 1820, p. 53.

[2] Report dated 14 December 1820, and Minister of Marine to Governor Guiana, 3 February 1821, A.C., Guyane F1-09.

W. Macomb, had approached the governor and proposed building a steamer (which would be named for the governor, Comte Donzelot) for use between two ports on the west coast of the island, St. Pierre and Fort Royal. He claimed to have directed a similar operation earlier at Trinidad. Donzelot agreed on 6 March 1820, and Macomb came to France to procure the ship. The Ministry of Marine became involved because the project called for the colony advancing funds from its account in Paris to build the ship, which Macomb's company would later repay in the colony. The ministry approved these arrangements on 30 June 1820 on Donzelot's recommendation, with the provision that the steam engine used be built in France.[1] On 24 July Macomb contracted with Humphrey Edwards, director of the Scipion Périer works at Chaillot, for a steam engine of 20 horsepower, and on 28 September he contracted with the Bordeaux shipbuilder Coureau, builder of the two best steamers then in France (Triton and Henri IV) for a hull measuring 30 by 6 meters.[2] The engine was to have been ready in December 1820, but the ship only ran trials in October 1821 and failed miserably, being barely able to move against the current in the river. Macomb wrote that he was astonished by the failure, as Edwards had by then built about sixty engines, but felt that

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[1] Macomb to Minister, 28 July 1820 and 9 December 1820; Director of Colonies to Minister, 31 July 1820 and 29 October 1822; A.C., Martinique 143-1284.

[2] Macomb to Minister, 28 July 1820; Macomb to Director of Colonies, 19 and 29 September 1820; Director of Colonies to Minister, 31 July and 11 October 1820; A.C., Martinique 143-1284.

perhaps the difficulty was due to the fact that these were the first engines he had built for a ship.[1] (Edwards had, of course, built the engines for _Africain_ and _Voyageur_, but had not been responsible for their installation.) Edwards worked on the engines and paddle wheels all winter, and in April 1822 crowned his efforts with wholly successful trials. The paddle wheels were then dismounted and stowed on deck, and on 25 May 1822 the ship left under sail for Martinique.

However success soon turned again into failure, for when the ship arrived in Martinique on 7 July, Macomb's company declared that it had no funds to operate her and abandoned her to the colonial government.[2] Macomb, who French observers said was a very poor businessman, had run up costs of almost 233,000 francs for the ship against an estimated cost of 109,000 and capital raised by subscription in the colony of only 89,000 francs.[3] The colony had to take over and run the ship in an effort to get its money back, and in a period from March 1823 to July 1825 the ship earned only 39,622 francs against total costs to that point of 430,260 francs.[4] Oblivious to the

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[1] Macomb to Minister, 4 October 1821, A.C., Martinique 143-1284.

[2] Commandant Général de la Marine, Bordeaux, to Minister, 9 April, 25 May and 5 September 1822, A.C., Martinique 143-1284.

[3] Commandant Général de la Marine, Bordeaux, to Minister, 25 May 1822; Director of Colonies to Minister, 29 October 1822; A.C., Martinique, 143-1284.

[4] Account dated 25 November 1825, A.C., Martinique 143-1284.

magnitude of the fiasco, Macomb wrote in September 1822 that "by the grace of God I will have founded within a year from today another company for Guadeloupe for coastal navigation--this type of ship will be very useful there."[1] There is no evidence that he or anyone else did so, and for its part the Navy made no effort to have a steamer in the French Antilles before the 1840's.

Although she caused a financial catastrophe, Comte Donzelot marked another important step in the development of steam navigation in France. The Navy representative in Bordeaux reported that the six steamers then in service in the Garonne all had engines built in Britain, and it is probable that the other early French steamers, except possibly the unsuccessful ones of Jouffroy and Pajol, did too. If so, this would make Comte Donzelot the first steamer produced entirely French industry (Africain and Voyageur were produced in part by the government). The navy's stipulation that the engine be built in France and its rapid acceptance of Donzelot's and Macomb's rather unorthodox financial arrangements indicate that the government fully appreciated the importance of the step to be taken. The navy's representative at Bordeaux, in reporting on the successful trials of the ship (in which her engines functioned well while burning half as much fuel as the British engines) congratulated France on her achievement:

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[1] Macomb to Minister, 19 September 1822, A.C., Martinique 143-1284.

> I saw, as a good Frenchman, the success of the steam engine from the Chaillot foundry. . . . [We] can hold our own with the English, which should be an inestimable resource if good relations cease to exist between France and England, for we will never be able to make a descent on England except by the use of steamers. Commercial shippers get all their engines from England, because they cost a third less--it is important to stop this importation by doubling the tariff duties. . . .[1]

The difficulty with the steamer for Martinique had little effect on the situation in French Guiana, besides discouraging hopes for private funding, because key colonization plans drawn up in 1820 and 1821 all called for one or more steamers. A proposal drawn up in July 1820 noted that settlers arriving at the mouths of the three main rivers in Guiana would have no way of getting upriver to the highlands, and called for the provision of large steamboats like those on the Mississippi to carry them and their supplies.[2] Plans for settlement in Guiana began to take more specific form in late 1820 when a commission was sent from France to examine the possible sites for a settlement. It reported in favor of concentrating on an effort to settle French farmers on the Mana river.[3] The Mana

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[1] Commandant Général de la Marine, Bordeaux to Minister, 9 April 1822, A.C., Martinique 143-1284.

[2] Memorandum by Catineau-Laroche, 5 July 1820, A.C., Guyane F5-01.

[3] Budget, 1822, p. 37; Budget, 1823, p. 29; Michel Lohier, Mana, début de la colonisation, ses échecs, oeuvre émancipatrice de la Mère Javouhey, supérieure de la congrégation des Soeurs de Saint-Joseph de Cluny (Clamency, 1969), pp. 13-18, 66-67.

was at the far western edge of the colony while Cayenne, the capital, was in the east, making it all the more necessary to overcome the problem of communications along the coast. Two steamers were included in the plan for the settlement of the Mana, one for use on the coast and the other in the river, while the commander of the brig that had carried the expedition pointed out in his report that a steamer could make a major contribution to the economy of the new settlement by carrying its products to market quickly and more efficiently than present means allowed.[1] In December 1821 a royal commission approved the project of settling Europeans on the Mana, and the first of several expeditions was sent out in 1822.

At the same time, the decision was finally made to procure a steamer for the colony. In May 1821 the governor of French Guiana had included a steamer, whose estimated cost was now 80,000 francs, in his request for the distribution of the 500,000 franc special credit allocated to the colony for 1821; but the ministry informed him that it had already made other plans for the money and promised to reconsider the request the following year.[2] On 22 October 1822 the minister ordered that a "steam schooner" of 50 horsepower be built at Rouen under the

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[1] Memorandum by Catineau-Laroche, 26 July 1821, A.C., Guyane F5-01; Commanding Officer Isère to Minister of Marine, 9 March 1822, A.N., Marine BB4-432.

[2] Governor, French Guiana to Minister, 7 May 1821, and Director of Colonies to Minister, 27 August 1821, A.C., Guyane F1-09.

supervision of the naval constructor Jean-Baptiste Marestier (who a few days previously had been ordered to build two other steamers there), with the stated purpose of providing communications between Mana and Cayenne.[1] The ship, originally named _Galibi_ but soon renamed _Caroline_, sailed from France in 1824 under the command of Lieutenant Louvrier, who had also been the first commander of _Voyageur_, carrying as passengers three families from the Jura who were to settle near the mouth of the Mana. The three families asked to come home in 1828 and had to be replaced with other settlers, but the steamer became a permanent part of the colony, performing the trip between Mana and Cayenne in forty-eight hours, while sailing ships needed ten and sometimes fifteen days.[2] It became official policy to have a steamer available in French Guiana at all times, though when _Caroline_ (renamed _Louise_ in 1828) was taken out of service in 1833 the colony had to wait until 1837 for the arrival of her replacement.

Steam Tugs for the Navy

So far, none of the steamers built by the navy had been intended for its own use: all were for use in the colonies and were charged against the colonial budget. However from an early date the navy was intrigued by reports and claims regarding the

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[1] Minister of Marine to Governor, French Guiana, 1 December 1822, A.C., Guyane A11-03; A.N., Marine BB5-13; H. P. Spratt, "Le premier vapeur transatlantique de la France," _Revue trimestrielle canadienne_, no. 144 (1950-51), pp. 409-11.

[2] Governor, French Guiana to Minister, 14 July 1830, A.C., Guyane P1-2.

military potential of steam, and made a deliberate effort to collect accurate information on it. Perhaps the first contribution was made by Charles Dupin, who beginning in 1816 made a number of trips to England to study the innovations made there in naval organization and materiel during the wars. His enthusiasm for many of the British innovations brought upon him the displeasure of the Restoration government, but his detailed technical descriptions and his faith that France could imitate and surpass everything done in England aroused widespread interest in the navy. Among the many things that he described were the steamers then in service in the northern part of the country, although he and others felt that the information he collected on new British designs for battleships and large frigates was far more important.[1] However this initial information on steamers aroused the desire for more, as did the navy's involvement beginning in 1818 with the production of steamers for the colonies. In 1819 the minister of marine, Portal, probably at the suggestion of the head of the naval constructors' corps, sent out two officers, one a naval officer already interested in steam and the other a naval constructor, with the primary mission of collecting as much new information about steam navigation as possible. Both men were sent to the United

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[1] Baron J.-M. Tupinier, "Rapport sur le matériel de la marine," Ann. Mar., no. 67 (1838), p. 197; Jones, Voyageurs, pp. 140-145; Dupin's statement of service dated 31 July 1821, A.M., Marine CC7-779; Ann. Mar., no. 4 (1816), p. 399; Ann. Mar., no. 8 (1818), p. 732.

States, where Fulton had had his great success and where steam navigation was spreading even more rapidly than in England.

The first mission was entrusted to Lieutenant Jacques-Philippe Mérigon de Montgéry, who on 27 July 1819 received orders to take command of transport Prudente, escort Voyageur to Senegal, and then proceed to the United States to study steam navigation there. Montgéry was actively interested in many technological innovations, and published in the early 1820's pamphlets on artillery, floating mines, Congreve rockets, iron ships and submarine warfare. Portal noted in his orders to Montgéry that the latter had been searching for a long time for ways to apply steam engines to "floating machines suitable for defending our ports against attacks by an enemy superior in strength, or even for carrying destruction into the interior of his maritime establishments." He was given the specific mission of studying American warships "propelled by water reduced to steam," and was

> . . . particularly to examine what use the Americans have been able to make of the steam engine, in floating batteries for the defense of their ports, for ships used for carrying merchandise, or even for war. The general layout of their "steam-boats," their equipment and how they are maneuvered are the main objects upon which it is most important for you to concentrate your attention, so as to determine from what point we will have to start if it is found advisable to introduce ships of the same type in the system of French naval forces.

That he felt this was far from being inevitable was shown by his reference to steam propulsion as "a process whose power

necessarily has limits beyond which its application presents only dangers without probability of success."[1]

While Montgéry was to concentrate on the aspects of steamers that concerned practical naval officers, such as their nautical qualities and potential military use, the other mission was intended to provide the technical information that would be needed by naval constructors in designing and building steamers. Ultimately it proved to be the more important of the two, and its report was and remains a classic on early steam navigation. The naval constructor chosen to carry it out was Jean-Baptiste Marestier, selected due to the "extent of his theoretical and practical knowledge in the art of naval construction," not, apparently, for any special knowledge of steamers. Portal cautiously explained to him, in orders dated 19 June 1819, the reasons for the mission:

> The Americans are, up to now, among maritime peoples, the ones who have made the most use of steam engines for propelling floating objects. That which we know of their constructions of this type leads us to suppose that they only arrived at these results after many trials; and if it were found useful for France to imitate them it would be very advantageous to benefit from their experience, so as not to repeat the same mistakes.
>
> Without making any judgment yet on the greater or lesser influence that the introduction of these mechanical means on board warships may some day have on European navies, it is essential that France not remain any longer in ignorance of the progress that this branch of naval architecture may have made in other nations.

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[1] Baronne de Gervain, Un ministre de la marine et son ministère sous la Restauration: Le baron Portal (Paris, 1898), pp. 133-136.

> I have therefore decided that an officer of the naval constructors' corps is to be sent to the United States, to examine there the methods used by the Americans in the equipping and maneuvering of their "steam-boats" and to bring back information on these ships more exact than the descriptions which have been published in France for the past several years.[1]

He instructed Marestier to contact the American minister in Washington, who was to arrange for him to visit the ports where there were steamers.

> You should concentrate particularly on how these ships are equipped and on the various ways in which motion is imparted to them by means of water reduced to steam, and try to get the most precise possible information on these matters. Above all you should see what factors the Americans use to determine the dimensions of their steam engines relative to the different uses to which the ships which receive them are put, and you should determine if they have been able to establish an exact relationship between the effect to be produced and the force necessary to obtain it.
>
> It would be most desirable if you could procure with some precision a detailed description of these ships, of their various functions: attack, defense, or even merely the transport of passengers and merchandise at sea or on rivers. If you can examine them in enough detail to analyse their capabilities, you will be able to form for yourself a precise opinion on what one can expect some day from this type of ship in commercial use and in war.[2]

Marestier was also ordered to keep his mission strictly secret, whether from fear of antagonizing the Americans or arousing the suspicion of the English is not stated. On his return to France he was to incorporate the material he had gathered into a report to the minister.

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[1]Ibid., pp. 136-137. [2]Ibid., pp. 138-139.

The French minister to the United States reported on 1 September that Marestier had arrived, and that he anticipated that the only problem would be language: Marestier could read English but spoke only a few phrases, and would be given an interpreter. The French minister had already collected a considerable amount of information, and was certain that the Americans would hide nothing, as they had always been most open towards him and the French in general. On 31 August he and Marestier had visited Fulton's "steam frigate," and the port commander had been eager to show them all the machinery.[1] Marestier subsequently made this ship the subject of a special report, which was not published and appears to have been lost.

Marestier proceeded to visit a number of the ports on the east coast of the United States, and, while unable to visit the Mississippi River, also gathered information on the many steamers in use there. He returned to France to work on his report, which was published by order of the Minister of Marine in 1824. Meanwhile in 1822 Marestier had confirmed his reputation as one of the bright young men of the navy by marrying the daughter of the senior officer in his corps.

Marestier's report began with a review of the history of steam navigation. He pointed out that the main lesson of recent experience was that the early efforts had all failed because the

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[1]French Minister, Washington, to Minister of Marine, 1 September 1819, A.M., Marine CC7-1675.

power needed to propel a ship had been greatly underestimated: J.-C. Périer's experiment in 1775 had used an engine of one horsepower, while Fulton had needed twenty to succeed in 1807 and had later used even more.[1] He then used his data on American steamers to derive an equation showing the relationship between speed, horsepower, and the dimensions of the hull, which would permit him to calculate the horsepower for a ship if he were told what size it was to be and what speed was desired.[2] An additional equation permitted working out the proper dimensions of the paddle wheels. However much of the value of Marestier's report, both for his contemporaries and for historians, lay in his extensive descriptions of the steamers he saw, his trips in them, and his notes on details in their construction, which could be copied in building steamers in Europe. He also described some of their machinery, though his instructions did not call for extensive study of the engines themselves and he carefully avoided making his report a treatise on steam engineering.

Marestier and Montgéry returned from their missions in the middle of 1820, and shortly thereafter the French navy took

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[1] Jean-Baptiste Marestier, Mémoire sur les bateaux à vapeur des Etats-Unis d'Amérique (Paris, 1824), pp. 31-40, 52.

[2] Marestier, Bateaux à vapeur, pp. 56, 205-211. For the curious, he first divided horsepower by the resistance it had to overcome (the beam of the hull multiplied by its draft), then took the cube root of this quotient and multiplied it by an empirically-derived constant (1.94 for meters, 12.6 for feet) in order to get the predicted speed of the ship.

its first step towards acquiring a naval steamer. In his report on the budget for 1821, probably prepared around November 1820, the minister stated that it was proposed to allocate 180,000 francs for the construction of a steam floating battery, similar to the one owned by the Americans. A year later he reported that the navy had been unable to begin work on the ship in 1821 (she was to have been built at Rochefort), but that the budget for 1822 included 200,000 francs for her.[1] However, during 1822 the navy's steamer program changed course towards a more practical application of steam power. A floating battery would cost a lot of money without being of any practical use during peacetime, while the ports, particularly Rochefort, needed small steamers to act as tugs and assist sailing ships in and out of the difficult harbor approaches. Such ships would also be of some use in coast defense during wartime, while Montgéry indicated that the military value of Fulton's floating battery had been overestimated and that it had serious defects: even the Americans were now thinking in terms of more conventional steamers.[2] On 10 September 1822 the minister decided to build two small steamers for Rochefort, followed on 22 October by a similar ship for French Guiana; and shortly thereafter plans for the floating battery were dropped.[3]

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[1] _Budget, 1821_, p. 9; _Budget, 1822_, p. 18.

[2] _Ann. Mar._, no. 22 (1824), pp. 564-573.

[3] _Budget, 1823_, p. 12; Ports to Minister, 10 September 1822, A.M., Marine CC7-1675.

The problem of producing the ships was naturally given to Marestier. He was able to rely on the knowledge that he had acquired in America in designing the hulls of the ships and determining the size of the machinery, but that left half of the problem unresolved: how to produce the engines and boilers. It had been assumed from the beginning that the machinery would be built in France, but the French steam engine industry was still in a very primitive state. Only one French firm, Périer of Paris, was at all prominent, and it specialized in engines which operated with high-pressure steam (about three atmospheres) which Marestier felt were less reliable than the low-pressure engines of Watt's pattern which operated at about one atmosphere of pressure. However the period of 1821-1825 was one of rapid economic development in France, and one aspect of this development was the influx of English capital and entrepreneurs into the French metallurgical and mechanical industries. Perhaps the most prominent of these British entrepreneurs was Aaron Manby, who played a major role in the introduction of coal-burning forges in France for the production of iron, notably at Chatillon and at Creusot. He also introduced the first iron hulled steamer, named after himself, into France: the hull and the engine of this ship were made at Manby's factory at Birmingham, but later sisters were built by him in France, for use on his steamer line on the Seine. Finally he had long experience in building steam engines, and soon founded a large factory under the name of Manby and Wilson at Charenton to build them in France.

Other steam engine companies were established by Englishmen in France, of which the firm of Aitken and Steel at Ivry was but one.[1]

It was to these new English firms that Marestier turned for the engines for his ships. They were mostly located in the vicinity of Paris, and it was decided to build the hulls at Rouen so that Marestier, by traveling back and forth, could supervise the construction of both the hulls and the engines. Marestier decided that the two tugs each needed 80 horsepower, while the colonial ship would need only 50 horsepower. The ships were named respectively Coureur, Rapide and Caroline, and in December 1822 the machinery for Coureur and Caroline was ordered from Manby and Wilson while that for Rapide was ordered from Aitken and Steel. The hulls were ordered from private yards at Rouen. While he was building these ships Marestier was directed to build two more: a steamer for the Calais-Dover postal service (probably the Duc de Bordeaux of 50 horsepower, whose engine was ordered from Aitken and Steel), and the colonial steamer Serpent, whose 40-horsepower machinery was built by Manby and Wilson.[2]

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[1] Jean Vidalenc, "Quelques remarques sur le rôle des Anglais dans la révolution industrielle en France, particulièrement en Normandie, de 1750-1850," Annales de Normandie 8 (1958): 287; Gille, Sidérurgie française, pp. 84, 134-136. For a description of Manby and Wilson see Bulletin de la Société d'Encouragement pour l'Industrie Nationale 24 (1825):123-126; and for Aitken and Steel, ibid. 25 (1826):161-163.

[2] A.M., Marine 7DD1-13, and 7DD1-46; Spratt, "Premier Vapeur transatlantique," pp. 409-411; Director of Colonies to Minister, 18 October 1824 and 20 January 1825, and Insp. Génie to Minister, 15 October 1823, A.C., Sénégal XVI-43.

The first of Marestier's ships, Coureur, was placed in service on 1 March 1824 under the command of Lieutenant Louvrier, the former captain of Voyageur, who had conceived the project of taking her all the way to Rochefort under steam power instead of sail. During March Marestier put the ship through a careful series of trials, designed primarily to test her machinery and study the ship's consumption of fuel. Louvrier then took the ship from Rouen to Le Havre on 29 March, taking a merchant ship in tow on the way to show what his ship could do.[1] Coureur then proceeded to Brest, where she was thoroughly tested under the supervision of an official trials board. Her performance was in general very satisfactory, but it was noted that her boilers did not produce enough steam to drive the engine at full power, a design fault attributable to Manby and Wilson. (Later writers, writing after the next generation of steamers had entered service, also claimed that the relationship between horsepower and size of hull arrived at by Marestier had not turned out to be correct.)[2] The navy, however, was pleased with the results of the trials and gave Marestier an official commendation.

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[1] Busson, "Débuts," pp. 38-39; Conseil des Travaux, 8 April 1824, A.M., Marine BB8-1106 and 1110; Minister of Marine to Marestier, 13 April 1824, A.M., Marine CC7-1625.

[2] A.M., Marine 7DD1-13; A. Campaignac, De l'état actuel de la navigation par la vapeur et des améliorations dont les navires sont susceptibles (Paris, 1842), p. xiii.

After taking Coureur on to Rochefort, Louvrier hurried back to Rouen to put the second of the three steamers, Caroline, in service on 10 July 1824. Her trials appear to have been successful, and she sailed under Louvrier in late 1824 for French Guiana, making the first transatlantic crossing by a French navy steamer. The last of the three ships, Rapide, was less fortunate. Commissioned only on 1 January 1825, she broke down during her trip from Rouen to Cherbourg and had to be towed into port by a fishing boat. On 28 October 1826 she suffered the first serious accident to occur aboard a French navy steamers: her boiler exploded while she was towing a ship off Rochefort, killing or wounding eleven men, ripping up part of her deck, and toppling her tall smokestack. She was repaired, however, and soon resumed her service as a tug at Rochefort.

The French navy's experience with steamers to this point was similar to the English, with the exception that the British navy was never responsible for providing steamers for local service in the colonies. The special requirements of an overseas expedition, in this case an exploration of the Congo River, caused the Royal Navy to build its first steamer, Congo, in 1816, but she was not a success as a steamer and her engine was removed before she left on the expedition.[1] The British navy did not build another steamer until 1822, when they launched the Comet

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[1]Roger T. Anstey, Britain and the Congo in the Nineteenth Century (Oxford, 1962), p. 5; Rowland, Steam at Sea, p. 62.

of 80 horsepower, intended for use as a dockyard tug, followed by two similar ships, Lightning and Meteor in 1823-1824. While the Royal Navy built fewer steamers throughout the 1820's than the French, the number of merchant steamers in England (including government-owned postal packets) was vastly greater than in France, and these ships were often cited on both sides of the channel as potential naval vessels in time of war.

The trials of Coureur gave the French navy its first chance to evaluate first-hand the potential of steamers for use in war. The board that observed these trials reported on 1 July 1824 that Coureur was capable of bringing aid to a ship in distress even outside the entrance to a port in weather that would stop any of the other rescue craft in the harbor, and that she had sufficient power to tow anything up to a large transport out of port in fair weather against both wind and tide. She was not considered strong enough to tow a frigate by herself, but the board felt that two similar ships could do it together.

Assessing the Military Potential of Steam

The need for an evaluation of steamers at the highest level in the navy became urgent when in August 1824 the ministry received a report from the French consul-general in London that the British planned to use steamers in an expedition being prepared against Algiers, and that there were 150 steamers in England which would be available for use against France in case of war between the two countries. The Minister of Marine referred this letter to his technical advisory board, then called the Consultative Commission but soon renamed the Council of Works,

with a request that it advise him on how the French navy should use steamers in peace and war, how many it should have, and how they should be armed.

The Council, referring to the trip of Coureur from Le Havre to Brest and the experience of the cross-channel steam packets, noted that steamers could navigate in anything but a large storm, while sailing ships were often held in port by adverse winds. They could tow ships in or out of port against the wind, ascend rivers, and cross bars at the entrance to ports. They could help ships in danger of being blown on a lee shore, and could carry passengers and supplies to small ports along the coast which were difficult of access.

In wartime, the council continued, these ships should be armed as the old galleys and as modern gunboats with two large guns forward, or as small conventional sailing vessels with eight to ten small guns on the broadside. They could then perform the same services as their sailing equivalents, but with the advantage of being able to navigate in practically all weather, hence being more useful in defending the coasts, attacking an enemy that menaced them, and finally in protecting convoys. Perhaps the most significant idea mentioned in the report was that steamers could tow convoys out of port against the wind or whenever the wind drove away a blockading force, tending to

make close blockade such as used by the British in the Napoleonic Wars no longer possible.[1]

The Council felt that ten steamers were enough for peacetime, but that arrangements should be made to increase the number to twenty immediately upon a declaration of war. They appeared to be satisfied with Coureur, recommending that the ships be given machinery consisting of two engines, each of 40 horsepower.

These recommendations were conservative indeed compared to the claims of some other writers during the 1820's, who said that if associated with another new invention, steamers could make existing navies obsolete. Beginning in 1819, a French artillery officer, Henri-Joseph Paixhans, began to claim that the day of the ship-of-the-line had passed, and that "it is possible, in the present state of the art, . . . to build a very small ship which, manned by only a few soldiers without experience at sea, would be powerful enough to destroy the most heavily armed seagoing battleship."[2] The secret was a gun which would fire explosive shells instead of solid shot. Explosive shells had long been fired from mortars, but these used a vertical

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[1] C.T., 12 August 1824, A.M., Marine BB8-1106 and 1110; Anthiaume, Propulsion, p. 222. For a later reference to the theory on blockades see speech of Minister of Marine in Chamber of Deputies, 30 June 1829, in France, Sénat et Chambre des Députés, Archives Parlementaires de 1787 a 1860 (hereafter cited as Arch. Parl.), 60:743.

[2] H.-J. Paixhans, Nouvelle Force maritime (Paris, 1821), cited in Ann. Mar., no. 16 (1822), p. 385.

trajectory which precluded accurate aiming, particularly from a moving ship. A number of artillery officers had experimented with firing explosive shot from regular cannon, which, with their horizontal trajectory, could be accurately aimed; and Paixhans felt that he had finally overcome the technical problems that had stopped his predecessors.

Paixhans had originally intended to mount his gun in a small launch, propelled by oars or sail, but his critics were quick to point out that even experienced seamen could not handle such craft: they had already been tried in the Boulogne flotilla and many had been lost.[1] But Paixhans was quick to see that steam more than answered these objections: steam would give his craft mobility independent of the winds, and would require only a few trained seamen, nullifying the single greatest advantage that Britain had over France, her seamen. Steamers would also have other advantages, mainly due to their lack of heavy rigging: they could fight unimpeded by falling spars, they would be nearly invisible at a distance, and they could be given shallow draft, enabling them to operate from any French port, large or small, and take advantage of covering fire from coastal batteries. In short, steamers armed with shell guns were the ideal means for

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[1]Criticism by Montgéry in Ann. Mar., no. 16 (1822), pp. 387-388.

overcoming the British superiority, both in numbers of battleships and in the number of trained seamen.[1]

The navy did not welcome the broader ideas in Paixhans' work, but it was interested in the technical details of his gun, and in January 1824 tried it against the old battleship *Pacificateur*. The effects were terrible: the explosions of the shells tore gaping holes in the sides of the ship, and it was realized that a hit on the waterline might have sunk her. From that day on the navy faced a dilemma: they rejected instinctively the thought that small ships could be made more powerful than large ones (and, in fact, such proposals have so far always proved to be chimerical), yet the *Pacificateur* trials indicated that the only large ship that they knew, the sailing wooden battleship, was doomed.

The report of the trials board was a classic response to such a technological dilemma. The members of the board recommended the wholesale adoption of the new invention in areas peripheral to the main activities of the navy, where it would only indirectly threaten the battleship: in coastal forts, gunboats, mortar vessels, and in floating batteries, both sail and steam. However they only recommended very limited use of it in battleships themselves: two or four shell guns in each, and only after further tests. They indicated that their main

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[1] H.-J. Paixhans, *Expériences faites par la marine française sur une arme nouvelle* (Paris, 1825), pp. 22-28. Paixhans is discussed in more detail in J. P. Baxter, *The Introduction of the Ironclad Warship* (Cambridge, Mass., 1933), pp. 17-32.

fear was that large quantities of explosive shells could not safely be stowed in a wooden ship under enemy fire,[1] but it was also true that as long as they refused to abandon the sail battleship, or until a successor were found that could take its place in the traditional structure of the navy, they would have to keep the shell gun out of the line of battle except in token quantities. This view was supported, probably unintentionally, by Montgéry in 1822. He pointed out that if one side used shell guns, the other would too, requiring each side to develop defenses against them. Experiments had been conducted in the United States, and it had been found that five inches of iron armor would stop projectiles from shell guns. Hence the new weapon could be nullified, after the expenditure of much money, leaving neither side better off than before its introduction.[2] The shell gun was not, in fact, formally included in the armament of battleships and frigates even in small amounts until 1837, and its devastating effect in combat was not shown until 1854, when a Russian squadron annihilated a Turkish one at Sinope. Thus the evasion of the full implications of the new innovation, coupled with a long period of peace, bought almost thirty years for the old navy.

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[1]Paixhans, Expériences, p. 18. The Council of Works concurred with the trials board on 23 June 1825; A.M., Marine BB8-1106 and 1110.

[2]Ann. Mar., no. 16 (1822), pp. 389-390.

Paixhans, of course, saw the evasion as exactly that, and while glad that the trials board recommended putting a few shell guns in wooden battleships, insisted that this did not change the fact that shell guns, in large ships or small, would destroy any conventional battleship afloat. However he appreciated the desire of the navy for a large ship, and in a remarkable leap of the imagination predicted that the answer might be a large ship with an iron hull, armor on its sides, and steam propulsion; accompanied by smaller unprotected steamers, also with shell guns. He erred only in thinking that iron hulls and armor would neutralize artillery, and that the main armament of such a ship would be large numbers of soldiers which would carry the enemy by boarding![1] At the time Paixhans conceived of this ship, it is doubtful that technology had advanced sufficiently to produce either the iron hull, the armor, or the steam engine to propel them. All three were feasible by the time of the battle of Sinope, indicating that the thirty-year evasion had served a technological purpose as well.[2]

A second report on the Paixhans gun in October 1824 included steamers in the list of ships to be given the new weapon, although these ships were intended only for the subsidiary

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[1]Paixhans, Expériences, pp. 19, 23-25, 92-98.

[2]Paixhans proposed for the interim putting his shell guns into frigates, which he saw as the best compromise between seakeeping ability and cost. Paixhans, Expériences, pp. 19-20, 87-89.

missions described by the Consultative Commission in the same month, not to replace the battleship as desired by Paixhans. Even so, the Paixhans gun and the experiments and deliberations of 1824 added to the importance of the navy's steamers. So far none of them had been on the navy list, the colonial steamers being the property of the colonial administration and the navy tugs being in the subsidiary category of service craft, but now they were promoted to the full status of naval vessels and added to the list, Caroline in 1824 and the others in 1825.

Foundations for a Steam Navy

The events of 1824 also encouraged new experiments, and the budget for 1826 (drafted about March 1825) also included three new steamers. These were originally to have had 80 horsepower each but, probably on the basis of the trials of the earlier ships, this was doubled to 160 horsepower, which was also well above the 100 horsepower which was then the maximum in the British navy.[1] This increase in size would hopefully enable each to tow a frigate alone, and would give them better qualities at sea. The budget also included a fourth steamer, Requin, a small ship for harbor use with an engine of only 32 horsepower, which was apparently the engine of the old Voyageur re-used in a new hull.

The three large ships of this program, Nageur, Souffleur and Pélican, were experimental: they were to have identical hulls but engines by different builders. The hulls were designed

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[1] Budget, 1828, p. 21.

by a commission consisting of five engineers, of which Marestier was a junior member. Two of the engines were ordered from the same English-run firms that had built the machinery for Coureur and Rapide: that for Nageur from Manby and Wilson and that for Souffleur from Aitken and Steel. The third, for Pélican, was entrusted on Marestier's recommendation to the Frenchman, Philippe Gengembre, who had been in charge of the machinery at the Paris mint under Napoleon and who, after the war, had established a successful steam engine factory at Paris. His reputation was such that the navy, after sponsoring several students at the school of Arts and Trades at Chalons, had placed them with Gengembre as apprentices.[1] It appears that the navy wanted to see how engines built entirely by Frenchmen would compare with those built by the transplanted English firms. Marestier was assigned the duty of supervising the construction of the engines, while the hulls were to be built at the Naval dockyards.

These ships had many of the same defects as their predecessors, but, as they were larger, their defects were harder to overlook. They were initially delayed by the increase in their horsepower, which caused both technical and budgetary problems. When Nageur went to Rouen, under the command of the ubiquitous Lieutenant Louvrier, to receive her engines, they

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[1] Busson, "Débuts," p. 39; C. P. E. Roche, Sommaire des travaux industriels de M. Roche (Paris, 1869), p. 5; Budget, 1828, p. 31.

were not ready for her, and when they were finally installed they were found to be seriously overweight. Her paddle wheels had to be raised in order to function properly, requiring extensive alterations to the hull and machinery, and the ship always suffered from being too heavy for her size. The engines worked well, however, and were put into a new hull for further service in 1839. Souffleur was also greatly delayed by the non-delivery of her engines, and when she ran trials it was found that she suffered from the same defect as Coureur: her boilers did not produce enough steam for her engines, which therefore were unable to develop their designed power. At length the navy decided that it was not worth while to compel the contractor to correct the defect, and the machinery was accepted even though it did not meet the terms of the contract.[1] Pélican was thought to be the most successful of the three by the commission headed by Marestier that inspected her in 1829,[2] but she was a very peculiar ship: she had no less than four paddle wheels, two on each side, driven by two separate sets of engines. Although her initial trials were successful, this arrangement subsequently gave a lot of trouble: she was hard to steer and her four paddle-boxes offered tremendous resistance in the open sea and were

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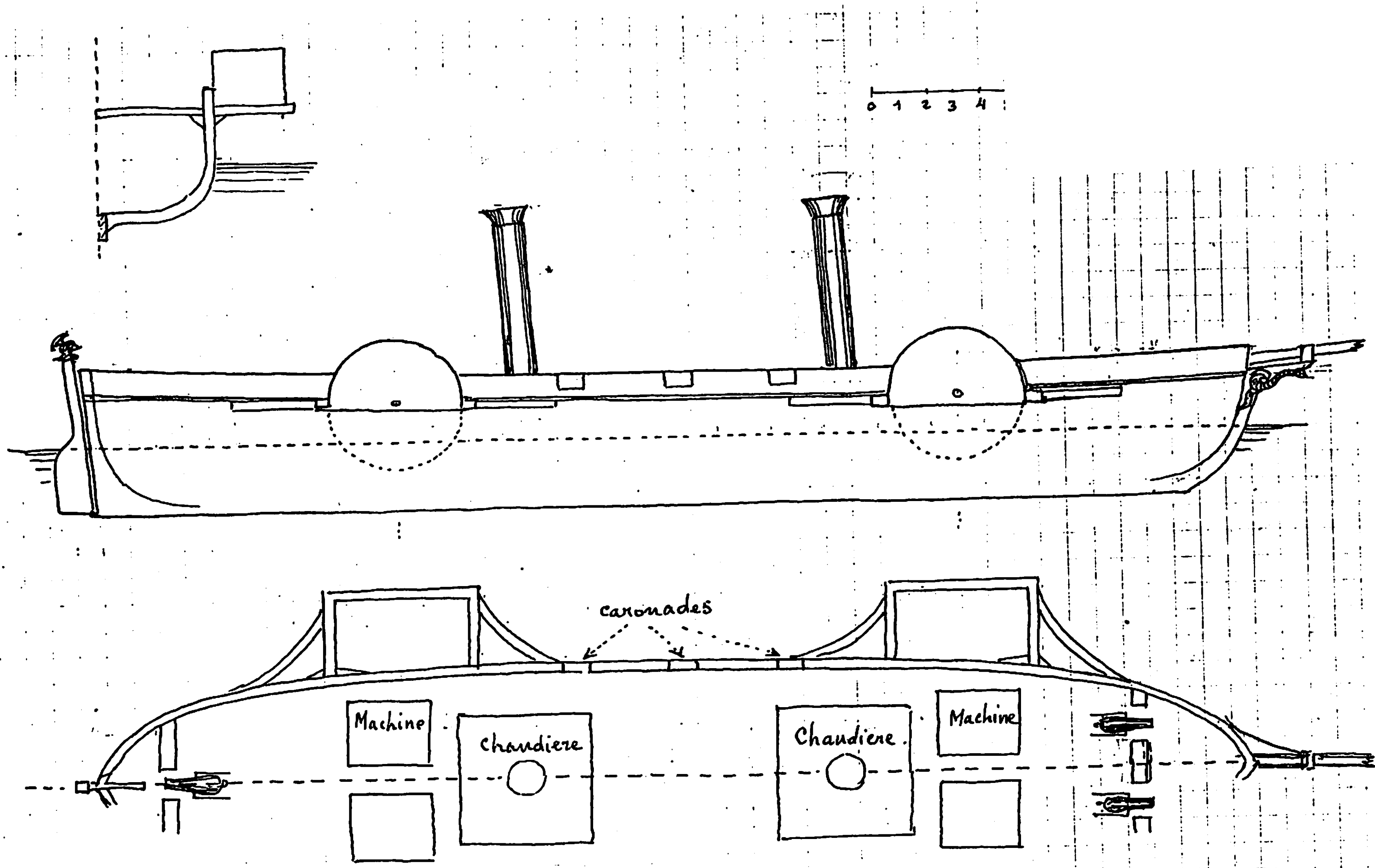
[1] Commandant de Balincourt and Pierre Le Conte, "La marine française d'hier: V: Navires à roues," Revue Maritime, no. 154 (1932), pp. 477-482; C.T., 18 November 1829, A.M., Marine BB8-1107 and 1110; Busson, "Débuts," p. 39.

[2] Report dated 18 March 1830, A.M., Marine 1DD1-20.



The 160 horsepower steamer Pelican (1828) with her four paddle wheels and two separate sets of machinery. (Brest archives, drawing by Adm. Rouyer from the ship!s records)

particularly vulnerable to damage, being placed near the ends of the ship. She was not used at sea after 1831, and in 1834 the after set of engines and paddle wheels was removed and put into a smaller hull for further service.[1]

These ships had barely been begun when further plans were made to expand the steam navy. In the budget for 1827, compiled around March 1826, four additional steamers were included for construction in the dockyards: Castor, Crocodile, Sphinx and Vautour. The budget report indicated that the navy was following this course with some reluctance, mainly due to the fact that they already realized that a steam navy would be enormously expensive. The budget for the following year estimated that for 1827 alone two million francs would be needed over and above the normal budget as established by Portal (and which had not yet been attained), and to produce the initial number of steamers desired, a total of eight to ten millions, spread over four or five years, would be needed just for the ships themselves. The main reason for the high cost of steamers was the cost of their engines: in the case of a 160-horsepower steamer, a hull costing 163,122 francs took an engine costing 586,450 francs. The rise in horsepower was also expensive: Rapide, of 80 horsepower, cost only 201,886 francs complete. Additional money would also have to be spent to provide repair

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[1] CT, 29 January 1828, A.M., Marine BB8-1107 and 1110.

facilities in the ports to maintain the ships, schools to train engineers to operate and repair steam engines, and extra pay to keep these engineers from seeking their fortune in private employment.[1]

However the navy had little choice, for steam navigation "has already made great progress in other maritime nations, and France might someday have cause to regret it if she lags behind in this regard."[2] The minister noted, writing in 1826, that while it was not yet possible to appreciate exactly the changes that steam would bring about in the composition of navies or in maritime warfare, it was already known that steamers would be very useful for the defense of ports and roadsteads and for the protection of coastal trade, and the services of _Coureur_ and _Rapide_ confirmed the value of steamers as tugs. He had therefore decided to build enough steamers to have some in each of the main naval ports, and he had appointed a special commission to look into the wider problem of how much confidence could be placed in steamers, either as an offensive agent or simply as a means for defense.[3] In the presence of the innovation, he proposed to proceed with caution, avoiding either precipitous

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[1] _Budget, 1826_, p. 19; _Budget, 1827_, p. 35; _Budget, 1828_, pp. 21, 42-43; _Budget, 1830_, pp. 3-4.

[2] _Budget, 1827_, p. 35; see also _Budget, 1826_, p. 19.

[3] _Budget, 1827_, pp. 34-35.

adoption of the new system or over-investment in the old, until the value of steam became clearer.[1]

The special commission reported later in 1826 in favor of further expansion of the steam navy, although it does not appear to have added to the list of missions that it was to perform. It called for an initial fleet of thirty steamers: 24 of 160 horsepower plus the six smaller ones already existing. This program would cost 18 millions, which the commission recommended spreading out over four years.[2] The minister, apparently extending this period to six years, stated in his budget reports for 1828 and 1830 that three millions per year would be needed for the proper development of the steam navy, although so far it had only been possible to allocate part of that sum. However the program also ran into delays for other reasons. The four ships planned for 1827 first had to be deferred to 1828, because the increase in horsepower of *Pélican* and her sisters had absorbed all the funds for steamers in the 1827 budget, and because the builders of the engines for the earlier ships had fallen behind in their work. The boiler explosion in *Rapide* also indicated that some technical problems remained to be overcome, suggesting that perhaps the delay was not as unfortunate as it seemed. The

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[1] Minister of Marine in Chamber of Peers, 6 June 1826, *Ann. Mar.*, no. 29 (1826), pp. 93-94.

[2] The report itself has not come to light. See *Moniteur Universel*, 15 December 1828, for missions; Minister of Marine in Chamber of Deputies, *Arch. Parl.*, 61:225 for the program; and *Budget, 1828*, p. 22, for the general nature of the inquiry.

situation was not much better a year later: delays in the completion of the engines of the earlier ships forced postponement of three of the four new ships an additional year, to 1829.[1]

As early as March 1827 the navy had realized that its principal problem was the production of steam machinery: private industry in France, consisting of the Charenton establishment and two or three that had followed it, was simply not sufficiently developed to fill its needs.[2] In this the navy perceived the essential difference between the development of steam technology in Britain and France: the British navy could afford to hold back and rely on private commercial and industrial activity to produce the technological advances that it needed, while if the French navy were to profit from the new technology, it would have to take an active part in introducing it from abroad and developing it.[3] In this regard, it saw its previous policy of relying on Charenton and Ivry as wholly inadequate: it had been unable to acquire the engines it needed for shipboard and dockyard use without excessive delay, and had had great trouble in finding engineers to operate the engines and repair them.[4]

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[1] Budget, 1828, pp. 21, 42-43; Budget, 1829, p. 28; Budget, 1830, pp. 3-4.

[2] Budget, 1828, p. 45; Budget, 1829, p. 28.

[3] Tupinier in Chamber of Deputies, 24 July 1828, Arch. Parl., 56:412; Ann. Mar., no. 52 (1833), pp. 453-458.

[4] Budget, 1828, p. 45; Budget, 1829, p. 28.

In addition the reliance on English-run plants rankled: anglophobia was rampant in these years, only a short time after the humiliation of 1815, and the minister of marine pointed out in the Chamber of Deputies that if war broke out between England and France, the English manufacturers could cripple France simply by packing up and going home.[1] Official reports avoided overt anti-English statements, but pointed out that the financial situation of these companies was not sound, and that their financial failure would have the same crippling result.[2]

The solution that the navy decided upon was to intervene directly in the process of creating an industrial base for steam engine production and go into the steam engine business itself. A little-used cannon foundry on the island of Indret, in the Loire near Nantes, was selected for conversion into a steam engine factory, and a shipyard was built alongside the factory, so as to concentrate all aspects of steamer construction in one place. The project was approved by the king on 24 November 1827, and the budget for 1829, drafted in April 1828, included an ambitious program for the new yard: the three steamers deferred from the previous program were to be built at Indret instead of in the dockyards, and three additional steamers (named _Ardent_, _Chimère_ and _Salamandre_) were also to be begun

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[1]Minister of Marine in Chamber of Deputies, 23 May 1827, _Arch. Parl._, 52:266.

[2]_Budget, 1829_, p. 28.

in 1829, using the most up-to-date information from France and abroad. The money in the 1828 budget freed by the deferment of the three steamers planned for that year was to be used for the initial equipping of the factory at Indret.[1]

The navy still faced the problem that it did not have either the experience or the equipment necessary to run such a factory, but it found an ingenious answer. By a contract of 10 December 1827 it arranged with the Paris steam engine builder Philippe Gengembre to transfer himself, his employees and his tools to Indret, where he would direct operations for ten years and would be paid a percentage of the value of the engines that he built.[2] He was also to train the workers at Indret, and also others who would set up repair facilities in the ports for steamers, and it was probably expected that after ten years naval personnel would have enough experience with steam engines to be able to take over direct management of the plant.

The final step in the establishment of Indret was to get the funds from Parliament, and here the navy encountered considerable political opposition. The perennial complaint about the navy in the Chambers was that its administration was unnecessarily large and expensive, and any extension of the bureaucracy or of the shore establishment was bound to arouse some opposition. What added to the seriousness of the situation

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[1] Budget, 1829, p. 29.

[2] Jean-Pierre Dubreuil, "La vapeur dans la marine de guerre: Toulon, 1830-1860" (Mémoire de maîtrise d'histoire, Nice, 1971), pp. 80-81.

was that, in July 1828 when the matter came up for debate, the opposition to the government consisted primarily of liberals, whose position was based not only on distrust of the bureaucracy but on doctrinaire economic liberalism, which opposed any government meddling in the economy and sought to reduce government spending to the absolute minimum. In early 1828 the navy suffered a severe setback when the budget commission, which held preliminary hearings on the budget prior to sending it to the Chamber of Deputies for debate, took direct aim at the manufacturing facilities run by the navy and other ministries: they cut half the funds for the existing foundry at La Chaussade and eliminated the funds for Indret altogether. Its spokesmen explained in the commission's report and in the debate in the chamber that government-run plants were inevitably inefficiently run, and also had to support the expense of developing innovations which otherwise would be done by private industry at no cost to the government. They claimed that private industry could supply all the items desired, including steam engines, at less cost and at equal or better quality. They felt that if the government relied on private industry, competition in the marketplace would hold down the price, while the fear of having the navy reject products that did not meet quality standards, and the financial ruin that might follow, would keep up quality. They also deplored the effect of government-run factories on private industry, which couldn't compete with a rival whose administrative costs were paid by the state and which would get most of

the government's orders. Reliance on private industry might impose some sacrifices on the navy, but it was in the national interest: the wealth of the state lay in the wealth of the country, which in turn lay in unrestrained economic exchange.[1]

The navy fought back, taking the issue to the floor of the chamber. It claimed that government-run plants were not exorbitantly expensive: while they cost more to administer than some private facilities, they did not have to pay 10 percent or more each year in profits to owners or stockholders. The navy spokesmen indeed took no exception to the principle that ideally the navy should procure what it needed by contract, and indeed it did so for most items; but they claimed that experience had shown that the state could produce items of higher quality than private industry, and that where quality was more important than price, as with fittings on which the safety of ships depended or the ships themselves, the navy had found it necessary to make these items itself. Presently only one foundry in France, Fourchambault, could match the products of La Chaussade in quality, and its director was cited as saying that to disband Chaussade would be a catastrophe. The navy claimed that its facilities helped the economy by procuring raw materials in the open marketplace, and that the only loss to the economy was

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[1]Report of the Budget Commission, 18 June 1828, _Arch. Parl._, 55:92; Sebastiani in Chamber of Deputies, 24 July 1828, _Arch. Parl._, 56:413.

the profits that a few speculators could reap from the use of labor in converting the raw materials to manufactured goods.

But the main thing the navy wanted the deputies to understand was the reason why it had found it necessary to intervene directly in the process of creating an industrial base for the production of steam engines. The opposition was badly mistaken, the navy spokesmen said, in claiming that the interests of both private industry and the nation demanded that the navy leave the development and manufacture of new innovations to private initiative. This was indeed the case in England, where the existence of a private navy (the East India Company) and a large merchant marine gave a strong impetus to the search for improved methods and equipment. The large market provided enough business, even without navy orders, to sustain a large number of manufacturers who competed with each other by developing and offering to sell all sorts of technological improvements which, if successful, could be sold in sufficient quantity to make a profit. Hence the state of the art advanced rapidly and spontaneously in England without any government intervention, and indeed the British navy could do no better than to go to private industry when it needed a few steam engines.

In France, they continued, the situation was very different: the merchant marine was tiny, and while there were over two hundred steamers in Britain, there were at most twenty in France.[1]

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[1]This figure is too low: a list of all steamers in France in 1827 has seventy-one ships, including nine naval. However there were only about twenty non-naval steamers which were as

Thus the market in France was insufficient to support more than a few companies, and the small number of orders that could be anticipated were insufficient to offset the costs and risks of technological improvements. Indeed, it was at times too small to ensure the continued extence of the companies. Therefore, without government help, the state of the art would stagnate in France. Only the government had the capital necessary to pay for the introduction of new processes and mechanisms from abroad, and the period of experimentation and error that would inevitably come before the innovations became usable. In the case of metal anchor chains (introduced by La Chaussade) and steam engines, the national interest did not permit the navy to wait for private industry to find the capital and the markets for the innovation: it had to take the lead itself.

The navy spokesmen finally pointed out that, far from harming private industry, the initiative of the government in introducing new technology would ultimately help it. In the initial phases of the introduction of a new item, there would be no domestic industry to be hurt by navy competition. More important, the government, by assuming the cost of the initial period of innovation and development, would open to private industry a way free from pitfalls and clear for all to follow. Thus not only the national interest, but the interests of French

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large as the smallest naval steamer (32 horsepower or more). Tourasse and Mellet, Essai, pp. 16-22.

industry required the government to take the initiative in introducing innovations which required a large capital investment to develop.[1]

The navy's arguments carried the day, and the deputies in the Chamber restored to the budget the funds for La Chaussade and Indret. In addition, they revealed the broader significance of the establishment of Indret: it was to be the vehicle for the introduction of British steam technology into France, and would be the means by which this technology was made available to French industry. Whether the navy would later buy some of its engines from French industry would depend on the progress of the latter, but government intervention in the process by means of Indret was a necessary first step.[2]

The initial problem was to import the new technology from England, and the navy's efforts in this direction were already underway. The one ship of the 1828 program that had not been deferred to 1829, Sphinx, was a landmark in French naval history, for she was the first French naval steamer to fulfill completely the expectations of the navy. At that time the most successful steam engines were those built by a number of British firms on the patterns of Watt: what they lacked in novel features they made up for with solidity of construction

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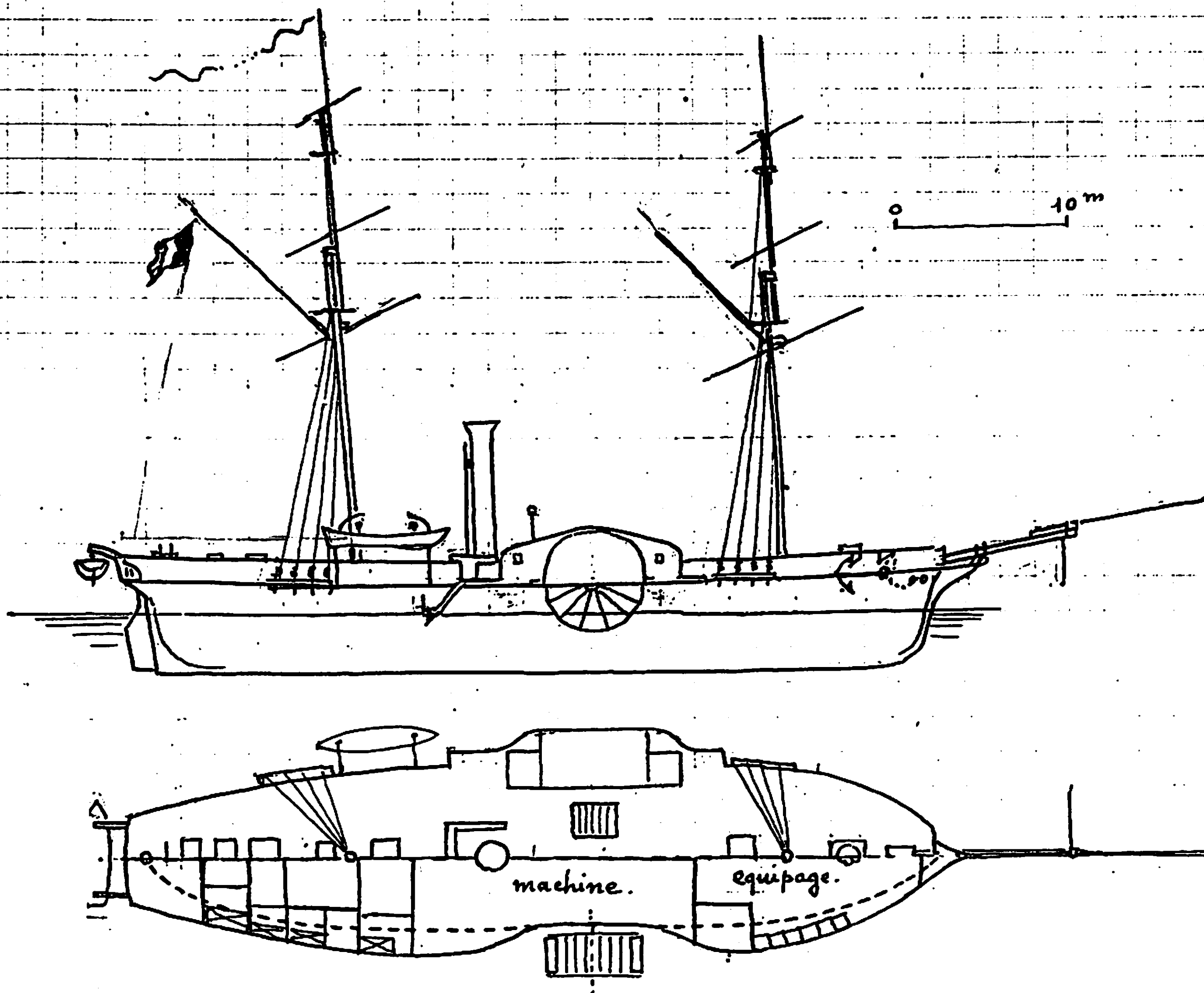
[1] Tupinier, de Leyval and Dupin in Chamber of Deputies, 24 July 1828, Arch. Parl., 56:410-14.

[2] Dupin in Chamber of Deputies, 24 July 1828, Arch. Parl., 56:414; Ann. Mar., no. 52 (1833), pp. 454-456.



A near sister of <u>Sphinx</u>, the 160-horsepower <u>Ardent</u> (1830) in 1855. This class originally had three masts. (Brest archives, drawing by Adm. Rouyer from the ship's records)

and long, dependable service. The French navy decided that it had to have one of these for comparison with the various types of engines being developed in France by Gengembre and others: the best engine, or at least its best features, would then serve as the model for production at Indret. The British-run firms at Charenton and Ivry were incapable of introducing these engines, for the navy's experience with their products showed that they either did not know or did not use the proportions that had proved successful for Watt.[1] But in 1827 a good British engine appeared at Bordeaux, installed in a British steamer named Leeds, which in addition seemed to have a seaworthy hull well proportioned to the engines. One of the senior naval constructors at Rochefort, Jean-Baptiste Hubert, was ordered to design a steamer on the lines of Leeds, and in addition to travel to England and order engines for her there.[2] In England Hubert ordered a set of engines of 160 horsepower from the firm of Fawcett of Liverpool, known for its fidelity to the Watt system and for the solidity and dependability of its engines. The ship, Sphinx, was launched on 3 August 1829 and was commissioned early in 1830.

The Steam Navy and French Politics

Events soon induced a change in the initial program for Indret. On the one hand, the work of setting up the steam engine

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[1] Roche, Travaux industriels, pp. 5-6.

[2] Paul Dislère, Les croiseurs; La guerre de course (Paris, 1875), pp. 11-12; Ports to Minister, 5 January 1833, A.M., Marine 7DD1-14; Ann. Mar., no. 95 (1846), pp. 83-87.

factory went more slowly than expected, and on the other, favorable mention of steamers by members of the opposition in Parliament led the navy to think it could get Parliamentary approval for acceleration of steamer construction. It therefore added a request for two million francs for steamers to a supplemental appropriation bill which was intended to cover extraordinary expenses connected with the war of Greek independence, and other diplomatic efforts. However, while the ships nominally were intended for use in the Mediterranean in connection with the war, no one took this connection seriously and the navy made no effort to transfer its existing steamers there.[1]

It was normal practice to begin spending money requested for extraordinary expenses before Parliament acted on the request, and early in 1829 the navy obligated 800,000 of the two million francs.[2] This appears to have been spent in connection with contracts for engines for two ships, Castor and Ardent, originally planned for construction at Indret but now ordered from two French steam engine builders that the navy had not yet tried. The engines for Castor were ordered from Emile Martin and Company of Fourchambault, of whose products the minister had spoken highly in the debate on Indret. The engines appear

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[1] Dupin and Minister of Marine in Chamber of Deputies, 10 July 1829, Arch.Parl., 61:213, 225.

[2] France, Ministère de la Marine, Compte rendu par le ministre de la Marine et des colonies (exercice 1829), pp. 4, 32-33.

to have worked well, but unaccountably they were only of 120 horsepower for a hull the size of Sphinx, leaving the ship underpowered. The engine for Ardent was ordered from an entrepreneur named Frimot who proposed to build a factory at Landerneau near Brest to produce engines which he claimed would burn half as much coal and weigh half as much as those of Sphinx and her predecessors while producing the same speed. While the navy was attracted by the idea of a source of supply of steam engines near its largest Atlantic base, it appears to have been pushed into the venture mainly by Frimot's political connections. It later had cause to regret the move: Frimot's engines did not work, while his supporters succeeded in dragging the claims and counter-claims on into the 1840's at a cost to the navy considerably above the initial contract price of the engines.[1]

Unfortunately the navy chose a bad time to stick out its neck with unauthorized expenditures, for in 1829 two crises were coming to a head: the final political crisis of the Restoration, and a severe economic depression. At the beginning of 1829 a political truce was in effect: the ministry was headed by a moderate, Martignac, and it was hoped that through him the ultra-conservative king and the liberal-dominated parliament could still cooperate in the government of the country, but this hope

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[1] Among masses of material on the Frimot affair, see France, Marine, Conseil d'Amirauté (hereafter cited as C.A.), 19 April 1834, A.N., Marine BB8-865; and Arago and Las Cases in Chamber of Deputies, 7-8 May 1834, Arch. Parl., 90:64-69, 73-80.

was dashed in early April 1829 when the king caused Martignac to withdraw a bill on local government which Parliament was making too liberal for his taste, and after that date the liberals in Parliament became implacably opposed to the king and all associated with him, including his ministers. The second problem was the economic crisis: the country showed no signs of pulling out of the depression which had started when the Bourse collapsed in late 1825, and it was also reeling under an agricultural crisis whose main index, the price of bread, saw its largest rise in the winter and spring of 1828-29. Liberal doctrine regarded high government spending as harmful to the economy, providing them with economic as well as political arguments against the new bill.

The attacks on the navy in the chamber began as early as 27 April, soon after Martignac withdrew the local government bill, but the main assault came a month later in the committee reports, both written by liberals, on the budget for 1830 and on the supplemental credits for 1829. In these, the high cost of the navy led the liberals to question for the first time in almost a decade the principles on which Portal's program had been based. The navy, they claimed, was over-developed in France: many more ships were kept in commission than were warranted by the size of French overseas trade, and the number of battleships was excessive for the type of war that France was most likely to fight, a defensive war, while being wholly inadequate for an offensive war against England. They added

that the main threats to French interests and her main opportunities came not from overseas but from the military powers on the continent: a strong army was the guarantee of her safety and could perhaps achieve supremacy on the continent, while an inflated navy would only provoke retaliation from England without ever being able to achieve predominance at sea.[1] When applied to the navy's materiel, these considerations led the liberals to resurrect the traditional alternative to the battleship navy: a fleet composed primarily of frigates, they claimed, would be sufficient for a defensive war, while also being capable of doing severe harm to England if the need arose.[2]

But the liberals also saw steam navigation as a possible second alternative to the traditional battleship navy. The committee on the 1829 credit reported that they thought that "this precious invention will someday be of great use to us, and that it may be its destiny to reestablish at sea an equality between nations which has for a long time been lost."[3] This theme was developed further in the debates by Benjamin Constant, who had fewer inhibitions against speaking out against England than some of his liberal colleagues. France should have, he declared, a navy large enough only to protect her traders from

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[1]Report to Chamber of Deputies, Budget for 1830, 23 May 1829, Arch. Parl., 59:455-56; Report to Chamber of Deputies, 1 June 1829, Arch. Parl., 59:645.

[2]Arch. Parl., 59:456.

[3]Arch. Parl., 59:645.

piracy and arbitrary action by smaller powers, but not against England and her arrogant view of international law. Constant felt that, when at war with England, France should not rely solely or principally on battles at sea, but should strike her in her home islands. "If such efforts did not succeed in previous wars, it was because, on the one hand, the development of steam navigation had not reached its present extent, and, on the other hand and more important, because the despotism that the ruler of France had imposed on Europe had forced all nations into alliance with England as the sole enemy of that despotism." Now things were different: the government of France was pacific and did not want to oppress any state by force, and every nation in Europe had a grievance against the arbitrary and fickle power of England. Today "steam navigation contains the secret of the deliverance of Europe" from this power.[1] France should prepare steamers in her dockyards, as did England (who, he said, had at the moment 338 to four for France), and in case of war use them for incursions against the British Isles. This was the only way France could fight on an equal footing with England and, he also dared to hope, would cause the impoverished urban masses of England to rise against their oppressors. He added that such incursions would have to be supported by some line-of-battleships, but not as many as the navy was trying to build.

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[1] Constant in Chamber of Deputies, Arch. Parl., 1 July 1829, 61:11-12.

The navy was apparently caught by surprise by the sudden outburst of criticism, but quickly rose to its own defense, and was joined by others including the liberal newspaper Le Constitutionnel.[1] They rejected the criticism of the large number of ships in commission, explaining that these had as their mission not only the protection of existing French commerce but the development and encouragement of new trade opportunities. As in the case of steam engine manufacturing, the navy was thus encouraging the development of one of its own sources of strength, for much of its manpower came from the merchant marine, while its own men received much of their training on these overseas navy cruises.[2] They also rejected the belief of Constant and others that the battle fleet as established by Portal was useless against England. Constant had based his criticism on the lack of another maritime power with which France could ally herself against England, but the navy's advocates pointed out that, if no ally were visible at the moment, times change, and sooner or later one or more would arise. Finally, and perhaps most important, they opposed the adoption of any fixed, exclusive system of naval warfare such as excessive reliance on frigates or steamers at the expense of a balanced, general purpose fleet. The minister of marine told the Chamber that one day a "great

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[1] Cited prominently in Ann. Mar., no. 30 (1829), pp. 6-11 and 114-115.

[2] Minister of Marine in Chamber of Deputies, 30 June 1829, Arch.Parl., 60:742. For a rebuttal by Humann on 2 July see Arch. Parl., 61:30.

captain" had told him that there was "no better way to be beaten than to become accustomed to a fixed rule in warfare, unchanging for both attack and defense, and to draw up in advance a plan for an entire campaign in one's office. The system to follow, he added, is that which the enemy's method of attack or defense indicates and makes necessary.[1] Therefore the navy had to maintain an ability to fight in many different ways, including the conventional way with a battle fleet. However, he continued, in a future war it was unlikely that France would turn to fleet actions, for she had other ways to fight with success, particularly after the development of steam navigation permitted the hope that close blockades would henceforth be nearly impossible: France had usually been defeated at sea when her ports had been closed and her fleets isolated from each other. The navy had therefore been moving cautiously in the direction indicated by its critics: it had increased the number of its steamers, while the Portal program had practically reversed the old ratio between battleships and frigates.

Charles Dupin, a political liberal but also an advocate of the traditional balanced fleet, also warned his colleagues against "a few men with their systems" who recommended relying on a fleet composed entirely of frigates, and also warned

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[1] Arch. Parl., 60:743.

against expecting too much too fast from steamers.[1] So far, he said, there was not in all of Europe a steamer larger than a mere corvette, and the number of war steamers was also very small: nine in France and six in England. (Other speakers had included an estimated three hundred merchant steamers in their figures for England.) Dupin pointed out the obvious weakness in Constant's proposed use of steamers: the success of his incursion still depended on a fleet of battleships temporarily clearing the channel for the invaders, which was the same problem that Napoleon and his predecessors had faced. The thought that his liberal colleagues were recommending steamers in the name of economy bemused him: he estimated that a fleet of steamers for an incursion into England would cost 300 million francs, while routine operation of steamers cost twice as much as sailing ships for the same amount of cargo carried or distance covered. While France could build and man sailing ships more cheaply than England, the opposite was the case for steamers: Dupin cited primarily the cost of fuel, but the difference in the cost and availability of machinery and skilled engineers in the two countries was also an important factor. Dupin also pointed out several factors that made steamers as they then existed unsuitable as warships: they were too vulnerable to be able to stand up in combat, and they were

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[1] Dupin in Chamber of Deputies, 1 July 1829, Arch. Parl., 61:5.

limited by their coal capacity (which at best lasted only ten or fifteen days) to use along the coasts of France, leaving all the overseas stations the undisputed domain of sail. Steamers, he said, should be valued for their proven capabilities as tugs, as dispatch boats, and as mobile flotilla craft (he called them the galleys of the nineteenth century), but as such they could not take the place of large seagoing sailing vessels. Finally there were technological reasons for caution: each year the steamers of the previous years looked more and more imperfect, due to new advances in the state of the art.

In spite of all these disadvantages, Dupin was careful to warn his colleagues against discounting the possibility of important improvements in the capabilities of steamers. France must, he said, study closely all the improvements made in England and those suggested by French engineers, and maintain a modest steamer building program to experiment with these. But she should also wait until the technological problems that presently made steamers unsuitable as warships had been solved before making an extensive investment in them as part of the navy, and before relying on them as an element of her security.[1]

It was ironic, in view of the ideas of the liberals in Parliament, that when the dust cleared the only part of the navy's budget to be seriously reduced was the part concerning steamers. Despite the vigor of their criticism, the budget commission and

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[1] Dupin in Chamber of Deputies, 10 July 1829, Arch. Parl., 61:214.

the chambers had cut only 160,000 francs out of a budget of over 58 millions. But in the supplemental request for 1829 the members of the commission uncovered a fine point of fiscal orthodoxy which they felt took precedence over their interest in expanding the steam navy. Of the funds asked for by the navy, they felt that one million requested for commissioning extra ships and the entire two millions for steamers were recurring expenses, and hence should be in the ordinary budget and not in a bill for one-time extraordinary expenses. They saw the government's request as a subterfuge to justify the expenditure of funds not authorized by Parliament, and rejected it as a lesson in ministerial responsibility.[1] It appears that continuing resentment over Indret also played a role: one speaker noted that when the Chamber had approved the funds for Indret the previous year, it had not been told that additional engines would also be ordered outside Indret, and he felt that both propositions should have been presented at the same time so Parliament could make its decision with complete information.[2]

The navy was seriously embarrassed by the need to cut its expenditures for the year by three millions, particularly as half of the year had already passed and most of the funds had been obligated. The steam navy apparently did not suffer

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[1] Arch. Parl., 59:645.

[2] Lepeletier d'Aunay in Chamber of Deputies 10 July 1829, Arch. Parl., 61:223.

as much as it might have, because part of the money for the new program had already been committed when the engines for Castor and Ardent were ordered. However the completion of the facilities at Indret and the work on the first engines there went more slowly than planned, and this may have resulted partly from the budget cuts. Despite the offhand nature of the chamber's action, the budget debates of 1829 in fact marked the first peak in the development of the French navy after 1815: before this time it had been expanding, aided by slowly increasing budgets and extensive supplementary appropriations, while afterwards it was forced to retrench due to declining or steady budgets and severe limits on supplemental funds.

However before the period of retrenchment really started with the July 1830 revolution, the steam navy had an unexpected chance to prove itself in combat. In 1827, after a diplomatic dispute was exacerbated by an affront with a fly-swatter, the French declared a blockade of Algiers, which turned into an exercise in futility: it was enormously expensive for the French, it was unable to stop most Algerian vessels, and it could not be given up without France losing face. In 1829 Benjamin Constant, echoing the sentiments of many liberals, lambasted this ruinous blockade which the pirates ridiculed, and declared that he would gladly grant funds for a bombardment to destroy the city, but not for the continuation of the blockade.[1]

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[1] Constant in Chamber of Deputies, 9 July 1829, Arch. Parl., 61:199.

Perhaps encouraged by such talk, the government decided that resolute action in North Africa might both end a diplomatic stalemate and a running sore in the budget, and also win some friends at home. It therefore decided on nothing less than the military conquest of Algiers, and in a remarkably short time prepared and dispatched a large expedition to carry it out.

The problems of Algeria had already aroused new ideas on the military use of steam. The British had used two steamers in their bombardment of Algiers in 1824, but these had not achieved any particular distinction. In 1829 a French navy lieutenant, wrestling with the problem of the blockade, proposed to the Minister of Marine to cut the Gordian knot by the use of a steamer. The ship, equipped with Paixhans shell guns, would rain fire and ruin on the city, while using her engines to choose her position, avoid fire from shore batteries, and escape the main danger that kept sailing vessels away from the coast, that of being caught in a calm by hordes of Algerian small craft.[1] The idea was not accepted, but was symptomatic of the desire of some naval officers even at this early stage to exploit the military value of steam and the Paixhans gun.

In the event, the navy did make an effort to use its steamers in the operation. In late 1829 it dispatched to Toulon the five largest steamers in the northern ports, _Rapide_, _Souffleur_, _Nageur_, _Pélican_ and _Sphinx_, where they joined _Coureur_ and a

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[1] Georges Benoît-Guyod, _Bruat, amiral de France_ (Paris, 1960), pp. 2-3 (frontispiece), 98-99.

similar steamer purchased in 1828, Ville du Havre. The importance of the naval steamers was shown by the fact that the port of Marseille was unable to provide a single merchant steamer for the expedition, and by the fact that two Sardinian steamers had to be hired to provide the daily messenger service between Marseille and the naval base at Toulon.[1] Most of the navy steamers sailed with the expedition when it sailed from Toulon in May 1830, with the mission either of towing some of the slower transports or of carrying messages. Thereafter the fortunes of the different ships diverged. Rapide, Souffleur and Ville du Havre broke down on the trip to Algiers and had to be sent back to Toulon. Coureur had to be taken under tow by frigate Thétis, and apparently was not of much use. Pélican joined the force late, due to the need to repair damage incurred during her transit from the north. Nageur performed well on the trip over, and then provided valuable support for the landing at Sidi-Ferruch by approaching close to shore and bombarding Algerian positions. But the real sensation was Sphinx. Not only did her machinery work like clockwork and her hull prove well proportioned to both the engine and the seas, but she also provided a superb example of the services steam could offer by being the first ship to bring to France the news of the capture of Algiers.[2]

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[1] Giraud, Vapeur à Marseille, p. 14.

[2] Balincourt and Le Conte, "Navires à roues," pp. 474-485.

The Algerian campaign, plus the fact that the ship had made ten knots on her initial trials, made _Sphinx_'s reputation: in the view of commentators there was simply no comparison between her and the ships with French engines, either in reliability, design or workmanship.[1]

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The success of _Sphinx_ brought to a close the first phase of the introduction of steam technology in the French navy, the experimental phase. During the 1820's the navy learned that steam navigation was technically feasible and that it offered a number of important advantages. Steamers were found to be indispensable in the colonies, where they made possible travel along coasts and up rivers that were previously all but inaccessible to white men, while giving them a technological advantage over the local inhabitants. Steamers were also found to be useful in naval harbors, both for towing sailing ships in and out of port and for limited military operations along the coast. Finally, the Algerian campaign showed that steamers might have some uses with a fleet, such as towing ships at sea and carrying messages. It was clear that steam had come to stay, and the ministry confirmed this by announcing in the budget report for 1831 a decision taken some years previously that the navy should include thirty steamers in addition to the sailing fleet planned by Portal and his successors.[2]

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[1] Campaignac, _Navigation par la vapeur_, pp. xii-xiii.

[2] _Budget, 1831_, p. 20.

But the French also found that they did not have the industrial facilities needed to build the ships, particularly their engines. The French merchant marine bought many engines in Britain, but the French navy rejected this idea from the very beginning in the hopes that, with a little encouragement, a steam engine industry would soon develop in France. During the mid-1820's it faithfully bought its engines from French factories (most of which were run by Englishmen), but the engines were of mediocre quality and, worse, the steam engine industry in France did not grow as hoped. The navy finally realized that, while in England the private economy was strong enough to sustain the development of a steam engine industry, this was not true in France and, if the navy wanted such an industry to develop in France, it would have to intervene in the process itself. In 1827 the navy therefore established its own steam engine factory at Indret.

The French were even further behind England in their understanding of steam technology during this period than they were in their ability to build steam engines. In 1816 the *Moniteur* had not even understood how steam could be made to propel a boat. In 1819 the navy sent two officers to the United States to bring back the basic facts concerning steam technology, but many of the fine points still eluded them and their early steamers left much to be desired. In 1827 the navy therefore decided to buy an example of the latest type of British engines, which it put in the steamer *Sphinx*.

Together Indret and _Sphinx_ were the main contribution of the French navy towards the introduction of steam technology into France in the 1820's. The function of Indret was to provide the engines that the navy needed, and also to serve as a model factory which private French industry could copy. The engine of _Sphinx_ was purchased in order to give the French navy an engine that would work and to make available to French industry, through Indret, an example of the latest British technology which it could copy if it desired. Indret and _Sphinx_ thus provided the foundation on which the further development of the steam engine industry and steam technology in France during the 1830's took place.

CHAPTER III

STEAM ON THE PERIPHERY OF THE FLEET, 1830-1839

During the 1830's the development of steam technology in the French navy generally followed along the lines laid down for it in the late 1820's. Following the success of _Sphinx_ during the Algerian campaign, steamers were given the function of carrying mails and messages, and a great demand for such services, especially in the Mediterranean, led to a considerable increase in the number of steamers in the navy. However steamers were not assigned military missions during the decade (despite indications during the Algerian campaign that steamers might prove useful in a naval fleet), and they thus remained on the periphery of the "real" navy, the battle fleet.

The navy also continued its policy of fostering the development of the steam engine industry in France. It brought its plant at Indret into full production, and encouraged several private firms to develop the capability of building large marine engines by supplying them with a series of contracts. But it insisted that the designs for most of its engines follow that of _Sphinx_, and steam engine technology in the French navy thus remained frozen for much of the decade.

Towards the end of the decade the restrictions on the further development of steam in the French navy began to break down. Experiments were conducted with the military uses of steam, and the size of steamers began to increase, causing a break with the model of Sphinx and also greatly increasing the potential military uses of steam. This potential was not, however, to be realized until the 1840's.

The decade of the 1830's opened with a bad omen for the French Navy. Only a year after reaching the level of expenditure (65 million francs per year) established as normal by Baron Portal in 1820, the Navy was ordered by the cabinet, shortly after the July Revolution, to reduce its budget request for 1831 to 60.5 million. The Minister of Marine complained tactfully but firmly in his report on the budget, and expressed the hope that the budgetary restraints would be temporary.[1] However the ordinary budget was not to reach 65 millions again until 1838, while extraordinary credits, which had provided the navy with substantial additional funds in the 1820's, were severely limited in the 1830's and did not reach the level of 1828-30 again until the crisis of 1840.

The Navy's materiel, both sail and steam, took the brunt of the reductions. Baron Jean-Marguerite Tupinier, the official in the ministry responsible for materiel, felt this was largely due to the fact that, while during the Restoration the ministers

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[1]Budget, 1831, p. 35.

of marine had all been civilians, during the July Monarchy they were mostly admirals, and therefore more receptive to the needs of personnel than of materiel.[1] There was, in fact, strong pressure, professional, political and otherwise, brought to bear in favor of the navy's personnel during the decade, and the argument was frequently heard in the Chamber of Deputies and elsewhere that the primary resource of the navy was not its ships but its trained crews.[2] But it was also true that personnel costs, which were easy to increase in good times, were hard to reduce in bad times without infringing on the rights of the individuals affected, while it was always possible to save an appreciable amount of money by deferring or cancelling a shipbuilding program. The main feature of the 1830's for the French navy was, therefore, the need to retrench within a severely limited budget, and the inevitable effects were felt in both the sail and steam fleets.

The sail navy also faced an additional problem: it became clear during the early 1830's that, despite alarming forecasts each year, the existing fleet program had practically been achieved, leaving little for the dockyard workers to do. The navy had roughly the right number of battleships and frigates afloat, and the ships on the ways were nearly at the prescribed degree of completion. The problem was to find a way to keep the

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[1] Tupinier, Memoirs, pp. 284, 291.

[2] Report to Chamber of Deputies, Budget for 1837, 13 May 1836, Arch. Parl., 103:538-40.

dockyards busy without increasing overall expenditure, and in October 1834 Tupinier suggested that this could be done by reducing the proportion of the fleet that was to be maintained afloat from two-thirds to one-half. This would allow the dockyards to start work on seven additional battleships and eight frigates, while saving money on an equal number of old ships afloat which would be allowed to disappear without replacements. The plan was approved by the Council of Admiralty in November 1834, forestalling a move by the minister to spend the money saved on personnel instead of on shipbuilding.[1] In the meantime Parliament was again becoming critical of the size of the fleet desired by the Navy, and in response the navy formally reconsidered its decision in 1836 and incorporated its plan into a royal ordinance, signed on 1 February 1837. Except for the ratio of ships afloat to ships on the ways, this ordinance changed the standard fleet plan very little: it called for a fleet of forty battleships and fifty frigates, of which half would be afloat, and not more than thirteen additional battleships and sixteen frigates at a less advanced stage of construction.[2] However during the next several years, budgetary

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[1] C.A., 6 November 1834, A.N., Marine BB8-866; Budget, 1836, p. 603.

[2] Report to Chamber of Deputies, Budget for 1837, 13 May 1836, Arch. Parl., 103:538-40; Ports to Minister, 12 October 1836, A.M., Marine 1DD1-34; C.A. 27 October 1836, A.N., Marine BB8-866; Ann. Mar., no. 62 (1837), pp. 221-230; Tupinier, "Matériel," pp. 133-219. The Parliamentary critics were naturally not satisfied: Report to Chamber of Deputies, 15 May 1837, France, Chambre des Députés, Procès-verbaux des séances de la Chambre des Députés (hereafter P.V. Députés), 1837, Vol. 5, part 2, pp. 658-667.

restrictions prevented the laying down of as many ships as planned, and the total number of battleships and frigates in the French navy began to decline in the late 1830's.[1]

The 1830's were also a period of stagnation for the steam navy. There was little innovation until the end of the decade, either in the design of steamers or in the development of new uses to which they could be put. The military functions of steamers, so tentatively explored during the Algerian expedition, were not further developed until late in the decade, and steam remained on the periphery of the navy's combatant forces. However the steam navy was able to benefit from its performance in Algeria in another way. The Army needed regular communications with its forces and its administration in the new colony, and steamers had shown in 1830 that they could now be relied on to do the job. At first the army planned to contract with a private firm for the operation of a line of steamers between France and Algeria, but the private firm that showed the greatest interest was unable to justify the huge capital investment required unless the contract were guaranteed to it for a period of twelve years. At this point, in August 1832 the navy stepped in and offered to run the service with its own ships, claiming that its service would be more economical

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[1]Ports to Minister, 31 October 1835, A.M., Marine 1DD1-34; Ports to Minister, 12 November 1836, A.M., Marine 1DD1-36. In the budget for 1838 extraordinary credits were in theory renounced altogether: C.A., 8 and 10 December 1836, A.N., Marine BB8-868; <u>Budget, 1838</u>, p. 727.

and in addition would help the navy by keeping its steamers busy. (It was believed, with some justification, that machinery deteriorated more rapidly when idle than when in use.) The army was happy to drop the contract negotiations and accept the navy's offer, and in April 1833 the service began with seven steamers (nearly all that the navy had available) under the command of Corvette Captain Auguste Louvrier who, after having commanded Voyageur and other early steamers, was once again opening a new phase in French naval steam navigation.[1] The base for the Algerian service was established at Toulon, which, as a result, rapidly became the busiest steamer port in France.

From the very beginning, the needs of Algeria for steamers were practically insatiable. Experience with the packet line first showed the need to replace the older ships with Sphinx-class units, and then gave rise to the need for more ships. Nearly all the French naval steamers built in the 1830's were connected in some way with the expanding colony in Algeria, either on the regular packet service or on special missions. An additional reason for building a substantial number of steamers

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[1]The correspondence on the Algeria packets is in A.N., Marine BB4-1031: see particularly War to Navy Department, 12 September and 17 October 1832, and Minister of Marine to Toulon, 24 October 1832; Report to Chamber of Deputies, Budget for 1833, Ann. Mar., no. 52 (1833), p. 504; Eschasseriaux and Dupin in Chamber of Deputies, 21 March 1833, Arch. Parl., 81:408-409; Dubreuil, "Toulon," pp. 20-26; Michel Barak, "Quelques tentatives marseillaises d'organisation de la navigation à vapeur (1832-1854)," Provence historique, no. 83 (1971), pp. 50-51; Giraud, Vapeur à Marseille, pp. 18-19.

was that the navy wanted to keep Indret and several private engine builders supplied with a steady stream of work. But there were also limits to the navy's steamer building program during the 1830's. The size of the budget was naturally the main one. In addition, as Charles Dupin explained to steam enthusiasts in the Chamber of Deputies in 1833, the navy did not want to commit itself excessively to a technology that might in a few years become obsolete, and it did not want to build steamers so quickly that the program of thirty ships would be reached in a few years and construction would have to stop.[1] The budgets thus provided a modest program of steamers (about three per year between 1834 and 1837), which was still a large program compared to the amount of work done on sailing ships during these years and which ensured that the steam navy, though not benefiting from new innovations, would at least not decline in numbers as the sail navy was doing.

Establishing an Industrial Base

In one crucial respect the steam navy did not stagnate in the 1830's, for during this period important efforts were made to establish its industrial base. The key to this effort was Indret, which was just coming into production in the early 1830's. When initially established, Indret had been given instructions to build the hulls and engines of six steamers beginning in 1829, and two more were assigned in 1830. However it was unable

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[1] Report to the Chamber of Deputies, Budget of 1834, 30 May 1833, Arch. Parl., 84:380.

to live up to this ambitious program, and was only able to begin on time two hulls, Crocodile and Castor, while construction of a third, Ardent, had to be transferred to Brest. In 1830 only one additional hull, Vautour, was begun at Indret, while four in the program, Chimère, Salamandre, Fulton and Phénix still had not been begun. While retaining Indret as the primary source of steamers, the navy began to experiment with building some hulls in the naval ports. In 1830 two were ordered built at Cherbourg (where a small repair facility was being established to support the small steamers working on the new breakwater), while in 1831 Fulton was transferred to Rochefort, Phénix was dropped, three new steamers were added at Toulon and only one was added at Indret. These changes apparently brought the program into balance with Indret's capabilities, for during the next several years it nearly monopolized the construction of steamer hulls. In 1832 it got back one of the ships that had been transferred to Toulon in 1831, and it then received orders for all the hulls and many of the engines for the thirteen steamers in the 1834-1837 programs. Construction of steamers in the dockyards during the mid-1830's lagged: the two ships ordered at Cherbourg in 1830 were cancelled, and the ports received an order for only one more ship under the 1833-1837 programs. Thus by the mid-1830's Indret was functioning as

planned as the primary supplier of steamers, and was capable of maintaining a respectable rate of production.[1]

Indret was as slow in beginning production of engines as it was of hulls. Of the four ships begun in 1829 and 1830, it was only able to provide engines for two, Crocodile and Vautour. In June 1831 the navy received an offer from an entrepreneur to help establish a government steam engine factory near Paris which would be able to produce ten large engines annually. However a navy commission, including Charles Dupin and Jean-Baptiste Marestier, decided that, while Indret had been a good idea, any supplementary steam engines that were needed should be provided by private industry rather than by a second government plant.[2] Opinion in Parliament tended to agree: one member in 1832 said that Indret was valuable as a model installation for advancing the state of the art, but he opposed any further increase in it which, he claimed, would be at the expense both of the taxpayer and of private industry.[3] It was in the direction of private industry that the government began to move in 1831.

The particular problem faced in 1831 was to build four 160-horsepower engines which had been added to the program after

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[1] See annual lists of ships building and ordered in Budget, 1829 through Budget, 1837.

[2] Ports to Minister, 11 June 1831, and report of committee dated 23 July 1831, A.M., Marine 1DD1-26.

[3] General Tirlet in Chamber of Deputies, 27 March 1832, Arch. Parl., 77:41.

Indret's work schedule had been reorganized: two for *Salamandre* and *Chimère*, which had just been increased in size from 80-horsepower, and two for *Météore* and *Fulton* whose hulls were to be built at Rochefort. The navy found that all the private firms except Périer with which it had done business in the 1820's were no longer building steam engines,[1] and that of the remaining French engine builders there were two clear leaders: François Cavé of Paris and Alexis Hallette of Arras.

Francois Cavé was born in 1794, the son of a rural carpenter, and entered the mechanical profession in 1820 as an employee of an English manufacturer at Paris. He caused a sensation in 1822 by designing and building for his employer a new type of steam engine. (Its cylinders, instead of being fixed, oscillated back and forth as the engine ran.)[2] In 1823 he went into business for himself, and he subsequently built a large number of engines for factories plus a series of iron-hulled river steamers. He continued to develop new designs for his products: his river steamers, for example, had special hull lines and also used an early type of feathering paddle

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[1]Ports to Minister, 8 April 1830, A.M., Marine CC7-1675.

[2]Cavé does not appear to have innovated this engine, but instead to have imitated one brought from England by Manby and Wilson. His production of it with next to no capital or industrial resources was still a remarkable achievement. Jacques Payen, "La Technologie des machines à vapeur en France de 1800 à 1850," in *Actes du colloque international sur l'acquisition des techniques par les pays non-initiateurs, Pont-à-Mousson, France, 1970* (Paris, 1973), p. 393.

wheel. He achieved a new triumph when he supplied the machinery for a French cross-channel postal packet, Courrier, which was launched in 1830 and proved to be faster than the English steamers on her route. He followed this with an engine of 140 horsepower for a tug, Neptune, which remained the most powerful steamer in the French merchant marine until 1837.[1]

Alexis Hallette, born in 1788, took over in 1819 a hardware business that his father had established at Arras in 1810 and, with the help of a number of British mechanics, some of whom had originally come to Arras as prisoners of war, enlarged it to a point where he could start building steam engines in 1822. He does not seem to have produced any technological innovations comparable to Cavé's oscillating-cylinder engine, but he built a lot of machinery, including some engines for coastal and river steamers, and achieved a reputation for the simplicity and the solidity of his products.[2]

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[1] Emile Jonveaux, "La légende des inventeurs: IX: François Cavé," Revue Britannique, May 1866, pp. 43-74; Bulletin de la société d'encouragement pour l'industrie nationale 33 (1834):277-279; ibid. 41 (1842):469-473; Maurice Daumas, "Les mécaniciens autodidactes français et l'acquisition des techniques britanniques," in Actes du colloque international sur l'acquisition des techniques par les pays non-initiateurs, Pont-à-Mousson, France, 1970, pp. 323-326; Jules Gaudry, "Notice sur François Cavé, constructeur de machines," Mémoires et compte rendu des travaux de la société des ingénieurs civils 30 (1875):486-499.

[2] Daumas,"Mécaniciens autodidactes," pp. 314-317; Bulletin de la société d'encouragement pour l'industrie nationale 41 (1842):475-477; Gaudry, "Cavé," p. 489.

The navy engines offered a big challenge to both firms, for they were bigger than anything either had ever built before. To build them the firms had to make major improvements in their facilities. Cavé, for example, had to buy or make a new machine to bore cylinders, new hammers to forge the main shafts, and new instruments to adjust and align the machinery. He also had to set up his own boiler shop, as the firms that had previously built boilers for him could not supply ones large enough for the navy engines.[1] However, while the difficulties were great, so were the possible rewards. The prices for steam engines were such that the sale of even a modestly-sized one (20 to 40 horsepower) would provide the capital needed to build two others and perhaps more, leading to quick prosperity if times were good. An order for a large engine of 160 horsepower could make the firm's owner's fortune, which he would normally reinvest at once in the business; and the prestige from such orders would also give him access to more capital through loans and credit.[2] The navy hoped that these incentives would lead to the creation of the private factories that it needed as an industrial base for the steam navy, and Hallette and Cavé found that the risks of the enterprise were well worth taking. In late 1831 Hallette bid successfully for a contract for an engine of 160 horsepower

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[1] Jonveaux, "Cavé," pp. 63-64.

[2] Daumas, "Mécaniciens autodidactes," p. 322. The other main ways of establishing one's reputation at this time were through awards at the septennial Paris expositions or through medals awarded by the Société d'encouragement pour l'industrie nationale.

for _Fulton_ similar in all respects to the machinery of _Sphinx_, and in mid-1832 Cavé won a contract for the engines of _Chimère_ and _Salamandre_, again similar to those of _Sphinx_, while Hallette was given a contract for the machinery of _Météore_ on similar terms.[1]

By 1834, as these engines neared completion, it was clear that the first experiment with private engine builders had succeeded. Both Cavé and Hallette had had some difficulty in equipping their factories to produce such large engines, and both had been unable to meet the delivery dates in the contract, but they had solved most of their problems and had built good engines. Both firms now needed additional orders to keep their facilities busy, and the navy felt that it was in its interest to encourage private industry to continue developing its capabilities by making available to it a steady supply of contracts. Parliament agreed, and designated about 800,000 to 1,000,000 francs per year during the 1830's for the construction of steam engines in private facilities.[2] Under the budgets for 1834 and 1835 the navy had funds for four more sets of engines, and decided once again to put them up for competitive bidding. However this time it decided to limit bidding to the firms that it felt had sufficient experience with marine engine construction

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[1] Ports to Minister, 7 April 1832 and 11 July 1832, A.M., Marine 1DD1-28. In 1832 it was proposed to award a fourth engine to Périer but this was not done.

[2] Report to the Chamber of Deputies, Budget for 1835, 25 April 1834, _Arch. Parl._, 89:311.

and sufficient tools to guarantee successful completion of the contract. This clearly favored the two firms that had already built similar engines for the navy, and the other two firms that were invited to bid, including Périer, did not bother to do so. As a result Cavé got the order for two more engines and Hallette got one, while the navy, apparently surprised and disappointed by the lack of additional bidders, deferred the award of the fourth engine.[1]

The same process was again followed in 1836 for two more engines. Initially the navy only invited Hallette, Cavé and Périer to bid, but a fourth firm was admitted on its own request. Hallette won the contract for one engine, and Cavé was awarded the other on similar terms.[2] For a similar competition in 1837 the navy expanded the list of invited bidders to six: Hallette; Cavé; Périer; Sudds, Atkins and Barker of Rouen; Stehelin and Huber of Thann; and Louis Benet of La Ciotat. Of the new firms, Benet had just set up a large factory near Marseille, backed by the largest shipping interests of that city, while Stehelin appears to have been one of the prime suppliers of textile machinery for the region around Mulhouse. A seventh firm petitioned successfully to be added to the list, MM. Schneider frères et Cie., the new owners of the mines, forges and foundries

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[1]Ports to Minister, 23 July and 10 September 1834, A.M., Marine 1DD1-32 and 7DD1-20.

[2]Ports to Minister, 30 March, 6 April, 28 May, 18 June, 20 July and 3 August 1836, A.M., Marine 1DD1-35.

of Le Creusot. The Schneider brothers, Adolphe and Eugene, were in the process of resurrecting the extensive facilities at Le Creusot from a long period of bankruptcy and inactivity, and in this competition they made their first appearance as prospective suppliers to the navy.[1] The contract was actually won by one of the new firms, Sudds, a late version (if not descendant) of the English-run firms of the 1820's. Its chief engineer appears to have been an English mechanic named Turner, who had previously worked for Hallette and before that for one of the British firms in France, Emile Martin. Sudds was also well known for its extensive assortment of the latest English equipment.[2] The contract for another 160-horsepower engine was won in November 1837 by another newcomer, R. de Villack et Cie. of Charenton, who appear to have taken over the factory of Manby and Wilson.[3] Thus by the end of 1837 several firms were bidding successfully for contracts to build large naval steam engines, and three of them, Cavé, Hallette and Schneider, appeared to be particularly well established in the business.

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[1]Joseph-Antoine Roy, Histoire de la famille Schneider et du Creusot (Paris, 1962), pp. 21-34; J.-B. Silly, "La Reprise du Creusot, 1830-1848," Revue d'histoire des mines et de la métallurgie 1 (1969):233-278.

[2]Ports to Minister, 13 August, 21 August, 27 September and 25 October 1837, A.M., Marine 1DD1-38 and 7DD1-27; Ports to Minister, 20 February 1839, A.M., Marine 1DD1-44. For Turner see Boucher to Minister of Marine, 9 April 1840, A.M., Marine 7DD1-56.

[3]Ports to Minister, 25 October, 26 October, 1 November, 15 November and 6 December 1837, A.M., Marine 1DD1-38.

Deferring Technological Innovation

To build a sizeable number of usable steamers and develop the industrial base to produce them was a big job for a country that had started practically from scratch, and in the process the French navy found that it had to do without some things. One of these was technological progress: while the navy kept in touch with events in England, it found it necessary to freeze the design of the engines that it built or bought for its ships. The idea of choosing a good model and carefully imitating it was a strong tradition in the French navy: it had been applied to battleships since 1786 and to frigates since the Napoleonic Wars. In the case of steam, such standardization had the advantage of facilitating construction of the engines and ensuring that they would work, but it overlooked the fact that, unlike sail, steam was in a phase of rapid technological change. The price of standardization was therefore high, for it inevitably led to the premature technological obsolescence of the ships.

The decision to standardize the design of the navy's steamers came only after a flurry of innovative efforts in 1830-31. The navy had already taken a chance in granting the contract for the engine of Ardent to an engineer, Frimot, who had been suggesting an improved form of steam engine since the mid-1820's, despite the fact that he lacked both capital and industrial resources. In 1830 the navy granted a contract under similar circumstances to MM. Pelletan et de la Barre for a 40-horsepower engine on a pattern proposed by them which dispensed

with paddle wheels.[1] Later in the year it also granted a contract for an experimental 60-horsepower engine to MM. Dumoulin et Cie., who cited the advantages of their design and also the need "to aid an interesting branch of industry and to occupy a numerous and agitated class." (This was just after the July Revolution.)[2]

About this time the success of Sphinx showed the navy that it had at least one reliable steam engine that it could count on, and the navy ordered in August 1830 that the first 160-horsepower engine to be built at Indret (for Crocodile) should be an exact copy of the British engine.[3] However the navy received two more serious suggestions for improved types of engines. The first was from the director of Indret, Philippe Gengembre, who had strong ideas on steam engine design and wanted the navy to try a number of improvements. He first proposed replacing the low-pressure engines in a ship he was building for Senegal (the second Africain) with medium pressure engines of 40-horsepower. This would enable dispensing with the condenser and would, he claimed, be lighter and more reliable than the standard Watt model. His more important proposal, which was accepted in April 1830, was to build a set of high-pressure

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[1]The ship was named Remorqueur. Ports to Minister, 24 June and 9 October 1830, A.M., Marine 1DD1-20.

[2]This ship was named Rameur. Ports to Minister, 4 September 1830, A.M., Marine 1DD1-20.

[3]Trial report of Crocodile dated 5 January 1833, A.M., Marine 7DD1-14.

engines of 160-horsepower on his pattern, which would be installed in Vautour and tried against the Watt-type engines in Sphinx or Crocodile.[1]

The second major suggestion came from Cavé, who had specialized in high-pressure oscillating-cylinder engines and who proposed in January 1831 building an experimental set of 160-horsepower for the navy. A number of delays ensued, but the navy remained highly interested in the project and reserved funds for it in the 1832 budget. However additional delays occurred when the navy balked at Cavé's price, and in the meantime opinion began to turn against high-pressure engines and against experiments in general.[2]

The biggest factor in the change was undoubtedly the continued success of Sphinx, particularly when compared with the increasingly evident inadequacies of her French-built predecessors, which were themselves the product of a period of experimentation. Another factor was the failure of the experiments of 1829-30: Frimot's and Pelletan's engines were complete failures, while the engines of Dumoulin, both in the navy ship and in the mercantile Scipion, were of dubious value and were built on a system said to have been long since abandoned by the

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[1] Ports to Minister, 6 October 1830, A.M., Marine 1DD1-20. The engine of Vautour is described in Jacques Armengaud, Publication industrielle des machines, outils et appareils, 29 vols. (Paris, 1843-1884), 2:169-184.

[2] Ports to Minister, 21 January 1832, A.M., Marine 1DD1-28; Ports to Minister, 25 October 1834, A.M., Marine 1DD1-32.

British. When Dumoulin asked to build another engine for the navy, this time of 160-horsepower, the whole question was submitted to the Council of Works.[1]

The council came down decisively against further experimentation, advising the minister to reject not only the proposed engines of Dumoulin but any (including those of Cavé) "built on any system which does not have an incontestable superiority over that of Watt, as applied to navigation by Maudslay and Fawcett." They said the navy should use a single type of steamer at sea with engines of uniform power, and smaller steamers with engines on the same system for harbor service. The advantages of this would be improved manufacturing, since designers would no longer be tempted to tinker and workers would soon become familiar with the standard models; more efficient operation, since seagoing engineers would only have to learn to operate one type of engine; increased safety and ease of repair, since spare parts could easily be made available and ships out of service could provide parts to those in use; and finally "encouragement for private industry, because, with the government having renounced changes in design in order to adopt a

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[1] On the Pelletan engine see Ports to Minister, 7 February 1835 and 7 April 1838, A.M., Marine 7DD1-43. On Dumoulin see Ports to Minister, 11 July 1832, A.M., Marine 1DD1-28. The problems with Scipion were serious for the French merchant marine, as she was the first seagoing steamer to be based at Marseilles.

good system, industrialists and speculators will follow an example which will guarantee them success."[1]

This decision, approved by the minister on 11 July 1832, insured that all the steamers built by the navy in the next several years would be copies of Sphinx. (Ultimately the class, excluding Ardent but including three others with special 160-horsepower engines, would number twenty-two units.) The decision appeared to be vindicated shortly thereafter by the successful trials of Crocodile, which proved that Indret, and presumably French industry in general, was able to make good copies of Fawcett's engines.[2]

This policy did not stop experimentation altogether, however. Cavé temporarily dropped his proposal to build an oscillating-cylinder engine for the navy when he won the contract for two standard 160-horsepower engines, since he would have been hard put to build a third engine at the same time. However he revived his proposition in 1834, and the navy was again attracted by the simplicity, compactness and light weight of his engines and their supposed low cost and low fuel consumption. The negotiations appear to have stalled again over price and contract terms, though in the process Cavé did receive authority to try

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[1] Ports to Minister, 11 July 1832, A.M., Marine 1DD1-28, citing the Council's decision. The Council later explained its decision on 19 July 1834, agreeing that the engines of Sphinx were far from perfect but stating that at the time it was more important to stay with something that worked than to make further experiments. C.T., 19 July 1834, A.M., Marine BB8-1109.

[2] Trial Report of Crocodile dated 5 January 1833, A.M., Marine 7DD1-14.

another of his innovations, a system of feathering paddle wheels, on one of the standard sets of machinery that he was building for the navy.[1]

Other engineers also made proposals for new types of 160-horsepower engines. In 1834 and 1835 Vautour, with the high-pressure engines designed by Gengembre, was tried against Styx, which had engines on the pattern of Sphinx. While Gengembre's engines did have some advantages, the trial board noted that they also experienced excessive wear and vibration which nullified the anticipated fuel economy and raised doubts (subsequently justified) about the reliability of the machinery in extended service.[2] Not daunted, Gengembre proposed making a number of changes to the standard models being used for 160-horsepower engines, but he was told in no uncertain terms to make none besides substituting one type of English throttle valve for another.[3] (When Gengembre died in 1838 it was found that he had disobeyed these orders.) The other main proposal came from the British firm of Fenton, Murray and Jackson of Leeds, and their system offered such clear benefits in safety of operation and price that the navy sent an engineer to Britain

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[1] Ports to Minister, 25 October, 13 November, 29 November and 13 December 1834, A.M., Marine 1DD1-32.

[2] C.T., 12 March 1835 and 20 October 1836, A.M., Marine BB8-1114.

[3] C.T., 30 July 1835 and 19 January 1837, A.M., Marine BB8-1114.

to buy a set for one of the 160-horsepower steamers, Papin. This ship was tried against one of the standard 160-horsepower steamers, Cerbère, in 1836, and was shown to be superior to her in all respects. The Council of Works recommended that if Papin's engines held up under several years of service, they should replace those of Sphinx as the standard pattern for future ships.[1]

The navy made practically no effort to improve boiler design during the 1830's, in spite of the fact that Frenchmen as well as Englishmen were already experimenting with a much improved type, the tubular boiler. The navy limited its efforts to trying to find a way to reduce the fouling of boilers, and it paid 20,000 francs to an inventor for the rights to a process which consisted of putting a clay-like substance into the water which would absorb the salts before they could harden on the boiler surfaces. However boilers continued to require frequent purgings and cleanings, and continued to deteriorate rapidly under even the best of care.[2]

Technological progress thus did not stop altogether in the French steam navy in the early and mid-1830's, but the

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[1] C.T., 20 October 1836, A.M., Marine BB8-1114. Parliament was not opposed to such experiments if safety and economy were the results: Report to Chamber of Deputies, Budget for 1835, 25 April 1834, Arch. Parl., 89:313.

[2] The innovator's name was Chaix, and he was granted the Legion of Honor in return for refraining from asking a higher price. C.A., 8 November 1836, A.N., Marine BB8-868; C.A., 2 May 1837, A.N., Marine BB8-869; Minister of Marine to Louis-Philippe, 19 May 1837 and 14 June 1837, A.M., Marine 1DD1-38.

decision to build only Sphinx-class steamers meant that such innovations as there were consisted of improvements in detail to existing technology rather than efforts to advance the overall state of the art. Sometimes improvements in detail can have a major impact, but in this case they did not, and the main technological problems of steam navigation: high fuel consumption and great weight of engines, continuous boiler problems and inefficient paddle wheels, all remain unresolved.

Another problem faced by the French navy was that of finding enough trained engineers to operate the machinery at sea. Initially it had to contract with individuals, usually Englishmen, to operate the ships. The main advantage of this system, besides providing for day-to-day operation of the ships, was that it offered a good way of importing English technical know-how. For example, an engineer named Taylor, who had helped to build and install the engine of Sphinx, was hired to operate the ship for a year and to teach a number of Frenchmen his trade.[1] Shortly afterward, a Mr. Turner who had installed the engine in Castor was hired to remain aboard long enough to teach the ship's captain and chief engineer how it worked. (An effort was even made to get him to join the navy, but instead he seems to have joined private French firms, first Hallette, then Sudds.)[2]

[1] Ports to Minister, 7 January 1830 and 11 March 1830, A.M., Marine 1DD1-20.

[2] Ports to Minister, 12 October 1831, A. M., Marine 1DD1-26.

This system was retained into the 1840's for engines imported from Britain, but it was at best only an expedient, and the dependence on foreigners to run the ships and the high wages they demanded were an affront to French pride.[1] In 1831 the navy set up its first program to train engineers. The success of this initial effort was indifferent, but the number of capable French engineers slowly grew, both inside and outside of the navy; and these were ably supported by a number of line officers and officers in the naval construction corps who had learned the mysteries of steam engineering.

Towards the mid 1830's the navy began to face a new problem: trained engineers were in such high demand in French industry that the navy's engineers, particularly the naval constructors, were being lured into private service by offers of pay much higher than that given by the navy. Initially these men were able to take such positions while on leave of absence from the navy, but in 1836 the navy set a limit of one year on such arrangements, after which the engineer would have to make a final choice between naval and civilian employment. This slowed but did not stop the brain drain, and one continues to

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[1] It was these considerations that led one line officer to write the first practical manual for captains and engineers of French navy steamers in 1831: M. Janvier, Manuel du capitaine, du mécanicien et du chauffeur des bâtiments à vapeur (Paris, 1831), p. 8, and handwritten note by Admiral E. Pâris inside front cover of copy at Musée de la Marine, Paris.

find long afterwards some of the navy's best minds being drawn off into commercial employment.[1]

Encouraging a Steam Merchant Marine

The interest of the navy in developing steam navigation in France was not limited to its own ships and men, however. It understood from the beginning that a large steam merchant marine would provide additional ships for wartime service, would support a large steam engine industry, and would provide a large pool of experienced steam engineers. The French steam merchant marine, however, was still in a very primitive condition. It appears to have grown very little between 1827, when a reliable source listed sixty-four non-naval steamers, and 1833, when the first official statistics on the subject list seventy-five.[2] The statistics show that France had 160 steamers of 7493 horsepower in 1838, at a time when Britain had 677 of 54,361 horsepower and the U.S. was estimated to have 786 of 55,969 horsepower.[3] Furthermore, of these 160, only about a fifth were intended to navigate at sea, the rest being river boats, while only a handful ventured beyond French borders. The American figure included a large proportion of river and harbor craft,

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[1] Ports to Minister, 19 November 1836, A.M., Marine 1DD1-35; C.A., 1 December 1836 and 23 October 1838, A.N., Marine BB8-868 and 870.

[2] Tourasse and Mellet, Essai, pp. 16-22; France, Ministère des Travaux Publics, de l'Agriculture et du Commerce, Direction générale des ponts et chaussées et des mines, Compte-rendu des travaux des ingénieurs des mines, 1839, pp. 22-24, with corrected figures for 1833.

[3] Ann. Mar., no. 72 (1840), pp. 375-390.

but this was not true for Britain, some of whose steamers had gone as far as India.[1] The British, and to some extent the Americans, had a resource in their steam merchant marines that the French lacked, and the French navy was keenly aware of that fact.

There were two ways the navy could encourage the growth of non-naval steam navigation, either through subsidies to private entrepreneurs or through encouraging and assisting other government agencies in setting up government-run lines. In nearly every case the second alternative was chosen. There were many reasons that led to this outcome, but they all boiled down to the fact that the government, in particular the navy, wanted a steam merchant marine for its own reasons and felt that the most economical way to get such a merchant marine, in view of the economics of steam navigation, was to build and run it itself.

The first involvement of the navy in non-naval steam navigation was in the Calais-Dover postal packet line. This service had been operated by the Post Office using sailing ships until 1822, when the British example forced it to convert to steam. It bought one of its steamers in Britain (Henri IV, formerly Rob Roy), and asked the navy to have Marestier build the other (Duc de Bordeaux) at Rouen with the navy steamers.

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[1] The French proportions are deduced from the 1841 statistics: Ministère des Travaux Publics, Travaux des ingénieurs, 1842.

However this service consistently lost money, and in 1830 the post office sold the ships and transferred the service to a private company, which ran it in return for a subsidy. This company built a steamer, Courrier, with a hull by a shipbuilder, Augustin Normand at Le Havre, who was destined to become one of the best in France, and an engine by Cavé. The ship was a great mechanical success but she could not do the job alone, and, since she had only sailing ships for running mates, the service as a whole was found wanting.[1] The Post Office tried the same system in providing postal service to Corsica, contracting with a private company which built its own ships, this time three of them (Var, Liamone and Golo) with engines by the British firms of Fawcett and Maudslay. The machinery ran well, reinforcing the navy's faith in English machinery, but the service was poorly managed and again did not come up to expectations.[2]

In 1832 the postal convention of 1802 that governed the Calais-Dover service came up for revision, and as a prerequisite for renewal the British demanded that the French upgrade their materiel to match the three steamers that the British maintained on the line. The French post office acknowledged that the British were within their rights in demanding this, and that compliance would not only protect French honor and dignity but

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[1] Post Office note dated 23 November 1832, A.N., Marine BB4-1028.

[2] Post Office to Minister of Finance, 14 September 1838, A.N., C-817.

also promote French material interests by increasing the number of French steamers and providing additional seamen with experience in steam. For the sake of economy they proposed that the post office buy _Courrier_ and again take over operation of the line, while the navy was to build two more ships and man and maintain all three.[1] There was very little time to build the ships before the new convention was to come into force, and there was no French engine builder capable of providing the engines in that time. (Cavé, the most logical choice, was fully occupied with two engines of 160 horsepower for the navy, and except for these had never built a low-pressure engine of the type desired.)[2] The navy had to build the hulls of the two packets (_Poste_ and _Estafette_) at Cherbourg and order the engines, each of 50 horsepower, from Fawcett, who had proved themselves with the engines for _Sphinx_. The two ships entered service in June 1834, and served with _Courrier_ well into the 1840's. While the ships belonged to the postal department, the navy provided officers on loan to command them and in addition loaned the post office a naval constructor to handle all technical problems, including ship design, for them.[3]

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[1]Post Office note dated 23 November 1832, A.N., Marine BB4-1028.

[2]Documents #91-92 providing information in support of Supplementary Credits for 1834, A.N., C-766.

[3]This constructor, Louis-Just Moissard, made a study of British packet services, which he submitted on 27 January 1833, A.N., Marine BB4-1028.

The navy's attention was soon drawn to a much larger opportunity for the expansion of steam navigation. France had long had close political and commercial ties with the Levant, and these had been strengthened by the presence of strong French naval and military forces during the Greek war of independence in the late 1820's. The Navy, the Ministry of Foreign Affairs, and private merchants all needed fast, reliable communications with their representatives in the eastern Mediterranean. The navy had satisfied its needs by using its ten-gun brigs as packets, while other correspondence continued to be entrusted to the captains of merchant ships that were traveling in the right direction. During the 1820's there were surprisingly few steamers in the Mediterranean (there was none registered at Marseilles until 1831), and those that did put in an appearance only lasted a short time. However in 1830 steam came to the Mediterranean to stay: the experience of the French navy in Algeria showed that steam was capable of extended operations in that relatively sheltered sea, while in February 1830 the British navy, using most of its serviceable steamers, established a packet line between Falmouth, Cadiz, Gibraltar, Malta and Corfu, replacing a similar sail line. They did not immediately extend this line to the eastern Mediterranean, and the French soon became interested in establishing this service themselves. France had strong interests in that area, both commercial and political, which made it desirable not to have to rely on the English for communications; and in addition the geographic position of France was such that an efficient packet line from

Marseilles to the east could draw off much English traffic from the Falmouth packets. Thus the government began to receive proposals for the formation of a French Mediterranean steam packet line.

The first branch of the government to get involved with the idea apparently was the Ministry of Foreign Affairs, which early in 1831 sounded out the navy on the possibility of setting up a steam service to Italy (especially Civitta Vecchia and Naples) and more distant points such as Alexandria and Constantinople. The navy replied that it only had two ships (Sphinx and Nageur) that could be relied upon for such a service, that both of these were in use in Algeria, and that it lacked funds to build or buy more.[1] No further progress was made until early 1832, when the navy received and sent to the Ministry of Foreign Affairs a proposal from a certain M. Poidebard to set up a regular steamer service between Marseilles and Constantinople if the government provided a subsidy. At the same time the Ministry of Foreign Affairs revealed that it had been in touch with a group of French, Austrian and Russian companies at Constantinople which wanted to set up a similar service. The Ministry of Finances favored the latter group as they would not require a subsidy, but in the meantime these had renounced their project to avoid competing with Poidebard. In May 1833, pointing

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[1] Ports to Minister of Marine, 9 February 1831, and other correspondence in A.N., Marine BB4-1028.

to a similar decision concerning sail communications with Mexico, the Ministry of Finances pointed out that communications via merchant ships were usually slower and less precise than by navy ships, and proposed again that the navy take on the job of providing communications with the Levant. The navy's estimate of the cost of such a service was once again unacceptably high, and the three ministries agreed toward the end of 1833 that the contract for the line and its subsidy would be put up for competitive bidding. The post office, under the Ministry of Finances, would do most of the legal work, but the navy was to provide technical assistance.[1]

During 1834 the postal department made extensive studies of the problem in the process of preparing the contract, and ultimately reported to the Minister of Finances in October 1834 that the service would need ten steamers of about 140 horsepower and 300 to 320 tons.[2] The Director of the Post Office made the project known to the navy, and also to leading merchants at Marseilles, who laid the groundwork in December 1834 for a private company which would bid for the contract. The director of the company was to be Pierre Andriel, who had brought the steamer Elise to France in 1816. Its intentions were to bring steam navigation eventually to all parts of the Mediterranean basin.[3]

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[1] Minister of Finance to Minister of Marine, 9 May, 20 July and 4 December 1833, A.N., Marine BB4-1028.

[2] Post Office to Ports, 30 October 1834, enclosing report dated 15 October 1834 for comment by the Navy, A.N., BB4-1028.

[3] Giraud, Vapeur à Marseille, pp. 21-24; Barak, "Tentatives marseillaises," pp. 51-56; Report signed Miège (French consul at Malta), 24 March 1835, A.N., Marine BB4-1028.

However the government had not yet made its final decision on the project, and instead of accepting outright the report of the Post Office and proceeding with the bidding, the Minister of Finances referred it to a special commission on which the naval constructor Mathurin-François Boucher, Tupinier's right-hand man, represented the navy. Boucher expounded to the commission the virtues of the navy's 160-horsepower steamer, which at 700 to 750 tons was over twice as large as the ships proposed but which had proved to have all the qualities desirable for operations in the Mediterranean. In addition, of course, additional copies of Sphinx would be easily incorporated into the navy in case of war. At length the commission agreed that the ten ships should be of this type; and, in addition, to ensure that the ships would have the solidity and special fittings necessary for naval auxiliaries, it decided that they should be built in the naval dockyards. The navy also asked for and got the responsibility for ordering the engines, fearing that a private company would choose its engines for profitability instead of long-term durability.[1] Not surprisingly, the navy applauded the findings of the commission and urged the Ministry of Finances to pursue the project.[2] The company at Marseille was now actively campaigning for the contract for the line, but

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[1]Minister of Finance to Minister of Marine, 9 February 1835, enclosing report of commission (meetings of 23, 24, and 27 December 1834), A.N., Marine BB4-1028.

[2]Minister of Marine to Minister of Finance, 19 February 1835, A.N., Marine BB4-1028.

the decision that the government build the ships and that their dimensions be dictated at least in part by military needs made it almost inevitable that the government would eventually decide to run the line itself. (The influence of ship design was shown by the fact that the Marseilles company asked a subsidy of 1,500,000 francs if 160-horsepower ships were used, but only 600,000 francs for 100 to 120-horsepower ships.) The bill as presented to Parliament provided for a government-run line of ten Sphinx-class steamers, and the Marseilles interests were unable to reverse the decision in the Parliamentary committees or on the floor of the Chambers.[1]

The historian of shipping at Marseilles blamed the Parliamentary decision on the influence of sailing ship firms who saw the government as a safer competitor than private steamship lines, which would soon try to expand their business from mail and passengers to freight.[2] However the influence of the navy was at least as significant: Tupinier's assistant, Boucher, had helped write the bill, while Tupinier himself, who had been a deputy since 1834, not only voted on the bill in the Chamber of Deputies but previously had sat on the Parliamentary committee that had examined it. But perhaps even this degree of influence was not necessary to bring about the result, for the economics

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[1] Bill on Mediterranean packets, 23 March 1835, P. V. Députés, 1835, 4:217-21; Report to the Chamber of Deputies, 12 May 1835, P.V.Députés, 1835, 6:181-91; Debate, 28 May 35, P.V. Députés, 1835, 6:538-40.

[2] Giraud, Vapeur à Marseille, pp. 21-24. See also Barak, "Tentatives marseillaises," pp. 54-56.

of steam navigation was still unfavorable for a private enterprise. A steam line required an enormous initial outlay of capital for the ships, and exposed the firm to sudden losses through shipwreck. In return they could only hope to profit from passengers and mail service, since paddle steamers were not well suited for carrying cargo. (Their machinery took up most of the space normally reserved for cargo, while any variation from the designed waterline due to loading or discharging cargo would reduce the efficiency of the paddle wheels.) It was, in fact, impossible to think of setting up such a service without a large government subsidy, and under these conditions Parliament agreed with the government that the money was best spent on a government line. The bill therefore passed the chambers essentially as written and became law on 2 July 1835.

The arrangements for the operation of the Levant packet line were similar to those for the Calais-Dover line. The ships belonged to the postal department, which operated the service; while the navy built and maintained the ships and provided the crews. The ships were built in the navy yards, to the disadvantage of the navy's own program, which "in the interests of the working class" was slowed down while the packets were being built in order to maintain a stable level of work and employment in the dockyards.[1] As many of the engines as possible were allocated to Indret and French industry, but such a large order

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[1] Ports to Minister of Marine, 8 July 1835, A.M., Marine 1DD1-34.

on top of the navy's own program quickly saturated these facilities and six of the engines had to be ordered in England. The ships were designed with strong framing for naval use, and were intended to carry the same artillery as the navy's 160-horsepower class.[1] The first sailing of the new service was by the packet Scamandre, which left Marseilles on 1 May 1837 for the Levant.[2]

Towards Larger Steamers: 220 Horsepower

Through the mid-1830's, the steamers built by the navy (including the postal packets) were almost exclusively of the 160-horsepower Sphinx-class. However around 1830 the British began building steamers that were somewhat larger--200 to 220 horsepower. From time to time suggestions were made that the French do likewise, but they ran into repeated delays, due in part to overt opposition but generally to the lack of a sense of urgency among the navy's administrators charged with the project. The result was that it took eight years from the time of the initial proposal for the navy to launch a steamer larger than Sphinx.

Nothing shows more clearly than this slow response to the proposal for increased horsepower the attitude towards technological change that prevailed among the navy's officials during the early 1830's. Their lethargy was based, for the most part, not on opposition to technological change, but on a lack

[1] C.T., 6 July 1835, A.M., Marine BB8-1114.

[2] V. Bourselet, Les paquebots français et leurs cachets, 1780-1935 (Paris, 1936) discusses the postal side of the packet services.

of awareness of it. Theirs was a static world, and they took it for granted that steam technology, and the uses to which steamers were put, would stabilize, just as the technology of sailing battleships had stabilized in 1786 with Sané's designs. To be sure, sailing ship technology had been upset momentarily around 1819 by the introduction of the 24-pounder gun in frigates, but it had quickly been restored to equilibrium by Tupinier in 1822. Experience with the Sphinx-class had not indicated any need for an increase in the horsepower of the navy's steamers, and the navy's officials felt that, just as Tupinier's designs had become the standard types of sailing ships, the Sphinx-class had proved itself and would remain the standard steamer class in the navy for the foreseeable future.[1]

An example of this attitude was provided by the Council of Admiralty in a recommendation it made in 1834 that the navy should reconsider its policy of encouraging further development of the French steam engine industry. The council pointed out that the navy would soon have the thirty steamers allowed by its program and that, once it did, the only new construction work on steamers would consist of repairs and replacement of the few ships that would wear out or be lost. Indret and the repair facilities in the ports could handle this work, and the council felt the navy should avoid encouraging private industry by further expanding a market that it would soon necessarily lose.[2]

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[1] C.A., 28 October 1834, A.N., Marine BB8-866.

[2] Ibid.; Ports to Minister, 20 December 1834, A.M., Marine 1DD1-32.

However in the 1830's the navy was in fact entering a new technological era. Its officers did not see intuitively what steam engineers were beginning to recognize professionally: that steam technology was constantly capable of improvement, and that these improvements would constantly be opening new capabilities and new fields of activity for steam. These engineers do not seem to have been inherently any wiser than the traditionalists--there were no outstanding visionaries among them--but their self-interest and professional qualifications were carrying them with the times. The French navy was, in fact, on the brink of a technological spiral, in which change did not bring a new level of stability but instead suggested the possibility of further change. Such spirals had occurred before, but had usually acted over a period of centuries and were rarely perceived by the participants as a continuous process. In this case, however, the spiral was to be telescoped into the period of a lifetime, and its revolutionary effects would soon be apparent to all. The proposal to make the first increase in horsepower for seagoing French naval steamers was simply the first upward step in the spiral.

The specific technical reason for adopting increased horsepower and size for steamers at this stage was that large steamers could travel further under steam than smaller ones, since their hulls could carry more coal.[1] (They would also be

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[1] C.T., 17 January 1831, A.M., Marine BB8-1110.

more seaworthy.) This was important, since one of the main arguments against the military use of steamers was that they were unable to operate at sea for extended periods of time or far from their supply of coal.[1] The Council of Works saw this as early as 1831, but it was in a minority. Many believed, with the Council of Admiralty, that the increased coal capacity would be offset by the increased rate of fuel consumption of the larger engines. (The admiral who was minister of marine from 1832 to 1834 shared this belief, and felt that eleven days was the maximum possible endurance for steamers.)[2] The Council of Admiralty felt that the only use for higher horsepower was to give ships greater speed or to permit them to carry more weight (generally in the form of guns). When faced with a proposal to build a 220 horsepower engine in 1834, the Council of Admiralty consented to the project as an experiment but indicated that the only use it could find for the engine was to put it into a ship designed especially for port and harbor defense, where its extra power would be used to carry extra guns.[3] It took considerable time and experience to show that increased horsepower

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[1] Coal consumption, followed by the weight of the machinery, were cited by the Minister of Marine as the main limitations of steamers as of 1831: they prevented the ships from carrying much cargo or traveling very far. Ann. Mar., no. 44 (1831), p. 367.

[2] Rigny in Chamber of Deputies, 26 March, 1832, Arch. Parl., 76:767.

[3] C.A., 28 October 1834, A.N., Marine BB8-866.

did, in fact, give increased endurance under steam, for while the carrying capacity of a hull (including its fuel capacity) increased as the cube of its dimensions, its resistance, or the power needed to drive it through the water, increased much more slowly, as the square of those dimensions.[1]

In spite of all these doubts and misconceptions, the Ministry of Marine did undertake, and finally achieved, the development of a steamer larger than Sphinx. Greater endurance under steam, higher speed and the ability to carry more guns were all offered as arguments in favor of the project. The mere fact that it was technically feasible was sufficient to guarantee that the navy would receive proposals that it be done. But the main reason why it was done seems to have been the British example. During the 1820's the British navy had built a series of mediocre steamers of 80 to 120 horsepower, some of which were literally ten-gun sailing brigs which had been cut in half on the ways and given steam engines. However at the end of the decade the British merchant marine had developed steamers in the 200 to 220 horsepower range, and the Royal Navy imitated it and launched five similar ships in 1832 and 1833.[2]

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[1] Rowland, Steam at Sea, p. 73. For a contemporary explanation see Ann. Mar., no. 66 (1838), pp. 525-528.

[2] One of the early French reports on these British ships, dated 14 September 1832, is in A.M., Marine BB7-1. For lack of an intelligence bureau, it was prepared by the navy's historical section from information in London newspapers.

It seems to have shared the French doubts concerning the need for such ships, for it did not build more large steamers until the late 1830's, concentrating instead on building packets of moderate power for the various navy-run packet lines and relying on the large British merchant marine and steam engine industry to supplement its forces in time of war. However the example the British had set of an advance in horsepower was quickly noted in France, and in 1831 the Council of Works, after reviewing the various other reasons for increased horsepower, noted that these had perhaps not been the primary motivation for the ministerial decision to develop a 200-horsepower steamer: "The British have some, and this motive perhaps sufficed to make up the minister's mind."[1] The pressure to keep up with foreign nations increased as time passed: in May 1835 the Parliamentary reporter on the 1836 budget noted that France had fallen behind not only Britain and America in the size of its steamers, but even behind the Viceroy of Egypt.[2]

The first move of the French navy towards the actual development of larger steamers was taken in June 1830, when the minister of marine instructed the naval constructor Jean-Baptiste Hubert, who had purchased the engines for _Sphinx_ in England and built the ship at Rochefort, to use his knowledge of British

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[1] C.T., 17 January 1831, A.M., Marine BB8-1110; Ports to Minister, 25 October 1834, A.M., Marine 1DD1-32.

[2] Report to the Chamber of Deputies, 29 May 1835, _Arch. Parl._, 96:629.

practice to draw up plans for the hull of a steamer of 200 horsepower.[1] The project was "interrupted by the effect of events" in 1830, but in 1831, during initial negotiations with Cavé, Périer and Hallette for the construction of engines of 160 horsepower, Hallette offered to build one of 200 horsepower at a proportionally higher price. Hallett's eagerness for the contract was increased "by the need to find ways to occupy his workers." He was invited to go to Rochefort to meet with Hubert and draw up a contract.[2] The two submitted proposed plans for the hull and engines on 24 October 1831, but at this point the ministry drew back. Noting that Hallette had not yet built an engine for the navy, they decided that it would be more prudent first to give him the order for an engine of 160 horsepower similar to that of Sphinx so as to be able to judge his ability to build the larger one.[3] Accordingly on 18 November Hallette was given the contract for a 160-horsepower engine for Fulton, and the project for a larger ship was again shelved.

The navy clearly felt that the project was not urgent, for it did not take it up again until June 1833. By this time it had decided that all its engines were to be on the model of Sphinx, and on 28 June 1833 the minister ordered the director of

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[1] C.T., 17 January 1831, A.M., Marine BB8-1110.

[2] Ports to Minister, 31 August 1831, A.M., Marine 1DD1-26.

[3] Ports to Minister, 25 October 1834, A.M., Marine 1DD1-32.

Indret, Gengembre, to send plans for an engine of 220 horsepower, following as closely as possible those of _Sphinx_. Unfortunately this project became entangled in a contest of will between Gengembre and the ministry, for the former was determined to use as many of his own ideas in the new engine as possible, while the latter was determined to avoid the risk of experimentation. In September 1833 Gengembre's proposal to use high pressure steam was rejected, and in March 1834 the ministry slapped down a new design of his which was closer to the unsuccessful engine of _Souffleur_ than to _Sphinx_. In October 1834 Gengembre submitted new plans which incorporated many features of _Sphinx_'s engines but which still differed in the principle of their operation, and the ministry indignantly instructed him to follow his instructions and simply scale up the plans of _Sphinx_. While the ministry rarely showed itself less receptive to new ideas, it had good justification in this case: it had long since decided in principle against high pressure engines, the engines of _Souffleur_ had suffered from major design faults while those of _Sphinx_ had proved highly successful, and Gengembre's own efforts to improve on _Sphinx_ in his engines for _Vautour_ were viewed with considerable suspicion, which soon turned out to be justified.[1]

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[1] C.T., 7 September 1833, 15 March 1844 and 23 October 1834, A.M., Marine BB8-1113.

While the navy's effort to get the larger engine from its own factory bogged down in controversy, the idea of having Hallette build it came again to life. The navy had moved slowly on the project even after Hallette had proved he could build good 160-horsepower engines, because it feared that the English, in increasing the size of their engines, had made some technological advances that the French were not aware of. However Hallette, who had completed construction of his two 160-horsepower engines in late 1833, needed more work and revived the project. His engineer, a Mr. Turner (very likely the same who had put Castor in commission in 1831) was at Rochefort putting Hallette's engines into their hulls, and Hallette instructed him in May 1834 to meet with Hubert and update the plan for the larger engine. (In the process its horsepower was raised to 220, matching the British engines.) Meanwhile a French navy engineer visited England and reported that the new British engines, while larger, differed very little technologically from those in Sphinx.[1] In October 1834 the Director of Ports recommended proceeding with Hallette's project, but the Council of Admiralty objected and once again the emphasis in the 220-horsepower steamer project shifted back to Indret. The project finally went into high gear when in March 1835 Gengembre produced plans for an engine which at least appeared to conform to the

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[1]Ports to Minister, 25 October 1834, A.M., Marine 1DD1-32.

model of Sphinx. Plans for the hull were ordered from Hubert in 1835, and the ship, to be named Lavoisier, was begun at Indret in 1836 in lieu of one of the three 160-horsepower steamers in the budget for that year.[1] Another 220-horsepower engine was ordered from Indret in 1836, and a third in 1837.

The ministry, however, had serious doubts about the process it had followed in developing the new engines, and was not at all sure that Gengembre's engines would work. It was uneasy over the magnitude of the changes it had made in its steam engines, and over the fact that they had been made without the benefit of a British model. Thus, when it came time to distribute the money in the 1836 budget for steam engines, a way was found to include another 220-horsepower engine, which was to be bought in England. Tupinier argued that "we will thus have a good model to compare with the engines of the same power that M. Gengembre is making at the factory at Indret." He continued that, "it would be imprudent to entrust such an important piece of work to our private factories, which have not yet made any of these large engines." He noted also that the private plants were then full to capacity with private orders (the late 1830's were a period of economic boom), to the point that the navy's orders were seriously delayed; and he did not anticipate any objections from them, particularly if the two 160-horsepower

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[1] C.T., 26 March 1835, A.M., Marine BB8-1114; Ann. Mar., 66 (1838), p. 526.

engines in the program were ordered from them.[1] The extreme caution of the navy was reflected in the fact that, despite the wide variety of highly competent firms in Britain, Tupinier proposed going straight to Fawcett for the new engine. He cited the success of Fawcett's engine in Sphinx as justification, but he clearly also wanted to stick with a pattern of engine with which the navy was familiar rather than introducing a new and possibly better model by another British manufacturer. However the navy was curious about British techniques in fabricating engines, and the engineer who was sent to Britain to negotiate with Fawcett was also instructed to visit several other factories and report on any new tools or processes which might help perfect the navy's steam engine facilities.[2] The engineer made the trip in May 1836, and soon afterwards the ship that was to receive Fawcett's engines, Véloce, was begun at Rochefort. The plans for this ship and for Lavoisier benefited from British experience: the design was lengthened and the paddle wheels moved forward on Fawcett's recommendation.[3]

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[1] Ports to Minister, 30 March 1836, A.M., Marine 1DD1-35. The report to Parliament on the budget for 1839 expressed the hope that the navy could supply all its needs from Indret without going to private industry for engines. This sentiment, unusual for Parliament, was probably just an indication of good times and full order books. Report to Chamber of Deputies, 12 May 1838, P.V. Députés, 1838, vol. 5, part 2, p. 425.

[2] Ports to Minister, 30 March 1836, A.M., Marine 1DD1-35.

[3] C.T., 7 July 1836, A.M., Marine BB8-1114.

Later in 1836 one of the main barriers to the further expansion of the steam navy fell. During its planning for the 1837 budget, the navy had found in October 1835 that, after the three steamers scheduled for 1837, only four more would have to be built to reach the program of thirty.[1] However, just as this cutoff point was being reached, the debate over battleships and frigates caused the entire fleet program to come up for revision, and in August 1836 Tupinier took the opportunity to recommend a number of changes in the quantities of smaller ships, including raising the number of steamers from thirty to forty. He prophesied that steamers would soon become so useful that their use would spread to most of the overseas stations, and that the navy would need at least forty of 150-horsepower or more. The addition of a lower limit for horsepower was as important as the increase in numbers, for by putting the 160-horsepower class so near the bottom limit for seagoing military steamers, Tupinier in effect implied that henceforth the 220-horsepower steamer would be the standard class. Series production of the 160-horsepower _Sphinx_-class in fact stopped with a group of three units added to the 1838 budget immediately after the decision on the program, while production of 220-horsepower steamers went into high gear a year later in October 1837, when the king, in a special ordinance, approved adding three more to the four already on order. These three ships were specifically

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[1] Ports to Minister, 31 October 1835, A.M., Marine 1DD1-34.

intended for Algerian service: steamers had just transported an army regiment from France to Bône as part of a renewed effort to pacify the colony, and the navy pointed out that the availability of large steamers to transport troops to Algeria when needed would cut down on the number of troops that had to be maintained in the colony. Funds were to be borrowed from the sail program, and returned when the program of forty steamers was complete.[1]

The addition of these three ships to the program in 1837 indicated that other sources besides Indret would have to be found for the engines. The navy apparently felt that, due to experience with the 160-horsepower engines plus the availability of information from Britain, French industry could now handle the larger engines, and the engine for one ship, Pluton, was put up for competitive bidding in October 1837. By this time Périer was no longer bidding and the plant at Charenton was bankrupt, but five firms bid (Hallette, Cavé, Sudds, Stehelin and Schneider), of which Schneider won the order, his first from the navy.[2]

The results of this first attempt by the French navy to produce larger engines were mixed. Véloce and her British machinery proved to be a complete success, and by the end of

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[1]Ports to Minister, 16 October 1837, A.M., Marine 1DD1-38.

[2]Ports to Minister, 11 September and 12 October 1839, A.M., Marine 1DD1-44.

1838 she had been accepted into service. Schneider's engines also proved highly successful and helped to make him a major competitor for further orders. However the navy was severely disappointed with the engines from Indret. They had been designed by Gengembre, who died just before the first one, installed in Lavoisier, was ready for trials; and the first two (for Lavoisier and Caméléon) had been begun before the British plans for the machinery of Véloce had been received.[1] The first indication of trouble came in a report from Gengembre's interim successor, who disclosed that Gengembre had made a large number of unauthorized changes to the plans approved by the Minister of Marine, of which many seemed to offer serious disadvantages. The navy had to accept most of those incorporated in engines already built, but rejected most of them for future engines.[2] The seriousness of the matter was confirmed when Lavoisier ran trials early in 1839 and had a continuous series of breakdowns, mostly due to her boilers. (The navy was never able to fix these, and replaced them in 1841.)[3] The engines themselves were judged to be satisfactory, but further experience with the class showed that the ships engined by Indret were seriously

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[1] Trial report of Caméléon, 31 July 1840, A.M., Marine 7DD1-9.

[2] C.T., 3 May 1838, 31 May 1838 and 9 August 1838, A.M., Marine BB8-1115.

[3] Trial report dated 24 May 1839, A.M., Marine 7DD1-29; C.T., 19 August 1839, A.M., Marine BB8-1115; Ports to Minister, 17 March 1841, A.M., Marine 1DD1-52.

inferior to those engined by Fawcett and Schneider.[1] The result was a series of reorganizations at Indret, which eliminated its semi-independent status within the navy and brought it under the control of the naval construction corps.

Enhancing Military Capabilities

Although French naval steamers had grown in size in the 1830's, their mission had not grown, as shown by the fact that the three large ships of 1837 were intended mainly for transport duties. However some Frenchmen had already begun to consider the possible military uses of steamers. The brief period of speculation on this subject before and during the Algerian campaign of 1830 had been stifled by budgetary restrictions, the technical limitations of the early ships, and by the nearly insatiable demands of the Algerian packet service for such ships as were built. Even steam enthusiasts saw the technical limitations: in 1831 Corvette Captain Louvrier, the pioneer of the 1820's, wrote that, in their present state, steamers should be used only as packets and avisos, and criticized the tendency to fit them out in the same way as sailing ships, with heavy rigging and artillery and large amounts of stores which they would never need as packets.[2] In the same year the ministry, in a report to the king, stated that steamers were very good, even indispensible, for rapid communications between ports

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[1] Dubreuil, "Toulon," p. 45.

[2] Ports to Minister, 27 August 1831, A.M., Marine 1DD1-26.

relatively near each other and for moving heavy objects in restricted areas (meaning either use as harbor tugs or as harbor defense ships with heavy artillery). But the possibility of further military uses was dismissed, at least for the present, because steamers, with their heavy engines and high fuel consumption, could not cruise over extended distances, and thus could not take the place of sail, especially on the foreign stations.[1]

However, while the present technical limitations of steamers were widely realized, and even exaggerated, there was also a widespread belief that eventually steam would make further progress; and some men, both inside and outside the navy, continued the search for additional uses for steamers. While they were sometimes regarded as eccentrics, their cause was recognized to be in the national interest and was given, in principle, considerable official encouragement. This combination of pessimism for the present and optimism for the future is best exemplified in the reports of Charles Dupin to Parliament on the budgets for 1834 and 1835. He contested the claims of the steam enthusiasts, noting that little progress had been made recently with steam navigation--steamers were still limited to an auxilliary role of providing messenger services and helping sailing ships against wind and current. But he felt certain that future progress would soon be made, and called on the

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[1] Ann. Mar., no. 44 (1831), pp. 367-368.

government, instead of investing too heavily in the current type of steamers, to take the lead in experimentation and, in particular, to establish a prize for the greatest improvement in building steamers or in fitting them for military use.[1] (Dupin unexpectedly became Minister of Marine for three days during a political crisis in 1834, just long enough to carry out his own recommendation.)[2] In 1838 Tupinier was to make a similar call for solutions to the main problems preventing the military use of steamers, and showed himself receptive to such ideas, especially during the latter part of the decade when Mathurin-François Boucher joined him at the top of the navy bureaucracy as head of the naval construction corps.[3]

But the most comprehensive early examination of the subject came in a series of deliberations by the Council of Works in July 1834 on a detailed memorandum by Lieutenant Philippe-Etienne-Alphonse Bertrand on the military uses of steamers, which foresaw most of the possibilities that would be experimented with during the next decade. Bertrand first pointed out what he felt to be the reason for the current stagnation in

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[1]Report to the Chamber of Deputies, Budget for 1833, Ann. Mar., no. 52 (1833), pp. 401-403; Report, Budget for 1835, Arch. Parl., 89:311. For the views of some extreme steam enthusiasts see Roger and Tirlot in the Chamber of Deputies, 26 and 27 March 1832, Arch. Parl., 76:762 and 77:40-42.

[2]Victor Lacaine and Charles Laurent, Notice historique sur M. le baron Charles Dupin (Paris, 1837), p. 31. The prize was not awarded until 1854.

[3]Tupinier, "Matériel," pp. 186-187.

steam navigation: early claims of its capabilities had been exaggerated, and a period of disillusion had set in. The proper response, he felt, was not another round of theoretical speculations on the eventual advantages of steam, but an effort to define the missions that steamers were currently capable of carrying out, and making the limited changes in their construction that would enable them to carry out those missions. He saw two main areas of operations for steamers: in company with a sailing fleet, and as harbor or coast defense ships. Bertrand made no effort to claim that steam might eventually replace sailing fleets, but pointed out that it could be an important auxilliary to them: steamers could carry orders and messages within a fleet and between it and its base, and could provide a new dimension of mobility to battleships by towing them into position in the battle line and rescuing them if they were disabled. Combat was not a primary mission of steamers, though Bertrand noted that they seemed destined to fight end-on instead of on the broadside due to their design, and that the size of their guns would therefore be more important than quantity.

These missions were essentially the application of the existing roles of steamers as packets and tugs to a battle fleet, but even this limited step was impossible without some changes to the ships. The main deficiencies of current steamers that Bertrand felt would have to be overcome before they could support a fleet were that they were presently unable to accompany a fleet under sail alone (which was the only way he saw of

overcoming their limited endurance under steam) and that their engines were presently too vulnerable to allow them to venture into a fleet action without being disabled. Some way would therefore have to be found to protect the ships, especially their ends, against shot, while to improve sailing qualities two things were necessary: the rig would have to be enlarged and improved, and a way would have to be found to eliminate the drag of the paddle wheels in the water while the ship was under sail. As for coast defense steamers, Bertrand felt that these should have heavy guns behind strong breastworks and should have no rig at all, at least in wartime.[1]

The Council of Works was not enthusiastic about developing specialized steamers for coast defense, noting that, due to the cost of steamers, it was essential that they be able to carry out as many different missions as possible. It added that it did not share Bertrand's hope that steamers could be made to sail well enough to stay with sailing fleets under sail alone, but added that this question and that of protecting steamers against shot were of sufficient importance that experiments should be encouraged.[2]

This opinion, soon followed by the institution of Dupin's prize, was shortly reinforced by the British example. In January 1835 the French ambassador in Constantinople (who also happened to be an admiral and a former Minister of Marine)

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[1] C.T., 19 July 1834, A.M., Marine BB8-1113.

[2] Ibid.

informed the Minister of Marine that one of the British 220-horsepower steamers, Medea, had recently arrived at Constantinople and had made a big impression there. "The characteristic trait of this ship, Admiral," he reported, "is the high speed that it attains under sail alone: it seems that in this regard a big step has been taken in the application of steam to high-seas navigation, by thus practically eliminating the disadvantage of the large coal supply which was indispensable in the case of continuous use of the engine, which can now be greatly reduced since a speed of nine knots can be obtained without using it. There is therefore no doubt that ships of this type can be attached to fleets of sailing line-of-battle ships, and one can see the prodigious advantage they will give in case wind, current, calm or damage neutralizes the ships which are otherwise the most ready for action."[1] The ambassador was not the only Frenchman to be impressed by Medea, for she was stationed in the Mediterranean for an extended period and was frequently seen by French naval officers. There were still unresolved problems--Medea's rig was supposedly unsafe in heavy weather--but it was equally clear that the French had nothing comparable to her.

The example of Medea and the earlier discussions in the navy led the French to try to improve the military capabilities of their own steamers. The first step was to try to eliminate

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[1]Roussin to Minister of Marine, 15 January 1835. Filed with Ports to Minister, 8 July 1837, A.M., Marine 7DD1-52.

the worst disadvantages of paddle wheels. Paddle wheels were militarily the most undesirable feature of steamers and, in addition, they appeared to be the least efficient part of the propulsion mechanism. The navy saw little merit in the numerous schemes to do away with paddle wheels altogether, but it welcomed some of the more practical suggestions regarding paddle wheel design. The loss of efficiency in paddle wheels appeared to come from the fact that the paddles entered and left the water at an oblique angle, and a number of innovators besides Cavé tried to develop feathering paddle wheels which would tilt the paddles so they were always perpendicular to the surface of the water. One naval officer fitted out a small boat with his system and demonstrated it to the Council of Works at his own expense. Neither his scheme nor Cavé's was immediately successful, though feathering wheels did eventually come into use. The other main problem with paddle wheels was that they offered serious resistance in the water when the engines were stopped and the ship was under sail, and a number of innovators experimented with linkages that, by disconnecting the paddle shaft from the engine, would allow the wheels to rotate freely while the ship was moving under sail. Others proposed ways of removing the submerged paddles while the engines were not in use. The navy experimented with a number of these ideas, and adopted several towards the end of the 1830's.[1]

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[1]These and other inventions are collected in a special volume of proceedings of the Council of Works: A.M., Marine BB8-1246. See also Anthiaume, Propulsion, p. 330; Ann. Mar., no. 101 (1847), pp. 412-414.

These were followed by two much more ambitious proposals, which involved modification of not only the paddle wheels but also the rig and other features of the ship in an effort to produce a steamer with serious military capabilities using existing technology. The first of these was the brainchild of Corvette-captain Jean-François-Théodore Bechameil, who had been designated as the commanding officer of the first of the 220-horsepower steamers to get to sea, *Véloce*. Bechameil had great faith in the future of steam, and claimed that many admirals agreed that its future was promising. They might have disagreed on its specific uses, for Bechameil was of the school that felt commerce raiding would be a more productive form of warfare than fleet actions, and felt steamers would be better used as commerce raiders than as auxiliaries to a fleet. Both uses, however, required overcoming the limited endurance of steamers, and Bechameil felt that the only way to do this was to give them the ability to make full use of the wind as well as steam, and to draw the maximum benefit from each by shifting rapidly back and forth between them. The navy gave him a month's leave in May 1837 to develop his ideas, and at the end of that period he submitted a detailed proposal for modifications to his ship. She was to receive a full ship rig with proportions based on sailing corvettes, which would give the ship the speed under sail of an average sailing ship. However the upper spars were to be of iron, and were to be fitted with an elaborate system of winches and tackle so they could be adjusted in height or

even run down altogether to cut down on wind resistance while the ship was under steam. (This also permitted compensating for changes in stability due to consumption of coal and for getting the rigging out of the way when towing a large ship alongside.) In return, the paddle wheels were to be disconnected from the engines by a special linkage to give the ship maximum efficiency under sail.[1]

The Council of Works did not agree with all of Bechameil's ideas on the uses to which such a ship would be put, but, due to the importance of the question and the enthusiasm and ability of Bechameil, it approved the trial. On 8 July 1837 the minister approved the experiment, and Véloce was fitted out on Bechameil's lines and sent on a long cruise under his command to the Antilles, the United States and Newfoundland to test the new system thoroughly.[2]

Before long a semi-official project was developed in response to Bechameil's. The director of construction work at Rochefort, Jean-Baptiste Hubert, who had designed the standard 160- and 220-horsepower steamers as well as many sailing ships, had undoubtedly come into contact with Bechameil's scheme while constructing the hull of Véloce at Rochefort, and in October 1837 he proposed an equivalent but much less complex scheme

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[1] Bechameil to Minister of Marine, 3 May 1837 and 30 May 1837, A.M., Marine 7DD1-52.

[2] C.T., 29 June 1837, A.M., Marine BB8-1115; Ports to Minister, 8 July 1837, A.M., Marine 7DD1-52.

for her sister, Caméléon, which he was also building. It simply consisted of the rig of Sphinx modified along the lines of Medea (as this was primarily a fore-and-aft rig, it would not interfere unduly with the ship's speed under steam), coupled with an apparatus to cut down on the drag of the paddle wheels while under sail.[1] In comparative trials with Véloce, Caméléon was slightly slower under sail but heeled less, and this, coupled with the fact that her rig was based on traditional sail technology, insured that future steamers would follow her pattern.[2] Together, Véloce and Caméléon represented the French answer to Medea, though they ran their trials some five years after the British ship appeared in the Mediterranean.

While sails could make steamers more useful as auxiliaries to the fleet or as cruisers, their armaments show that they were still a long way from being true combatants. The sail corvettes on which Bechameil based his rig carried from twenty-four to thirty guns, but the initial armament for Véloce and Caméléon was only seven.[3] Three of these guns were long-range shell guns mounted in the bow and stern, but, despite the havoc such guns could cause, they were not regarded as a credible

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[1] Ports to Minister, 27 January 1838, A.M., Marine 1DD1-43; Ann. Mar., no. 66 (1838), pp. 525-528.

[2] Report of commission on Bechameil's system dated 6 September 1841, A.M., Marine 7DD1-52.

[3] The standard armament for this type as established by the Council of Admiralty on 9 January 1838 was three 80-pounder and four 30-pounder shell guns. A.N., Marine BB8-870.

substitute for the full broadside armament that steamers, due to their paddle wheels, could neither carry themselves nor stand up to in an opponent. Efforts to arrive at a standard armament for steamers gave considerable trouble in the 1830's: commanders of ships used as packets claimed that the standard was too cumbersome, while the commanders of the few that were commissioned for other duties (such as Météore, used in the surveillance of the Spanish coast in 1836) complained that both their armament and the size of their crews were too small.[1]

In spite of these difficulties, a first feeble step was taken towards a wider use of steamers when two 160-horsepower ships, Météore and Phaeton, were included in the expedition sent to demand satisfaction in a diplomatic dispute with Mexico in 1838. In the bombardment of St. Jean d'Ulloa by the French squadron on 27 November 1838, the two steamers first towed two mortar vessels into position, and then towed two of the frigates to their bombardment stations. Otherwise they gave nearly continuous trouble: Phaeton could never steam three days straight without breaking down, while Météore was constantly in danger of having major parts of her engines fail.[2] Two sisters,

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[1] Tartare (used as packet) and Météore were discussed by the Council of Admiralty on 23 August and 16 January 1836 respectively. A.N., Marine BB8-868 and 867.

[2] Jurien de la Gravière, Jean Pierre Edmond, Les gloires maritimes de la France: L'amiral Baudin (Paris, 1888), pp. 118, 130, 142-143.

Styx and Tonnerre, were used in the blockade of the Plata in 1840-41, but the routine use of steamers on overseas stations, despite Tupinier's prophecy, was still several years away.

Further Growth: 320 and 450 Horsepower

Just as the French navy was gaining some familiarity with the construction and uses of 220-horsepower steamers on the pattern of Véloce and Medea, the technological spiral took charge again. In 1837 news came from England that the Royal Navy had decided to increase the horsepower of a steamer then building, Gorgon, from 220 to 320 horsepower. (This ship was also to carry her main armament below-decks, the first attempt to produce a steamer with a credible broadside armament on the pattern of sailing frigates.) A French officer managed to inspect this ship in 1838, and his report prompted the French navy to include a large steamer of "300 to 400" horsepower in the budget for 1840. Concurring in this action, the Council of Works noted that the British Admiralty had just ordered five other engines similar to those in Gorgon, and added that "France cannot remain in the passive role of a spectator in such an important matter--she must hasten to arrive at a decision if she does not want to condemn herself to an inferiority which could become very prejudicial to her interests."[1]

The efforts to produce the new large steamer showed that, while the French no longer needed to rely on foreigners for the

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[1]C.T., 18 May 1839, A.M., Marine BB8-1115, citing earlier decision.

fabrication of their steam machinery, they still felt dependent on them whenever a major technological advance was required. Word filtered through that the engine of _Gorgon_, besides being twice the power of _Sphinx_, was on a novel new pattern developed by the firm of Seaward and Capel: it was light for its power, and most of it was below the waterline where it was protected against shot. The French began their efforts to produce a similar ship in January 1839 in the now-traditional way of asking the Director of Construction at Rochefort, Hubert, for a plan; but soon afterwards the ministry saw that this alone would not be enough and also asked for plans from Toulon, whose engineers had observed the numerous foreign steamers in the Mediterranean. In March 1839 Boucher, who was now head of the naval construction corps, went to the heart of the problem and advised the minister that _Gorgon_ seemed to draw all her advantages from her new type of engine, and that if the French wanted the same advantages it would be advisable to buy similar engines from Seaward for one or two ships.[1] At the same time he proposed measures to catch up with the recent advances in technology: two constructors were to be sent to Britain, one after the other, to buy the engines and learn as much as they could about British steam engine technology, while a naval officer was to visit Britain and study the more general elements

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[1]Ports to Minister, 27 March 1839, A.M., Marine 1DD1-44.

of steam navigation in Britain. (One of these constructors was scheduled to become director of Indret, and the other was one of the leading constructors at Toulon, where most of the French steamers were concentrated.)[1] In late March the program was limited to one ship for the time being, due to lack of funds for two, but Boucher noted that one engine was sufficient to provide a model that would enable French factories to produce similar ones, while French industry might object if a second were ordered abroad.[2]

The first of the two constructors arrived in Britain in May 1839, and, after initial negotiations with the builder of *Gorgon*'s engine, Seaward, recommended ordering the engine as intended from that firm. The ministry gave him authority to negotiate the contract, but in the meantime he had witnessed trials of a ship with Seaward engines against two with Fawcett engines in which the former made only nine knots against thirteen for the others. In addition he noted a number of mechanical defeats in the Seaward engines which indicated that there were still some problems with the new system that needed to be solved. In a second report he recommended waiting until Seaward had had more experience with his system before adopting it, and ordering the French engine instead from the firm of Miller and Ravenhill, whose reputation was as good as any firm

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[1] Ports to Minister, 27 and 30 March 1839, A.M. Marine 1DD1-44.

[2] Ports to Minister, 30 March 1839, A.M., Marine 1DD1-44.

in England. The navy would thus get the highest possible quality and durability, while benefiting from the fact that Miller's engines were lighter than Fawcett's and used less coal. The ministry approved his recommendation, and also had him order a 120-horsepower engine from Maudslay to get a recent example of that firm's work.[1] The minister approved the contract on 8 June, noting that the "acquisition of this engine, of a power new to France, should procure a model valuable not only for the [French] Royal Navy but also for French industry."[2] At the same time the ministry ordered Hubert to build the hull for the ship at Rochefort. Subsequent programs caused the hull and engine of this ship to part company--the 320-horsepower engine was ultimately put in a ship named Cuvier, while the hull was completed with larger engines under the name Infernal.

The advent of the 320-horsepower steamer soon made the 220-horsepower steamer look as unsatisfactory as a standard type as the latter had made the 160-horsepower Sphinx seem. In May 1839 Boucher reported to the minister that "as a result of what is happening today in Britain, it is indispensible to increase in France the power of our machinery, as well as the capacity of the steamers destined for military use." In addition, French 160- and 220-horsepower steamers were based on old plans

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[1]C.T., 18 May 1839, A.M., Marine BB8-1115; Ports to Minister, 25 May 1839, A.M., Marine 1DD1-44. Mandslay's engine does not appear ever to have been delivered.

[2]Ports to Minister, 8 June 1839, A.M., Marine 1DD1-44.

which compared badly with new French post office packets and new British merchant steamers. Boucher therefore recommended limiting the 220-horsepower class to six units, thus cutting it off just as it entered series production, and concentrating on the development of the larger ships.[1]

However the contract with Miller had hardly been signed when the French navy took another jump in the size of its steamers, this time to 450 horsepower (double the size of Véloce). This change was not a reaction to the British navy, which had no plans at the time to go beyond 320 horsepower and did not do so until 1841. Instead it appears to have been due to reports of some remarkable developments in the British merchant marine. The British engineer Isambard Kingdom Brunel, had conceived of the project of using a giant steamer of 450 horsepower to establish a scheduled transatlantic passenger service, and the maiden voyage of his ship, Great Western, was a brilliant success. Competitors appeared even before Brunel's ship was launched, and a ship chartered by one of them, Sirius, beat Great Western to New York by the narrow margin of a few hours. The significant thing, however, was not so much the crossing itself as the fact that, when it was over, Great Western still had an ample supply of coal in her bunkers. (Sirius had nearly run out.)[2] The theory that larger ships had greater

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[1] Ports to Minister, 15 May 1839, A.M., Marine 1DD1-44.

[2] Rowland, Steam at Sea, pp. 70-78.

endurance than smaller ones was thus vindicated, and it was shown that the increase in the size of steamers had significantly reduced one of their main shortcomings, the inability to steam over great distances or for any great length of time.[1] No longer could an admiral claim that no steamer could remain at sea under steam over eleven days, as had one French admiral in 1832. It was now clear that greater endurance could be bought simply by building larger ships.

Specifically, the experience with Great Western showed that 450 horsepower was an ideal size for ships intended to cross the Atlantic, and also showed that such ships would have an endurance under steam of about twenty days, enough for nearly any major voyage in the Atlantic or Mediterranean basins. The French engineer who had purchased the 320-horsepower engines had also been instructed to examine the large British trans-atlantic steamers, and he undoubtedly reported that the size of Brunel's ship was the key to her success. The French quickly adjusted their building program accordingly: two ships of 220 and 160 horsepower, Asmodée and Gomer, scheduled in the budget to be begun during 1840, were upgraded to 450 horsepower, while

[1] Ann. Mar., no. 95 (1846), pp. 227-228. For a view of the shortcomings of steamers for ocean travel written a year before Great Western's voyage see Ann. Mar., no. 64 (1837), pp. 943-949. The ultimate solution to one of the shortcomings cited, the buildup of deposits in boilers due to the use in them of sea water, appeared at this time in the form of Samuel Hall's surface condenser, but this innovation did not come into general use until after 1860. Rowland, Steam at Sea, pp. 103-104.

three more of that size were added to the program to be begun in 1841. For the engines two means of procurement were to be tried, similar to those tried for the 220-horsepower engines: one naval constructor was to be sent to England to buy the engine for _Gomer_, while the constructor who had just returned from there was to use his new knowledge of British engines to design and build the engine for _Asmodée_ at Indret, where he had just become director.

The new French mission arrived in England in September and contacted five of the best English firms: Maudslay, Seaward, Robert Napier, Miller, and Fawcett. However the first three of these refused to accept the French schedule of payments, while Miller could not meet the desired delivery date. The French particularly regretted not being able to order from Maudslay, who had built the engine of _Great Western_, but the firm refused to alter its terms and the French settled for a contract with their traditional English supplier, Fawcett, whose machinery had abundantly proven itself in _Sphinx_ and _Véloce_.[1]

In February 1840 the new director of Indret submitted his plans for the engines for _Asmodée_, but the Council of Works was alarmed by the new system that he proposed for them (four cylinders and only one condenser), and recommended trying it in a small engine first.[2] Hence other arrangements had to be

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[1] Ports to Minister, 23 October 1839, A.M., Marine 1DD1-44.

[2] C.T., 27 February 1840, A.M., Marine BB8-1115.

made for the engine of Asmodée. Boucher reported that the engine could not be ordered from French manufacturers, "who have not yet built one of such power, nor even approaching it, and because, moreover, the administration does not possess any plans that it could give as a model." Therefore the navy would have to go to England again, and this time Boucher asked that he himself be selected to make the trip. Tupinier concurred, noting that Boucher had never been to England, and that the reports of his subordinates had aroused in him the desire to see the British factories and naval dockyards for himself.[1]

Boucher clearly wanted to try again to get from Maudslay a copy of the engine of Great Western: Maudslay was the first firm that he visited on his arrival in Britain in April 1840, and when he heard that Great Western was due to arrive at Bristol he hurried to that port to inspect her. (There he also saw "the big iron steamer [Great Britain] of over 2000 tons burden which is to receive an engine of 1000 horsepower built on a new system," which was then building, and he would have marveled even more had he known that in a few months Brunel would decide to do away with her paddle wheels and alter her for the new screw propeller.) He noted with awe that Great Western had completed fourteen transatlantic crossings equivalent to ninety crossings between Algiers and Toulon, without any injury to the engines. However Maudslay refused to alter their

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[1] Ports to Minister, 29 February 1840, A.M., Marine 1DD1-49.

terms on payment, and Boucher proceeded to look elsewhere. He reported that even in Britain the number of sources for steam engines of this size was very small. He quickly eliminated three prominent builders: Miller and Ravenhill, who were behind schedule in producing the French 320-horsepower engine; Seaward and Capel, whose new model of engine still needed to be proven by experience; and Robert Napier, who he reported worked with little care and produced engines that lacked solidity. (Cunard, who drew most of his engines from Napier, would have disagreed.) The best available source besides Maudslay, he felt, was Fawcett, who, he reported, had kept up with technological advances and had made improvements in their engines since building those for Sphinx. Fawcett had recently built 320-horsepower engines for three British Navy packets which had performed extremely well. Boucher concluded by offering the ministry three choices: accept Maudslay's conditions and get a copy of Great Western's engines, which were the best available and a pattern new to the French navy; pass another contract with Fawcett, who would produce excellent engines with all the latest improvements at a good price; or order from one of two secondary firms, Butterley of Derby or Scott and Sinclair of Greenock, who could beat Fawcett's price and produce good engines which, however, would not be quite up to date technologically.[1] The ministry initially

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[1] Boucher to Minister of Marine, 23 March, 9, 14, and 20 April 1840, A.M., Marine 7DD1-56.

instructed Boucher to order from Fawcett, but then changed its mind and authorized him to negotiate with Maudslay--to everyone's disappointment the change in the instructions reached Boucher a day after he had concluded the agreement with Fawcett.[1] Boucher and Tupinier proposed to make the best of the situation by installing the two engines in hulls with different lines, to see if the plans of Hubert, which had been followed for French steamers ever since Sphinx, could be improved upon: Boucher's observations of British packets suggested that even war steamers could be given substantially lighter hulls than previous practice had indicated.[2]

Boucher's negotiations with Maudslay did have one result, for he discovered that they were developing an engine essentially the same as the one proposed by Indret for Asmodée. This British sanction rescued Indret's large engine from oblivion, and in June Indret was ordered to proceed with its construction. It was eventually installed in Infernal.[3]

The ships that resulted from this jump in size, first to 320 and then to 450 horsepower, were considerably more versatile

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[1] Minister of Marine to Boucher, 9 and 17 April 1840, A.M., Marine 7DD1-56.

[2] Ports to Minister, 13 May 1840, A.M., Marine 7DD1-56; Ports to Minister, 27 June 1840, A.M., Marine 1DD1-49.

[3] Ports to Minister, 8 January 1840, A.M., Marine 1DD1-49. In December 1840 Indret's engine was assigned to Infernal and a new, smaller hull was ordered for Miller's 320-horsepower engines under the name Cuvier: Ports to Minister, 9 December 1840, A.M., Marine 1DD1-49.

than earlier steamers. The 320-horsepower steamer was the first French steam vessel designed with a main deck battery (six guns per side with six more on the upper deck).[1] The 450-horsepower steamers carried this concept even further: they were to have ten guns per side in the battery and twelve to sixteen on deck, for a total of thirty-two to thirty-six guns, equivalent to a small frigate or a large corvette.[2] Boucher noted with satisfaction that the 450-horsepower ships went far beyond anything in the British navy, both in horsepower and artillery: the British did not have plans for any steamers larger than Gorgon, and that ship, although designed to carry eighteen guns, could only carry six because her battery gun-ports were too close to the water to be usable. (This was to be the case with the French ships as well, though their trials were still far in the future.) The French ships would also have the main advantage of the big British merchant steamers: a twenty-day coal supply, more than sufficient to cross the Atlantic under steam.[3]

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[1]Ports to Minister, 8 January 1840, A.M., Marine 1DD1-49. This was the hull completed as Infernal.

[2]Ports to Minister, 15 February and 27 June 1840, A.M., Marine 1DD1-49. Asmodée, designed by Boucher with finer lines, had four guns less than Hubert's Gomer. These were ultimately completed with larger engines under the names Vauban and Descartes respectively.

[3]Ports to Minister, 8 January and 15 February 1840, A.M., Marine 1DD1-49; Boucher to Minister of Marine, 24 June 1840, A.M., Marine 7DD1-56. The 320-horsepower steamer was rated at eighteen to twenty days' endurance under steam.

The 1830's closed with a mixed record of accomplishment and stagnation in the development of steam technology in the French navy. On the positive side, the navy made important progress in the creation in France of the industrial base needed to produce steamers and their engines. It completed the development of its own steam engine factory at Indret, and also kept several private engine builders, notably Cavé and Hallette, supplied with orders that provided them with the encouragement and the means to develop the ability to build large engines. This was a deliberate policy of both the navy's administration and of Parliament, and it resulted from the fact that the French economy alone could not have done the job. At any given time the engines under construction for the navy were at least twice as powerful as those being built for the merchant marine, which in turn were larger than the engines built for industrial use ashore. By the end of the decade there were several firms in France capable of building on a routine basis engines the size of those in _Sphinx_.

Also on the positive side, the number of steamers, both in the navy and in the Post Office's packet services increased greatly during the decade due to an insatiable demand for packet and transport services in the Mediterranean. The navy thus acquired many ships that would be available in case of war, along with many men experienced in steam plus a major steamer base at Toulon. But, on the negative side, these ships were used for strictly non-military purposes. It seemed as if,

after the brief successful experience during the Algerian expedition of 1830 and a few isolated experiments later, the navy had lost interest in the military uses of steam. One reason was certainly the technical deficiencies of steamers as they existed during the 1830's. This, however, was soon to change, for the increases in the size of steamers at the end of the decade produced ships that could carry an appreciable armament and make long voyages under steam. Perhaps a more important reason was the fact that there seemed no reason to make the change. The sail navy had supported French prestige and carried out the small missions given it with complete success during the 1830's, and as long as the navy was satisfied with its performance, it was unlikely to transfer any military missions to the new and untried steamers.

The navy also made little progress during the 1830's in one other area: the development in France of the technological skill needed to produce designs and eventually innovations in the new technology. For much of the decade innovation had actually been discouraged and engineers had been ordered simply to copy the successful engines of Sphinx. This was due partly to budgetary limitations, which made the financial risk of large-scale experiments unacceptable, and also partly to the easy availability of British technology and to a widespread conviction in France that Frenchmen could never match the British genius for mechanical innovation. As a result the French had considerable difficulty in developing plans for new types of

engines, even when the problem was simply scaling up existing plans in order to produce greater horsepower. The French had to go to England for successful engine designs and for model engines for their 220, 320 and 450-horsepower steamers, and were still almost completely dependent on England for engine design as the decade of the 1830's ended.

Fig. 1.--A transatlantic packet of the 1840 program, *Panama*, fitted as a navy steam frigate. The paddle wheels were located on each side amidships beneath the large paddle boxes. Plan dated 28 February 1847. SOURCE: A.M., Marine 8DD1-379.

Frégate à vapeur Le panama

[illegible]

Artillerie

[illegible]

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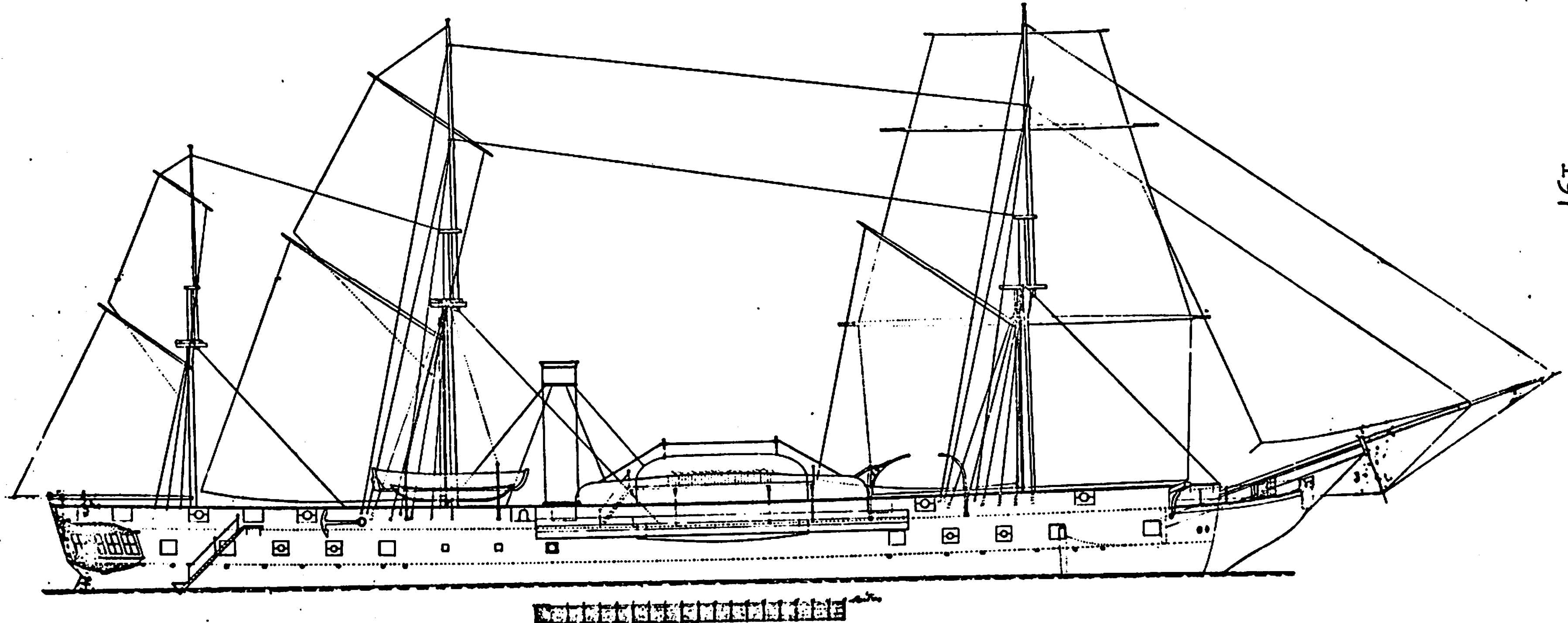

CHAPTER IV

THE CRISIS OF 1840 AND THE TRANSATLANTIC PACKET PROGRAM

Eighteen hundred and forty was a decisive year for the introduction of steam on a large scale in the French navy. At the beginning of that year the navy had still not seriously considered the use of steamers for military purposes; French factories did not have the capability of building engines larger than 160 horsepower or, at the most, 220 horsepower; and the French were still almost completely dependent on the British for the design of large marine engines. By the end of 1840, however, the navy was assured of the use in case of war of many large military-capable steamers; it had embarked on a crash program to build engines of the largest size (450 horsepower) in French factories; and it had resolved to end its technological dependence on Britain.

These achievements were due to the coincidence in time of three events. The first, already discussed, was the development in England just before 1840 of steamers large and powerful enough to cross the Atlantic, and of steamship companies to operate them. The French, in response, also began planning their own transatlantic steam packet lines. The second event was the political upheaval that put Adolphe Thiers in power as

French premier in March 1840. Thiers believed that the French transatlantic packet program should be so designed as to provide the navy with large steamers suitable for military use in case of war, and he modified it accordingly. The third and most decisive event was the diplomatic crisis between France and Britain over the Middle East that came to a head in July 1840. During the crisis the navy's sailing fleet in the Mediterranean proved powerless to deter Britain from following an anti-French policy, raising the question of whether Portal's sail fleet was still capable of defending French interests in either peace or war. This naturally increased the importance of the main alternative to sail, steam, and brought home to the navy's administration the danger of relying any longer on France's rival, Britain, for the construction or the design of large steam engines. The navy therefore seized on the packet program as a ready-made opportunity, which offered far greater resources than the navy's own budget, for achieving once and for all industrial independence from Britain, and for starting on the road towards technological independence as well.

The rush to form transatlantic packet lines started in Britain in the late 1830's almost as soon as the technical specifications of Brunel's giant steamer, Great Western, became known. By the time that ship made her first voyage four transatlantic steamship companies had already been formed in Britain, and more soon followed. (One of these, Cunard, still exists.) British lines were planned to North America and to the Caribbean,

and it appeared that there would soon be a British steamship line on every major route in the North Atlantic.

The French were soon impelled to follow the British example and establish their own transatlantic steam packet lines. In the original projects, commercial concerns dominated and military considerations were largely absent. The success of Great Western indicated the possibilities of profit in transatlantic steamers which, due to their independence of wind and currents, could provide a much more reliable scheduled service than sailing ships, and also showed the danger to French commercial interests of allowing the British to monopolize transatlantic steam communications. The threat was perhaps most visible at Le Havre, where the British transatlantic companies opened booking agencies, but it was felt in all French ports.[1] At Bordeaux one investor tried without success to form a Bordeaux-New York line of thirteen steamers of 450 horsepower. However the most serious effort to compete with the British came from Marseilles. In a note dated 30 August 1838 the French consul at Barcelona proposed a steamer line between Marseilles and the West Indies via Spanish ports.[2] Meeting a favorable response, he enlarged his plan to include three lines, all from Marseilles:

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[1] Louis Brindeau, Les anciens paquebots entre Le Havre et New York (Le Havre, 1900), p. 19.

[2] Pierre Guiral and Michel Barak, "La navigation française dans l'Atlantique de 1814 à 1914," Anuario de estudios americanos 25 (1968):358-359, 369.

one to New York, one to the West Indies, and one to Brazil. On 2 September 1839 he secured a promise of support for his project from the General Council of the Department of Bouches du Rhone, which included Marseilles.[1] The proposed concentration of three lines in one port caused an uproar in the other French ports, some of which were better placed than Marseilles due to geography and commercial ties, and these also began to prepare transatlantic schemes. This plan, and all similar ones, included a large postal subsidy (two million francs per year for the Marseilles plan), and this alone insured that the government would be deeply involved in any transatlantic venture.

The packet program came up for consideration just as a political crisis broke in France. One of France's most prominent political figures, Adolphe Thiers, who had been dismissed from office after a brief ministry in 1836, was planning his return to power, and in 1838 he joined forces with the other principal opposition leader, François Guizot. In 1839 the combined opposition launched an assault on the government and harried it first into resigning, then into retracting its resignation and fighting an election which it lost. At the crucial moment Thiers and Guizot fell out over the division of the spoils and, after six weeks without a true government (Tupinier became

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[1] Giraud, _Vapeur à Marseille_, p. 40; Roger Pasquier, "Bordeaux et les débuts de la navigation à vapeur vers le Brésil," _Revue historique de Bordeaux et du département de la Gironde_, n.s., 6 (1957):220.

Minister of Marine in a non-political cabinet during this period), Louis Philippe succeeded in forming a government without Thiers.

Barely had the dust settled from this political storm when the Middle East exploded. The Pasha of Egypt, Mohammed Ali, had conquered most of Syria from his nominal overlord, the Sultan of Turkey in 1833, and when the Ottoman Empire tried to recover it in 1839 it fell into a triple disaster: its army was shattered at Nezib on 24 June, its sultan died on 30 June leaving a boy as heir, and its fleet deserted to Mohammed Ali on 4 July.[1] The Western powers were able to cooperate in an initial move in July designed to keep Russian forces out of the Straits, and France and Britain actually agreed to combine their Mediterranean fleets near the Dardanelles and enter the Straits if Russia did so. However further negotiations served only to bring to light the fact that Britain and France had very different objectives in the Middle East. The British felt that their position in the Mediterranean depended on a strong Turkey keeping the straits closed against the Russians; while French opinion was strongly in favor of Mohammed Ali, who had used mainly French advisors since the 1820's and who was seen as the center of French influence in the Levant. Thus while Britain wanted to shore up the

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[1]On the diplomacy of the Middle East crisis see Pierre Renouvin, ed., Histoire des relations internationales, 8 vols. (Paris, 1953-58), 5:114-26; Charles Kingsley Webster, The Foreign Policy of Palmerston, 1830-1841: Britain, the Liberal Movement, and the Eastern Question, 2 vols. (London, 1951), 2:629-80.

Ottoman Empire at the expense of Mohammed Ali, the French government adopted diplomatic delaying tactics, hoping to prevent intervention by the powers long enough for Mohammed Ali to use his clear military superiority to accomplish his objectives. But these tactics did not satisfy the French press and political opinion in Parliament, which clamored for a less timid policy and less deference to the opinions of other powers, especially Britain. Even Thiers, who was more anglophile than the ministry, told an English acquaintance that no French politician could abandon Mohammed Ali under these circumstances, and he spoke out himself against such an abandonment.[1] Caught in the middle, the French government saw a dangerous diplomatic situation developing, for Russia had unexpectedly swung over to the British point of view and was drawing Austria and Prussia with her, while Palmerston had made it clear to the French in August 1839 that he would conclude an agreement without France if he could not get one with her. The French, however, had many supporters in the British cabinet, who placed the entente with France above any advantages to be gained in the Middle East, and the French government counted on these, plus the many points of dissention that still existed between the powers as well as France's own diplomatic ties with Austria and Prussia to prevent Palmerston from achieving any final agreement. On this basis they turned down several compromises offered by Palmerston in late 1839 and

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[1] Webster, Palmerston, 2:269. Thiers made this statement in January 1840.

made it clear that the French position in support of Mohammed Ali was inflexible. French opinion was further inflamed by Palmerston's public criticism of France and his single-handed effort to forge an alliance which looked like a re-creation of the hated anti-French coalitions of 1813 and 1814.

The French Packet Program

At first the increased diplomatic crisis had little impact on government consideration of the packet program. As early as September 1838 the Department of Foreign Affairs and the navy held preliminary discussions on the question. On 6 February 1839 a navy commission was charged to examine a project for steam communications between France and America, and in its report dated 8 March 1839 it recommended that the scheme include both a line to the West Indies and one to the United States.[1] (This was probably one reason for the enlargement of the Marseilles scheme during 1839.) The military value of the program was seen early, and the arguments used in favor of government operation of the Levant packets were revived. In August 1839 Charles Dupin, in a speech in the Chamber of Peers, urged the government to proceed with the project and indicated its importance to the navy as a means of further expanding steam navigation in France as well as expanding the number of suitably skilled seamen.[2] But in initial planning such arguments took a distinctly secondary place to commercial considerations, and

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[1]Report to the Chamber of Deputies, 8 June 1840, P.V. Députés, 1840, 7:411.

[2]Dupin in Chamber of Peers, 3 August 1839, Ann. Mar., no. 70 (1839), pp. 476-478.

proposals that the government operate the lines were at first based more on financial than military reasons.

The post office was charged with drawing up detailed proposals for the government's role in the project, and its director submitted his report to the Minister of Finance on 30 September 1839. He pointed to the dual necessity of multiplying French markets overseas and also protecting those that she had, and indicated that the use of steam on the transatlantic route by Britain required a French response if France were to maintain her commercial and cultural ties with the new world. But, after adding up the expected expenses and receipts of such a French line, he found that a realistic estimate of the dividend for private investors would only be 1-1/4 percent, which would hardly attract the amount of capital required. He concluded that only the government could execute the project under these conditions. However he felt this would be entirely proper, for such a move would simply be a new step in a long tradition of the government opening new paths of communication for the public welfare which had begun centuries before with the creation of royal highways and the postal system within France. In addition to the commercial and financial benefits from the lines, he also elaborated on the political and military ones: French steamers in America could facilitate French diplomatic communications, protect French commerce through the

habitual presence of French ships, and provide ships for use in war without the burden of maintaining them as warships in peacetime.[1]

The director of the post office indicated that further study by experts would be advisable before adoption of a plan, and in fact a number of the features of his report quickly came under criticism, particularly in a memorandum from the Finance ministry dated 30 November. In late December the ministry under Marshal Soult decided that, in view of British progress and the competition between French ports for the French lines, it was essential to resolve the matter without further delay, and Soult had the king appoint a special interministerial commission to examine the problem and prepare legislation.[2]

The president of this commission was none other than Baron Tupinier, Director of Ports at the Ministry of Marine, and the Navy was also represented by one of its more prominent rear admirals. Representatives were also assigned from the

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[1] Director of the Post Office, "Note pour Son Excellence M. le Ministre des Finances sur un projet de communications régulières entre la France et l'Amérique au moyen des Bâtiments à Vapeur armés au compte de l'Etat," dated 30 September 1839, A.N., C-807.

[2] "Proces-verbaux des séances tenues par la Commission des Paquebots Transatlantiques" (hereafter "P.V. Paquebots"), 4 January 1840 (meeting #1). These are filed in the records of the Chamber of Deputies, not with the papers on the law of 16 July 1840 but with those on the packet laws of 1847, A.N., C-871. These share a characteristic of most commission documents of this period in that individual speakers (except "M. le president") are not identified by name.

ministries of Finance, Commerce and Foreign Affairs and from the customs and postal administrations, all of which had interests in the project. An element of practical experience was provided by the inclusion in the commission of a representative of the Levant packet line, while a Paris merchant was appointed to represent private commercial interests.

The commission first met on 4 January 1840, and Tupinier posed the question, "Has the moment come to organize and establish a regular service of steam packets between France and the two Americas?" In response, "A sort of unanimity having spontaneously manifested itself in the Commission on this question, it was resolved affirmatively after several remarks enthusiastically presented in support of this solution by various members of the Commission."[1] But the unanimity stopped there, for the commission immediately split over what all members described as the conflict between commercial and political-military interests: the former demanding commercially-run subsidized lines, and the latter preferring lines owned and run by the government. Despite the preponderance of government bureaucrats in the Commission, commercial interests were strongly represented, for the representatives of several of the ministries identified more closely with commercial than with military interests. In addition the Commission received a large number of petitions from a wide variety of special interest groups,

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[1]"P.V. Paquebots," 4 January 1840 (#1), A.N., C-871.

and in the early part of its proceedings it allowed representatives of the four major commercial ports (Le Havre, Nantes, Bordeaux and Marseilles) to present their points of view personally to the commission.[1]

The director of the Post Office, in his study of the problem, had concluded in favor of government-operated lines, feeling that a 1-1/4 percent profit would not satisfy investors but would be more than enough for the Treasury, which would only want to break even. Tupinier also favored government-operated lines, but for him the political and military advantages of government operation were at least as important as the financial. He claimed that a primary motive of the British government in giving large mail subsidies to firms like Cunard was the political one of increasing the number of steamers available for war, and he claimed that Britain now had the capability to throw an army of 40,000 to 50,000 men at any point of the European coastline by using steamers. He felt that any French response to the English packets should keep such objectives in mind. As to the means of executing the program, Tupinier felt that France did not have the commercial resources that England had, and he feared that the subsidies that would be needed to make French lines competitive would be prohibitively expensive. But he did not insist on government operation of the lines, and

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[1]"P.V. Paquebots," 4 and 13 January 1840 (#1-2), A.N., C-871.

said he would be willing to accept a commercial solution provided the subsidies could be kept within reason.[1]

The reaction of the ports varied according to their estimates of their chances of establishing a paying line. Nantes, with little capital or trade, came out in direct support of lines run by the government for primarily political and military purposes.[2] Bordeaux, well placed geographically but in a period of commercial eclipse, also emphasized the political and military reasons for the project, without being willing to rule out commercial lines altogether. Their representative, the same investor who had previously tried to set up a Bordeaux-New York steam packet line, invoked the British threat before Tupinier did and called for a crash program, at any cost, to respond to it, though he admitted he was uncertain whether the lines should be run by the government or by private companies. No such doubts existed at Le Havre or Marseilles, both of which campaigned vigorously for private lines and claimed, as a matter of principle, that, without losing sight of the political and military interests involved, the commercial interests should dominate. Their point of view prevailed in the Commission, which decided to consider commercially-run lines first, and to consider government-run lines only if commercial ones proved impracticable.[3]

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[1] "P.V. Paquebots," 16 January 1840 (#3), A.N., C-871.

[2] "P.V. Paquebots," 12 February 1840 (#11), A.N., C-871.

[3] "P.V. Paquebots," 16 January 1840 (#3), A.N., C-871.

The remaining decisions soon fell into place. The route to New York was given to Le Havre, and Marseilles was given the principal route to the principal port in the Caribbean, Havana, which would be connected to Mexico by a satellite line using smaller ships. Something had to be done for Bordeaux, and at length it was given a line to Martinique with connections to Central and South America, despite vigorous objections (probably instigated by Marseilles) that such a line could never pay and should be dropped. The subsidies for the three lines were set at 1,200,000 francs, 1,5000,000 francs and 1,600,000 francs per year respectively. As for the line to Brazil, with a connecting line to Buenos Aires, the commission agreed that it would not pay commercially and would have to be government-run. In the interest of keeping the subsidies low and preventing litigation in case of financial failure of the lines, the commission agreed not to put any restrictions on the characteristics of the ships besides horsepower (320 for Le Havre, 400 for the other ports) and coal supply: it specifically refused to require that ships provided by the commercial companies be able to carry guns, and made no specifications as to where the ships or their engines should be built.[1]

The commission then turned to the question of what to do if commercial lines could not be organized. It briefly considered a mixed system in which the government would build

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[1]"P.V. Paquebots," 16 January-15 February 1840 (#3-12), A.N., C-871.

the ships and private firms operate them on loan, but this was abandoned, primarily because the legal complications of such an arrangement seemed insurmountable. A system of government-operated lines was then drawn up which essentially paralleled the commercial lines except that the Marseilles-Havana line, whose political functions were better filled at each end by the Bordeaux-Martinique line, was dropped. There would be alternate sailings to Martinique from Nantes and Bordeaux, and Brest was to be the terminus of the line to Brazil. One change would have to be made in the type of service offered, for the commission decided that legal problems precluded government ships from carrying even the small amount of cargo that the commercially-run ships were to carry.[1]

One question that the commission was unable to resolve was the problem of which government agency was to run the government lines, the navy or the post office. One argument advanced against navy operation was that one purpose of the project was to increase French maritime strength while avoiding an overt increase in French naval forces. A bill to buy a large number of steamers for the navy would run counter to France's policy of maintaining a diplomatic entente with Britain and avoiding actions which might antagonize her. But another member asked if it would really be all that bad to show England that France knew how to protect her interests; while a third

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[1]"P.V. Paquebots," 12-17 February 1840 (#11-13), A.N., C-871.

claimed heatedly that France should not base her policy on the effect that it might cause abroad, and that a more direct policy would be more in line with public opinion. Although this debate occurred in February 1840, well before the height of the diplomatic crisis in the Middle East, it showed that anglophobia was never far below the surface in maritime affairs in France.[1]

With the commission leaning towards privately-run lines, the ports moved energetically to establish transatlantic steamship companies. In the van was Marseilles, where a report to the Chamber of Commerce in February 1840 was followed by the establishment of a company, whose capital of six million francs was subscribed in a few days. The Chambers of Commerce of neighboring areas, particularly Lyons, strongly supported the venture. On 4 May 1840 the Marseilles company formally submitted its request to the commission for a subsidy of two million francs for a line from Marseilles touching at Spain, Martinique, Havana, Mexico and New Orleans.[2] There was also much activity at Le Havre, where at one time there were three companies in the process of formation, one of which raised eight million francs.[3] In May a subscription was opened at Nantes, and there was also activity at Bordeaux, Cherbourg and even

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[1]"P.V. Paquebots," 17 and 22 February 1840 (#13-14), A.N., C-871.

[2]Giraud, Vapeur à Marseille, p. 40; "P.V. Paquebots," 4 May 1840 (#23), A.N., C-871.

[3]Brindeau, Anciens paquebots, pp. 21-22.

Dieppe.[1] Despite the enthusiasm, capital was not always easy to find: even the strongest of the ports, Marseilles, had to go to Rothschild for backing, while one of the Havre companies had to seek capital in Britain.[2]

Thiers and the Packets

However at this point the packet program was overtaken by political and diplomatic events. In February 1840 Thiers launched a new assault on the government, and succeeded in overthrowing it (and avenging himself on the king for his exclusion from office in 1839) by engineering the rejection in the Chamber of Deputies of a marriage grant for one of Louis Philippe's sons. The king had no choice but to call on Thiers to form a government, which he did on 1 March 1840.

Thiers brought a change of style to the French government, without really changing its policies. In particular, he continued the efforts of the preceding government to help Mohammed Ali by preventing intervention by the great powers, although he did so with more confidence in ultimate success: when warned in July that the other powers were combining to impose a solution, he exclaimed that they wouldn't dare as long as he, Thiers, was premier in France.[3] Thiers' confidence was based

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[1] Félix Libaudière, Histoire de Nantes sous le règne de Louis Philippe (Nantes, 1900), pp. 219-20.

[2] Guiral and Barak, "La navigation française," p. 393; Brindeau, Anciens paquebots, p. 22.

[3] J. Lucas-Dubreton, Aspects de monsieur Thiers (Paris, 1948), p. 134.

on the same factors that had sustained his predecessors and on two assets that they had lacked: Thiers' own reputation for decisive action in foreign affairs, and secret negotiations he had initiated (soon discovered by Palmerston) to preempt the powers by arranging a direct settlement between the Sultan and Mohammed Ali. Domestically, his need to conciliate the many enemies he had made while out of office (including the king) precluded any major departures from the previous government's policy. However Thiers needed an outlet for his own energies (which included a tendency to intervene in the smallest details of the operation of each ministry) and wanted something to hold the public attention, and he therefore embarked on a number of projects designed to encourage national strength and prestige. The best known of these projects was the return of the ashes of Napoleon from Saint Helena, but a number of them took the form of encouraging the development of large capitalist ventures, such as railroads and the Bank of France, which would strengthen themselves and France at the same time.[1] The transatlantic packet program was clearly such a project, and Thiers took an early and intense interest in it. It is not clear who persuaded whom, but in early March 1840 Tupinier and Thiers discussed the packet program and concluded that its benefits to the nation would be significantly increased if the government built and owned the ships and ran the lines itself. (Tupinier later

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[1] Andre Jardin and A.-J.Tudesq, La France des notables, 2 vols. (Paris, 1973), 1:155.

explained to the commission that Thiers had asked for information which he felt would corroborate his own opinion, but it is also possible that Tupinier helped him perceive the contribution the program could make to national strength if properly organized.)[1] Thiers therefore decided to bring about a change in the decisions arrived at by the commission, using Tupinier as his agent.

Tupinier began his campaign in the seventeenth meeting of the commission, on 13 March 1840. He submitted an analysis of the anticipated operating costs of the proposed commercial lines, and showed that, while the proposed subsidy was satisfactory for the Le Havre line (permitting a profit of nearly 6 percent), it was inadequate for the Marseilles line, which would barely break even, and for the Bordeaux line, which would suffer a 1 percent loss. To give the last two the same chance for a profit as Le Havre, subsidies of 1,900,000 francs and 2,300,000 francs would be required. However this would eliminate the financial advantage of commercial operation, for it would raise the cost to the government of commercially-run lines from 21,500,000 francs to 27,000,000 francs, nearly equal to the cost to the government, estimated at 28,348,105 francs, of running the lines itself, with the important provision that its ships be allowed to carry cargo. The main difference between government and commercial operation now became the fact that, under government operation, the government would own a large number of steamers built to its own specification, ready at a

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[1]"P.V. Paquebots," 6 April 1840 (#20), A.N., C-871.

moment's notice in case of war, while ships built by private companies would not be built with war service in mind and would only be available after several months of legal formalities and conversion work. Thus, Tupinier concluded, if the interests of the state were to prevail and the program were to be designed so as to increase the number of steamers available for war, as many of the lines as possible should be operated by the government. The main objections to this (the extra cost and the limitations on service) would be eliminated if the commission changed its opinion and allowed government ships to carry cargo.[1]

Tupinier's proposals caused an uproar in the commission, at least among the members who supported the major ports. One pointed out that the inequality of the subsidies had been intentional: the commission had realized that the Le Havre line needed additional help due to its proximity to British competition, while it felt that the Bordeaux line would have to find some other way besides government subsidies to compensate for its natural disadvantages. He also revived the old legal arguments against government ships carrying cargo, and also said that French naval officers, unlike the British, would not accept commercial responsibilities. Tupinier retreated in some confusion, saying that he would rework his figures, and he and Thiers saw that stronger pressure would have to be applied.

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[1]"P.V. Paquebots," 13, 21, and 28 March 1840 (#17-19), A.N., C-871. A copy of Tupinier's memorandum is bound in the back of A.M., Marine 1DD1-55.

Thiers therefore informed the commission that he wished to meet with it himself.

Thiers met with the members of the packet commission twice, at the end of March and the beginning of April 1840, and, while not allowing them to arrive at any conclusions in his presence (these meetings were unofficial and no minutes were kept), he made it clear what was expected from them. He told the commission that he saw the question first and foremost from the political and military point of view. He specifically stated that he could not present the project to the Chambers unless it combined two essential conditions: it must satisfy the interest of the State by providing for the construction of ships destined to augment the navy in time of war, and it must satisfy a legitimate need of commerce by providing for the rapid transportation of merchandise on the ships. He also laid down one other condition: his government needed the political support in the Chamber of the deputies from the Gironde region, and to get this the principal line from France to the Gulf of Mexico would have to be transferred from Marseilles to Bordeaux. (He proposed giving Puerto Rico and Vera Cruz to Bordeaux and Martinique and Havana to Marseilles.) He silenced protests by saying that if commercial reasons alone governed, all of the lines should be concentrated at Le Havre.[1]

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[1] "P.V. Paquebots," 21 March-6 April 1840 (#18-21), A.N., C-871.

Thiers intervantion accomplished its purpose. The supporters of the ports accused Tupinier of misleading Thiers, protested against improper interference in the work of the commission, and tried to have it write up its report as of the time of the change of government. (Its work had then been essentially complete.) But Tupinier and his supporters argued that Thiers' intervention had been legitimate: formerly the commission had had no political guidance and had allowed commercial considerations to prevail, but now it had received political guidance and had the duty of taking it into account and changing its views where necessary. He won over the majority by proposing that the final report include both the state of affairs as of the change of government and the results of the new deliberations which he now proposed to undertake.[1]

The new deliberations concentrated on two questions: the carrying of cargo aboard government ships (the key to government operation of the lines), and the changes in routes desired by Thiers. The carrying of cargo was adopted after legal objections were overruled and navy constructors assured the commission that ships built for military use could carry two hundred tons of cargo, only one hundred tons less than comparable merchant ships. (Total hull capacity would be about 1500 tons: steamers of any type were still severely limited in cargo capacity.) The commission then overrode opposition from

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[1] "P.V. Paquebots," 2 and 6 April 1840 (#20-21), A.N., C-871.

Marseilles and attempted to adjust the routes according to Thiers' desires. However Tupinier found that any change would require a vast increase in the subsidies, and the commission found itself faced by a dilemma: there was no practical way to divide Havana and Mexico between two lines, while the only other possible Caribbean route, the one to Martinique, could not be made to pay from either Marseilles or Bordeaux. The only way out, duly adopted by the Commission, was to decide on alternate sailings from Bordeaux and Marseilles (one per month from each port) to a single port in the Caribbean (Havana), which would be connected to other points, including Mexico, by satellite lines of smaller ships. However there was no way to arrange for two commercial lines to share one route amicably and profitably, and operation of the Caribbean lines by the government therefore became unavoidable.[1]

The final recommendation of the commission, signed on 8 May 1840, thus called for government operation of three out of the four lines. Tupinier and Thiers settled for commercial operation of the Le Havre-New York line, because the intensity of British competition on that route precluded designing the ships for anything but commercial purposes. The other three lines (Bordeaux and Marseilles to Havana, Brest to Brazil) would provide sixteen ships, which would amply satisfy the navy's needs. A bill incorporating the commission's findings was presented to the Chambers on 16 May 1840.

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[1] "P.V. Paquebots," 6 April-8 May 1840 (#21-25), A.N., C-871.

Thiers saw to it that the bill received rapid attention in the Chambers. The Chamber of Deputies appointed a nine-member commission to report on it, and among the nine members were Tupinier, another member of his commission, and the man who had represented Bordeaux before it.[1] The report of the nine deputies, dated 8 June 1840, made prominent mention of the strides that the British had made in transatlantic steam communications, and emphasized the need for France to match the British in order to maintain her commercial, political and cultural ties with the new world. But now, as diplomatic affairs in the Middle East approached their climax, the deputies saw fit to say in public what Tupinier's commission had discretely said only among themselves. They pointed out the military advantages that Britain drew from her enormous steam merchant marine (estimated at 840 ships of 64,700 horsepower). The speed of steamers, their maneuverability and their ability to proceed in any direction regardless of winds and seas had changed the nature of maritime war. A country with a superiority in steamers, even if inferior in the size of its land forces, could at any time invade and lay waste the coasts of its opponent. Therefore, powerful as the commercial reasons for the project might be, "they are only accessory and secondary. In telling you [the Chamber of Deputies] what steam adds to the offensive capabilities of another Empire, we have revealed to you the necessity of giving

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[1] Report to the Chamber of Deputies, 8 June 1840, P.V. Députés, 1840, 7:400-469.

this auxiliary to the defensive forces of France. In reality the bill augments the navy in its most deficient part. . . . We will form for use in war a personnel composed of officers, sailors and engineers experienced in an art new to seamen. That is the supreme reason. To make you appreciate this, if it were necessary, we would only have to give you the figures on steam navigation in French ports."[1] There was no need to give the figures: the deficiency of France in steam navigation was well known to the Chambers.

The parliamentary commission made only minor changes to the bill: it increased the number of sailings per year to the Caribbean from Bordeaux to eighteen, compared to twelve from Marseilles; increased the number of ships to eighteen to provide for the additional sailings; and changed the main Caribbean terminus from Havana to Martinique, which had the single crucial advantage of being French territory. The terms for the contract for the Le Havre line were also altered in an effort to make the venture more attractive to investors. The bill sailed through the Chambers and became law on 16 July 1840. The matter was now in the hands of the navy, for under the law it was given 28,400,000 francs to build fourteen steam packets of 450 horsepower and four of 220 horsepower.

The Battle Over the Engines

Thanks partly to the deepening crisis in the Middle East and partly to the personal efforts of Thiers and Tupinier, the

[1]Ibid., 410-411. See also ibid., p. 406.

early trend toward commercial packet lines in Tupinier's commission had been reversed and a law had been obtained that would provide a large number of the new large steamers which would be available to the navy for use in wartime. However another issue with perhaps even greater military significance received surprisingly little attention prior to the peak of the diplomatic crisis in July 1840: the question of who was to build the engines for the ships.

From the military viewpoint, this was a question of the short term versus the long term: was it more important to have the ships immediately or to develop the industrial base that would permit construction of such ships in the future. Opinion in Parliament generally favored immediate procurement of the ships, and this seems to have swayed the leadership in the ministry of marine away from its usual policy of emphasizing the development of an industrial and technological base for steamer construction over actual construction of the ships. There were additional pressures in the same direction from outside the navy. Manufacturing interests had not been represented on Tupinier's commission, and commercial interests, which had been, naturally wanted to have the best possible engines at the lowest possible price. This meant British engines, for these had the reputation of being better made than French engines and they cost about 30 percent less. The commercial interests claimed that, when competing with English firms, French firms needed every possible financial break, and that they could not

afford the luxury of buying French engines.[1] In addition the representative of Bordeaux noted that French industry had never built any engines of the size contemplated, and blasted the quality of the products of French heavy industry, claiming that the French even bought heavy chains in Britain due to lack of confidence in their own. He recommended a crash program to buy the engines in Britain at any price.[2]

Tupiner replied that, as far as the navy was concerned, the criticism of the quality of French products was entirely "too absolute": good engines were built at Rouen, Arras, Marseilles and elsewhere, and out of some thirty engines in the French navy, all but four or five had been built in France. But he also complained about the difficult position of the navy, caught between demands that it buy its engines in France and the fact that the performance of some firms had proven inadequate: this, he said, had been a main reason why the navy had established its own factory at Indret and steam engine repair facilities at Lorient and Toulon. In addition he complained that the navy had been seriously inconvenienced by the fact that French steam engine firms were not financially secure. Recently Charenton had suspended payments for the third time, and the navy had been forced to finish in its own factories a 160-horsepower engine begun there. One cause of this weakness, he

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[1]"P.V. Paquebots," 10 February 1840 (#10), A.N., C-871.

[2]"P.V. Paquebots," 16 January 1840 (#3), A.N., C-871.

added, was that, in order to execute government orders, private firms had to make a heavy capital investment in tools and facilities. This was in fact an excellent reason for giving more orders to French industry: another member pointed out that the more engines that were built in France, the more her production facilities would expand. But Tupinier did not get the point, and seemed in the end to agree with the Bordeaux representative that the national interest (meaning readiness for a maritime war, especially with Britain) required getting an adequate number of steamers without delay regardless of the source of the engines.[1]

On 10 February 1840, in the period before Thiers' intervention, the question of supplying the engines came up for discussion in the commission. The matter had previously been raised elsewhere by the government in a proposed revision to the customs law, which would reduce the duty on large engines intended for international navigation from about 30 percent to about 10 percent. This did not satisfy the ports, which demanded total elimination of the tariff (particularly for the packet program), while the manufacturers, badly outnumbered politically, fought to keep at least part of their protection. In the commission, the port representatives claimed that French industry was not sufficiently advanced to take advantage of the tariff if it were retained, and that the lower prices resulting from

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[1] Ibid.

its abolition were a necessity for the commercial success of the proposed shipping companies. They pointed out that the government bought some of its own engines abroad, and that it had not hesitated to override the interests of the metallurgical industry and allow importation of locomotives and rails to insure the success of the first railroads.

The few supporters of the manufacturers in the commission complained that the proposal amounted to granting a subsidy to the shippers of merchandise at the expense of industry, and argued against the short-sightedness of a policy that, they claimed, would destroy the steam engine industry in France. (Both sides agreed that if the tariff were lifted, private companies would buy all their engines in Britain.) "In case of war," they asked, "where would France supply herself with these motors if she had not carefully developed in advance in her own territory establishments able to provide them." They "deeply regretted to see that commerce in general disowns French industry. If a rupture should some day break out with England, then commerce would bitterly deplore this neglect and this improvidence." Government orders had helped and would continue to help: "The navy, to be sure, places some orders with these national establishments, but in a circle that is necessarily very restrained."[1]

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[1]"P.V. Paquebots," 10 February 1840 (#10), A.N., C-871.

But the most they felt they had a chance of getting from the commission was the retention of the tariff on the smaller engines for the secondary lines, and they lost even this in the final vote, which was seven to two for exemption of the large engines and five to four for exemption of the smaller engines from the tariff. This decision was not affected by Thiers' intervention. The only favorable aspect of the commission's final report for the steam engine industry was the recommendation that the government operate three of the lines, for the government would probably buy some engines in France while private firms would not. Even this was no guarantee: Schneider wrote on 21 March 1840 that he relied very little on the government or on the Chambers for any help during the following year.[1]

During the deliberations in Tupinier's commission and in Parliament, it was not the government that rallied to the support of French manufacturers but the manufacturers themselves. Still in the depths of the depression that had begun in the financial crisis of 1837, and unable to compete with the British abroad, they now saw the principle of protective tariffs, on which they relied to keep the French domestic market, come under attack. The metallurgical industry moved first, forming the Committee of Metallurgical Interests on 19 January 1840 to lobby on its behalf.[2] While this group included some of the

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[1] J.-B. Silly, "Creusot," pp. 258-259.

[2] Comité des intérêts métallurgiques, Circulaire du 15 février 1840 (no. 1), Bibliothèque Nationale, Paris (Hereafter B.N.):V-35150.

largest manufacturers of steam engines, the stakes for their industry were so high in the packet program that, after the adverse report of the Tupinier commission, they formed their own lobbying group, the Union of Constructors of Machinery.[1] The central committee of the Union submitted two letters in June to the commission examining the packet bill in the Chamber of Deputies, and these were probably only part of a much more intensive lobbying effort mounted by the group.[2] Their arguments were much the same as those previously advanced in Tupinier's committee. They stressed the advantage to both the French economy and to French security of having a strong steam engine industry, and combated the claim that they would be unable to produce the engines if given the chance. They pointed out that where tariff protection was adequate, namely in the interior of France and on her rivers, they had achieved an enviable record of technological excellence at a reasonable price. For river steamers the French manufacturers had developed a type of engine not found in either Britain or the United States (a high-pressure engine with light but strong iron construction

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[1] Union des constructeurs des machines, Compte rendu des travaux du comité des constructeurs de machines (1840-41) (Paris, 1841). (Hereafter C.R. Constructeurs.) B.N.:V-13681. A list of members is at the end.

[2] "Note sur le projet de loi sur les paquebots à vapeur transatlantiques," dated 1 June 1840 and signed by François Calla, a member of the central committee, and letter from Comité central des constructeurs de machines to members of the Commission des bateaux transatlantiques, dated 5 June 1840, both in A.N., C-807. See also Comité des intérêts métallurgiques, Circulaire du 24 mai 1840 (no. 4), B.N:V-35150.

which made maximum use of the expansion and condensation of steam in order to maximize fuel economy), and they had succeeded in driving out British competition. However it was a different story along the coast, for the ports had succeeded in circumventing the tariff on engines for use on the high seas even before the proposal was made to abolish it legally and were buying nearly all their engines for seagoing steamers in Britain. As a result the steam engine industry had been unable to get a foothold in the ports (all the major firms were inland) or to get the orders that it needed in order to gain experience with large marine engines and to prove the fallacy of the traditional belief that all their products were inferior. The only major help in this respect that they had received had come through navy orders, but these were necessarily few, due to the size of the navy budget, and only benefited a few builders. They asserted that they could produce the desired engines well before the hulls were ready to receive them, and that, due to the central position of their industry in the economy and in the national defense, fifty million francs spent on the packet program, if spent in France, would be more productive than two hundred million francs spent on any other public works program.

The results of their lobbying were not impressive. They were unable to get language inserted into the bill to require buying the engines in France or to get any commitment from the parliamentary committees on the tariff. They had to settle for a pledge from the government to do what it had been expected all

along to do--to order at least some of the engines in France. The parliamentary committee was sympathetic to their arguments and pointed out in its report that, if the French manufacturers were never given orders for large engines, they would never develop the special tools and the skilled workmen able to cast the large parts, assemble and adjust them; and the prejudice against French engines would remain. It called on the government to have faith in French ability, and to break the dependence of the navy and of France in general on foreign suppliers by placing some of the orders in France. It went so far as to obtain assurances from the Minister of Marine that he intended to do this. But the committee also felt that French industry, even including Indret, was not sufficiently developed to produce all the engines, and that some would still have to be ordered in Britain. It stated that it felt the allocation of orders proposed by the Minister of Marine was in proportion with the present state of French industry. It added that the navy's intention was to order primarily new models in Britain, which it hoped would hasten the day when France would no longer have to seek engines abroad.[1]

The Levant Crisis and the Engines

One day after the packet bill became law, Palmerston invited the French ambassador, François Guizot, to the Foreign Office and gave him some bad news: the French diplomatic gamble in the Middle East had failed, and Palmerston had succeeded in

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[1] Report to the Chamber of Deputies, 8 June 1840, P.V. Députés, 1840, 7:452-455.

negotiating a treaty with the other European powers that would impose a settlement in the Middle East. Guizot was stunned, for he had at least expected to be consulted before the final signing, which he learned had taken place on 15 July. But this was just the beginning, for the terms of Palmerston's treaty could not have been a more direct challenge to France. Mohammed Ali was given ten days to agree to the terms of the powers (hereditary possession of Egypt and possession of southern Syria for his lifetime). If he did not agree, he would be stripped of Syria, and if he waited another ten days he would be deposed from his position in Egypt as well, if necessary, by the combined forces of the powers. For France the treaty left no way even to save face: she would have to submit abjectly or fight a united Europe. It did not even leave time for talk, for Palmerston had included in it an unprecedented clause making it effective before formal ratification. But what outraged France most was that her old rival, England, had combined with Austria, Prussia and Russia and revived the European coalition against her--the same coalition that only twenty-five years before had pushed France back within her old frontiers and imposed on her the treaties of 1814 and 1815, which many Frenchmen still bitterly resented.

France exploded with rage. The entente with Britain in the 1830's had never done more than cover over the animosities left after hundreds of years of Anglo-French wars, and now anglophobia erupted all over France and in all sectors of opinion. Challenged by Europe, many Frenchmen wanted to fight

and avenge the humiliations of 1814 and 1815. Thiers, whose own pro-English tendencies had been so cruelly deceived, was in the forefront of the bellicose French reaction. While denying any aggressive intention, he set in motion extensive war preparations: additional men were called up for the army, massive new fortifications were begun around Paris, and supplementary credits were passed for the navy. Thiers spent much of his remaining months in office closeted with the war and navy ministers, concentrating on the task of putting France's defenses in order.[1]

However no one in France was hit as hard by Palmerston's treaty of 15 July as the navy. The navy was a traditional center of anglophobia in France: no group of Frenchmen had been more thoroughly or more repeatedly humiliated by English arms. In addition, the navy had been directly involved in the efforts to support Mohammed Ali. During the late 1830's it had put much effort into building a strong, active Mediterranean Fleet, and this fleet's most recent commander, Rear Admiral Julien-Pierre-Anne Lalande, had brought it to a peak of efficiency that was greatly admired even by British naval officers.[2] Lalande's fleet had been prominently deployed to the eastern

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[1] Lucas-Dubreton, Thiers, p. 142.

[2] Pierre-Henri Roux, "Le rôle de la marine française dans la crise franco-égyptienne de 1839-1840" (Thesis, Ecole de Guerre Navale, 1962), pp. 5-10, 23-25. Lalande was personally on very good terms with his British counterpart in the Mediterranean, Admiral Sir Robert Stopford.

Mediterranean during the crisis, and Palmerston's action in essence told the navy that even the most efficient naval squadron France could put together was not enough to deter England when she felt that her basic interests were involved. The navy felt directly humiliated by the treaty of 15 July, and its humiliation was deepened when, to avoid an accidental clash, the French government recalled Lalande to Paris on 4 August and withdrew his fleet from the eastern Mediterranean shortly thereafter.

The navy therefore participated vigorously in Thiers' defensive preparations after 15 July, hoping to show that its basic fleet organization, with half of its ships on the ways and additional ones in reserve afloat, could still help deter England. Special credits were passed, and the dockyards were ordered on 1 and 3 August to recommission five ships of the line and eleven frigates then in reserve or completing afloat in order to bring the active fleet to twenty ships of the line (all in the Mediterranean) and twenty-two frigates.[1] Five days later, Brest, Rochefort and Toulon were ordered to launch eight frigates then on the ways, and similar orders may have gone to Cherbourg and Lorient for additional ships.[2] However the navy

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[1] France, Ministère de la Marine et des Colonies, Compte définitif des dépenses de l'exercise 1840, p. 9; Circulars, from Minister of Marine to ports, 1 and 3 August 1840, A.M., 1DD1-49. A circular of 5 August ordered the ports to report the dates by which each ship in reserve could be made ready if needed.

[2] Circular, 8 August 1840, A.M., 1DD1-49.

ran into unexpected difficulties in readying the ships: the hulls needed more work than expected, guns and stores were not immediately ready for issue to the ships, and, most important, crews could not be found on such short notice. As a result the navy was obliged to cancel the launchings of the frigates on 2 September.[1] The crisis did not last long enough or become serious enough to turn into a full-scale test of the fleet organization, but the limited experience was not encouraging. The navy found that its sailing fleet might not be as formidable a means of defense as both they and the British had previously thought.[2]

As for the packet program, now in the hands of the navy, the impact of the crisis was direct and immediate. The navy, faced with the possibility of a rupture with Britain, suddenly realized the importance of technological and industrial independence from Britain, and saw that the program would be an ideal vehicle by which to attain it. After the treaty of 15 July all talk of building some engines in Britain came to an end. The Union of Constructors of Machinery gleefully reported to its members that circumstances had "marvellously served" their

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[1] Circular, 2 September 1840, A.M., 1DD1-49.

[2] The British had taken the French reserve ships on the building ways very seriously. C. J. Bartlett, Great Britain and Sea Power, 1815-1853 (Oxford, 1963), p. 126. For a list of ships commissioned or recommissioned during the period 1 January 1840 to 1 July 1841 see A.N., C-879, Document 9. Only two of the thirteen battleships and frigates commissioned in this period had been launched during 1840, and these were launched in April before the crisis of July.

interests at a crucial time, and a parliamentary committee later agreed that the treaty of 15 July had been the decisive factor in ending the government's plans to buy some of the engines abroad.[1] The orders could have been placed, since commercial relations remained open even at the peak of the crisis. But, as the Union of Constructors reported, the crisis compelled France to count her forces and her resources, and she found that steam engines were a means of maintaining national security at home as well as commercial strength overseas, and that steam engine factories were military arsenals, just as were the naval dockyards.[2] The parliamentary committee, repeating in 1844 the sentiments of 1840, noted that steam engines were instruments of war, and that they helped compensate for one of France's main weaknesses at sea, the lack of trained seamen. It was unthinkable that France should continue to depend on England for them--such dependence was a threat to French security.[3] The industry could not survive on private orders, and the government would have to take an active role if it wanted the industry to remain healthy and to develop new capabilities. The engine constructors were delighted with the attention they received, but were well aware that it was not given for their sake: "It

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[1] Report to the Chamber of Deputies concerning new ships for the Calais-Dover route, 10 July 1844, P.V. Députés, 1844, 11:328.

[2] C.R. Constructeurs, 1840-41, pp. 10-11.

[3] Report to the Chamber of Deputies, 10 July 1844, P.V. Députés, 1844, 11:328.

must be said [that] raison d'état was the principal motive of this apparent liberality. If it had not shown itself, the orders would have escaped the French factories."[1]

The navy decided very soon after the July treaty that the engines would all be built in France if at all possible, although the decision was only committed to paper in October in the report of a special navy commission. This commission noted the magnitude of the task being undertaken: French companies had never built engines of the size contemplated, and did not have the machine tools needed to do so. All of them would have to make extensive capital outlays to undertake the project. Yet, the commission continued, these problems did not justify buying the engines abroad: the navy needed to help an industry whose future was so closely tied with that of the navy and of commerce, and needed to seek by all possible means to free France from the tribute that she presently paid to the industry of her rival and to develop industrial resources in France that would be adequate, if necessary, to support a war effort. The backwardness of French industry was simply another reason for helping it. On the positive side, some firms were reasonably well developed, and government orders, whose profits would cover the cost of the additional tools they needed, would be sufficient to give them the manufacturing capability that they lacked. In addition, these firms had build good engines in the past, though smaller

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[1] C. R. Constructeurs, 1840-41, p. 20.

ones than those proposed, and there was every reason to hope that their products, while not as polished as those that they might build a few years hence, would fulfill the essential conditions for good service. The commission therefore concluded that it was both necessary and practicable to build the engines in France.[1]

Preparing to Build the Ships

The navy therefore had to build eighteen hulls and supervise the construction of eighteen engines in factories that were not completely prepared to take on the job. The normal administrative technique used by the navy to manage a special program such as this was to set up a special commission to deliberate on all problems that might arise. Accordingly, a Steam Packet Commission was established within the navy on 18 July 1840.[2] However the ministry saw that the size of the program, plus the increased importance that it was bound to give to the steam navy, required fundamental changes in the navy bureaucracy itself. On 26 August 1840 an Office for Steam Vessels was created in the Direction of Ports. Its initial purpose was to supervise the operation of the packets after they were built, but this clearly also involved supervision of their construction. Furthermore, as the lessons learned from the packet program would also benefit the steam navy, the ministry

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[1] Ports to Minister, 17 October 1840, A. M., Marine 1DD1-52.

[2] Ports to Minister, 27 July 1840, A.M., Marine 1DD1-49.

decided to take maximum advantage of the situation and give the new office control of everything in the navy associated with steam, including the construction, fitting out and use at sea of both naval and packet steamers. In the broadest sense, the mission of the new office was to hasten the development of steam navigation in France by coordinating in one office all available knowledge about steam, observations on the operation of steamers at sea, and suggestions for improvements, both from France and from abroad. To increase its effectiveness it was given full administrative authority over Indret and the steam engine repair facilities in the ports.[1]

While the British had established a similar office in 1837 under a Comptroller of Steam Machinery, the French reorganization went much further. The British office was only given authority over the procurement of steam engines, and appears to have been created primarily to give the Admiralty an agency with the technological expertise needed to negotiate with the numerous British engine manufacturers. (The Admiralty had no steam engine manufacturing capability of its own, due to the availability of many private builders, and even had major repairs done in private factories.) It may also have been created in order to free the Surveyor, Sir William Symonds, who detested steamers, from responsibility for their engines, while leaving

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[1] Ports to Minister, 26 August 1840 (two reports), A.M., Marine 1DD1-52; Ann. Mar., no. 71 (1840), pp. 949-50; Ann. Mar., no. 73 (1840), p. 445; Ann. Mar., no. 74 (1841), pp. 12-15; Budget, 1842, p. 624.

him control over their hull design. In contrast, the French office was founded on the conviction that "the steam navy seems destined to render, sooner or later, immense services; an incontestable advantage will be gained by the country which first prepares itself to profit from the resources that it promises."[1] The occasion and the funds for the French reorganization were provided by the packet law.

The new program also increased the importance of maintaining a high level of technological expertise in the navy. Boucher first recommended expanding and institutionalizing the method used in the 1830's to keep up with technological developments, namely sending naval officers and constructors to visit Britain. Previously these officers had been sent only on specific errands, usually to buy engines, although the opportunity was also usually taken to have them study British factories and ships. In addition, some officers had been given leave to travel there at their own expense. Now Boucher and Tupinier recommended that one or more officers be sent on a regular basis each year "to keep us up to date with new developments in the arts which are of interest to the [French] Royal Navy." They also proposed allocating these assignments to insure that each of the five French naval ports had at least one constructor who

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[1] Ann. Mar., no. 74 (1841), p. 13. The British Admiralty's Steam Department is mentioned briefly in Rowland, Steam at Sea, pp. 64, 66, 68.

had visited England and studied on the spot the design of large steamers.[1]

The next step, taken at the same time as the Office of Steam Vessels was established, was to obtain additional qualified French naval constructors to supervise the construction of the new ships and engines. It was found to be impossible to get either the number of constructors or the experience level desired, and Boucher settled for the time being for authority to recruit ten additional junior constructors. He noted that experienced constructors would be obtained only through increased recruitment at the Ecole Polytechnique, followed by several years of experience at the Ecole Spécial du Génie Maritime and in the ports. This, plus the expansion of French private industry, would eventually be the key to French technological self-sufficiency, but the packet program itself was still heavily dependent on British technology.[2]

The navy then turned to an examination of the steam engine manufacturing facilities available to it in France. Its initial evaluation of the capacity of private French industry was not encouraging, and on 8 August, during the height of the reaction to the treaty of 15 July, Indret was ordered to evaluate its facilities and develop a plan to double its capacity and ultimately to achieve an output of twelve 450-horsepower engines

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[1]Ports to Minister, 25 July 1840, A.M., Marine 1DD1-49.

[2]Ports to Minister, 26 August 1840, A.M., Marine 1DD1-52.

per year.[1] To support this effort, the navy instituted a crash program of buying machine tools for Indret and the ports, and at least one purchasing mission was sent to England at this time.[2] However the navy feared that these efforts would not bear fruit in time to allow Indret and the large French private builders to provide all the engines for the packets, and on 8 August the ministry ordered a naval constructor to inspect some smaller French companies (including Pauwels at Paris and Stehelin at Thann), and then to see if additional resources might be found in Belgium, where orders could be placed "with more security than anywhere else."[3]

At the same time, negotiations began with French industry for production of the fourteen 450-horsepower engines. Specifications were drawn up by the Steam Packet Commission on 14 August. The technological problems involved seemed to preclude competitive bidding, and on 23 August the four French firms considered most capable of producing the engines, Cavé, Hallette, Schneider, and Sudds, Atkins and Barker of Rouen, were invited to submit proposals.[4] (Sudds, then on the verge of bankruptcy, did not

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[1]Ports to Minister, 11 November 1840, A.M., Marine 1DD1-49.

[2]Ports to Minister, 28 November and 23 December 1840, A.M., Marine 1DD1-52.

[3]Ports to Minister, 8 August 1840, A.M., Marine 1DD1-49.

[4]Ports to Minister, 23 August 1840, A.M., Marine 1DD1-49; Ports to Minister, 17 October 1840, A.M., Marine 1DD1-52.

participate further.) Almost immediately the navy became the focus of intensive lobbying. The Chamber of Commerce of Arras (the location of Hallette's factory plus a number of smaller engine builders), wrote on 4 August telling of the suffering of the workers there and the need for work; and it was supported later in the month by a letter from its departmental General Council.[1] Other similar petitions doubtlessly arrived from every town in France with a steam engine factory. Adolphe Schneider spent the fall in Paris negotiating with Tupinier, and becoming increasingly frustrated with the dilatory navy bureaucracy.[2] The delays ultimately worked to Schneider's advantage, however, for the navy was in the process of making the pleasant discovery that French industry had greater capabilities than expected. They found that Schneider's plans for the engines, based on some he had brought back from his trip to England earlier in 1840, were fully satisfactory, and these were adopted by Cavé and Hallette as well. On 17 October the Steam Packet Commission allocated the orders: three each to Schneider, Cavé and Hallette, four to Indret (on plans similar to Schneider's prepared by Indret), and one to be assigned later, at a cost of 810,000 francs each.[3]

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[1] Minister of Agriculture and Commerce to Chamber of Commerce of Arras, 22 August 1840, and Conseil Général du Département du Pas de Calais, meeting of 30 August 1840, A.N., F12-2214.

[2] Silly, "Creusot," pp. 258-259.

[3] Ports to Minister, 17 October 1840, A.M., Marine 1DD1-52.

There remained to be ordered four engines of 220 horsepower for the ships for the secondary lines. The constructor who had inspected the smaller companies recommended inviting only two firms to bid, Stehelin of Thann and Benet of La Ciotat, but these were not so clearly superior to their competition as were Cavé, Hallette and Schneider; and the commission prudently asked for proposals from a large number of firms, of which ten responded. The commission again decided against competitive bidding, and awarded two engines each to Pauwels of Paris and Stehelin. At the same time they awarded a similar engine for a navy steamer, Archimède, to Schneider, who thus became the greatest single beneficiary of the packet program.[1]

The success in placing these orders showed that the navy's estimate of the capacity of French industry had been unduly pessimistic. This allowed dropping the idea of placing orders in Belguim, and also led to a reconsideration of the future role of Indret. In October it was decided to limit the planned capacity of Indret to six engines of 450 horsepower per year, and to rely on private industry for a substantial proportion of future navy needs.[2] Even this limited expansion of Indret, however, required major changes in the facilities there and the acquisition of many new machine tools, and the navy

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[1] Ports to Minister, 23 August and 21 October 1840, A.M., Marine 1DD1-52.

[2] Ports to Minister, 11 November 1840, A.M., Marine 1DD1-49.

continued and expanded its program of buying machine tools wherever available, for both Indret and the ports. In October the Netherlands Steamboat Company of Fijenoord (near Rotterdam) offered to supply a large number of tools for Indret, some new and some second-hand English ones, and the director of Indret was sent there to examine them and negotiate a contract.[1] In November a special commission was established to coordinate further purchases of machine tools.[2] On 15 November Sudds, Atkins and Barker, then in receivership, proposed selling their extensive outfit of modern British tools to the navy if the firm could not be reorganized. A constructor was sent to inspect it, and the purchase was consummated in February 1841.[3] In December two constructors made buying trips to Britain in search of more tools.[4]

The private firms building the engines for the packets also had to make big capital investments. Cavé had to build a new foundry, since the subcontractor who had previously provided

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[1]Ports to Minister, 28 October 1840, A.M. Marine 1DD1-49.

[2]Ports to Minister, 28 November 1840, A.M., Marine 1DD1-52.

[3]Ports to Minister, 28 November 1840 and 17 February 1841, A.M., Marine 1DD1-52.

[4]Ports to Minister, 23 December 1840 and 8 January 1841, A.M., Marine 1DD1-52; J. Cros, "Considérations sur le matériel de notre flotte: Améliorations à introduire dans le régime de nos arsenaux," Nouvelles Annales de la Marine 4 (1850):104; Bulletin de la société d'encouragement pour l'industrie nationale 41 (1842):469-477; Jonveaux, "Cavé," pp. 65-67.

his castings refused to tackle the huge parts for the large engines. He also had to build a new shop in which to assemble and test the engines. Hallette had to install a large rolling mill and a foundry and buy some large machine tools. In all, over two million francs were spent by the government on machine tools in this short period, and the Union of Constructors of Machinery estimated that the private firms also spent two million francs in expanding their facilities.[1]

Work on the engines was soon underway. Barely a month after signing his contract, Hallette reported that he had satisfied the requirements for the first payment, and the navy set up a board to inspect the progress of the engines and ultimately to accept their delivery. The two permanent members, a naval constructor and a naval officer, exercised an active surveillance over the firms building the engines, with the result that the government got an increasingly accurate impression of the capabilities of the major French steam engine manufacturers.[2]

The subsequent execution of the packet program occurred under more relaxed political and diplomatic circumstances. The military situation in the Middle East was resolved in September 1840, when the intervention of the British fleet, notably the

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[1] Ports to Minister, 9 January 1841, A.M., Marine 1DD1-52; C.R. Constructeurs, 1840-41, p. 20; Ann. Mar., no. 95 (1846), pp. 229-230.

[2] Ports to Minister, 4 November 1840, A.M., 1DD1-52.

capture of Acre, in which steamers played a prominent role, forced Mohammed Ali to withdraw from Syria. The powers then decided to confirm him in hereditary possession of Egypt despite their earlier threat to depose him. Meanwhile the French reaction to the crisis cooled after October 1840 when Thiers was replaced by a government led by Guizot, which remained in power until 1848. The after-effects of the crisis were serious, however. France remained in actual diplomatic isolation until July 1841, and throughout the 1840's the memory of Palmerston's coalition insured, particularly in the navy, continuing resentment against Britain and continuing efforts to find a way to counteract her crushing maritime superiority.

While negotiations to procure the engines for the packets were going on, the navy began preparations to execute its own part of the program, the construction of the ships' hulls. Its efforts brought to the surface the main flaw in the program: the fact that it called for combining military and commercial functions in a single ship design. It had been assumed by everyone since the earliest stages of Tupinier's hearings that the hulls of any government-owned ships would be built in the navy yards on navy plans, since it was felt that only the navy yards would guarantee the solidity of the hulls and build into them the special fittings that would be needed in wartime. The design was thus necessarily a military one (very similar to the navy's _Gomer_ and _Asmodée_), modified for commercial use. In July Boucher drew up the general

specifications for the ships. They were to be able to carry twenty guns in wartime (twelve in the battery and eight on deck, including four large shell guns). In peacetime they were to carry 120 to 130 passengers and two hundred tons of cargo. The hulls were to be light enough and with fine enough lines to allow a speed of "ten knots at least at maximum power and in favorable circumstances," while being strong enough to withstand the firing of the ships' own guns. They were to be able to use sails whenever circumstances permitted in order to reduce coal consumption, requiring a relatively extensive rig on three masts. The coal supply was to be sufficient for twenty days' steaming, and the total displacement, computed from these requirements, was to be 2720 tons. The main military features were the heavy rig and the heavy construction of the hull, which would inevitably detract from the ships' speed.[1]

Boucher's specifications were sent to a number of naval constructors, who were all invited to submit plans. Following a technique used previously for sailing ships (especially frigates) but not for steamers, a number of these plans were to be adopted, in order to give the navy experience with a wider range of ideas concerning steamer design. However no designers of merchant ships were consulted, unless one counts the naval constructor who was on more or less permanent loan to the Post

[1] "Programme des conditions auxquelles devront satisfaire les projets de Paquebots transatlantiques de 450 chevaux," A.M., Marine GG1-23.

Office and who designed most of its packets. The hulls were allocated to the ports for construction on 23 August, and the building plans were approved, four in September 1840 and two in January 1841. Boucher himself drew the plans for the four 220-horsepower packets, along lines very similar to the navy's _Lavoisier_ class.[1]

But very soon doubts began to arise over the designs. From the beginning the very idea of using military hulls for commercial purposes had been criticized on technical grounds. In an early session of Tupinier's commission the representative of Le Havre, Augustin Normand, who was also perhaps the most proficient shipbuilder in France, stated that, "Packets constructed in anticipation of military service would clearly be lacking most of the qualities necessary for commercial packets and would not satisfy commercial needs in the least. In this regard they would be completely inferior to the English packets, whose competition they would be unable to withstand." They would be slow and uncomfortable, due to their weight and excessive stability.[2] Recent observations in Britain seemed to confirm these doubts: two ships very similar to the proposed French ones, _British Queen_ and _President_, which had been designed to compete with _Great Western_, had proven to be notably inferior

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[1]Ports to Minister, 26 September 1840, 16 January 1841 and 20 February 1841, A.M., Marine 1DD1-52.

[2]"P.V. Paquebots," 15 February 1840 (#12), A.N., C-871.

to her, and the French concluded that the reason was that their hulls were too large for their engines. Boucher felt compelled to rework his specifications in February 1841, eliminating one hundred tons of the cargo capacity and reducing the overall displacement to 2500 tons, which he felt was the proper size hull for 450-horsepower engines based on the proportions of Great Western. This required redrawing all the plans, but here a new problem arose, for a number of the ships had already been begun, and four of the large ones were too far along to be altered.[1]

Fortunately for Boucher, the navy's own budget included a number of steamers to be begun in 1841 and 1842, including four named Descartes, Vauban, Sané and Monge. Boucher proposed transferring the four packet hulls to the navy as a sort of head start on its own program, and starting new hulls for the four packets. Besides providing four steamers for the fleet, Boucher indicated an additional benefit from his proposal. Experience showed that the hulls originally designed for the navy's Gomer and Asmodée, which were supposed to receive Fawcett's engines of 450 horsepower, could take (and would probably need) engines of 540 horsepower. He therefore proposed transferring both the engines and the names of these ships to two of the packet hulls, and using their original hulls (under the names Descartes and Vauban) to experiment with yet another

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[1] Ports to Minister, 27 February 1841, A.M., Marine 1DD1-52.

increase in horsepower when the state of the packet program permitted.[1]

The whole design process for the packets thus had to start all over again. New specifications were sent to the ports on 1 February 1841 and this time plans by eleven different constructors were adopted in March and April for the large ships, while Boucher produced new ones for the three small ones that had not yet been begun.[2] Thereafter construction proceeded without incident. All eighteen ships were laid down before the end of 1841, and the first two large ones were launched on 7 August 1842. The only remaining problem was that the packet program with its high priority took over much of the labor and space in the dockyards that would have otherwise gone to the navy's own steamer program, and no large naval steamers were started between 1840 and late 1842 besides those begun in connection with the packet program.

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[1] The result of this sleight of hand was that the original _Gomer_ and _Asmodée_ became _Descartes_ and _Vauban_ (540-horsepower engines to be provided later), while the four packet hulls became the new _Gomer_ and _Asmodée_ (with Fawcett's engines) and _Sané_ and _Monge_ (450-horsepower engines to be provided later). Ports to Minister, 27 February 1841, A.M., Marine 1DD1-52. By similar reasoning the navy had decided that the hull originally begun for Miller's 320-horsepower engines would need larger engines, and Rossin's experimental engines of 450 horsepower, previously unassigned, were allocated to this ship (_Infernal_) and a new smaller hull was begun for Miller's engines under the name _Cuvier_, Ports to Minister, 9 December 1840, A.M., Marine 1DD1-49.

[2] Ports to Minister, 24 March, 21 and 28 April, and 17 July 1841, A.M., Marine 1DD1-52.

Tribulations and Triumph

However the main reason for the delay in the navy's own program, as well as the main factor that threatened to delay delivery of the packets, was the saturation of steam engine building facilities in France. A new packet program in 1841 added to this burden. The French packet service in the Mediterranean had come under fire, particularly at Marseilles, because it was slow and because it brought news from the Levant to Italy before it did to France. In addition, a British company had just established a service with two steamers of 420 horsepower which provided faster and more direct communications with Alexandria than did the French ships.[1] As a result, in November 1840, the Minister of Finance appointed a commission, of which Tupinier was again president, to find a solution. The commission decided to establish a new packet service between Marseilles and Alexandria with six ships of 220 horsepower. Ships of this size were judged to be the smallest that could guarantee eight knots' speed and carry an adequate coal supply, and were also felt to be the smallest that could be used to advantage in wartime.[2] The commission itself did not emphasize the use of the ships as warships--it was the Chamber of Deputies that added a paragraph to the bill requiring that the ships be

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[1]Giraud, Vapeur à Marseille, pp. 30-31.

[2]"Proces-verbal des séances de la Commission instituée par arrêté du Ministre des Finances en date du 16 novembre 1840" (meetings of 8 and 29 December 1840), A.N., C-817.

able to carry guns and that stated that this was the most powerful argument for the whole program.[1]

The navy's lack of interest in this program probably stemmed from two causes: the relatively small size of the steamers (no technological advances were involved), and the saturation of its own construction facilities. The law gave the responsibility and the funds for building the ships to the Minister of Finance rather than to the navy. Five of the six hulls were built in private shipyards, and the engines were awarded to Hallette and Cavé (one each) and Pauwels of Paris and Benet (two each). The navy's role was limited to approval of the plans for the ships and the engines by the Council of Works and the minister.[2] The existing Mediterranean service was not affected--in fact, early in 1841, two more ships of 160 horsepower had been ordered for it.[3] The same law also called for the government to take over the postal service between Marseilles and Corsica, and provided funds for three ships of 120 horsepower for this route. One of these ships, Napoléon, will be encountered in the next chapter, for she was the first steamer built in France with a screw propeller.[4]

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[1] The parliamentary documents on this bill are in P.V. Députés, 1841, 4:435-39 and 6:115-24.

[2] C.T., 8 July and 15 October 1841, A.M., Marine BB8-1116.

[3] Ann. Mar., no. 80 (1843), pp. 863-864.

[4] The minutes of the commission on the Corsica packets and other documents on this project are in A.N., C-817.

The packet programs alone meant that there were twenty-four engines of 220 horsepower or larger building in French factories by the end of 1841. Further orders were out of the question for the time being, and the navy was only able to order one large engine not associated with the packet program between 1840 and 1842 (a 220-horsepower one from Schneider).[1] However it wanted to begin work on the 540-horsepower engines for Descartes and Vauban as soon as possible, since they would take eighteen to twenty months to build and would provide valuable experience with increased horsepower. Once again, therefore, and for the last time, the navy looked abroad for its largest engines.

In March 1841 Tupinier reported to the Minister of Marine that "Britain offers more immediate resources, but, besides the political considerations which counsel looking elsewhere for the means of making up the deficiency in our present means of [producing engines], it is of great interest for the future to assure ourselves of what we can expect in case of need from the establishments of Belgium and Holland, reported to be very large." As a result a commission composed of Boucher and two other constructors was ordered to inspect the major factories in the Low Countries. The commission reported that three plants were capable of building the engines: Cockerill at Seraing, the Netherlands Steamboat Company of

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[1]Ports to Minister, 5 January 1842, A.M., Marine 1DD1-66. This engine was for Cassini.

Fijenoord, and Van Hell at Amsterdam. Of these, Cockerill asked too high a price, while Van Hell was not yet quite ready to build 540-horsepower engines.[1] Conditions were more favorable at Fijenoord, and in addition this company was already well known to the navy. In March 1840 its head had submitted a design for a new type engine to the Council of Works (it was rejected because it used high-pressure steam),[2] and later in the year he had been ready with an offer to provide machine tools as soon as Indret had completed the list of its requirements. The commission therefore recommended ordering both engines from the Netherlands Steamboat Company, and their contract was approved in June 1841.

The main problems for the French navy in producing steam engines came not from private industry, however, but from Indret. The administrative and technological turmoil that followed the death of Gengembre in 1838 had never properly been resolved, and the dismal performance on trials of Lavoisier and her sister Gassendi, both engined by Indret, raised serious doubts as to the success of the other engines building there. (The navy hoped that the failures could be attributed to the fact that both engines had been begun under Gengembre, "who thought mistakenly that he could do better than the authors

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[1] Ports to Minister, 10 March 1841 and 23 June 1841, A.M., Marine 1DD1-52.

[2] C.T., 19 March 1840, A.M., Marine BB8-1115.

of the engines of Véloce, which he had been ordered to copy.")[1] In addition, the process of expanding the factory, begun in 1840, had disrupted its facilities at the very time that it had received major new orders, with the result that its work was falling behind schedule. In June 1841 Boucher and two other constructors were sent to inspect Indret and the steam engine repair facilities at Lorient, and to supervise new trials for Lavoisier, Gassendi, and also a new Rapide, which was fitted with a 60-horsepower prototype of the experimental 450-horsepower engines Indret was building for Infernal.[2]

The director of Indret informed the inspectors of an additional reason for the delays--a large hammer ordered from Fawcett at the end of 1840 for the fabrication of the heavy shafts for the 450-horsepower engines had not arrived, and many other machine tools, mostly ordered in France, were also late in arriving.[3] The problems of forging heavy shafts for large steam engines had led in 1840 to the simultaneous invention in Britain and in France (by an employee of Schneider) of the steam hammer, and the hammer ordered by Indret may have been of this type. The steam hammer not only solved the problem of making

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[1] Ports to Minister, 26 June 1841, A.M., Marine 1DD1-52.

[2] Ports to Minister, 26 June 1841, A.M., Marine 1DD1-52.

[3] Rossin, "Note sur la situation des travaux relatifs aux appareils de 450 chevaux," A.M., Marine 7DD1-27.

450-horsepower engines, but was to make possible further large increases in power.[1]

For the moment no changes were ordered at Indret, but the problems did not clear up and in January 1842 Boucher and Tupinier decided that they could not be tolerated further. Indret was operating inefficiently (some shops were clamoring for work while others had long backlogs), and it was clear that it could not deliver its four large packet engines on time. Boucher made a new trip to Indret and decided to redistribute the engines ordered under the program. Two of the four packet engines building at Indret were transferred to the navy's Sané and Monge (the two remaining former packet hulls), whose delivery was not urgent. This left three packets without engines (one engine had never been ordered), and two of these were awarded to Schneider and one to Cavé, who were both performing well on their contracts. To further help Indret, the large shafts for its remaining two packet engines were subcontracted to Cavé. Of the private firms, Hallette, who had gotten off to the best start, was now falling behind schedule and giving some cause for concern, but his problems were minor compared to those at Indret.[2]

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[1] Rowland, Steam at Sea, p. 84; E. Flachet and G. Boutmy, "La légende des inventeurs: VIII: François Bourdon," Revue Britannique, February 1866, pp. 439-452.

[2] Ports to Minister, 19 January, 26 February and 26 March 1842, A.M., Marine 1DD1-66.

Indret was increasingly losing ground to the private manufacturers. In addition a new source of supply for large engines opened in July 1842 when it was decided to have the repair facility at Lorient build a 160-horsepower engine. Thereafter these facilities were available to provide new engines when needed, usually small ones, but occasionally large.[1]

One by one, however, all the problems in producing the packet engines were overcome. Except at Indret, the results of the efforts to build them had been highly satisfactory. Schneider and Cavé had produced their engines expeditiously, and Hallette was not far behind them. The trials of the new ships were awaited as a final test of the program. The English engines of Gomer and Asmodée were carefully tried when delivered in 1842, both to test Fawcett's workmanship and to provide a standard against which to test the French engines. The big moment came in May 1843 when Labrador, the first of the packets to be completed, ran her trials. On 18 May a member of the trials board reported jubilantly to the ministry that the trials were complete and that, after careful comparison with the English engines of Asmodée, the French engines of Labrador had proven superior in all respects. "Such a result does the greatest honor to MM. Schneider frères, from whose factory the engine of Labrador came, and it cannot fail to exercise a most beneficial influence on

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[1] Ports to Minister, 27 July 1942, A.M., Marine 1DD1-66.

public opinion in showing that as of today French industry, in the matter of fabrication of large steam engines, has not only succeeded in raising itself to the level of British industry, but that it can even surpass it."[1] In an earlier report, passing on some encouraging news about Hallette, he quantified the achievement:

> M. Hallette has now surmounted the difficulties which from the beginning plagued and delayed his work, with the result that his establishment is now on the same level of production as those of M. Cavé and MM. Schneider. It is certain that each of the three is capable of delivering as of now three large engines per year. In case of pressing need we can easily go to four, which will provide annually twelve large engines to augment the steam navy, independent of the engines of lesser dimensions which each of these factories can also build at the same time. This is more than it would have been reasonable to hope for. France is now freed of the need to resort to foreign industry.[2]

The importance of the navy's role in this achievement is indicated by a survey made in 1842 of the French firms that produced "large steam engines and locomotive machines."[3] Eleven companies were included in the survey: Cavé, Schneider, Hallette, Benet, Pauwels, Mazeline (a new firm at Le Havre), two smaller Paris firms and three locomotive companies. Of these the first three had by far the greatest total career output, ranging from 6460 to 7780 horsepower. Of this total output, navy orders as

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[1] Ports to Minister, 18 May 1843, A.M., Marine 1DD1-75.

[2] Mimerel to Minister of Marine, 29 March 1843, A.M., Marine 7DD1-68.

[3] Bulletin de la société d'encouragement pour l'industrie nationale 41 (1842):467-484. See also Ann. Mar., no. 95 (1846), pp. 234-236.

of 1842 (including orders for post office packets) accounted for a third to a half (2370 to 3420 horsepower). In addition the navy engines, while few in number, were by far the largest ones built by these companies, and therefore were the only ones seriously to challenge their technological and industrial abilities. The average size of the engines installed in French factories and mines during 1841 was about 13 horsepower (Schneider was exceptional in having built an engine of 250 horsepower for a coal mine), while the largest engine in the French merchant marine in 1841 was a British one of 180 horsepower in a ship (Paris) which ran between Le Havre and Hamburg.[1] The three smaller firms named above were established between 1836 and 1839 and benefited even more heavily from navy and Post Office orders: of the seven ships built as of 1842 by Benet, with a total horsepower of around 1140, four ships totaling 760 horsepower were built for the government, while Pauwels, a relatively small firm, received government orders for six ships of 1200 horsepower. Only Mazeline, which as of 1842 had built engines for only four small ships, had not yet built an engine for the navy, but its subsequent growth was to be based largely on navy orders.

After this triumph, the rest of the story of the French transatlantic packets was very much of an anticlimax. As a commercial venture, they were a complete failure. The first

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[1] C.R. Constructeurs, 1842-43, pp. 233, 240; Anthiaume, Construction, p. 58.

suggestion of trouble came when the government failed to find any bidders for the Le Havre to New York line. The Le Havre companies claimed that the subsidy offered was too low to compensate for the conditions imposed by the government. This plus the continuing criticism of the navy's designs for the ships and, above all, the fact that British experience had shown that the profits from transatlantic steamer lines had been greatly overestimated in the enthusiasm of 1838-1840, led the French government in 1843 to send a commission of experts in Gomer on a tour of the ports to be served by the packets.[1] The commission reported that the program as established in the law of 1840 would not produce the expected earnings and that the designed speed of the navy-built ships (eight knots sustained sea speed) had long since been exceeded by the competition.[2] In November 1843, even before Gomer returned, the navy began considering abandonment of the lines, and in fact nothing further was done to implement the law of 1840 besides completing the ships and laying them up in reserve.[3] During the Moroccan crisis of 1844 the navy was allowed to use temporarily six of the large ships, and one of these, Groenland, was lost during the campaign.[4]

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[1] Ann. Mar., no. 79 (1842), pp. 370-372.

[2] Brindeau, Anciens paquebots, p. 25.

[3] Ports to Minister, 3 November 1843, A.M., Marine 1DD1-75.

[4] Minister of Marine to king, 30 June 1844, A.M., Marine 1DD1-86.

In December 1844 the government decided to ask for a new law altering that of 1840. By this time conditions were very different from 1840: changed diplomatic circumstances, the improved state of the steam navy and the experience with the 1840 law all combined to reduce interest in the military aspects of the program, and it was decided to give all the lines to private companies. However technology had also advanced, making possible a new type of ship with mixed sail and steam propulsion (the steam consisting of a small auxiliary engine using the screw propeller) which could carry almost as much cargo as sailing ships. The resultant controversy between the different ports and between sail and steam interests effectively blocked the project.[1] However, before the bill died, the navy, invoking one of its provisions, obtained the provisional transfer to the fleet of six of the large packets and all four of the small ones, to fill important naval needs and to stop the deterioration of the engines due to idleness. Three more were transferred under similar circumstances in 1846.[2] The government resurrected the 1845 bill in 1846 but was again unable to bring it to a vote,

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[1] Chambre de Commerce du Havre, "Observations sur le projet de loi relatif au service des correspondances transatlantiques," 8 June 1845, A.N., C-766; Bill and Report to the Chamber of Deputies, P.V. Députés 1845, 3:447-453 and 10:85-116. See also Giraud, Vapeur à Marseille, p. 42; Pasquier, "Bordeaux et les débuts," pp. 222-224.

[2] Ports to Minister, 29 July 1845, A.M., Marine 1DD1-99; Ports to Minister, 3 March and 3 September 1846 and Minister of Marine to king, 10 March 1846, A.M., Marine 1DD1-109.

and then tried again with new legislation in 1847.[1] Efforts to establish three of the lines again foundered in Parliament, but this time a proposal was made by a private company to put the Le Havre-New York line in operation using, in lieu of a subsidy, the four packets of the 1840 program that were still laid up. The ships, now technologically obsolete and suffering from their extended period of inactivity, made a very poor showing. The first one, sailing on 21 July 1847 under the name Missouri, ran short of coal at sea and had to get some, first from a passing ship and then in an unscheduled stop at Halifax, before she could get to New York. Later crossings showed that the ships were capable of thirteen-day crossings, similar to the performance of the first Cunard ships of 1840, but the average was closer to eighteen, and the line never came close to being competitive. Service ended in January 1848 and the new French Republic transferred the ships to the navy in April.[2]

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While the transatlantic packet program failed to fulfill its primary purpose of providing transatlantic communications under the French flag, it still deserves a place in French maritime history, for it played a crucial role in the introduction

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[1] Bills and Reports to the Chamber of Deputies: P.V. Députés, 1846, 3:178-89; 1847, 2:137-39 and 163-69; 1847, 6:109-85; 1847, 11:385-407. The debate on the Le Havre-New York line is in P.V. Députés, 1847, 3:48-55.

[2] For the company's explanation of its failure see A.M., Marine GG1-23. See also Brindeau, Premiers bateaux, pp. 65, 80-81, 89; Brindeau, Anciens paquebots, pp. 26-28.

of steam technology into the French navy and into France. Its most direct contribution was the fourteen large packets, which in the original plan were to be available to the navy for use in war and which, in the end, were used by the navy in peacetime as well. From the beginning some officials had argued that an important function of this packet program, as those before it, was to increase the number of large steamers and of seamen trained in steam for use by the government in case of war. Their arguments did not at first prevail, but when Thiers came to power as premier in March 1840 he had the program altered along these lines. Long before the packets appeared on the official list of French naval vessels they had taken their place in calculations of comparative strength on both sides of the Channel, and in doing so they put the French steam navy on the strategic map. It was clearly now a force that would have to be reckoned with, both in France and in Britain.

The second major turning point, so far as the naval implications of the packet program were concerned, came with the diplomatic crisis of July 1840. The way Palmerston ignored the French sailing fleet in the Mediterranean while dictating a solution to the crisis severely shook the confidence of the French in the ability of the sail navy to support French policy, either in peacetime or in wartime. The need to find an alternative naval force suggested itself, and steam was the most logical candidate.

However the immediate impact of the crisis was to reverse an earlier decision concerning the production of the engines for the ships. Initially it had been planned to buy some or all of the engines in England, so as to have them as quickly and as cheaply as possible. However the crisis convinced the navy's administration that it was unacceptable to have to rely on one's possible enemy for the production of what might prove to be important weapons of war, and that the development of industrial independence must take precedence over the rapid acquisition of the ships. It therefore decided to build all the engines in France, and embarked on a major effort to develop French industrial facilities, both at Indret and at private factories. Many difficulties were encountered, but the trials of the ships were successful and demonstrated that, for all practical purposes, France had achieved the ability to build the largest size of steam engine independently of Britain.[1]

The crisis of July 1840 also resulted in another major decision: the navy resolved to break its technological dependence on Britain as well as its industrial dependence. While much progress had been made before 1840 in developing French industrial capabilities, very little progress had been made in technology and in 1840 France was still almost completely dependent on Britain for designs of large steam engines. The packet engines had to be based on plans brought back from England

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[1] Ann. Mar., no. 95 (1846), pp. 226-27, 229, 232-33.

by Schneider. But, at the same time that it expanded its factories, the navy also expanded its program of sending engineers to Britain in an effort to learn all it could about engine technology. More important, it renounced the practice of importing English engines as models. All future French navy engines, including some larger than 450 horsepower and many involving new technological innovations, were, in fact, designed as well as built in France; and the ultimate success of this effort was due in part to the equipment and the experience acquired during the execution of the packet program. This decision, and the one to build the packet engines in France, were hard ones to make, for they involved great expense and, were sure to result in some mistakes during the initial phases of the process. The importance of the crisis of 1840 was that it impelled the French navy to make these decisions sooner and more completely than it would probably have done under more ordinary circumstances, and insist on the development in France of self-sufficiency in the design and construction of large steam engines.

CHAPTER V

STEAM AS AN ALTERNATIVE TO SAIL: 1840-1845

During the period from 1840 to about 1845 the development of the French steam navy was very much under the influence of the transatlantic packet program. Construction work on naval steamers all but stopped due to the saturation of shipyards and engine factories with orders for the packets. Towards the end of the period, just as the construction of naval steamers began to speed up again, French engineers were confronted by a series of British innovations in machinery design and hull construction for steamers. They mastered these innovations and introduced them into France, although as they were no longer able to import British machinery as models they did so only with considerable difficulty.

The most important feature of the period, however, was the great progress made in the development of ideas concerning the military uses of steamers. One of the main results of the packet program was that it provided the navy with the use in wartime of fourteen large steamers of 450 horsepower, which were technologically far more capable of carrying out military missions than any of their predecessors. The navy's own building program was also changing the character of the fleet. In

1840 navy planners estimated that, while the total size of the active fleet (130 ships) would not change between 1840 and 1841, the number of steamers in it would rise from twenty to thirty and the horsepower of the largest ones from 220 to 450.[1] This change in equipment was matched by a change in ideas, for the crisis of 1840 had suddenly called into question the ability of the sailing navy to defend French interests, either in war or in peace, and suggested that only new forms of warfare that made maximum use of new technological inventions could neutralize Britain's overwhelming superiority in conventional forces. The result was an outburst of ideas in the early 1840's concerning the military use of steamers which, thanks to the presence among the steam enthusiasts of a real leader who was both a high-ranking naval officer and a son of the king, were collected into a complete doctrine for a steam navy. This doctrine called for the use of a steam fleet, not in support of a sail fleet, but as an alternative to it; and the result was that by 1845 there was a direct confrontation between the strategic and tactical ideas of the sail navy and those of the supporters of steam.

The large majority of line officers in the navy continued to support the old ideas. They saw the steam revolution as just that--a radical change in technology and in the form of naval

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[1] Budget, 1841, p. 520. It should be noted that these figures were future projections--the actual figures differed.

warfare that would be harmful to both French security and to their own careers. They believed in the traditional missions of a navy: fleet actions and overseas cruising, and felt that the traditional sail navy was the only force that could carry these out. Few spoke out in the "debate" (which was thus very one-sided), for their leaders were in control in the ministry and the sail navy did not therefore seem to be in jeopardy. Those who did, however, had practically the entire line officer corps behind them.

The advocates of steam, on the other hand, tended to come from groups peripheral to the line officer corps, both inside and outside the navy. For simplicity's sake, these groups can be reduced to three. The first consisted of politicians. During 1840 the Chambers had heard a great deal about steam, and the outcome of the crisis showed that the traditional naval policy based on sail battle fleets was less than infallible. While there was no major movement to make political use of naval issues (as there was later in the 1880's and 1890's), the Chambers still tended to be cautiously receptive to new ideas on naval matters. The second group consisted of a number of relatively junior naval officers who, for one reason or another, had become discontented with the standard paths of advancement in sail and who had chosen an alternative career based on expertise in steam. This group had existed ever since Lieutenant Louvrier had taken _Voyageur_ to Senegal in 1819, but in the 1840's it acquired a leader who was also independent of

the traditional paths of advancement but for a different reason: the king's son, the Prince de Joinville. The third group was the naval construction corps, which, by continuing as a matter of professional routine to introduce technological advances, kept the situation in a state of flux during much of the 1840's and ultimately made possible the accommodation between sail and steam that occurred toward the end of the decade.

In the early 1840's the two influences that had done most in the preceding twenty years to determine the size and structure of the French navy were removed. In 1842 Baron Tupinier resigned as Director of Ports and, while remaining on the Council of Admiralty, turned over effective control of the navy's materiel to his hand-picked successor, Mathurin-François Boucher. Boucher had promoted many innovations in steam navigation in the late 1830's and continued to favor its development in the 1840's. The other change consisted of the final abandonment of Portal's standard budget of 65 million francs as the basis of naval planning--the frantic spending during the crisis of 1840 and the higher level of naval activity that followed made it wholly unrealistic for the new decade. Tupinier tried in 1841 to develop a new standard budget appropriate to the new conditions, but his plan never developed the authority that Portal's budget had had in its day.[1] The navy therefore went

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[1] Baron J.-M. Tupinier, Considérations sur la marine et son budget (Paris, 1841); Ann. Mar., no. 78 (1842), pp. 417-433.

through the 1840's with budgets well over a hundred million francs, but without a standard budget integrated with a standard fleet plan.

The Steamer Program of 1842

The first new step forward taken by the steam navy after the passage of the transatlantic packet program in 1840 and its implementation was at least in part the result of the interest of French politicians in steam as an element of naval strength. During 1841 the Thiers ministry (which had fallen in October 1840) was taken to task in the Chamber of Peers for the fact that its rearmament efforts in 1840 had included supplementary credits for the sail navy but not for the steam navy. In response Thiers' minister of marine told the Chamber that the possibility of requesting supplementary credits for the steam navy had indeed been considered in 1840, and had been rejected for purely práctical reasons: the packet program had filled all French steam engine factories for the next two years, ordering engines abroad was out of the question during the crisis when a European war was a possibility, the navy wanted experience with 450-horsepower machinery before committing itself to buying more, the cost of a meaningful expansion of the steam navy (up to 1,600,000 francs per ship) would be very high, and the navy in wartime could always fall back on the packets.[1] Meanwhile in the Chamber of Deputies the commission examining a bill for

[1] Ann. Mar., no. 76 (1841), pp. 93-94. He noted that the ministry had, however, used 3,254,000 francs from its extraordinary funds for 1840 to expand its steam engine manufacturing capabilities.

supplementary credits for 1841 dropped the government a broad hint. It pointed out the great potential advantages of steam navigation, voiced confidence in the ability and willingness of the ministry of marine to encourage its development, and also indicated that the Chamber would gladly vote additional money for the steam navy if it were requested.[1]

By 1842 the navy was receptive to the idea because once again it was on the verge of reaching the statutory limit set in 1837 for the steam navy. The royal ordinance of that year had prescribed forty steamers of 150 horsepower or more as the limit for the steam navy, and in its budget for 1842, prepared at the end of 1840, the navy reported that by 1842 it would have thirty-six of these afloat and the other four under construction.[2] At the end of 1841, after gaining the approval of the Cabinet, the ministry of marine drew up a new steamer program.[3] Experience had shown that the bottom limit in size for military steamers (those designed to carry guns and fight) should be 220 horsepower instead of 150 horsepower, and that the forty war steamers in the 1837 program should conform to this new limit. When broken down into classes the new steam navy was to consist of five ships of 540 horsepower, fifteen of 450 horsepower and twenty of 220 horsepower. The navy then had only seventeen

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[1] Ann. Mar., no. 75 (1841), pp. 417-418.

[2] Budget, 1842, p. 162.

[3] Ports to Minister, 15 January 1842, A.M., Marine 1DD1-66.

steamers of 220 horsepower or larger built or building, and would need 34,450,000 francs spread out over the next ten years to build the rest. The smaller ships already on hand (mostly of the 160-horsepower Sphinx class) remained useful for packet, port and colonial duties, and thirty of them were included in the new steam navy, bringing the total to seventy.[1]

This program does not seem to have been drawn up with the British steam navy specifically in mind, but in fact the events of 1840 had provoked the British into a significant expansion of their steam fleet. As of the beginning of 1840 the French navy had actually built a few more naval steamers than had the British: forty French to thirty-eight British, most of which were still in service. While the British had more large steamers than the French, the numerous French 160-horsepower class was superior to the medium and small types of British steamers, so the result was a rough equality in steamers that contrasted sharply with the great British superiority in sailing ships. However in March 1840 the British ordered six large steamers of 280 horsepower, and in March 1841 followed these with a large program of ten similar ships plus six larger ones, planned for 300 horsepower but built with at least 400 horsepower. Although construction of half of the 1841 group

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[1] Budget, 1843, p. 646; Ports to Minister, 11 February 1842, A.M., Marine 1DD1-66 (also in Ann. Mar., no. 77 (1842), pp. 412-415 under date 4 March 1842); Bill dated 12 March 1842, P.V. Députés, 1842, 2:251-54.

was soon postponed to 1844, the new British ships considerably outnumbered the eight similar naval steamers begun in France in the same period and sent the British steam navy surging ahead of the French. (The French packets were recognized as a valuable auxiliary, but these were offset to a degree by the rapidly expanding British merchant marine.) British construction then slowed down again--only nine steamers, mostly experimental, were begun in 1842 and 1843. The French do not seem to have had accurate figures on the British programs, but the French program of 1842 was in fact large enough to close the gap between the two steam navies if properly carried out.

The French program was approved by King Louis Philippe in a royal ordinance on 4 March 1842, and the navy proceeded to request funds to carry it out. The only objection that came from Parliament was one of form: the navy had requested the money as an extraordinary credit, while the Chambers felt that it should be included in the ordinary budget.[1] The first tenth of the 34,450,000 francs was therefore appropriated when the 1843 budget was approved in 1842.

The navy ran into many problems in trying to execute the new steamer program. Some of these problems were associated with new technological advances, which are discussed below, but the principal problems in 1842 and 1843 were budgetary restrictions

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[1] Budget, 1843, pp. 173, 646; Budget, 1844, pp. 146, 722; Report to the Chamber of Deputies, 27 February 1842, P.V. Députés, 1842, 5:198-200.

resulting from a determined effort to retrench following the wild spending of 1840 and 1841, and, even more important, the continued saturation of production facilities due to the trans-atlantic packet program and an extensive backlog of repair work in the dockyards.[1] On 2 November 1842 the navy finalized plans for the work under the first two years of the program (1843 and 1844). A total of fifteen new steamers, including nine of over 220 horsepower, were assigned names and building yards for construction during this period.[2] But of these not a single hull and only a couple of engines were begun during 1843, and the engines were not begun at Indret, as intended, but at the steam engine repair facilities at Cherbourg (which soon abandoned the effort) and Rochefort. (Indret began two engines for the program in 1844.)[3]

By mid-1843 it was clear that the program was in trouble, and on 22 August the Director of Ports, Boucher, reported to the minister on the problems encountered. There was now considerable reluctance to invest in the larger classes until a number of questions had been resolved. The usefulness of 540-horsepower

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[1] Ann. Mar., no. 95 (1846), pp. 21-22.

[2] Ports to Minister, 2 November 1842, A.M., Marine 1DD1-63.

[3] Ports to Minister, 26 November 1842, A.M., Marine 1DD1-66; Ports to Minister, 16 February 1843, A.M., Marine 1DD1-75; Report to the Chamber of Deputies, 6 June 1844, P.V. Déptués, 8:330-31. The engines were intended for Colbert (Cherbourg) and Coligny (Rochefort). A 160-horsepower engine was also built at Lorient for a new Brandon to replace the one lost in 1841. The engines at Indret were for Solon and Eclaireur.

steamers for war purposes had not yet been tried at sea. A number of promising technological advances were still in the experimental phase. Finally the British had just tried a new way of producing a paddle frigate: a sailing frigate, HMS *Penelope*, had been cut in half and given a very large engine (650 horsepower). Under these conditions it seemed imprudent to build more ships of 450 or 540 horsepower, particularly as it now seemed likely that the navy would get at least some of the 450 horsepower transatlantic packets for its own use. As for the smaller combatant steamers, the 1842 program had called for 220-horsepower ships with two guns, but the British were now building ships with six guns and a minimum of 280 horsepower. Boucher therefore recommended reshaping the program in order to eliminate the larger ships for the time being and to concentrate on production of a new class of 320-horsepower steamers as a response to the English ships.[1] This was done, but due to new advances in technology and continuing congestion in the ports, no better progress was made with the new program than with the old. In fact, steamer construction from 1842 to at least 1846 did not follow any program but resulted almost entirely either from the desire to experiment with new technology or to fill specific operational requirements that arose.[2]

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[1] Ports to Minister, 22 August 1843, A.M., Marine 1DD1-75.

[2] One such requirement was the need for a hospital ship for Algeria--*Titan* (220 horsepower) was the result.

The major change in productive facilities in this period was a new reduction in the role of Indret. Parliamentary opposition to this government-run manufacturing facility grew after 1840, and Indret's performance on the packet program did little to enhance its reputation. Parliamentary commissions generally fought the effort of the navy to overcome Indret's problems through further expansion. One such commission agreed with the navy that the establishment of Indret had been justified due to the backward condition of the French steam engine industry in the late 1820's, but felt that French industry had since vastly increased its capabilities to the point where it could fill the navy's needs and concluded that the role of Indret should change accordingly. They felt that the emphasis on increased output should be dropped, and that Indret should serve simply as a model and a stimulant for French industry. Any further increase of its facilities would simply hurt the treasury (since it was an axiom that government plants were less economically run than private ones) and would harm private industry through unnecessary competition.[1] This remained the dominant attitude in Parliament throughout the 1840's.

The navy did not respond directly to this criticism, but in December 1842 it did carry out a significant reduction of Indret's role. The original plan for Indret had included

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[1]France, Ministère de la Marine et des Colonies, Compte définitif des dépenses de l'exercise 1842, p. 19n.

building both hulls and engines there, but the savings expected from concentrating steamer construction at one place had not materialized and the navy therefore decided to cease building hulls at Indret. (An exception was made for iron hulls, which could be handled by the metalworkers in the boiler shops.) The navy pointed out that the reform would simplify the administration of the facility and save money, while allowing Indret to concentrate all its resources on its role as a model steam engine factory. However the navy did not cut back the engine plant's productive capacity, and it retained its hope that Indret would remain a significant source of supply for steam engines, both in normal times and particularly during emergencies. The reform was also designed to give the navy a source of supply for iron hulls, which were then just beginning to come into use.[1]

Military Roles for Steamers

The steam navy did gain one lasting benefit from the 1842 program, however. For the first time the new program introduced military terminology and a hierarchy of classes into the official classification of steamers. The two largest categories were called "steam frigates" (540-450 horsepower) and "steam corvettes" (320-220 horsepower). Use of such terminology had been suggested in 1840 by a line officer serving in the steam navy, and, as his proposal was published in the Annales Maritimes, it apparently aroused some official interest.[2] The change was significant

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[1] Ports to Minister, 12 December 1842, A.M., Marine 1DD1-66.

[2] Ann. Mar., no. 75 (1841), pp. 106-107.

for two reasons. First, it indicated an awareness that steamers were not a single category of ship (expanding, to be sure, in size and numbers) with a single set of functions, but that they formed a fleet consisting of different classes, each of which had its own capabilities and missions. The steam navy thus took a form parallel to the sail navy, which also consisted of different classes, distinguished primarily by size. The other significant point was that the new terminology for the first time gave the larger steamers pretentions to military roles, and also gave the first indication, however tentative, as to what those roles might be. In classifying their steamers in this way the French both caught up with and passed the English, who had divided their steam navy into five numbered classes in 1837 but who did not officially adopt words like "frigate" to describe them until 1846.

The new classification scheme marked the beginning of a most important period for the French steam navy, in which it largely completed its development into a full-fledged military force. Between 1842 and 1845 it gave substance to its new organization, first indicated on paper in the ordinance of 1842, by developing its own strategic and tactical doctrines. However these doctrines did not follow the implication in the ordinance that the functions of steamers would be essentially the same as those of sailing ships of the same size. Instead the doctrines developed for the steam navy differed radically from those already accepted for the sail navy, and implied that henceforth

the steam navy was no longer to be a complement to the sail navy but a competitor to it.

The progress of the steam navy during this period was due largely to the line officers serving in it. By the early 1840's a number of the officers who had learned steam technology in the 1820's and 1830's had risen to the command of large steamers and were in a position to experiment with the capabilities of their ships. Their position within the navy was now more secure than before, as steam had clearly come to stay; and their numbers were growing, for the steam navy was by now the fastest growing portion of the navy and offered the greatest number of new command billets and other positions for officers. But three factors were primarily responsible for bringing them the success in the 1840's that had been denied them in the 1830's: technological advances made their arguments more credible, the crisis of 1840 raised doubts, both within and outside the navy, concerning the ability of a purely sail navy to defend French interests against Britain, and, perhaps most important, they acquired a leader who was in a unique position to compel the navy to consider the experiment with radical change.

This leader was François Ferdinand Philippe Louis Marie d'Orleans, Prince de Joinville and third son of King Louis Philippe. Two of Joinville's brothers chose careers in the Army, and Joinville selected the navy. Understandably his career pattern was extraordinary. He entered the navy in September 1834 as the equivalent of a midshipman, and was subsequently

promoted to higher grades as soon as he showed the ability to fulfill their responsibilities. Since he was intelligent, genuinely able and sincerely dedicated to his chosen profession, he rose rapidly, averaging one promotion per year between 1834 and 1839. His first command was a corvette in the squadron that bombarded the Mexican fort of St. Juan d'Ulloa in 1839, and, having made an excellent impression there, he was then given command of a larger ship, the frigate Belle Poule, in which he made a number of long cruises, including one in 1840 to St. Helena to bring back to France the ashes of Napoleon. In July 1843, less than nine years after joining the navy and at the age of only twenty-five, he was promoted to rear admiral and began to assert himself as a maker of naval policy.[1]

Joinville's position within the navy was utterly unique. He enjoyed all the advantages of being a naval officer--despite his privileged status and his youth he was fully accepted by the officer corps due to his obvious professional ability and his dedication to the service. His colleagues also appreciated the favorable publicity he brought to the navy and the influence he could wield in its behalf in high places. His influence within the navy was such that an English observer reported after the revolution of 1848 that the officers and men in the navy had been faithful supporters of the Orleanist regime because of their

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[1] Prince de Joinville, Vieux Souvenirs, 1818-1848 (Paris, 1894; reprint ed., Paris, 1970), pp. 64-242 passim.

devotion to Joinville.[1] Yet Joinville was also what Professor Elting Morison calls a "marginal man"--he was not dependent on his superiors for promotion, and he was not committed by sentiment or by long experience to any particular way of doing things.[2] He was able to study an innovation such as steam propulsion without fearing its effects on his career or his life style. He saw the positive aspects of steam navigation without feeling the negative, and he concluded that the need for expanding the steam navy was indisputable and urgent:

> To an adversary having means of attack that tame winds and tides, one had to oppose defensive forces with the same capability. That was A B C. This transformation preoccupied me acutely, for it was a question of the service to which I had passionately devoted my existence and which I wanted to see again become a formidable instrument of our national strength.[3]

He showed little patience with the doubts of those less "marginal" than he, and made the promotion of a true steam navy something of a personal crusade: "However to accomplish [this transformation] we had to fight against routine, the tenacity of old customs and of exclusive ideas taught in the schools. It was a daily struggle in which I took an assiduous part."[4] While

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[1] John William McCleary, "Anglo-French Naval Rivalry, 1815-1848," (Ph.D. dissertation, Johns Hopkins University, 1947), p. 391.

[2] Elting E. Morison, Men, Machines and Modern Times (Cambridge, Mass., 1966), p. 129.

[3] Joinville, Vieux Souvenirs, p. 143.

[4] Ibid.

Joinville does not seem to have tried to mobilize around him other steam enthusiasts within the navy, these naturally gravitated to him, and one soon finds him acting as protector for such brilliant but eccentric innovators as Lieutenant Nicolas-Hippolyte Labrousse among the line officers and Stanislas Dupuy de Lôme among the naval constructors.[1] Even the most senior officers had to think twice before giving Joinville a flat "no," for he was clearly being groomed for the top job in the navy, and when he wanted something studied by a commission or tried by the fleet, his superiors let him have his way. This was the break the steam navy needed, for it was through a series of commission reports and trials that Joinville and his supporters developed the doctrines for a steam navy that could be used in support of, or preferably as an alternative to, the sail navy.

Joinville was by no means the only officer interested in expanding the steam navy, and the process was already well underway before his promotion to rear admiral in 1843. Experiments had been conducted in the 1830's with steamers, particularly with their artillery and their rigging, in an effort to improve their military qualities. The most far-reaching of these experiments had been the novel rig of Corvette Captail Bechameil, which had been installed in 1837 in the 220-horsepower steamer Véloce and tried on a long voyage to North America. The general

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[1]Joinville to Mackau (Minister of Marine), 22 October 1843, Mackau papers, A.N., 156-AP-I-50; Joinville, Vieux Souvenirs, p. 244.

conclusion of most observers had been that Bechameil's system was too complicated to be worth adopting for other ships, but Bechameil protested the burial of his project so vigorously that the ministry had to appoint a commission to decide the matter. The commission ruled against Bechameil's hardware, but strongly supported his concept of the value of a ship able to use both sails and steam, and indicated how such ships would fit into the overall structure of the steam navy. The steam navy, it reported, should consist of two types of ships. One, intended for packet services or for coastal defense, would not be called upon to go far from port and could therefore be designed for maximum speed under steam, with powerful engines, hull lines appropriate for navigation under steam, and only a light fore-and-aft rig. The second class would be designed for the new roles that had been suggested for steamers but not yet tried: accompanying a fleet (primarily to tow ships-of-the-line when needed) or to make short independent cruises to harass the enemy, protect convoys and support troop landings. Such missions did not require continuous high speed or even continuous use of the engines, but did require having the machinery and an adequate supply of coal available at critical times during the operation. Such ships, the commission stated, should not be developed from present steamers but should be designed from the keel up according to the new concept, with less coal, shorter hulls (a return to traditional sailing ship lines, as pure steamers were much longer than their sailing equivalents), and a substantial square

rig. This would give "the most complete warship possible, a ship which would have the capability of attacking or defending itself in many circumstances where, in spite of its strong armament, the ship of the line today finds itself paralysed."[1]

The idea of modifying steamers to give them improved sailing qualities received considerable support. In August 1840, after witnessing some trials carried out by _Véloce_, the commander of the royal yacht at Tréport wrote to the _Annales Maritimes_ concerning the immense importance of developing ships "capable of employing, separately or simultaneously, according to the circumstances, these two great motive forces, wind and steam."[2] Only in this way, he wrote, could steamers overcome the two objections against their use as warships: their inability to cruise for long distances (for fear of not being able to replenish their coal supply when exhausted) and their helplessness in case their machinery broke down. The idea also found considerable support in Parliament, and was mentioned several times during debates in 1841.[3]

But the time had not yet come for the combination of sail and steam, at least in the form generally envisioned. The technological problems of achieving it with paddle wheels were simply too great, and objections were raised to the theory itself.

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[1] Report dated 6 September 1841, A.M., Marine 7DD1-52.

[2] _Ann. Mar._, no. 73 (1840), pp. 441-444.

[3] Chamber of Deputies, 7 May 1841, _P.V. Députés_, 1841, 7:172-74.

Another writer in the Annales Maritimes doubted that such steamers could ever be as fast under steam as pure steamers, and felt that their inability to stand up in combat to pure steamers would be a fatal flaw.[1] The French navy apparently agreed, for it made no effort to design a special combined sail and steam paddle steamer, such as that called for by the Véloce commission, and instead contented itself with making minor improvements in the rig of existing pure steamers. These efforts did not meet with much success, and, while the larger French paddle steamers mostly came into service with heavy rigging and square sails, these rigs were soon reduced to simple fore-and-aft rigs.

The debate over the type of armament for steamers was also carried over from the 1830's, but its importance was greatly magnified in the 1840's by the fact that steamers were now much larger than before, and were now intended for use in combat. The navy undertook a major study of the problem in 1841: commissions met and deliberated in each of the five naval ports, and the Council of Works in Paris then studied their reports and made recommendations to the minister.[2] The commissions in the two ports with the closest connections with steamers, Rochefort and Toulon, reported that steamer tactics were very different from sailing ship tactics. Rochefort emphasized that

[1] Ann. Mar., no. 75 (1841), pp. 96-100.

[2] C.T., 14 July 1841, A.M., Marine BB8-1116.

steamers should fight end-on to avoid damage to their engines and paddle wheels, and that "a steamer should never present its flank to the enemy unless compelled to do so." Toulon reported that the advantage of a steamer in combat lay more in its speed and maneuverability than in the number of its guns. Both reports implied that the navy should abandon efforts to give steamers heavy broadside armaments, and instead concentrate on mounting a few large guns at their ends. The navy, in arming its first large steamers (Gomer and Asmodée), persisted in trying to give them broadside armaments, but it also tried to give them strong end-on fire as well.

During the early 1840's the navy also began limited experiments with a much more radical offensive weapon for steamers. In 1842 one of the most innovative line officers of the decade, Lieutenant Nicolas-Hippolyte Labrousse, submitted a memoir to the ministry claiming that, since steamers resembled the old galleys in having absolute freedom of movement, they should restore to naval warfare the dreaded weapon of the galleys--the ram. He proposed two models for ram steamers, one for coast defense and one to accompany the fleet. He had originally conceived the idea in 1838 and had presented it to a senior admiral who had encouraged him to take his idea to Paris. Thanks probably to this influence the ministry had sent Labrousse to Britain to make further studies of steam navigation and the

methods of building steamers.[1] Labrousse's memoir called for initially building an iron steamer of 300 tons with a ram (which could be removed if the tests failed) and using her in a series of trials against various target hulls. The Council of Works politely reported that the idea should be seriously considered--in case of war![2] Labrousse must have had powerful backers, however, for the matter did not rest there but was referred by the ministry to the Council of Admiralty with injunctions to deal with it urgently and, above all, with extreme secrecy due to its revolutionary potential. The Council therefore held the first two secret sessions in its history in December 1842 to discuss the proposal. While it was not satisfied with the design of Labrousse's ship (a number of details, including specifications for the coal bunkers and the curved deck that were to protect the machinery, had to be worked out), it felt the effect of a ram on a target hull could be simulated by sliding an imitation ram down an inclined plane against a suitable target. It also recommended testing at the same time the effect of solid and explosive projectiles on both wood and iron hulls and determining the effectiveness of coal bunkers as protection against shot.[3] During 1843 and 1844 a

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[1] C.A., 30 December 1842, A.N., Marine BB8-853; Ports to Minister, 7 July 1841, A.M., Marine 1DD1-52.

[2] C.T., 16 June 1842, A.M., Marine BB8-1116.

[3] Ports to Minister, 4 August 1842, A.M., Marine 1DD1-66; C.A., 4 November 1842, A.N., Marine BB8-872; C.A., 23 and 30 December 1842, A.N., Marine BB8-853 (secret register).

commission, including Labrousse, conducted these trials at Gavres, and, while Labrousse's ram steamer was not built, his ideas and the Gavres trials were of the greatest importance for the continuing development of the steam navy and ultimately the ironclad warship.[1]

Joinville Designs War Steamers

In late 1843 Joinville returned from a long cruise in Belle Poule, received his promotion to rear admiral, and was given a seat in the Council of Admiralty. However he felt he was wasting his time on the council, for it only deliberated about questions submitted to it by the minister and had no authority to initiate new proposals. In normal times, he felt, the Council of Admiralty was a valuable stabilizing element in the navy:

> But in 1843 we were on the threshold of the inevitable revolution brought to naval materiel by the use of steam.
>
> It was a question for us of creating, and creating rapidly, under the penalty of being outdistanced by others, a new naval force, more appropriate than the old one to our character and to our resources.
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> Impassioned for the greatness of my country, having leisure time . . . , being held back neither by the spirit of routine nor by an excess of experience, I ardently wished to apply myself where I could actively assist in the creation of a powerful element of national strength.[2]

Joinville therefore stayed on the Council of Admiralty for the shortest possible time, and soon began to occupy himself

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[1] Ports to Minister, 27 February 1843, A.M., Marine 1DD1-87. Labrousse was still promoting the ram in 1848: C.T., 21 June 1848 and 4 July 1849, A.M., Marine BB8-1122 and 1125.

[2] Joinville, Vieux Souvenirs, p. 243.

more directly with the steam navy. He claimed credit in his memoirs for the next step taken by the ministry in the development of the steam navy, the initiation of a navy-wide study of the question of steam and its potential impact on the navy, though it appears he must share credit with a new minister of marine who had just taken office, Vice Admiral Baron Ange-René-Armand de Mackau. On 19 October 1843 the ministry sent a circular to the ports ordering them to set up special commissions to examine a series of twenty questions on the composition and the organization of the steam navy. They were to determine the various classes of steamers (with their characteristics) that would be needed to enable the steam navy to fulfill its various missions, which were listed as wartime service, distant cruising, coast defense (by floating batteries), fast communications (by avisos), transport of men and supplies, and port and colonial service. They were also to make recommendations concerning various new technological innovations: iron hulls, armor protection for steamers' machinery, Labrousse's ram, the screw propeller, and direct-acting engines. Finally, they were also to discuss the old questions of the type of armament and rig for steamers, as well as a host of other questions concerning their equipment and their crews. Each commission was to consist of line officers who had commanded steamers, naval constructors familiar with them, and an artillery officer; but

all officers in the navy were encouraged to submit memoranda on proposed improvements.[1]

The reports of these commissions were then to be examined by a Central Superior Commission in Paris, whose organization was approved by royal ordinance on 22 October.[2] The manuscript proposal for the ordinance included only eight relatively senior officials on this central commission, but the final version as published added Joinville and six junior officers, all connected in some way with the steam navy. Joinville wrote to the minister that he was generally pleased with the composition of the commission and with his assignment to it, "convinced as I am that our maritime future lies in the steamer and that it is urgent to occupy ourselves with it seriously."[3]

But the central commission initially had little to do, as it had to await the reports from the ports, and Joinville therefore turned to a number of smaller projects pertaining to the steam navy. One of these had been initiated before the formation of the various commissions. When Joinville had been promoted to rear admiral, he had been given the steamer Pluton,

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[1] Ann. Mar., no. 80 (1843), pp. 1045-50. For the role of Joinville in creating these commissions see Joinville, Vieux Souvenirs, p. 243; and for that of Mackau see Mackau in Chamber of Deputies, 21 June 1845, P.V. Députés, 1845, 12:184-85.

[2] Ports to Minister, 22 October 1843, A.M., Marine 1DD1-75.

[3] Joinville to Mackau, 22 October 1843, Mackau papers, A.N., 156-AP-I-50.

of 220 horsepower, as his flagship, and he seems to have conceived almost at once the project of making her into a model war steamer. On 29 September 1843 the ministry duly appointed a commission with Joinville as president to decide how this ship should be fitted out.[1] Joinville wasted no time getting down to work, and his commission's report was ready by December.[2] In view of the just-initiated navy-wide study of steamers, Joinville limited his commission's work to the single problem of producing a steamer suitable for combatant use, that is, for fighting other ships.

In redesigning Pluton the commission had to decide the classic question in warship design: the correct ratio between mobility under steam, mobility under sail, offensive strength (the ship's armament) and defensive strength (the ship's hull, plus any special protective devices). Its solution essentially combined a number of earlier ideas into a unified concept of a war steamer. It agreed with the Toulon commission of 1841 that the prime advantage of a steamer such as Pluton was its speed under steam, and that nothing should be allowed to detract from it. The ship's armament and its other features were therefore to be kept strictly within existing weight limits so as not to overload the ship and slow her down.

Ideally, the second most important factor would have been defensive strength, to ensure that the ship would retain

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[1] Ports to Minister, 29 September 1843, A.M., Marine 1DD1-75.

[2] Undated report, Ann. Mar., no. 85 (1844), pp. 5-32.

the use of her speed in combat. The position of the paddle shaft, high above the waterline, meant that much of the machinery, as well as the paddle wheels, was above the waterline, and one projectile could disable an engine or explode a boiler. The protection of these clearly should not be left to chance. However, as of the mid-1840's, no way had been found to protect machinery against shot penetrating a ship's side, while a paddle wheel was a target _par excellence_. In May 1844, while conducting a similar study for another ship, Joinville wrote to the Minister of Marine to request that the trials begun at Gavres in 1843 to test Labrousse's ram and other ideas be extended in order to test various protective schemes, including wood bulkheads, iron bulkheads and coal bunkers, either by themselves or in combination. (The 1843 Gavres trials had shown that coal bunkers alone would not provide the desired protection unless made unreasonably large.)[1] But in the meantime it was a fact of life that, while the broadside was the strong point of a sailing vessel due to its rows of artillery, it was the weak point of a steamer due to its exposed machinery.

However Joinville's commission felt that a steamer's machinery could be protected from fire coming from ahead or astern. Shot would have to penetrate a good part of the ship's structure before reaching the engines, and could be stopped

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[1] Joinville to Mackau, 4 May 1844, Mackau papers, A.N., 156-AP-I-50. British experiments, which failed to produce a satisfactory form of protection, were reported in _Ann. Mar._, no. 81 (1843), pp. 92-93.

altogether by coal bunkers a meter and a half thick placed immediately before and abaft the engine and boiler rooms. (The commission also hoped that the Gavres trials would eventually show that iron bulkheads could provide equivalent or better protection.) The ends of the ship, which were the weak point in sailing ships, thus became the strong point in steamers, and Joinville's commission thus endorsed the opinion offered by steam enthusiasts since the 1830's that steamers be designed to fight end-on.

The armament of the ship was the next most important factor in her design, but the need to maintain the ship's speed and protect her engines meant to the commission that the steam enthusiasts were right in claiming that a broadside armament as given to sailing ships was inappropriate for steamers. The need to fight end-on required concentrating the guns at the bow and stern, but space and weight limitations were particularly severe here and meant that a few large guns would have to do the job of the many smaller ones that made up the normal broadside armament. The largest size of Paixhans shell guns was therefore mounted at the ends of the upper deck (one per end in the smaller ships and two in the larger ones), while ships with covered batteries also had similar guns at each end of the battery deck. The remaining weight available for artillery was then used to provide a few long guns on the sides. Since some exposure of the sides would be unavoidable during maneuvering, the end guns were to be fitted so that they could be swung around to fire on the beam if necessary.

Joinville's commission broke with previous thinking only in its treatment of sail power for steamers. It felt that speed under sail was the least important of the several factors considered for <u>Pluton</u>, and that both engine power and artillery should take priority over sail power. In <u>Pluton</u> the distribution of the artillery required reducing the rig from three to two masts, and the commission recommended various other simplifications of the rig as well. The commission tried to ease the blow by pointing out that the alterations had reduced the sail area of the ship by less than a tenth, and that the British had made a similar change, going from three masts in <u>Medea</u> to two masts in many of their newer large steamers. The main reason for the change, however, was that this commission and later ones headed by Joinville repudiated both of the missions that, in earlier thinking, had required heavy sail rigs for steamers: accompanying a sail fleet and making long-range cruises. As both of these missions had been developed in an attempt to co-ordinate steamers with the existing sail navy, the effect of Joinville's recommendations was notably to widen the split in the navy between sail and steam.

The commission concluded its report by indicating that a war steamer such as <u>Pluton</u> would have one mission besides combat: it might be called upon to carry troops and conduct landing operations. The commission therefore indicated how the spaces inside <u>Pluton</u> could be rearranged to permit carrying troops.

The important thing about the report on Pluton was not so much the ideas it contained (though for the most part it was a convenient summary of previous thought on steamers), as the publicity and the authority it gave those ideas. Joinville's participation insured that they would be put into effect, which they were with uncharacteristic haste: the report was approved by the minister in December 1843 and the modifications were applied to Pluton at Brest in January and February 1844.[1] In addition the full text of the report was published in the Annales Maritimes, thereby gaining considerable attention in the navy. This publicity almost immediately bore fruit: in March 1844 the prospective commanding officer of the large steam frigate Descartes, a 540-horsepower ship that was then nearing completion, wrote letters to both the ministry and to Joinville stating that he felt that the armament (primarily a broadside one) and the rig given to the steam frigates previously fitted out by the French navy (Gomer and Asmodée), were poorly suited for war steamers and requesting that a different system be applied to his ship.[2] The ministry agreed that it was important to make the best possible use of these large ships, due to their enormous expense, and decided that, since Joinville's commission on Pluton had worked out so well, the same route should be followed for

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[1] Ports to Minister, 18 December 1843, A.M., Marine 1DD1-75; "Devis d'armement et de campagne" for Pluton dated 20 May 1846, A.M., Marine 7DD1-40.

[2] Maritime Prefect of Rochefort to Minister of Marine, 23 March 1844, A.M., Marine 7DD1-68.

Descartes. In April 1844 Joinville found himself heading a new commission, this time with members drawn primarily from the large Central Superior Commission on Steam Vessels, charged to decide how to fit out the navy's largest steamer.[1] The ministry also asked him to decide on the fittings for Infernal, a smaller steamer that was also nearing completion.

By this time Joinville was disenchanted with the larger commission, which showed no sign of ever coming out of its dormant state, and he took advantage of his examination of Descartes and Infernal to develop a complete set of ideas on the military uses of steamers on the high seas. The commission in its report postulated that there were three main military functions for seagoing steamers: combatant warships, transports, and avisos or dispatch vessels.[2] Each required a different set of characteristics: the first needed a heavy armament, high speed, good maneuverability and a large coal supply; the second required space inside the ship for troops or cargo plus large dimensions, while the third required the highest possible speed plus lots of coal. However either the combatant steamers or the avisos would have sufficient internal capacity to act as transports, so the steam navy boiled down to two seagoing categories: combatant warships and avisos. (There would also be special service types for coastal, harbor and colonial use.)

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[1] Ports to Minister, 10 April 1844, A. M., Marine 1DD1-87.

[2] Report dated June 1844, A.M., Marine 7DD1-68.

Looking at Descartes and Infernal, the commission decided that the former, due to her size and power, was a combatant warship and should have a substantial armament, while the latter, due primarily to her anticipated higher speed, should be fitted as an aviso with no guns in her battery and only a few heavy guns on deck.

The commission on Descartes was less patient with old naval customs than had been the one on Pluton. It roundly castigated the navy for the spirit of routine which had led it to give Gomer and Asmodée "long rows of guns side by side," restricted to narrow gun ports along the sides, when anyone could see that such an armament was singularly inappropriate for steamers. And they struck at the core of the seagoing officer's life style by proposing to move his living quarters and his underway watch station from the traditional position in the stern to a new position amidships. The proposal was eminently practical (and is in general use today): a bridge amidships between the paddle wheels was the only place where the watch officer could both see all around him and also directly supervise the machinery, and in addition the move made the stern available for guns. But the position aft was better for supervising the handling of sails, and this plus the thought of giving up their privileged position aft and berthing and working on top of the machinery must have been the last straw for many old-time officers.[1]

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[1] Ibid.

Again the recommendations of Joinville's commission were promptly approved and put into effect: both ships were fitted out along the lines of the report in late 1844.[1] Overt opposition to Joinville's scheme was slow to develop, and it surfaced only in reaction to a proposal to fit out another large steamer, _Cuvier_, along the lines accepted for _Infernal_. The proposal was made in September 1844, probably at Joinville's instigation, in a report from the ship's commander to Joinville, and Joinville secured the ministry's approval in December. However a commission at Toulon, appointed to work out the technical details of the changes, instead challenged Joinville's whole system, calling for a return to broadside armaments in steamers. Their main argument was that it was impossible for two ships in combat to maintain an end-on aspect for any length of time (unless one chose to run away), and any combat would quickly degenerate into a broadside situation in which a ship with the traditional broadside armament would quickly gain the upper hand over one with guns only at the ends.[2] A young officer who was very close to Joinville and who was at Toulon observing the work on the ship warned him of the commission's findings, and, while the officials at Toulon were still reviewing the report before sending it to Paris, Joinville wrote a personal note to the minister complaining of the time lost while

[1] Ports to Minister, 22 July 1844, A.M., Marine 1DD1-87.

[2] Report dated 25 January 1845, A.M., Marine 7DD1-14.

Toulon held commission meetings and suggesting that it was not quite proper for a commission appointed by port officials to try to overturn decisions arrived at by one appointed by the minister himself.[1] The minister apparently sent a sharp note to Toulon, for when the Toulon commission's report arrived in Paris it was accompanied by a letter saying that the ship would be fitted out as Joinville desired.[2]

Joinville Triggers a War Scare

Active opposition to Joinville's ideas was rare, but opposition through inaction was almost universal. Now that steam was becoming a serious competitor to sail, relatively few projects associated with its military use were carried through unless sponsored by Joinville or by senior naval constructors. Joinville was acutely aware of how the spirit of routine (if not outright hostility) could suffocate new ideas, and he decided that the only way to move from experiments with a few ships to a more general organization of a steam navy was to break out of official naval circles and carry his case to a wider audience: public (particularly political) opinion. He therefore prepared a complete account of his ideas on the steam navy, which he published first in the 15 May 1844 issue of the Revue des deux mondes and subsequently as a pamphlet.[3] The

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[1] Joinville to Mackau, 1 February 1845, Mackau papers, A.N., 156-AP-I-50.

[2] Maritime Prefect of Toulon to Minister of Marine, 7 February 1845, A.M., Marine 7DD1-14.

[3] [Joinville], "Note sur l'état des forces navales de la France," Ann. Mar., no. 85 (1844), pp. 573-618. First appeared in Revue des deux mondes 58 (1844):708-746.

article was more successful as propaganda for the steam navy than Joinville could possibly have hoped, though in ways which he clearly did not anticipate or desire.

Joinville's article repeated the themes of his reports on Pluton, Descartes and Infernal concerning the ways in which steamers should be built and the ways in which they could fight. In a section which did not draw much attention, he savagely indicted the current state of the French steam navy: while 103 steamers (including packets) could be said to be available for war, only forty-three were actually afloat in Navy hands and of these only a handful (six of 220 horsepower or above) could be considered of any immediate use as war steamers. (The other three 220-horsepower steamers then in the navy were the ones with engines from Indret and were, Joinville claimed, so slow and so prone to breakdowns as to be a disgrace to the fleet.) Of the rest of the forty-three navy steamers, six or seven 160-horsepower steamers would also be available for military use, though poorly suited for it, while the remainder would be tied up in the Algerian service or in harbor or colonial duties. In contrast, at the present time, the British had forty-eight steamers carrying out military functions on the foreign stations alone (compared to eight for France), and could easily increase this crushing superiority if necessary.[1]

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[1]Ibid., pp. 588-89, 598-609. On 1 January 1844 the British navy actually had about fifty steamers (excluding those built as packets) compared to the forty-three French ones mentioned by Joinville, and of these nineteen were comparable in size to the

However the part of Joinville's article that attracted the most attention was not his warning concerning French deficiencies in steamers but his vision of the opportunity that the steam revolution opened to France if she chose to take advantage of it. He exposed the failure of the sail navy in the crisis of 1840: France had had twenty battleships in the Mediterranean bursting with enthusiastic, well trained crews, but any victory they might have gained would have been fleeting, since France did not have either the crews or the ships in reserve to make good battle damage, while the British would simply have sent out a new fleet from their massive reserves to avenge the loss of the old. The French sail navy was thus neither credible as a military force in wartime nor as a deterrent in peacetime. Joinville stated that there were only two viable functions left for sailing battleships: to act as a floating siege train in wartime, or to impress "superficial observers" in peacetime. They were not even suitable for training, for sailors should be trained in the weapons they would be using for war. A steam fleet would not only provide this training but would give rise to a flood of new ideas concerning the use of the new forces. As a corollary, there was no need to design steamers to accompany a sailing fleet, as they were in fact to replace it.[1]

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six good ones designated by Joinville. Many of the "stations" on which British steamers were used were packet lines in the British Isles, but the British still used more steamers overseas than did the French.

[1] Ibid., pp. 580-584.

In contrast, steam would make the use of seapower again possible for France, though in new, specialized ways. First, it would overcome one of France's main handicaps at sea: by supplanting sail as the motive power for ships it would replace trained seamen, which France chronically lacked due to her lack of a large merchant marine, with steam engines, which she could always buy. Second, it opened the possibility of new types of naval activity, in which the mobility of steam (which permitted setting precise schedules for military operations at sea despite wind and tides), would give the offense the advantage over the defense and would enable France to act at sea despite British supremacy in numbers. In a continental war steam would permit surprise landings along the shore: Italy, Holland and Prussia were all within easy reach; and Joinville cited with approval English warnings that England was also vulnerable to such attacks. Against England Joinville proposed surprise incursions by steamers to ravage the British coasts and show her that her insular position no longer guaranteed her security. Steamers could carry troops from various French channel ports, evade British naval patrols under the cover of night, converge at a given time and place, and overwhelm the local defenses. Such attacks, coupled with aggressive commerce raiding in the Channel by steamers and in distant waters by large sailing frigates, would hopefully soon bring Britain to desire peace. In addition, steamers, relying on France's favorable geographic position, could drive the English out of the Mediterranean.

Steamers had an additional role for France: coast defense. Naturally the new forms of warfare could be used by both sides, and the only response to steamers was steamers. Indeed, Joinville warned, if France allowed Britain to gain supremacy in steamers, the English would gain the same advantages that Joinville hoped to secure for France.[1]

Joinville therefore called on France for resolute action in building up her steam navy. He pointed to the progress that Britain had made in steam navigation and claimed that this showed that the British clearly perceived its future. France, he said, had also perceived it during the Algerian expedition in 1830 and again during the crisis of 1840, but each time had lost sight of the vision, cut back her building program, and relegated steamers to subsidiary uses. Where France had failed to lead, she should at least follow, and he proposed an extensive effort, spread out over ten to fifteen years, to develop the steam navy. If the money presently squandered on sail battleships and shore establishments were diverted to steamers, he said, this effort could be carried out without any increase in overall expenditures.[2]

Joinville's vision of the new navy was a surprisingly well balanced one, considering the radical nature of his ideas. While he proposed making up the fleet in European waters primarily of the two types of steamers described in the report on

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[1] Ibid., pp. 574-580.

[2] Ibid., pp. 584-591, 610-613.

Descartes, he felt that the overseas stations should remain the province of sail. He discouraged the use of steamers on the stations, due not so much to the technical problems of giving them a large rig for extended cruising as to the fact that, in case of war, Britain could cut off all supplies of coal. (He noted that the development of auxiliary steam power for sailing ships might eventually overcome this problem.) Instead he called on the navy, at the same time that it increased the steam navy, to increase also the number of the largest type of sail frigate for use on the overseas stations in peacetime and as commerce raiders overseas in wartime. His attitude towards frigates contrasted sharply with his attitude towards sail battleships, which he wanted practically to eliminate from the navy.[1]

The result of his proposals, therefore, was a fleet consisting of two parts: a strong steam fleet operating along French coasts and in the Mediterranean, and squadrons of large frigates on the stations. A fleet of at least twenty war steamers was to be maintained with the primary mission in peacetime of developing tactics for a steam fleet. These were to be supported by three sailing battleships, presumably for showing the flag in peacetime and for bombarding coastal positions in wartime. Twenty-two frigates of the largest type were to cruise overseas. A force of ten fast steam avisos and five sailing brigs was to be used to carry government orders and maintain

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[1]Ibid., pp. 591-595.

communications with the various fleets. The remainder of Joinville's fleet consisted of twenty-seven small sailing vessels for colonial patrols (to be replaced eventually by eighteen small steamers), twenty steamers and thirteen sailing ships for the Algerian service, and ten small steamers for harbor service in France and the colonies.[1]

Joinville's article showed the radical nature of the ideas of steam enthusiasts in the mid-1840's, and also showed the degree to which they had come into direct confrontation with the traditional sail navy. It also showed that the impact of such ideas was not limited to the navy. The maritime balance was an essential element in the diplomatic balance, and when Joinville published suggestions on how to upset the former, the shock waves also reached the latter. Anglo-French relations had been in a state of suspended animation since 1840: neither side (Louis Philippe and Guizot for the French and Lord Aberdeen for the British) wanted an open break, but the two powers were unable to agree on anything, due mainly to the ability of opposition leaders to arouse public sentiment against any compromises. Thus the opposition in France, led by Thiers, blocked ratification of a treaty, concluded in 1841, which would have permitted increased Anglo-French cooperation in the suppression of the slave trade, while economic pressure groups, including the metallurgical industry, succeeded in blocking a

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[1] Ibid., pp. 595-597, 613-618.

proposed commercial treaty with England and promoted instead a tariff agreement with Belgium which caused considerable uneasiness in Britain. There was also a series of irritating colonial disputes between the French and the English in West Africa and in the Pacific, particularly in Tahiti. Joinville seems to have had no intention of taking sides in any of these disputes (though he was incensed over the timid French reaction to events in Tahiti).[1] His purpose in writing his article was solely to promote the steam navy, and he explained that his constant references to England as the enemy were purely hypothetical and implied no ill will towards the British. But in such an unsettled diplomatic environment any proposal to upset the maritime balance, particularly coming from a price of the blood, was bound to cause an uproar. The first reaction of Louis Philippe and his government was to try to suppress the article, and when this failed they disowned it and hastened to make private excuses to the English. Joinville himself wrote to Queen Victoria that the unfortunate effects of his article and the trouble it was causing his father made him regret having published it.[2] But Joinville's arguments, particularly his vivid descriptions of French raids on British towns, were picked up and magnified by the press and by politicians on both sides of the Channel.[3]

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[1] Mc Cleary, "Anglo-French Naval Rivalry," p. 173.

[2] Ibid., pp. 179-181.

[3] For press and political reaction in Britain and France see ibid., pp. 181-191.

Many Englishmen were convinced that their coasts were defenseless, and their insecurity was increased by the discovery that, due to demands for ships from naval stations all over the world, very little of the Royal Navy was stationed in home waters. A number of English experts, including the Duke of Wellington, perceived the novelty of the technological challenge, and agreed with Joinville that the Royal Navy in its traditional form might not be able to respond to it, no matter what its size. Lacking a suitable naval response, they sought a land-based one and began a movement that, after a few years and several additional naval scares, resulted in the construction of numerous coastal fortifications and port facilities along the Channel coast and the creation of a home-defense militia to meet the French invaders.[1]

Just as the furor was quieting down, diplomatic disagreements arose between France and Britain, first in July over Morocco (whither Joinville had been sent with a fleet to chastise the Moroccans for helping the Algerian Abd-el-Kader against the French), and then in August over Tahiti (where a French admiral was accused of mistreating a British missionary who was also the British consul). The combination of a naval and a diplomatic

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[1] These crises and responses extended through 1852 and resumed after the Crimean War. Bartlett, Britain and Sea Power, chapters 4-6 passim. For a famous criticism of three of these scares see Richard Cobden, The Three Panics: An Historical Episode, 3d ed. (London, 1862).

challenge from France brought the naval scare in England to a new peak of excitement in August and early September, and Aberdeen, who felt rightly that the French were not hatching a sinister plot against the English, only averted by a narrow margin naval preparations by Britain that would have enflamed the situation even further.[1] The crisis subsided later in September after compromises were reached over Morocco and Tahiti, but after 1844 the British and French trusted each other even less than they had after 1840.

Most French naval officers had been able to tolerate Joinville's tinkering with a few steamers, but when he began to tamper with the very foundation of naval power, the sail battle fleet, some felt he had gone too far. A few replied to him in print--but surprisingly few. The first response appeared almost immediately in the Journal du Havre and was reprinted in the Annales Maritimes immediately following Joinville's article.[2] The second, by a line officer, appeared later in 1844 in the Annales Maritimes, and its author marveled that there had been no previous informed response to Joinville besides the one in the Journal du Havre.[3] The third and last direct response,

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[1] McCleary, "Anglo-French Naval Rivalry," pp. 208-45; Bartlett, Britain and Sea Power, pp. 162-64.

[2] Untitled extract from the Journal du Havre, 23, 24, and 25 May 1844, signed "V. B.," Ann. Mar., no. 85 (1844), pp. 619-34.

[3] Lieutenant de vaisseau de La Roncière le Noury, "Considérations sur les marines à voiles et à vapeur de France et d'Angleterre," Ann. Mar., no. 86 (1844), pp. 301-37, especially pp. 301, 329.

published in the Revue Indépendante in November 1844 and in the Annales Maritimes early in 1845, deplored the fact that only one line officer had previously replied to Joinville, and argued that a more energetic defense of the existing naval system by its supporters would have put a quick end to the alarmist polemics that had appeared in the popular press following the publication of Joinville's article.[1]

All three writers agreed with Joinville that the French steam navy had been neglected in the past and should be expanded and improved. However all opposed his effort to make it into the principal military arm of the navy, replacing the sail line of battle. Joinville, they said, had started with a good idea, but had inflated it into a theoretical system that became more defective the larger it got. For instance, they claimed, the use of steam would not redress the naval balance in favor of France, but would tip it even more towards England, for it relied on a good supply of iron and coal, and France had an even more desperate lack of these than she did of trained seamen. (French coal, located in the interior, was hard to get to the ports, and was of such inferior quality that the navy at that time continued to depend on Britain for its coal supply.) Even if this disadvantage were overcome, steam would give France no advantages that could not be turned against her, and if it did

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[1] [Lieutenant de vaisseau] de Lespinasse, "Considérations sur les vaisseaux et sur les vapeurs," Ann. Mar., no. 90 (1845), pp. 9-43.

in fact have the capability of annihilating existing fleets, the result would simply be a ruinous arms race, in which neither country could afford either to fall behind the other nor to pay the bills required to stay in the race.[1]

The critics also felt Joinville's strategic ideas had fatal flaws, both regarding the use of steamers in European waters and frigates overseas. One pointed out that incursions into Britain by troops carried in steamers would be highly risky: while the ships might be able to achieve surprise for their landings, they would certainly be attacked during their return to France. Steamers, while excellent on the offensive, had next to no defensive strength, and, particularly when burdened with troops, could be expected to suffer heavy losses when attacked by a determined enemy. The same writer doubted that even an initial surprise could be achieved for the landing, for he predicted that the British would soon develop a system of mobile coast defenses based on the railroad and the electric telegraph, that could rush defending troops quickly to any point along the coast. For attacking Britain he favored a full invasion, using a much larger army, carried in steamers but escorted by a strong traditional squadron of battleships.

Even Joinville admitted that the waters outside Europe would remain the province of sail, but two of his critics felt

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[1]Extract, Journal du Havre, pp. 620-23; La Roncière le Noury, "Marines," pp. 321-22; Lespinasse, "Vaisseaux," pp. 12-15, 35-36.

that his reliance on steamers in European waters would also create problems for his frigate squadrons overseas. Frigates had been successful as commerce raiders overseas in previous wars only because the presence of a battle fleet in French ports forced the British to keep all their battleships in European waters. If France abandoned her battle fleet, Britain could send her battleships overseas to oppose French frigates. France would then have to respond by providing battleships for overseas use, and in fact the present system would soon come back into being.[1]

Joinville's critics argued that his proposals failed to take into account a number of the general principles that lay behind traditional French naval policy, as embodied most recently in Portal's fleet program of 1820 and its successors. France's inability to match the British battle line in numbers had been fully understood, but had been compensated for using conventional means in a number of ways. First, French objectives were restrained: France's aim was not to wrest control of the seas from England, but simply to compel her to respect the right of other nations to the free use of the seas and to defend French commerce. This did not require having a fleet equal or superior to the British in numbers, but only one large enough and well enough organized and trained to compel British respect

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[1]Extract, Journal du Havre, p. 627; La Roncière le Noury, "Marines," pp. 329-30; Lespinasse, "Vaisseaux," pp. 14, 29-33. (Lespinasse disagreed with the last point.)

and make any effort of hers to gain an absolute guarantee of victory in case of war prohibitively expensive. (One writer went further and said that a fleet of thirty battleships properly led could actually defeat the British fleet if the moment were well chosen.) Furthermore such a fleet would be consistent with France's natural role in a confrontation with England as the "natural leader of the maritime opposition." A strong French fleet would attract both the diplomatic and naval support of other powers, equally resentful of British restrictions on the free use of the seas, and even a passive maritime coalition, led by France, would be an effective restraint on the arbitrary use by Britain of her sea power. Thus the French battle fleet had its uses, even against Britain.

Another situation completely overlooked by Joinville was the possibility of a war against another power besides Britain. France's traditional policy had made her the second strongest power at sea, and gave her the ability to overcome all powers except one by using existing conventional forces. Joinville's policy would make the exception the rule, and throw away the capability of responding to a wide variety of situations in order to concentrate on a single one, which might never arise.[1]

This led to the core of the argument against Joinville: the belief of most naval officers, then as now, that naval power

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[1]Extract, Journal du Havre, pp. 628-32; La Roncière le Noury, "Marines," pp. 324-26; Lespinasse, "Vaisseaux," pp. 14-15.

could be based securely only in the capital ship: that ship which combined maximum firepower with the ability to keep the seas for long periods despite the efforts of the enemy or the elements. Steamers as they then existed were capable of doing a few things extremely well, but were entirely unable to do many other things (including operate outside European waters), and suffered from severe defects that jeopardized even their ability to carry out their specialized missions. The reason for these limitations was that they relied, not on strength, but on stealth and mobility as their main military asset. Naval officers ideally wanted to be able to carry out any mission given them, and the only guarantee of success under these circumstances was brute strength. This was the primary characteristic of the sailing battleship, and this is what made it the only true general-purpose warship. It could act as part of a battle fleet in European waters or as a cruiser on distant stations (it was even better at this than were frigates, though more expensive), and it was also the best troop transport of its day. It was supremely capable of carrying out what most officers saw as the "truly maritime mission": maintaining the nation's presence at sea, showing her flag and making her strength felt around the globe in peace as well as in war. Steamers had neither the concentrated firepower nor the staying power needed to do this, and the improvements proposed for existing steamers, such as mounting one or two more guns at the ends and putting some protective structures around the engines, while well worth doing,

made very little difference as far as their general purpose capabilities were concerned.[1]

The three writers criticized not only Joinville's theories but also his tactics. His ideas and those of other steam enthusiasts, one said, were "so radical, so universal, that the boldest spirits were frightened away. Wanting to demand all, they were refused all."[2] It seemed common prudence to retain the sail battle fleet until experience revealed the full capabilities of steam, and any effort to change the naval system on the basis of pure theory should be resisted. Tactically, the advocates of steam should have refrained from attacking the core of the existing navy, the battle fleet, and concentrated their attacks instead on a much more vulnerable part of the navy, the small sailing corvettes and brigs which absorbed lots of men and money without adding anything to the navy's combatant strength. The money spent on these could fund a major expansion of the steam navy while keeping the battle fleet intact, and steamers could also take over the functions of the smaller sailing craft.[3] Joinville's critics felt that the long-range answer to the problem might be a compromise as

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[1]Extract, Journal du Havre, pp. 623-27, 629-30, 633; La Roncière le Noury, "Marines," pp. 308, 318, 328-30; Lespinasse, "Vaisseaux," pp. 21-22, 32, 38-39.

[2]Lespinasse, "Vaisseaux," p. 21.

[3]La Roncière le Noury, "Marines," pp. 319, 323, 331; Lespinasse, "Vaisseaux," pp. 13, 20.

well: if a way were found to put a steam engine into a battleship, a capital ship might be produced with the advantages of both steam and sail and the disadvantages of neither. In the meantime the advantages of steam and sail could be combined by assigning an equal number of steamers and battleships to the battle fleet, so that the former could take the latter under tow if necessary, as well as replacing smaller sailing ships as scouts and avisos.[1]

The Steamer Program of 1845

Joinville's pamphlet identified him squarely with the most enthusiastic advocates of steam navigation. While naval opinion on both sides of the channel took a dim view of his ideas, the publication of his article and the naval scare of 1844 were followed by a new wave of steamer construction in both countries. The new activity was the result of a number of independent factors, and each country seemed to be largely unaware of the details of the other's program. The British program seems to have been primarily a response to the naval scare of 1844. Between 1844 and 1846 the British ordered no less than fifty steamers of 100 horsepower or more. Unfortunately for them, they committed themselves to the screw propeller for many of these ships before all the technological problems associated with it (particularly the proper lines for the hull aft) had been worked out, and the resultant delays created havoc

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[1] Extract, Journal du Havre, pp. 624-25; La Roncière le Noury, "Marines," pp. 318-20, 330-32; Lespinasse, "Vaisseaux," pp. 11, 12, 20, 22, 32, 39.

with the program. Still, the British program was large enough to give them a clear lead in steamers unless the French succeeded in reviving their own program.

This the French were able to do, although they were unable to match the magnitude of the British effort. The first step was to revive the Central Superior Commission on Steam Vessels. One of the main reasons that this group had not so far produced any results was that it had been asked to do too much, and in February 1845 it was reorganized into two sub-committees. One of these, under Joinville, was asked to decide on the composition of the steam navy of the future, the functions to be filled by the different classes of steamers, and the proper size and power for the ships of each class; while the other sub-commission was to handle more practical problems concerning the organization and manning of the present steam navy and the best way of fitting out existing ships.[1] Thus divided, the commission was able to make rapid progress, and a joint report, which also included reports by each sub-commission, was ready before the end of May 1845.

The report of the second sub-commission added little of interest to the debate. It stated that existing steamers were useful only as tugs attached to sailing fleets, as scouts, and as transports or packets; though it left room for Joinville's

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[1] Minister of Marine to king, 6 February 1845, Ann. Mar., no. 90 (1845), pp. 151-52.

proposals by adding that the technological advances made in the mid-1840's meant that future steamers would bear very little resemblance to the ones now afloat. Concerning the fittings for the ships, it essentially endorsed the report of Joinville's earlier commission on Descartes and Infernal as generally suitable for application to all existing steamers, and called for a series of exercises and trials to decide some outstanding problems by actual practice.

In the report of his sub-committee, Joinville completed his trio of major official reports.[1] The report on Pluton had shown how a combatant steamer should be built, the report on Descartes had shown how combatant steamers fitted into the categories of high-seas steamers, and now the report of the sub-commission incorporated into an official report the ideas he had first revealed in his article on how high-seas steamers fitted into the navy as a whole. The report reaffirmed the strategic ideas of Joinville's article: naval war was likely to involve, first, operations in European waters, especially troop landings, which would be carried out primarily by steamers; and secondly commerce raiding overseas, which would be left exclusively to sail. However it now appeared that technology would soon permit giving sailing ships (battleships and frigates) small auxiliary steam engines, so the report was

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[1]Report dated 24 May 1845, Records of the Chamber of Deputies, A.N., C-879. A more complete version of this report was used by Dislère, Croiseurs, pp. 15-16.

able to claim that "the French navy should no longer use anything but steamers," even though ships with auxiliary steam were still considered to be primarily sailing ships.

The report also reaffirmed the three missions of the European fleet that had first been discussed in the report on Descartes: combat with other warships, transport of men and materials, and maintenance of communications. However, since the commission was no longer limited by the characteristics of existing ships, it considerably expanded its ideas on the specifications of the ships that were to carry out each of the three missions. The larger class of combatant steamers, called steam frigates, was to be designed primarily to fight other ships--it was to have twenty-four large shell guns in a covered battery and four large long guns on deck, with as many of these guns as possible concentrated at the ends. (Even so, it would have a strong broadside armament.) It was to have a light three-masted rig and engines of 600 horsepower or more, which would give it the highest possible speed under steam and moderate speed under sail. The smaller class of combatant steamers, called steam corvettes, which was intended primarily for use as avisos, was to be a smaller version of the preceding class but without the covered battery and with only two masts. They were to have engines of 400 horsepower and an armament of eight large guns on deck. Reflecting new technological developments during the 1840's, the commission called for use of the screw propeller in both these classes, which permitted placement of engines below

the waterline, and full use of the new lightweight types of engines and boilers. Iron hulls were rejected for combatant ships, however, as being too easily shattered by shot.

The third type of military steamers, transports, was now to be a distinct category instead of being temporary conversions of combatant ships or avisos. The commission felt that for ships intended to land troops, shallow draft plus the ability to go aground without injury were essential. Transports could also take advantage of the new technology of iron hulls and could retain paddle wheels, as they were not designed for combat. There were to be three classes of transports, distinquished by their size and their draft (ranging from one and a half to three meters).

No major changes in categories were proposed for the rest of the navy. Ships with auxiliary steam were to retain their sailing classifications, and the navy was also to include the usual special service ships, including steam tugs for harbors. One new special type was introduced, steam floating batteries for coastal defense, but the commission did not consider these a high priority item compared to the other types of steamers. Both commissions called for a major series of experiments and a resolute effort to build up the steam navy. France, they said, was presently far from leading in steam, but the new technological advances had given her a chance to regain that lead if she acted fast. They noted that the British parliament had just voted a large amount for their steam navy, and declared

that the Ministry of Marine and the French chambers must do no less.

Six months later the ministry acted on the commission's report, and incorporated it into a new steamer program that replaced the program of 1842. Again the number of steamers in the program was increased, this time to 100. Of these ten were to be steam frigates, twenty steam corvettes, and the remainder "light steamers" (often called steam avisos), which were simply the commission's transports under a different name. The new program was approved by royal ordinance on 10 November 1845.[1] Funding of the program was combined with an even larger program undertaken in 1846, which will be discussed in the next chapter.

Perhaps of more immediate importance, the ministry was also able to get steamer construction moving again during 1845. A major factor in this was a decision, taken in June 1844, to abolish much of the navy's fleet of sail transports, which permitted diverting funds and dockyard space to steamer construction.[2] Against only two steamers laid down in 1843 and six in 1844, the navy was able to begin construction of nine in 1845 and thirteen in 1846. For the most part these ships were intended as the vanguard of a new generation of steamers: they were built in accordance with the categories in the report of the Central Superior Commission, and they were designed to take advantage

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[1] Ann. Mar., no. 89 (1845), pp. 949-51.

[2] Ports to Minister, 24 June 1844, A.M., Marine 1DD1-84.

of four major technological advances, all of which had been introduced since 1840. One of these, the screw propeller, was of such importance that it will be discussed separately, but the other three also had a major impact on French steamer construction.

New Steamer Technology

The first of these innovations was the direct-acting engine. This type of engine got its name from the fact that the piston was connected directly to the paddle shaft instead of being linked to it through the enormous lever or "walking beam" used ever since the days of Watt. Direct-acting engines had the important advantage of doing away with the beam, which was both bulky and heavy, thereby making the engines lighter and more compact than beam engines of the same power. Although the idea was simple, its execution was not, and until the early 1840's direct-acting engines, particularly large ones, were regarded as less dependable than comparable beam engines.[1]

The second of the major innovations of the 1840's was the tubular boiler, which was essentially a marine adaptation of the boilers used in railroad locomotives. Earlier marine boilers had consisted of a reservoir of water through which the hot gases were carried in a few large rectangular flues. In

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[1]For general information on types of engines and boilers with drawings, see Encyclopedia Britannica, 8th ed., s.v. "Steam Navigation"; Paul Augustin-Normand, Le progrès des appareils propulsifs antérieurement à 1870: Ses incidences économiques et sociales (Le Havre, 1955), pp. 8-12; Anthiaume, Propulsion, pp. 225-26, 261-67; Jacques Payen, "Technologie des machines," pp. 384-90, 401.

tubular boilers a large number of small tubes were substituted for the flues, greatly increasing the heat transfer surface within the boiler and permitting operation at higher ("medium") pressure. The result was a much more efficient boiler, which burned less coal, took up less space and weighed less than flue boilers of the same power. Inversely, it made possible the generation of more power than had been feasible with flue boilers, and thus opened the way to further increases in the horsepower of marine machinery.

The third of the new innovations was the iron hull. The potential usefulness of iron as a shipbuilding material had long been recognized, but it was slow in coming into use, due mainly to the easy availability of wood and carpenters to work it. The first iron steamer was built by the same Aaron Manby who had transferred his steam engine business from England to France around 1820: his boat, named after himself, went into service on the Seine in 1822 and was soon followed by other iron river steamers, both in France and Britain. In France Cavé became the specialist in iron shipbuilding, producing after 1824 a whole series of iron steamers for the Seine. Iron was slow to go to sea: in 1838 an iron sailing ship crossed the Atlantic, but the decisive break-through in seagoing iron ships came a year later when the great British engineer, Isambard Kingdom Brunel, laid the keel for a monster iron steamer which was to run in the same transatlantic service as his _Great Western_. (This ship, named _Great Britain_, also became the first large ship to be given

a screw propeller.) Several British shipbuilders championed the cause of iron steamers, and in the early 1840's one of these built the first major iron warships: two for the East India Company and one for Mexico.

The primary advantage of these three innovations was that they permitted large savings in weight without any loss in performance. Since naval architecture consists primarily of obtaining desired operating characteristics within fixed weight limits (imposed by cost and stability considerations), the new innovations affected the very fundamentals of steamer design. The savings in weight in this case were so great that they verged on being revolutionary. Tubular boilers and direct-acting engines weighed about half as much as old machinery of equivalent power, while iron hulls were a quarter lighter than wood hulls of the same dimensions.[1] There were other important savings as well: the new machinery occupied less than two-thirds of the space taken by the old, and it burned significantly less coal. The British navy demonstrated the advantages of the new machinery in 1842 when they doubled the horsepower of a small steamer, *Black Eagle*, by replacing the old type machinery with the new. Iron hulls had their own set of special advantages, some of which, notably the ability to fit watertight compartments in them and to exceed the limits in the dimensions of ships

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[1]While iron has a greater density than wood, it is so much stronger that far less material has to be used in an iron hull than in a wood one, and the structure is therefore considerably lighter.

(particularly in length) imposed by the structural qualities of wood, eventually proved of great importance.

The first of the new innovations to receive serious attention in the French navy was the iron hull, and, as in the case of the steam engine before it, it was initially adopted for a special form of naval service. During the 1830's the French navy had made several unsuccessful efforts to produce steamers more suitable for the colonies than the early pioneers (Africain, Voyageur, Caroline, etc.), and in 1837 it decided that the iron hull might be the answer to the problem. An iron hull of given dimensions could be built with a significantly shallower draft than a wooden one, due to its lightness and strength, and it would also require fewer repairs and would last longer. The navy therefore ordered its first iron steamer, Erèbe, to be built at Indret for service in Senegal, and the Council of Works recommended that the ministry make an effort to learn everything possible about iron ship construction in England.[1]

Beginning in 1838 the British began to build large sea-going iron steamers, and in December 1841 one enterprising British manufacturer offered to build such a ship for the French navy. This proposal, which came not long after the crisis of 1840, gave the Council of Works an opportunity to assert the

[1] C.T., 13 July 1837, A.M., Marine BB8-1111, 1115.

need and ability of France to develop its own capabilities in the new field:

> . . . For a long time iron ships have been built in France for river and even coastal navigation, which have had complete success; . . . we have the necessary knowledge and a certain number of workers capable of this type of work, which presents no more difficulties than that of boilers for steam engines.
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> . . . In all cases in which it is a question of giving a greater extension to the fabrication of iron ships in France, we must apply ourselves to acquiring as quickly as possible anything we may still be lacking with regard to practical experience, and . . . this result can only be obtained by using our own resources.[1]

While rejecting the English proposal, the council encouraged the ministry to begin experimentation with iron hulls on a sufficient scale to resolve all outstanding problems.

The ministry was already laying the groundwork for such experimentation. In June 1841 it had adopted the principle of sending officers on a regular basis to study technological progress in Britain, and some of the first men sent under this program received orders to study with particular care British progress with regard to iron hulls and the screw propeller.[2] One of these missions was particularly fruitful. In June 1842 a young naval constructor, Stanislas-C.-H.-L. Dupuy de Lôme, was sent from Toulon to study in detail iron shipbuilding, and on his return he produced a masterly treatise on the subject, giving the history of iron shipbuilding in Britain, exact

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[1] C.T., 16 December 1841, A.M., Marine BB8-1112, 1116.

[2] Ports to Minister, 26 June 1841, 7 July 1841, and 9 October 1841, A.M., Marine 1DD1-52.

specifications on a number of British-built iron ships that he had inspected, and detailed information on the tools and types of labor needed to produce iron ships. His report brought him instant recognition and was the first of a series of brilliant projects that ultimately led him to develop the world's first ironclad warships in the 1850's.[1]

During 1842 the navy began to make use of the facilities available to it for iron shipbuilding. It turned first to Cavé, the undisputed leader in the field in French private industry, and in September ordered from him another shallow draft colonial steamer, Eridan. Two months later it ordered from him two more colonial steamers, Serpent and Basilic, which made much more radical use of the properties of iron: they were much smaller than earlier colonial steamers, drew only eighteen inches of water, and were shipped out to Senegal in four sections for assembly in the colony.[2] In these two ships (and in similar ones built in England since the late 1830's), the technological revolution in river travel that had begun in 1818 with Voyageur was completed, and they and their successors were to enable Europeans to penetrate and dominate one river system after another in places such as West Africa and Indochina during the remainder of the nineteenth century.

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[1] Ports to Minister, 18 May 1842, A.M., Marine 1DD1-66; S. Dupuy de Lôme, Mémoire sur la construction des bâtiments en fer (Paris, 1844).

[2] Ports to Minister, 23 March, 8 September and 30 November 1842, A.M., Marine 1DD1-66; and 2 February 1843, A.M., Marine 1DD1-75.

The navy then turned to its own facilities, and in December 1842 decided that the shipyard at Indret would be turned over exclusively to iron shipbuilding.[1] In addition, Dupuy de Lôme's preliminary reports made such an impression that the ministry decided in November 1842 to have him set up an iron shipbuilding facility and build an iron ship at Toulon. His plans for his facility were approved in August 1843 and his ship, Salamandre, was begun in November 1844.[2] Similar facilities were soon established at Cherbourg and Rochefort, and these went into production in 1845. Indret, while designated before the others, was slow in getting organized: plans for its iron shipbuilding facilities were approved only in September 1844 and its first iron ship, Solon, was only laid down in May 1845.[3]

Meanwhile, however, needs for iron steamers arose that could not await the completion of the navy's facilities. The first of these was a request from the governor of the Marquisas Islands for an iron steamer of 160 horsepower for the newly-acquired colony. In January 1843 Boucher, the Director of Ports, reviewed the possible ways of procuring the ship. He rejected

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[1] Ports to Minister, 12 December 1842, A.M., Marine 1DD1-66.

[2] Ports to Minister, 30 November 1842, A.M., Marine 1DD1-66; Ports to Minister, 28 August 1843, A.M., Marine 1DD1-75.

[3] Ports to Minister, 12 September 1844, A.M., Marine 1DD1-87.

the idea of building her in Britain, both because he considered it "very important to nationalize in France the construction of iron ships," and because he felt there were private facilities in France that could build her just as fast as could the British yards.[1] In fact, in the early 1840's a number of small shipyards and ironworks in French ports had been encouraged by the expansion or river and coastal steam navigation to develop the capability of building iron hulls and small- to medium-sized steam engines.[2] It was to one of these that Boucher turned, and during the next four years six private shipbuilders and four engine builders, located in the ports of Dunkirk, Nantes, Bordeaux, La Ciotat and La Seyne were brought into the navy's building program for the first time.

The French were not as quick to adjust to the new types of machinery as they had been to iron hulls. Like the British they had been trying off and on to increase the efficiency of steam engines, but the few small experiments conducted by the navy in 1840 and 1841 had concentrated on doing so by using higher pressure steam and exploiting the expansion of steam in the cylinder, and they were therefore unprepared when the most promising approach turned out to be direct drive. (Cavé was an exception: his oscillating-cylinder engine, which he had

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[1]Ports to Minister, 24 January 1843, A.M., Marine 1DD1-75.

[2]For information on one of these, Babonneau of Nantes, whose director came from Indret, see Roche, Travaux industriels, pp. 11-17.

been building for years, was a form of direct-acting engine, and in 1842 he received an order from the navy for two sets, each of 220 horsepower.)[1]

The French navy had, however, already had some exposure to direct-acting engines before the mid-1840's, and actually had two sets already on order. One of the earliest large direct-acting engines to come to its attention was the one built in 1839 by the British firm of Seaward and Capel for the British navy's Gorgon. The French had briefly considered buying a copy, but had decided this would be too risky and had instead ordered a regular beam engine from another British firm, Miller and Ravenhill. Miller, however, fell so far behind in building the engine that, order to save his contract, he offered to build instead a direct-acting engine, to be installed in Cuvier, at no extra cost.[2] A few months earlier the director of the Netherlands Steamboat Company had offered to provide, at his own risk, a set of direct-acting engines in place of the regular beam engines ordered for Vauban.[3] These two engines were carefully studied and copied, but they were early models and were almost as heavy as comparable beam engines. At least

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[1] Ports to Minister, 2 April 1842, A.M., Marine 1DD1-66.

[2] Ports to Minister, 18 December 1841, A.M., Marine 1DD1-52.

[3] Ports to Minister, 20 October 1841, A.M., Marine 1DD1-52; Augustin-Normand, Progrès des appareils, pp. 24-26.

one proposal to buy an example of the latest type of direct-acting engine in England in 1844 was rejected, and naval constructors at Indret and in the ports, who designed most of the navy's large engines during the 1840's, had to rely primarily on visits to England and their own ingenuity to keep up with the continual improvements made in the new engines.

The problem with tubular boilers was not only design but also manufacture--boiler tubes had to be provided in large numbers and had to be free of leaks or cracks. In 1844 the navy sent an engineer to England to buy two sets of tubular boilers from one of the best British manufacturers, and in 1845 it took steps to encourage the manufacture of boiler tubes in France, ordering officials in the naval ports to inform French manufacturers of the new innovation and to offer to buy boiler tubes, if at all possible, through competitive bidding.[1] The first French manufacturer to build tubular boilers for the navy was Mazeline of Le Havre, who put a set in the small steamer Pingouin. He had considerable difficulty with these: the first set produced too little steam due to Mazeline's unfamiliarity with the design of tubular boilers, and the second set, which he provided in replacement of the first, gave considerable trouble in service due to problems in both their design and manufacture.[2]

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[1] Ports to Minister, 22 August 1844, A.M., Marine 1DD1-86.

[2] Ports to Minister, 9 June 1845, A.M., Marine 1DD1-99; Ann. Mar., no. 95 (1846), p. 237.

Assimilating the New Technology

These problems, plus continued uncertainty over the advantages of the new system and the state of the art in England, retarded the introduction of the new machinery in the navy's shipbuilding program. It was initially introduced only in special-purpose ships, of which the most outstanding example was a royal yacht, ordered in 1843. Joinville saw to it that not one but all four of the new innovations (including the screw propeller) were used in this ship, which was to be a showpiece of French naval architecture. "It is mandatory," he wrote to the minister, "that the king have under foot when he goes to sea the very best that we can make."[1] To guarantee success he insisted that the job of building the ship go not to Indret, whose work he considered "miserable," but to the best private manufacturers, Normand for the hull and Schneider for the engines.[2] They were given a relatively free hand in the ship's design, and in their hands she grew from a small ship of 120 horsepower to a major unit of 320 horsepower.[3] Two years later another yacht was ordered--again she incorporated all four of the new improvements and again Joinville took an active role in her design, but this time the ship was smaller (120 horsepower)

[1]Joinville to Mackau, 6 October 1843, Mackau papers, A.N., 156-AP-1-50.

[2]Ibid. Cavé was also considered for the engines.

[3]Ports to Minister, 28 September 1843 and Minister of Marine to king, 9 October 1843, A.M., Marine 1DD1-75.

and was built at Indret.[1] The two ships were named Comte d'Eu and Passe Partout respectively and were intended for use by the king during his summers at Eu.

The navy was not so bold in its own program, however: it adopted iron hulls in principle for small ships only in 1843 and started building three beam engines as late as 1844. The new machinery was finally adopted as a result of two decisions taken in the second half of 1844. The first of these concerned the 160-horsepower class, the descendants of the original Sphinx. These ships were no longer considered combatants, but were still exceedingly useful as dispatch vessels, packets, and patrol craft for the colonies. These missions all required high speed, and the Sphinx class, loaded down with guns, a large coal supply and a heavy rig, was becoming less and less capable of carrying them out. In August 1843 Boucher had recommended giving future ships of this class a reduced armament and iron hulls, and now, in July 1844, he recommended completing the transformation of the type by using the new machinery to help maximize its speed under steam. The new ships would be quite similar to the ones built for the Marquisas Islands, and, as the navy was careful to tell Parliament, would be built in

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[1] Ports to Minister, 17 February and 1 September 1845, A.M., Marine 1DD1-99; Joffre (Indret) to Minister of Marine, 27 September 1845, A.M., Marine 7DD1-79.

the same way, by private French industry. The first three units of the new class was ordered later in 1844.[1]

By late 1844 the French had gathered sufficient information from Britain to realize that the British navy had almost completely abandoned the use of beam engines in its ships, and they also began to realize the magnitude of the savings in weight that the new types of engines and boilers permitted. In October 1844 Boucher recommended modifying the whole building program to take into account the new advances. (Tupinier, speaking for the Council of Admiralty, noted somewhat smugly that the delays in the French steamer program had turned to her benefit, since the ships that should have been begun but had not could now be built on the new designs.) Boucher proposed that ships for which engines had already been begun be given tubular boilers and, if possible, hulls that were proportionally smaller and lighter. By implication, ships not yet begun were to have the latest type of machinery, with wood hulls for large ships and iron hulls for ships of 220 horsepower or below. The most interesting change involved the largest class of steam frigate. The British were now building 800-horsepower engines that weighed no more than the old beam engines of 450 horsepower, and Boucher proposed imitating them and substituting new high-powered machinery for the 450-horsepower machinery originally

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[1] Ports to Minister, 1 July 1844, A.M., Marine 1DD1-87. See also Ports to Minister, 22 August 1843, A.M., Marine 1DD1-75.

intended for a French ship, Mogador (a former packet hull which had been under construction since 1840 under the name Monge but which was still only a little over a third built). There would be room in the hull for an 800-horsepower engine if a coal supply of ten days were acceptable, or for a 640-horsepower one if fourteen days' coal were required. The second option was at length chosen, and Boucher's modifications to the program were approved by both the Council of Admiralty and the minister at the end of 1844.[1]

The application of the new technology to the steam navy was completed by Joinville's section of the Central Superior Commission on Steam Vessels, whose descriptions of the various steamer categories took into account all four of the new improvements. It recommended that the screw propeller be used in large ships of 320 horsepower and above, while iron hulls were to be limited to small ships which were not intended for combat use. The commission also decided that the new machinery should be used to increase the horsepower of existing classes rather than to decrease their hull size, and as a result the standard classes grew in horsepower: steam frigates from 450 to 640 or more, steam corvettes from 320 to 400, and the three categories of smaller steamers from 220 to 300, 160 to 200, and 80 to 120 respectively. These new guidelines were at once implemented:

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[1] Ports to Minister, 28 October 1844, A.M., Marine 1DD1-87; C.A., 11 November 1844, A.N., Marine BB8-874; Ports to Minister, 28 November 1844, A.M., Marine 1DD1-87.

the navy told Parliament as early as June 1845 that they would be followed for all future steamers, and by September 1845 the minister was insisting that designs for new steamers conform to them.[1] It was briefly proposed to convert Mogador to the screw propeller to conform to the requirements for the largest category, but her hull was too far advanced to permit this and instead a second steam frigate of 640 horsepower, Isly, to be built with the screw, was added to the program as the first example of Joinville's ideal combatant steamer.[2]

The first French efforts at producing the new type steamers were not impressive--two 320-horsepower ships begun at Indret early in 1845 appear to have received direct-acting engines based on British designs dating from 1841, and were not much of an improvement over the Cuvier of that year.[3] But information on British engines was rapidly becoming available in France in 1845 and 1846, and later Navy steamers showed that, thanks to the foundations laid down in 1840, the French were capable of both designing and building good direct-acting engines and tubular boilers.

The greatest challenge was the machinery of 640 horsepower for Mogador and Isly. In October 1845 Boucher wrote that

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[1] Ports to Minister, 1 September and 4 December 1845, A.M., Marine 1DD1-99 (referring to Coligny and Catinat respectively).

[2] Maritime Prefect of Rochefort to Minister of Marine, 30 September 1845, A.M., Marine 7DD1-161.

[3] Ports to Minister, 28 February 1845, A.M., Marine 1DD1-99.

this task would be even more difficult than the construction of the engines for the packets of the 1840 program, since the new engines were to be more powerful and relatively much lighter than the old ones, and since they were to be built on an improved system that had not yet been tried in France, at least on a large scale. He noted that the plan followed in producing the fourteen large packet engines in 1841 had been to deal directly with the three best engine builders in France, and that the success of that effort justified following the same plan again. He therefore recommended having a commission draw up specifications for the two 640-horsepower engines and inviting Cavé, Hallette and Schneider to present plans and estimates for the machinery. He also proposed adding a fourth builder to the list, Mazeline of Le Havre, who had greatly expanded his factory since 1840 and who had shown particular aptitude for the screw propeller.[1]

The commission proceeded to tackle Mogador first, since her hull was nearing completion. It invited plans from both Schneider and Cavé, and after much discussion chose Schneider in July 1846. Schneider produced the machinery with no difficulty at all, giving a convincing demonstration of the ability of French industry to adopt itself both to an increase in horsepower and a change in engine design. Schneider's engines were direct-acting engines of 650 horsepower that weighed two hundred

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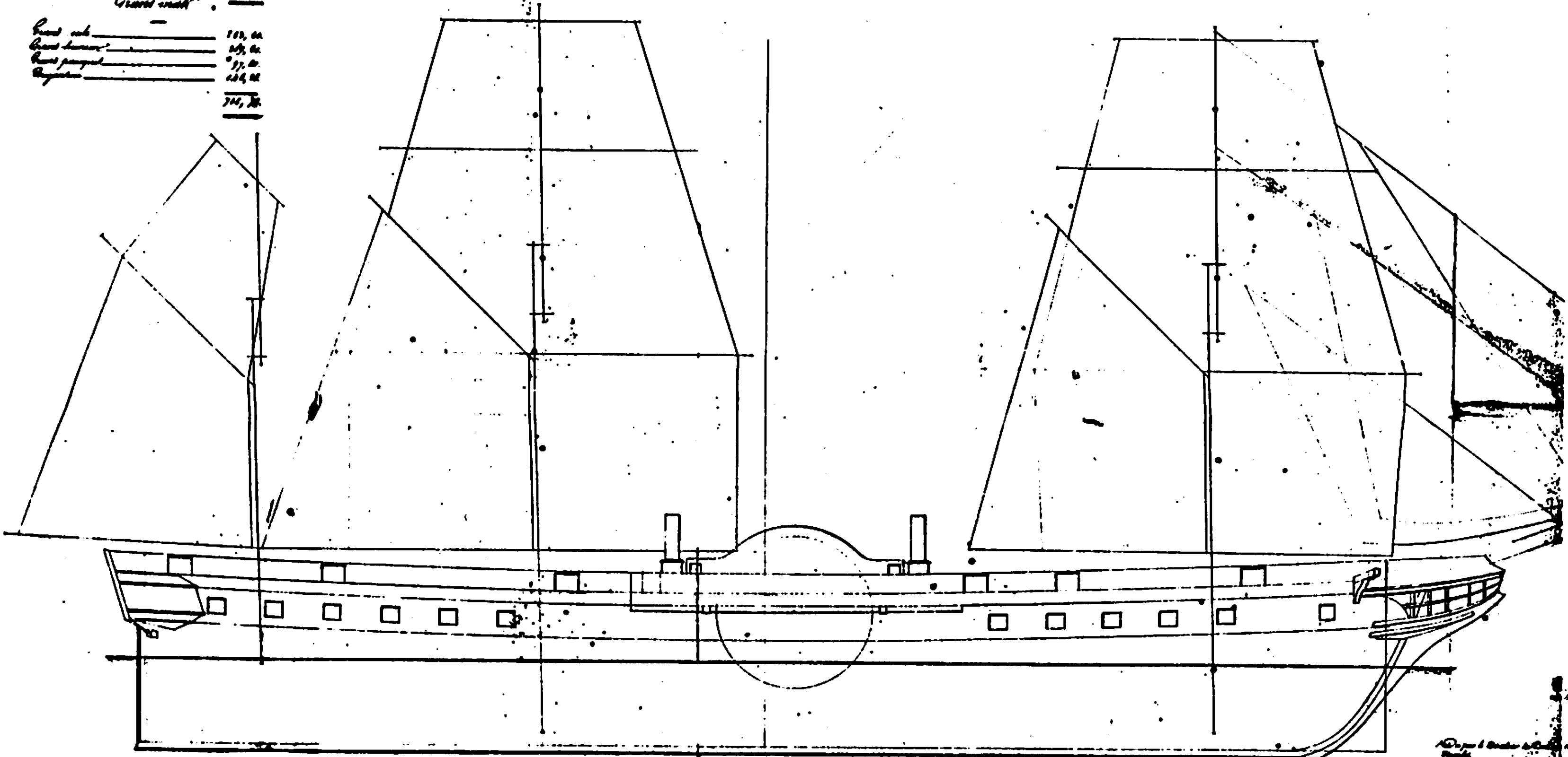
[1]Ports to Minister, 4 October 1845, A.M., Marine 1DD1-99.

Projet de Voilure pour le Mogador.



An 1847 sail plan for the 640 horsepower paddle frigate Mogador (1848). (A.M., Marine, 8DD1-379)

tons less than the beam engines of 450 horsepower in the trans-atlantic packets. The captain of Mogador, questioned in 1849, considered the engines "complete and perfect," although he felt the ship's boilers were not quite powerful enough.[1] Cavé in turn received the order for the screw machinery for Isly, but, compared to Schneider, his performance was disappointing. His engine design was too complicated (a weakness common to many early screw steamers), and ultimately in the early 1850's he had to supply new machinery in order to meet the terms of his contract.[2]

The smaller ships in the program offered fewer technical problems, but their sheer number was a challenge, due in part to a supplementary program decided on in October 1845. Earlier in that year the British and the French had finally agreed on a treaty calling for increased efforts by both nations to suppress the West African slave trade. The treaty called for the use of roughly equal naval forces by each power, and as the British

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[1]Ports to Minister, 4 July 1846, A.M., Marine 1DD1-109; France, Assemblée Nationale Legislative, Enquête Parlementaire sur la situation et l'organisation des services de la marine militaire, ordonné par la loi du 31 Octobre 1849, 2 vols. (Paris, 1851) (hereafter Enquête, 1849), 2:311. (Volume 3 of this series was to have been the final report by J. Dufaure. It was never finished, since the coup of 2 December 1851 interrupted the work of the commission, but the first section exists in page proof in the Navy Archives in Paris, and is referred to here as volume 3.)

[2]Gaudry, "Cavé," p. 492; Jonveaux, "Cavé," p. 72. Gaudry says that the problems with Isly's engine was that its frame was too weak, while Jonveaux ascribes the failure to the "mode of execution imposed by the navy and also to a lack of understanding with the navy's engineer."

Isly frégate à vapeur de 650 Chevaux

An 1856 sail plan for the screw frigate Isly (1849) after she received her second set of engines. (A.M., Marine, 8DD1-379)

were using a large number of steamers the French found that they would have to build eight new steamers (and six sail brigs) to meet their obligations.[1] Orders for the machinery of these and a total of six ships from the regular program were placed before the end of 1846, putting a heavy burden on French industry.[2] The private builders generally acquitted themselves well, proving capable of adjusting to the new technology and meeting the terms of their contracts.

Meanwhile the navy began to convert its own facilities for the construction of the new machinery and iron hulls, although in this regard it lagged behind private industry. The old type of machinery was finally abandoned in July 1846 when the minister accepted proposals to substitute new type engines for old ones in three ships that were under construction. (Their original engines were put in tugs.)[3] Thereafter Indret and the ports provided the new type machinery for new ships, generally without much difficulty.

Only one problem was encountered with the innovations, but this was a major one that affected both the English and the French. Almost from the beginning, doubts began to arise as to

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[1] Ports to Minister, 13 October 1845, A.M., Marine 1DD1-99.

[2] Ports to Minister, 21 November 1845, A.M., Marine 1DD1-99; Ports to Minister, 10 July 1846, A.M., Marine 1DD1-109.

[3] Ports to Minister, 3 July 1846 (_Coligny_ and _Catinat_) and 10 July 1846 (_Eclaireur_), A.M., Marine 1DD1-109; A. Lebelin de Dionne, _Notice biographique sur V. Sabattier, Directeur des Constructions Navales_ (Rochefort, 1885), p. 8.

the suitability of iron hulls for use in warships. These doubts were confirmed in 1844 when experiments, both in England and in France, showed that iron hulls would be deathtraps in action: shot striking them made large gashes in the hull plating and sprayed the interior with iron shrapnel. Its use was therefore limited to ships not intended for combat (in the French navy, those of 300 horsepower or less).[1]

However new problems soon appeared when the first iron steamers were sent to West Africa. They quickly developed a lush growth of barnacles and seaweed below the waterline which notably reduced their speed. Such a growth could only be removed in a drydock, and there were very few drydocks outside Europe. They also showed signs of rapid corrosion wherever the hull paint had worn away, particularly around the rivets and at the edges of the iron plates. Again, the damage could be repaired and the hull repainted only in drydock. This meant that iron ships would have to be restricted to European waters, and even there they would be costly to maintain.[2] In December 1846 the navy cancelled plans to give Brest and Lorient the capability to build iron ships, and in June 1847 the Council

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[1] The British trials involved the small steamer Ruby, which was shot to pieces; and the French trials were conducted at Gavres. Baxter, Ironclad, pp. 33-47 passim; Ports to Minister, 27 December 1844, A.M., Marine 7DD1-60.

[2] Ports to Minister, 28 June and 3 November 1847, A.M., Marine 1DD1-122.

of Works recommended adjourning all new construction of iron hulls until experience gave an idea of the value of those already built and building.[1] Neither the British nor the French navy built any more iron ships of any importance until the late 1850's. The problem of vulnerability to shot was solved only after 1855 by the use of iron armor, while the problems of underwater fouling and corrosion were only solved in the 1860's and 1870's when ways were found to attach wood and copper sheathing to the submerged part of the hull. The introduction of iron hulls in the 1840's thus turned out to have been premature.

The Steam Navy Goes Overseas

The period from 1840 to 1846 was, in retrospect, one of great importance to the French steam navy, for during these years it had developed its own strategic and tactical doctrines and its own organization as a military force. It had also adopted a number of technological innovations which went a long way towards overcoming the disabilities of earlier steamers. Yet in perhaps the most important test of all--the actual use of the ships--it made very little progress. Joinville had called for a battle fleet making extensive use of steam but, despite considerable expansion of its non-military functions, steam still had only a subsidiary role in the main fleet as of the beginning of 1846. In 1839 one steamer had been assigned to the Mediterranean fleet and one to the Levant squadron, primarily to

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[1] C.T., 2 June 1847, A.M., Marine BB8-1120.

maintain communications between the fleets and their bases, and at the beginning of 1846 each still had only one steamer assigned on a regular basis. (The sole advance during these years was to assign a small steamer to the ambassador at Constantinople to keep him in touch with the naval commanders.)[1]

Steam did make one important advance during the early 1840's, though it was limited in that it did not involve military functions. Most naval officers had come to appreciate the great advantages of steamers for maintaining communications and for transporting urgently needed supplies in European waters, and senior officers sent out to take command of overseas stations after about 1840 began to clamor for similar services for their parts of the world. In 1841 the new commander of the Station of the Antilles and the Gulf of Mexico called for a steamer, pointing out that at certain times of the year adverse winds made it all but impossible for him to maintain communications between the two parts of his station. In 1843 a crisis broke out in Haiti and the admiral added a new reason for having a steamer: with such a ship he could keep in touch with the situation in Haiti from his base in the French Antilles, while without it, due to the unreliability of sail communications, he would either have to go to Haiti himself and lose touch with events in the Antilles for a minimum of three months, or else renounce a personal role in the crisis. This French commander

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[1]For station assignments and movements month by month see A.N., Marine BB5-23 to 62.

was deeply suspicious of the English, and repeatedly pointed out that they had the advantage of steamer communications in the Caribbean while he did not. For the same reason he also complained bitterly when execution of the transatlantic packet program, with its terminus at Martinique, was postponed in 1843.[1]

Similar requests soon came from the Station of Brazil and the Plata, which needed a steamer to maintain communications between French forces in Rio de Janeiro and the Plata, or, alternatively, between forces at the mouth of the Plata and ships making shows of force upriver against the unruly Argentines. (The steamer was to be armed so it could participate if necessary in these shows of force.) As of July 1844 the British had three large steamers on the station while the first French steamer had not yet arrived.[2]

New colonial acquisitions also led to requests for steamers. In mid-1842 a French admiral took possession of the Marquisas Islands, in the Pacific to the northeast of Tahiti. A few months later, in December, he informed the ministry that if the government planned to develop the new colony, two or three small ships, preferably steamers, would be needed to carry out inter-island patrols and to maintain communications with Mexico, and thereby with France. They would also permit the

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[1] Rear Admiral de Mogues to Minister of Marine, 30 January, 28 February, 14 March, 20 April and 9 May 1843, A.N., Marine BB4-619.

[2] Vice Admiral Massieu de Clerval to Minister of Marine, 18 July 1844, A.N., Marine BB4-628.

governor of the Marquisas to keep in touch with events in Tahiti, which had become a French protectorate in December 1842.[1] Similarly the French colony of Bourbon (today Réunion) requested a steamer to maintain communications with its new satellite colonies along the coast of Madagascar (Nossi-Bé and Mayotte, taken over in 1841 and 1843) as well as the older French post at Sainte Marie de Madagascar.[2]

The navy had previously sent seagoing steamers abroad twice, but in both cases the ships had been part of special punitive expeditions (one to Mexico in 1838 and one to the Plata in 1840), and they had returned to France as soon as the expeditions had ended. Now, in 1843 and 1844, the navy began to assign steamers (of the 160-horsepower <u>Sphinx</u> class) to the stations on a routine basis. In April 1843 the navy promised one steamer for the Marquisas Islands and one for the Antilles. Later in 1843 a steamer was assigned to Bourbon, and in 1844 a second steamer was assigned to the Antilles, one to the Brazil station, and one to the West Africa station. In addition, a steamer was sent on a special mission to China in 1843. A major increase in the use of steamers overseas followed the agreement between Britain and France in 1845 to expand their efforts to suppress the slave trade from West Africa, and the

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[1] Rear Admiral Du Petit-Thouars to Minister of Marine, 8 December 1842 and 17 March 1843, A.N., Marine BB4-615 and 620.

[2] Minister of Marine to Capitaine de Vaisseau Desfossés, 16 and 17 June 1844, A.N., Marine BB4-627.

need to maintain forces on this station equal to the British caused the French squadron to be increased from eight ships (including two steamers) to twenty-six ships (including eight steamers).[1]

The navy then had to confront the various problems that, until then, had prevented the use of steamers overseas: the difficulty of maintaining the machinery without the help of a navy yard, and, above all, the problem of supplying coal for the ships, both during their transits and after they arrived on station. An attempt was made to overcome these difficulties through meticulous advance planning. Each ship was first given a complete overhaul in a French dockyard, involving delays of up to a year between the time it was promised to the station commander and the time it arrived. It then received detailed sailing orders which, except for the route to be followed, were essentially identical for each ship. The mission of each captain was to get his ship to its destination with its machinery in the best possible condition and with full coal bunkers. To do this he was to proceed under sail when at all possible, and to resort to steam only when unable to make any headway under sail. He was to be sure to top off his bunkers whenever possible, particularly at the last port before his final destination. (Station commanders were told to try to stockpile coal on their stations,

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[1] The bill to augment the station was presented 10 June 1845, P.V. Députés, 1845, 10:265-71; Report to the Chamber of Deputies, 21 June 1845, P.V. Députés, 1845, 12:125-33.

but until this system took hold the only sure coal supply for a steamer was the one in its own bunkers.) For repairs to the machinery, each captain had to rely on the skill of his engineers, spare parts carried on board or sent out from France, and good luck, which would be encouraged by sparing and careful use of the machinery.[1]

Under these conditions enterprising officers were sometimes able to expand the capabilities of their ships. The commander of the 220-horsepower _Archimède_, sent on a mission to China in 1843, conducted a large number of experiments during the trip with his ship, and discovered among other things that he could steam very economically if, instead of using both boilers, he extinguished the fires in one and under some of the furnace grates in the other, made maximum use of the expansion of steam in the cylinder, and accepted some loss of speed. The result was that he was still able to average six knots over a long period, while consuming less than a third the normal amount of coal.[2] This meant that steamers could make longer cruises under steam than had previously been thought possible.

However other ships were not so fortunate. The commander of the first ship sent to the Marquisas Islands, the

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[1] Orders to Commanding Officer _Phaeton_ 13 April 1843, _Styx_ 6 January 1844, _Crocodile_ 13 February 1844, _Archimède_ February 1844, _Tonnerre_ 12 September 1844; A.N., _Marine_ BB4-620, 628, 627, 630 and 628 respectively. In addition _Fulton_ was sent to Brazil and _Castor_ to West Africa during the same period.

[2] _Ann. Mar._, no. 91 (1845), p. 177; _Ann. Mar._, no. 95 (1846), p. 227.

160-horsepower Phaeton, soon noticed that his ship's boilers were deteriorating, and before Paris got around to sending out a replacement ship and recalling her, she was completely unable to steam. Efforts to buy new boilers for her and install them at Sydney or at Valparaiso fell through, and finally the ship was simply abandoned and the usable parts of her engines sent back to France.[1]

The use of steamers overseas was therefore still severely limited, both by the need to resort to sails for long transits and by the difficulty of guaranteeing a coal supply, especially in wartime. For these reasons, Joinville's sub-commission declared in 1845 that steamers were unsuitable as overseas cruisers in wartime, and the steamers that were sent overseas in the 1840's were intended to perform essentially non-military functions.

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Despite the problems encountered in the use of steamers overseas, the steam navy still made enormous progress during the first half of the 1840's. While the French navy did not build many new steamers for its own use during the period due to the saturation of its production facilities with ships being built under the packet programs, it did succeed in keeping up with technological progress in Britain and it introduced a number of new developments in steam technology into France.

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[1] Director of Personnel (Movements) to Minister of Marine, 13 January 1846, A.N., Marine BB1-89; Ports to Minister, 24 February 1846, A.M., Marine 1DD1-109; A.M., Marine 7DD1-40.

The first of these was the use of iron hulls for ships, and the French adjusted to this relatively easily due to the work of Dupuy de Lôme and to the fact that some French shipyards already knew how to build iron hulls on a small scale. Unfortunately the use of iron hulls for warships proved to be premature--their vulnerability to shot and to corrosion caused both the French and British navies to abandon them before 1850.

French naval constructors also introduced two other British innovations: the direct-acting engine and the tubular boiler. The problems of designing and manufacturing these were very difficult, particularly for a country which had just barely mastered the construction of the old types of machinery and which no longer permitted itself the luxury of importing British machinery as models. During most of the 1840's the French were simply struggling to keep up with the stream of technological changes coming from England, and they generally lagged behind the English by several years. However the changes were made: the navy decided in 1844 to give its new ships the new type of machinery, and in 1848 it completed a ship, _Mogador_, whose engine of 650 horsepower was comparable to some of the biggest and best in Britain.

However the main achievement of the steam navy during this period was in the realm not of technology but of ideas. The very notion of a steam navy dates from the program of 1842, which for the first time indicated that the navy's fleet of steamers consisted not of one type of ship, "steamers," but of a number of categories with military nomenclature and functions

similar to the categories of ships in the sail navy. Conditions were also favorable for the steam navy in other ways. Technology had finally produced large steamers that were capable of carrying out major military missions; and the crisis of 1840, by calling into question the adequacy of the sail navy, had aroused new interest in the military uses of steam. Finally the steam navy had acquired a leader in the Prince de Joinville who was free from any dependence on the old naval system and who was able to have any experiments done or studies made that he wished. Led by Joinville, the steam enthusiasts produced a series of reports in which they laid out their ideas on how war steamers should be designed, the military uses to which they should be put, and their place in the navy and in French maritime strategy.

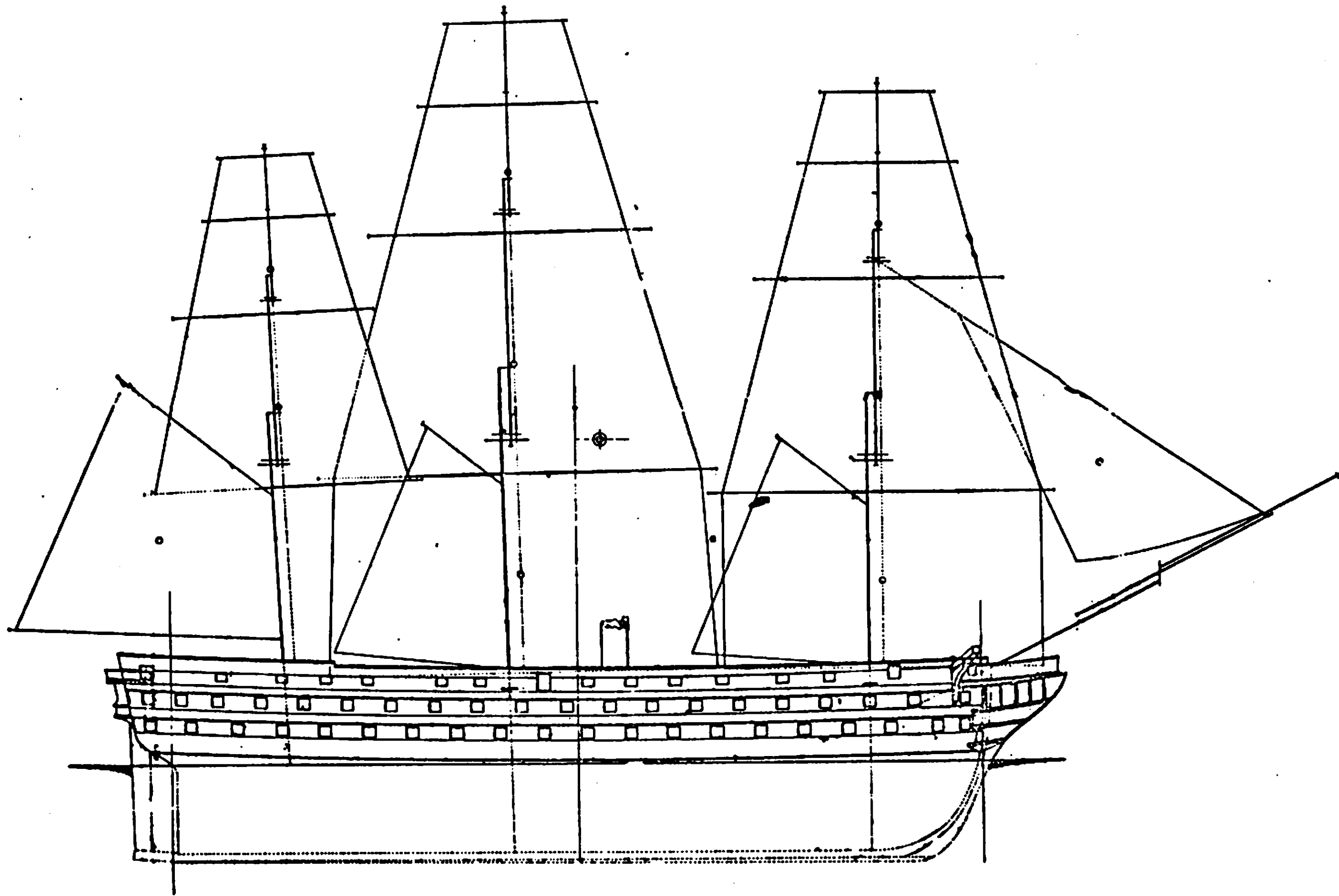
In generating these ideas the steam enthusiasts developed a set of strategic views that were very different from those of the sail navy. While the sail navy was designed mainly to fight large fleet actions, the steam enthusiasts put the emphasis on surprise strikes against the enemy, in the form of raids against his commerce and landings on his coastline. Steamers were no longer to act as auxiliaries to the battle fleet, but were to carry out these special forms of warfare. Steam was now being offered, not as a support to the sail battle fleet, but as an alternative to it, and the result was a split between the advocates of steam and those of sail. It was the steam enthusiasts who did most of the talking, but the opposition, although generally tacit, was still there in the form of bureaucratic

inaction and, occasionally, obstruction. There were also enough technical problems with the ideas of the steam enthusiasts to provide good reasons for not rushing into a mass conversion of the navy to steam. The result by 1845 was a standoff--the steam navy had developed its organization, its doctrines and a large number of ships, but steam had made hardly any progress in gaining entry into, or replacing, the only part of the fleet that really mattered, the battle fleet.

Fig. 2.--A mixed-propulsion battleship of the 1846 program, *Austerlitz*. The screw was located in the space aft just before the rudder post. Plan dated 23 February 1866. SOURCE: A.M., Marine 8DD1-375.

Vaisseau l'Austerlitz

Plan de mâture et de voilure (après transformation)



CHAPTER VI

THE SCREW PROPELLER AND THE MIXED-PROPULSION COMPROMISE: STEAM INTEGRATED INTO THE FLEET, 1846-1852

Two compromises were needed in order to resolve the confrontation between sail and steam that had resulted from the rapid growth of the steam navy during the 1840's. One was a policy compromise, implemented by the minister in 1846 in the form of a new naval program. But for that to work, a technological compromise was also needed, one that would provide a way to combine sail and steam physically in one ship in proportions that could grudgingly be accepted by both sides. This technological compromise was made possible by the development of the screw propeller in the 1840's, and it was the screw propeller that finally allowed steam to join the combatant fleet in the late 1840's. In addition, the introduction of the screw forced the French to solve on their own an extremely complex series of technical problems, and their success showed that they were rapidly drawing close to Britain in their command of steam technology.

The Advent of the Screw Propeller

There are few better examples of an innovation whose time had come than the propulsive device used today for ships: the screw propeller. After centuries of neglect (the water

screw had been invented by Archimedes, who died in 212 B.C.), it was offered almost simultaneously by numerous inventors in the 1830's and 1840's as a means of propulsion for ships. This occurred precisely at the time when men were realizing that the deficiencies of the paddle wheel were probably irremediable and that its advantages could probably never be combined with those of traditional sailing ships. This technological impasse was accompanied by the confrontation between sail and steam enthusiasts, which intensified the need for a compromise and made agreement on one even more difficult. The screw propeller owed its success to two factors: it was technically viable, and it was able to dissolve the sail and steam confrontation by giving not one but both sides essentially what they wanted. It gave the steam enthusiasts better steamers, and it allowed the advocates of sail to counter the more radical arguments of the steam enthusiasts with a system of ship construction that retained essentially unchanged (they hoped) the traditional battleship and battle fleet.

For steam enthusiasts, the main problems with steamers as they existed around 1840 were nearly all associated with the paddle wheel. Paddle wheels were spectacularly vulnerable to shot, and the fact that the paddle shaft was well above the waterline meant that the machinery also had to be exposed, at least in part. The attempts of the steam enthusiasts to get around this problem by stipulating that steamers should fight only end-on were not convincing and at best simply exchanged

one problem for another, for a ship with guns only at the ends could carry only a fraction of the artillery that a conventional sailing ship could carry in its broadside batteries. The position of the steam enthusiasts would be enormously improved if a way could be found to put the machinery and the propulsive device in a protected position below the waterline, and permit once again mounting a heavy gun battery on the sides and fighting in all positions.

Much more important for the success of the screw, however, was the fact that it also had much to offer to the advocates of sail. These had been objecting for years to the obvious defects of steamers as warships, and, despite being hard pressed at times, had generally been successful in holding the line against the use of steam in the fleet. Perhaps even more important than the military argument were the psychological and social ones. For us in the twentieth century, who have come to accept continuous change as the normal condition of life, it is hard to conceive of the enormous attachment sailors of the early nineteenth century, from admiral to apprentice seaman, felt for every detail of the standard large sailing warship. It was not just that they did not like seeing the middle third of their ship filled up with machinery and coal, the sides disfigured with an indescribable and unseamanlike mechanism, and everything and everyone on board covered with soot. Resistance to change went much deeper: even a minor change in a detail such as the stowage position of supplies below deck or a change

in the organization of the crew could give rise to vociferous objections. The reasons were, first, that daily life on board ship was governed largely by details, and that these defined the place on board, not only of every object, but also of every member of the crew. The configuration of the ship thus determined what each man's job was and how he did it, and the implications of changes therefore went far beyond those of a few calculations on a blueprint. Second, in the days before science could explain most natural phenomena, the sailor's best guarantee against catastrophe was experience, and seamen knew that even the details of shipboard organization, such as the stowage position for the ship's biscuit and powder, were the result of centuries of efforts to keep biscuit edible and powder dry.

It was therefore not enough for the advocates of sail to conserve the general characteristics of a battleship or frigate--they wanted to preserve the details as well, or as many of them as possible.[1] It was clearly out of the question to do this with steam technology as it existed around 1840, with big engines, big boilers and big coal bunkers--these would interfere at least as much with the internal organization of the ship as with its artillery and its rig.

But steam had one advantage that even the most dedicated traditionalist desired to benefit from. Anyone who had been to

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[1] For a discussion of these details by a contemporary expert see J.-G. Casy, _Organisation d'un vaisseau_ (Paris, 1840).

sea for any length of time had been held in port by adverse winds, becalmed for weeks in the doldrums, or forced to claw off a lee shore in a storm when, at times, prayer for divine aid offered the only hope. Naval seamen had also been reduced to prayer when dismasted by the enemy or deserted by the wind in a naval engagement. Perhaps now another form of help was at hand. Perhaps a small steam engine, just large enough to move the ship, could be installed in place of a couple of water casks, for use in just such emergencies. Even two or three knots' speed from an auxiliary engine could make all the difference in getting through the doldrums, keeping off a lee shore or saving oneself in a battle.[1]

Thus was born the idea of auxiliary steam propulsion or, as the French called it, mixed (sail and steam) propulsion. Its essential condition was that the introduction of a steam engine into a sailing ship should not change any of the ship's other characteristics. Under the mixed system the ship's rig, hull, stowage and accommodations would remain unchanged, and the engine would be too weak to compete with sail as the ship's prime mover. (The mixed system was thus the exact mirror image of the efforts of the steam enthusiasts, beginning with Bechameil in _Véloce_ in 1838, who had tried to give steamers some sailing qualities without affecting their qualities under steam.)

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[1] _Ann. Mar._, no. 70 (1839), pp. 729-31; Boucher to Minister of Marine, 30 December 1841, A.M., Marine 7DD1-164/5.

It was generally felt that an engine capable of driving a ship at a speed of four knots in a calm (perhaps two knots against headwinds, currents or heavy seas) could be incorporated by sacrificing about a month's provisions and part of the water supply. (The latter was compensated for by the installation of another recent innovation, an evaporator to convert seawater to fresh water.) Such a sacrifice, coupled with the introduction on board of the few men needed to operate the machinery, was considered acceptable--anything more would compromise the ship's character as first and foremost a sailing ship.

The mixed system offered naval officers (as well as merchant seamen) a way to get what they saw as the essential benefits of steam without most of its disadvantages, and they eagerly embraced it, both for its own sake and as a counter to the radical arguments of the steam enthusiasts. They could keep the sailing ship essentially as it always had been and still have some supplementary mobility for emergency situations or for naval actions. But, in trying to move from theory to practice, they came up against the same obstacle that the steam enthusiasts had: they couldn't make a good mixed-propulsion ship by using paddle wheels. The experiment appears to have been tried first in England when, in 1839, a sailing ship named Vernon was built for the India trade with an auxiliary engine of 30 horsepower. The machinery was designed to interfere as little as possible with the normal functions of a sailing ship: the paddle wheels were only four feet in diameter and could be

dismounted when not in use, and the two men who operated the engine and the boiler also had their assignments in the operation of the rigging.[1] The ship was considered successful as a merchantman, at least initially, but, despite interest shown by one lord of the Admiralty, the idea was not imitated in either the British or the French navies. For one thing, it did not answer the main objection against the military use of paddle steamers: the machinery and paddle wheels, though smaller, were still exposed to shot. In addition, small paddle wheels as contrasted with large ones had a special disadvantage: any appreciable roll or heel of the ship, due either to weather or to the use of the sails, would completely submerge one wheel and raise the other out of the water, nullifying their propulsive effect. The traditionalists were thus just as eager as were the steam enthusiasts to discover a new propulsive device that could be put entirely below the waterline and that would dispense once and for all with the disadvantages of the paddle wheel.

The need was thus clearly defined before the end of the 1830's, and it was met by a good half-dozen inventors, all of whom presented designs for screw propellers so nearly simultaneously that none of them, even after long litigation, was able

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[1] Ann. Mar., no. 70 (1839), pp. 729-31; Ann. Mar., no. 86 (1844), pp. 912-13. Vernon may have been the first ship designed with the theory of mixed propulsion in mind, but earlier ships did exist which conformed to it in practice, notably the American Savannah of 1819, the first steamer to cross the Atlantic.

to establish exclusive patent rights. The story of the invention of the screw propeller has been told many times, and only the essential details will be given here.[1] The development of the screw in England followed mainly from the work of Francis Pettit Smith, whose screw was patented on 31 May 1836 and convincingly demonstrated in Archimedes, a steamer of 237 tons which spent much of her career running trials for prospective buyers of the Smith screw such as I. K. Brunel and the British admiralty. Smith's main competitor, the Swedish engineer John Ericsson, whose patent was dated 13 July 1836, also successfully demonstrated his screw in Robert F. Stockton before emigrating to America in 1839. In France the main inventor was Frédéric Sauvage, who worked on the screw for most of the 1830's but who had no large scale practical success similar to those in Britain.

The British navy reacted quickly to the experiments with the screw propeller. In 1839 Archimedes was brought to Portsmouth where her performance was compared with that of one of the better Admiralty paddle steamers.[2] The results were encouraging and, on 15 December 1840 the Admiralty ordered the Surveyor (the chief naval constructor in the British navy) to propose drawings for a "propelling screw ship." This was one of the rare cases

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[1] Rowland, Steam at Sea, pp. 94-103; Bernard Brodie, Sea Power in the Machine Age (Princeton, 1941), pp. 32-37; Léon Du Parc, "De la vis et autres propelleurs pour les bâtiments à vapeur," Ann. Mar., no. 79 (1842), pp. 885, 1278.

[2] Rowland, Steam at Sea, p. 96. The navy steamer was probably Volcano of 140 horsepower.

in which the Admiralty adopted an innovation before it had been fully developed in commercial use, and, to make up for the lack of practical experience, it called in the best available experts as consultants, notably Brunel and Smith. However this also slowed down the project: the machinery was only ordered in October 1841 and the hull in February 1842.[1] The ship, named Rattler, was launched in April 1843 and began running a celebrated series of trials the following year. The Admiralty had already begun its experiments with the screw the previous year in a small vessel, Dwarf, and these two ships put it in the unaccustomed position of being the prime innovator in screw propulsion in Britain during the early 1840's. (In one year, 1845, no less than twenty-four different propellers were tried in Dwarf, and most of the major models were also tried in Rattler.)[2]

In France the navy would also have been the first to experiment with the screw had it not been for the energy on one man, Augustin Normand, the leading shipbuilder at Le Havre.

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[1] Surveyor's Submission Letter Book number 10 (July 1841-December 1843), Series 88, Admiralty Papers (hereafter ADM. 88), Public Record Office, London; Manuscript Navy List, 1840, Admiralty Library, London. The "screw steamer" was originally to have been built as a new ship, but to speed up the project the Admiralty ordered in January 1842 that the screw machinery be substituted for the paddle machinery in an existing steamer, Acheron. However Brunel reported that Acheron's hull lines, while appropriate for paddle wheels, were too full aft for use with the screw, and on 24 February 1842 the Admiralty ordered a new ship built instead, which was to take the name and place in the building program of the paddle sloop Rattler, one of ten sisters ordered in 1841. The report that Rattler was converted from a ship named Ardent is incorrect.

[2] Rowland, Steam at Sea, p. 99.

Normand had followed with interest the experiments that the French inventor Frédéric Sauvage had carried out with a screw propeller at Le Havre in 1832, and when Sauvage was unable to arrange for large-scale trials of his screw, Normand offered to conduct them on his terms and at his own risk, provided Sauvage gave him free use of his patent rights for the trial ship.[1] Normand was not a steam engineer and had a low opinion of French engineers, so in his dealings with Sauvage he associated himself with a British engine builder, John Barnes. (Barnes, then based in Britain, later became the chief engineer for the French firm of Benet at La Ciotat.) Having secured Sauvage's patent rights, Normand and Barnes then turned to the most likely source for funding, the government. It happened that the Ministry of Finance was then planning to build three small packets to carry the mails to Corsica, and Normand offered to build one of these ships and fit her with the screw at his own risk: if she did not make eight knots, she would remain on his hands.[2] The Minister of Finances was convinced, overrode an adverse report by a commission within his ministry, and approved the project.[3]

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[1] This is the version given by Normand's biographer of an agreement that later caused much controversy between Normand and Sauvage. Jean de La Varende, Les Augustin-Normand; Sept générations de constructeurs de navires (Mayenne, 1960), p. 81.

[2] Ibid.

[3] Brindeau, Premiers bateaux, pp. 46-47; Enquête, 1849, 2:177.

In designing the ship, Normand did not simply substitute the screw for the paddle wheel, but fully exploited one of the main advantages of the screw, its compatability with sail. The elimination of the paddle wheels meant that the hull could be given clean lines for sailing and the machinery could be distributed so as to accommodate the rig, instead of being concentrated amidships in the way of the main mast. Thus while Normand designed the ship as a pure steamer with full steam power (120 horsepower), he also gave her a large rig and intended that she should be fast under sail as well as steam and should be able to use both sail and steam together if desired.[1]

In accordance with normal practice for postal packets, Normand's plans were approved by the navy's Council of Works in December 1841, giving the navy its first official contact with the project.[2] Its involvement broadened when one of its most capable young officers requested command of the ship, proposing to follow from its beginnings the development of the screw and to give the navy the benefit of his experience, which, he said, might provide some important answers to the problem of combining in one ship the two motive forces of wind and steam. The navy duly nominated him to command the ship, and later approved his request to be sent to Britain while the ship was

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[1] La Varende, Les Augustin-Normand, p. 81.

[2] C.T., 4 December 1841, A.M., Marine BB8-1112, 1116.

still under construction so he could learn as much as possible about the British experiments with the screw propeller.[1]

The ship, named _Napoléon_ (often referred to as _Corse_, her name after she joined the navy in 1850), was launched in December 1842; and in 1843 Normand and Barnes ran a carefully planned series of trials in her with eight different forms of propeller. The ship's commander and a naval constructor stationed at Le Havre sent lengthy reports on the trials to the navy, some of which were published in the _Annales Maritimes_.[2] The ship was a great success, easily exceeding ten knots under steam. Her performance under sail attracted at least as much attention as her performance under steam--despite the fact that the size of her engine classed her as a pure steamer, she proved very fast under sail, both with the engine running and with it stopped and the screw feathering.

Napoléon was the delight of every sailor who saw her. At her launch the _Annales Maritimes_ reported that the ship, sitting on the ways, was free of "those heavy paddle boxes cutting so disgracefully the lines of the hull. One did not see that swelling of the belly which indicated the point at which all the effort of impulsion is made, and nothing troubled the eye which, from one end to the other glided along her elegant

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[1] Ports to Minister, 6 July 1842, A.M., Marine 1DD1-66.

[2] _Ann. Mar._, no. 86 (1844), pp. 462-90 and 889-915. Other reports are in A.M., Marine 7DD1-314. See also Armengaud, _Publication industrielle_, 3:409-17.

curves. It was the perfect model of a fine sailing ship, and one could have taken Napoléon for the most sleek of our corvettes if, at the stern, a special arrangement of the sternpost had not revealed a mechanical destination."[1] During her experiments at Le Havre in 1843, Napoléon ran comparative trials with several navy paddle steamers and joined for a time a squadron commanded by Joinville, who observed her with great interest. He related that "everywhere we went, as no one had yet seen a screw steamer, there was general amazement," and told of the astonishment of the British authorities at Chatham, one of the ship's ports of call, who saw her arrive noiselessly in the fog, stop, "then, thanks to her screw, turn practically in place to put herself alongside the pier, a new way of maneuvering which still had the commodore, an old salt, completely speechless when I disembarked."[2] The unexpectedly good maneuverability of screw steamers, much better than that of paddle steamers due to the relative position of the propelling device and the rudder, delighted their commanders, while sailing ship captains noted with approval that screw steamers seemed to be very good under sail, and could probably be excellent if the machinery were kept within limits.

The Mixed Propulsion Frigate Pomone

The French navy was not far behind Normand in beginning its investigations of the screw propeller. One of the major reasons why Boucher recommended in June 1841 that naval

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[1] Ann. Mar., no. 79 (1842), pp. 1392-94.

[2] Joinville, Vieux Souvenirs, p. 246.

constructors be sent to Britain on a regular basis was that he wanted frequent and exact information on two new ideas being experimented with there, the iron hull and "the use on board large sailing ships of steam engines of mediocre power as auxiliary motors, and the substitution of the Archimedian screw for paddle wheels in the construction of these mechanisms."[1] In 1841 alone two engineers and one line officer were sent to England and another line officer to the United States for this purpose, and many more followed in subsequent years.[2] However French contact with British screw experiments went back even before this, for when Boucher himself had gone to England in 1840 to buy the large paddle engines for Asmodée he had discussed the screw propeller with Fawcett, Preston and Company, and had also inspected Brunel's giant Great Britain, which was soon to be converted while still on the building ways from paddle to screw.[3] Boucher appears to have been primarily responsible for for the early steps taken by the French navy in the development of the screw propeller: in 1841 he initiated the construction of the first mixed sail and steam warship, before the idea had been tried by either the British navy or merchant marine, and

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[1] Ports to Minister, 26 June 1841, A.M., Marine 1DD1-52.

[2] Ports to Minister, 7 July and 9 October 1841, A.M., Marine 1DD1-52.

[3] Boucher to Minister of Marine, 9 April 1840 and Fawcett, Preston and Co. to Boucher, 13 October 1841, A.M. Marine 7DD1-56.

in 1842 it was again a proposal of his that led to the construction of the French navy's first pure steamer fitted with the screw.

Boucher's proposal for the first true mixed-propulsion warship, the frigate _Pomone_, grew out of two circumstances. On the one hand, the navy had fallen below its programmed strength in third-rank frigates and would have to begin construction of three in 1842 to fill the gap. On the other hand, Boucher had received information on various experiments conducted in Britain, including the trials of _Archimedes_. On 31 December 1841 he proposed taking advantage of the opportunity offered by the construction of the three frigates to try out two British innovations--increased beam for sailing ships and increased use in them of large shell guns--and to experiment with the "application to warships of steam engines of moderate power considered as auxiliaries of the power of the wind."[1] In doing so he was not just repeating the _Archimedes_ trials, since _Archimedes_ was a pure steamer of 80 horsepower in which the machinery took up a full third of the hull, but was making the first trial of what many saw as the primary advantage of the screw: the ability to incorporate it into a sailing ship without disturbing its other characteristics.

The military advantages of such an installation, Boucher argued, were clear: sailing ships with auxiliary steam propulsion

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[1] Boucher to Minister of Marine, 30 December 1841, A.M., Marine 7DD1-164/5. _Pomone_ was not converted from the ship of that name launched in 1804 as sometimes reported--that _Pomone_ was captured by the English in 1811 and broken up in 1812.

could join combat with or evade an enemy as appropriate, leave a battle to repair damage after being dismasted, make some progress in a calm or against a slight headwind, round a cape more easily, avoid being blown on a lee shore, and enter or leave port at will. Two problems had until now prevented such auxiliary steam installations. The first, the encumbrance of paddle wheels, which prevented mounting guns on the broadside and caused other problems, had been eliminated by the screw. The second, the weight and volume of steam machinery and its coal, remained, but could be kept within acceptable limits in three ways: by using direct-acting engines, by accepting a low speed such as five knots, and by embarking only a small coal supply (about six days). For a third-rank frigate this would reduce the weight of the steam installation to 300 tons out of a total displacement of over 1700 tons.

Boucher therefore suggested taking one of the three proposed frigates and adding a section four meters long amidships, which would provide much of the displacement and space required for machinery of 160 horsepower. The remaining weight and space would be provided by slight reductions to the amount of water, stores and ballast to be provided. The hull lines of the bow and stern were to be completely unchanged by the modifications, and the remainder of the ship, including her armament and rig, was to be essentially identical to her two sailing sisters. This, plus the fact that her engine was of relatively low power (a pure steamer of her size would have had at least 450

horsepower) fully qualified her as the first true example of the mixed propulsion system.

Boucher's proposal went through the usual deliberations within the ministry, and was acclaimed at each step. Tupinier, who was still Director of Ports, fully approved ot it and called attention to the importance of not remaining behind England in the matter of progress and technological improvements.[1] The matter was then submitted to the Council of Admiralty, where it received the full support of one of the main champions of a strong fleet of sailing battleships, Baron Charles Dupin.[2] Dupin noted that the trials of the screw in Britain seemed to indicate that it would work, and that it offered a form of propulsion that would be safe from battle damage and that would not interfere with the speed of a ship under sail. The council, however, asked for more information, and Boucher revealed what must have been one of the main reasons for his decision: the official report by the officer who had been ordered by the British Admiralty to observe the trials of Archimedes. How he got this is not clear, but it was probably one of the fruits of the policy of sending officers to England. Before the days of the proliferation of military secrets, such reports were often passed with official approval between officers of different nationalities as personal favors.

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[1] Ports to Minister, 2 March 1842, A.M., Marine 1DD1-63.

[2] C.A., 11, 18 and 22 March 1842, A.N., Marine BB8-872.

The British report revealed the enthusiasm of British line officers for the screw propeller. Every one that had visited *Archimedes* had left wanting a similar installation for his ship. The idea of retaining all the qualities of a sailing ship and still gaining a nearly invulnerable source of mobility in calms, in adverse winds or in combat was almost irresistible to them. The British reporter suggested that both battleships and frigates should receive steam engines, very small ones for the battleships, larger ones for the frigates but still intended for only occasional use. In addition to the usefulness of the screw for sailing ships, the British saw its advantages for pure steamers--they were delighted with the ease with which *Archimedes* could be manouevered, and felt that due to its silence of operation and its invisibility the screw was better suited than the paddle wheel for one of the main missions of pure steamers, raids on enemy ports.

The opinion of the Council of Admiralty fully summed up the French reaction to Boucher's proposal:

> . . . The application to warships of steam engines of moderate power will be a most useful auxiliary to the power of the wind.
> . . . The screw mechanism recently tried in England is free from all the inconveniences which have until now made us draw back from the application of steam to sailing ships.
> . . . The application of an engine of 160 horsepower with a screw to one of these frigates is a felicitous concept and which will probably be fertile in good results.[1]

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[1] Ibid.

The council's approval cleared the way for construction of the ship, and on 18 May 1842 the order was sent to Lorient to build her.[1] In the process of designing the ship her power was increased to 220 horsepower. The effect of her machinery on her other characteristics can be seen in the comparison in Table 1 of the weights of items carried on board her with those on board a slightly earlier sailing frigate of her rank.

The figures show that Pomone retained essentially all the features of a sailing ship, except for a slight increase in length (which, along with the beam, which was increased for other reasons, permitted carrying more weight) and a reduction in the water supply (which was compensated for by the addition of an evaporator). One of the main problems that plagued later efforts to implement the mixed propulsion system was sidestepped when it was decided, in this experimental ship, not to worry overly about maintaining all the details of the regular stowage pattern for the provisions and spare items kept in the hold.

The next problem was to procure the machinery, including the propeller and its shafting. The French had little information on how actually to build the new device, and the ministry therefore decided to negotiate with the holder of a successful British patent.[2] Shortly after the Council of Admiralty approved construction of the ship the navy opened negotiations with the

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[1]Ports to Minister, 20 April and 18 May 1842, A.M., Marine 1DD1-63.

[2]Enquête, 1849, 2:134, 140-41.

TABLE 1

MIXED PROPULSION FRIGATE COMPARED WITH SAILING AND STEAM (PADDLE) FRIGATES

	ERIGONE (sail)	POMONE (mixed)	GOMER #2 (paddle)
Comparative weights (in tons)			
Artillery, ammunition and associated equipment and spares	165	146	96
Masts, rigging and associated equipment and spares	180	211	?
Provisions for 326 men for 6 months in ERIGONE, for 326 men for 5 months in POMONE, and for 260 men for 5 months in GOMER. Includes wine, spirits, their containers and water casks.	112.812	118.800	87.5
Allowance for containers for provisions and storeroom utensils	8	3.500	?
Water	128	60	27.5
Firewood and wood used in stowage	19	8.800	?
Coal	12	150.600	750
Provisions and belongings of captain and officers	15	8	8
Crew, with belongings	32.600	36	26
Boats	10	15	?
Internal partitions, accommodations, etc.	70	59.260	?
Ballast	125	100	?
Engine and boiler	--	172	450
Screw and its support	--	4.05	--
Total of above (excluding hull proper)	878.012 (sic)	1093.010	--
Total ship (including hull)	1600	1965	2720
Comparative dimensions (in meters)			
Length	48.00	51.02	70.95
Beam	12.40	13.30	12.20

SOURCES: Enquête, 1849, 3:22-23; "Programme des conditions auxquelles devront satisfaire les projets de Paquebots transatlantiques de 450 chevaux," A.M., Marine GG1-23.

European agent of John Ericsson, Count Adolf E. von Rosen, who offered to provide the machinery and the propeller in conjunction with a new but rapidly expanding engine firm at Le Havre, Adolphe and Francois Mazeline.[1] The French navy and Rosen had been aware of each other as early as 1838, for in that year a French naval constructor had been sent to Liverpool at Rosen's invitation to witness trials of a new system of steam navigation in which the entire mechanism, including the "wheels," was below the waterline. (This was in all probability Ericsson's screw installed in Robert F. Stockton, which ran trials off Liverpool in that year.)[2] The French were apparently also considering the Smith propeller, but Rosen supplied such a mass of data on trials of the screw in America (where Ericsson was now working) that the Council of Works recommended in July 1842 proceeding with Rosen's project.[3] Negotiations over the contract dragged on due to a number of difficulties: the price rose due to the novelty of the parts relating to the screw and the arrangement of the engines, and the contractors would guarantee a speed under steam of only five knots due to uncertainty over the effect on the action of the screw of the full lines at the stern of the ship. The navy finally accepted these terms and approved

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[1] On Rosen and his relationship with Ericsson see William Conant Church, The Life of John Ericsson, 2 vols. (New York, 1911), 1:138.

[2] Ports to Minister, 6 August 1838, A.M., Marine 1DD1-43.

[3] C.T., 28 July 1842, A.M., Marine BB8-1117.

the contract on 14 September 1843.[1] The ship itself was laid down on 26 October 1842 and launched on 20 June 1845.

The reaction from across the Channel gave the French considerable satisfaction. The British response to *Pomone* was to order what was in effect a copy of the French ship. Since 1829 they had been building a sail frigate named *Amphion*, and as she had been designed by a surveyor who had since left office on a plan now considered obsolete, there was not much interest in completing her. Either the Admiralty or Rosen thought of using her to duplicate the *Pomone* experiment. On 30 May 1844 a constructor at Woolwich was ordered to inspect her and see if it was possible to incorporate in her the machinery proposed by Rosen and his associated British engine builder, Miller and Rovenhill, and still preserve her efficiency as a sail frigate. Apparently the answer was in the affirmative, for the tenders of Rosen and Miller were approved and the order given for the conversion on 18 June.[2] The French later claimed that the British had made a literal copy of the machinery provided for *Pomone* by Rosen and Mazeline, with the sole exception that they had raised the horsepower to 300. This seems doubtful, for Miller and Ravenhill had no need to copy engine designs from anyone, but the screw and its shafting were probably similar

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[1]Ports to Minister, 14 September 1843, A.M., Marine 1DD1-75; *Enquête, 1849*, 2:140.

[2]Surveyor's Submission Letter Book number 11 (1844-46), ADM. 88-11.

to those in the French ship and, more important, so was the general concept.[1]

While Pomone was under construction, her design came under attack. The major criticism seems to have been that she was essentially as large as the paddle frigate Gomer, but, with only half the horsepower, would be nowhere near as fast. Boucher replied that the critics had missed the whole point of the mixed system. There were two ways of applying steam to warships, he explained: in steamers with auxiliary sails (as in all the paddle steamers), and in sailing ships with auxiliary steam (as in Pomone). France had many of the first type and would soon be in a position to know what could be expected from these ships in speed, usefulness in the fleet, and cost. Pomone was the first experiment with the second type, and would show the speed and other advantages that could be expected from an auxiliary engine put into a ship that would retain the full armament, rig and configuration of a sailing frigate. There was thus no doubt that Pomone would be slower than Gomer under steam alone, but she would be faster under sail, carry more guns, cost much less (since she was shorter and had a smaller engine), use much less coal, and be able to carry out the long wartime missions outside European waters that were totally beyond Gomer's capabilities. She would combine all the advantages of sail with some of those of steam, and experience with her would show whether the concept

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[1] Enquête, 1849, 2:134; Cros, "Considérations," pp. 32-33.

of mixed propulsion was good or should be modified. It would be possible to do as the critics wanted and put an engine the size of Gomer's into Pomone (the British had done this in their Penelope), but this would require lengthening her by another seventeen meters and would simply make her into another pure steamer, with all the attendant problems of excessive size, cost and coal consumption.[1]

Assimilating Screw Technology

The Pomone experiment met with wide approval, but most particularly among those who valued the traditional sailing ship and wanted to see it continue, with only minor modifications, as the main element of naval strength. The steam enthusiasts, however, were bound to wonder what the screw could do if put into a pure steamer with horsepower and general proportions like those of existing paddle steamers. In April 1842, while his proposals for Pomone were still being deliberated, Boucher proposed another experiment which would provide the answer. The budget of 1842 included three steamers of 220 horsepower, and he proposed building one of these, Chaptal, with the screw propeller, an iron hull, and direct-acting engines (oscillating-cylinder engines by Cavé, among the first large direct-acting engines to be built in France). Another of the three ships, Titan, was to have identical engines and identical hull lines but was to be fitted with paddle wheels (and a wooden hull), thus providing the basis for an exact comparison between the screw and the paddle wheel.

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[1]Undated memorandum (written about 1843) by Boucher, A.M., Marine 7DD1-164/5.

The proposal was approved in July 1842, and as Lorient, which originally was to have built Chaptal, had no facilities for building iron hulls, Cavé was given a contract to build the hull of Chaptal as well as the machinery for both Chaptal and Titan.[1]

Cave's agreement with the navy called for him to build the engines for both ships on plans appropriate for paddle steamers--the screw for Chaptal and the linkages to connect it with the engine were to be covered by a supplementary contract once they were designed. He duly built both engines, and conducted experiments at the same time (between February and December 1843) in a small boat on the Oise to resolve the problems associated with the screw.[2] His experiments were inconclusive, but eventually enough information came to hand (particularly from the trials of Napoléon) to reveal the naivete of the original concept: there was, in fact, no satisfactory way to connect engines designed primarily for paddle wheels to a screw propeller and, in addition, such an installation would forfeit one of the prime advantages of the screw, the ability to put the machinery below the waterline. In late 1844 the navy found itself compelled to allocate to a new paddle steamer the engines Cavé had already built for Chaptal and to

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[1]Ports to Minister, 2 April 1842, A.M., Marine 1DD1-66; Ports to Minister, 2 July 1842, A.M., Marine 7DD1-11.

[2]Ports to Minister, 16 February 1846, A.M., Marine 7DD1-11; Jonveaux, "Cavé," pp. 68-69; Gaudry, "Cavé," pp. 495, 499.

order from him an entirely new engine for Chaptal, this time specially designed by Cavé for the screw and complete with the screw and its shafting.[1] Chaptal was launched on 9 December 1845, and her machinery was installed during 1846.

The French navy ordered a few more pure screw steamers during the early 1840's. Three have already been mentioned: the royal yacht Comte d'Eu, her small consort Passe Partout, and the first iron ship ordered from Toulon, the small Salamandre. A larger iron screw steamer, Caton, generally similar to Chaptal, was also ordered from Toulon and begun in 1844.[2] The report of Joinville's section of the Central Superior Commission on Steam Vessels in 1845 opened up a new period in the construction of pure screw steamers in France, although few ships were in fact built as a result of it. Joinville and his colleagues had immediately seen the advantages of the screw for the steam navy. They stipulated that both of their categories of combatant steam warships be built with screws. During 1845 a sample of each of these categories was begun: the steam frigate Isly of 650 horsepower, with her guns in a broadside battery as in a regular frigate, and the steam corvette Roland of 400 horsepower,

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[1] Ports to Minister, 25 October 1844, A.M., Marine 1DD1-87.

[2] Bonard to Director of Ports, 30 May 1843, and Ports to Minister, 28 August 1843, A.M., Marine 7DD1-130; S. Dupuy de Lôme, "Exposé de modifications apportées au plan du Caton," dated 1 November 1843, A.M., Marine 7DD1-130; Bonard to Director of Ports, 22 January 1844, A.M., Marine 7DD1-130; Ports to Minister, 29 January 1844, A.M., Marine 1DD1-87.

with her guns all on deck.[1] Finally, the need for steamers overseas led to orders for the construction of three diminutive mixed-propulsion ships, the schooner Pingouin of 30 horsepower for the Marquesas Islands in 1844 and two small corvettes, Biche and Sentinelle of 120 horsepower, for the West African station in 1846.[2]

The work on these ships produced a small number of men in France who were familiar with the screw propeller. Boucher was responsible for the proposals to build Pomone and Chaptal, and as Director of Ports he also supervised the work on all the screw steamers. Among private industrialists Mazeline, Cavé and Schneider benefited from their work respectively on Pomone, Chaptal and Comte d'Eu, while the former also had an important connection with England through Rosen. Another English connection was provided by John Barnes, builder of the screw machinery for Normand's Napoléon, who moved to France in the mid-1840's and became chief engineer for the firm of Benet at La Ciotat. All of these firms soon got additional orders from the navy for screw machinery: Cavé for Isly, Schneider for Caton, Benet for Salamandre, and Mazeline for no less than four ships

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[1] Roland had already been ordered as a paddle corvette, but plans with the screw, originally proposed in 1843, were substituted in June 1845. Bonard to Director of Ports, 21 May 1845, A.M., Marine 7DD1-92; Ports to Minister, 16 June 1845, A.M., Marine 1DD1-99.

[2] Ports to Minister, 31 July 1845 and 22 May 1846, A.M., Marine 1DD1-99 and 109; Ports to Minister, 18 January 1844, A.M., Marine 1DD1-87.

(Roland and the three mixed-propulsion ships).[1] Several French naval officers had also come into contact with the screw, notably those who had visited Britain as well as the commander of Napoléon. Finally, the navy's dockyards also began to gain some familiarity with the screw. At Indret a line officer, Ensign Siméon Bourgois, began running trials with the screw in a small launch in 1844. Indret soon afterwards built the small screw yacht Passe Partout. At Toulon Dupuy de Lôme designed the hulls for Caton and Salamandre and built both in his new iron shipbuilding facility. As of 1846 the French navy did not have many screw steamers, but those that it did have helped spread knowledge of the new technology quite widely, both inside and outside the navy.

To this point the application of the screw propeller in the French navy reflected the split between sail and steam that characterized the first half of the 1840's. Two different types of screw steamers had been developed, one with full steam power and the other with auxiliary steam. But towards the middle of the 1840's the basis for a compromise began to develop. In his studies on steam navigation, Joinville had come to the conclusion in 1844 that steamers, while of revolutionary importance for warfare in European waters, could not operate overseas

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[1] Schneider to Minister of Marine, 2 August 1844, A.M., Marine 7DD1-130; Ports to Minister, 4 and 18 July 1846, A.M., Marine 1DD1-109; Ports to Minister, 19 October 1846, A.M., Marine 1DD1-109; Ports to Minister, 17 May 1847, A.M., Marine 1DD1-122.

due to their need to replenish their coal supply frequently. Any general plan for the composition of the fleet, therefore, even if based on Joinville's theories of warfare, would have to include a sizeable number of conventional frigates and battleships for use outside European waters. The more radical steam enthusiasts disagreed: some felt a way could be found to use fast steamers overseas as well as in Europe, while others thought that any war would be decided in Europe and that operations overseas would be unimportant. However Joinville's ideas prevailed, and they became the basis of the program agreed on by the Central Superior Commission on Steam Vessels in 1845.

In 1844 Joinville had assumed that the ships to be used overseas would be sailing ships, but in 1845 his section of the Central Superior Commission recommended that they be given mixed sail and steam propulsion along the lines of *Pomone* but with smaller engines. They were to have coal for six days and a maximum speed under steam of four to five knots. Mixed propulsion had previously been supported primarily by advocates of sail, for use both in fleet actions in European waters and for cruising overseas, and it now became one of the few things that the supporters of sail and those of steam had in common.[1]

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[1] *Ann. Mar.*, no. 85 (1844), p. 595; Report of the Central Superior Commission on Steam Vessels, dated 24 May 1845, A.N., C-879; *Ann. Mar.*, no. 95 (1846), pp. 63-64, 233; Siméon Bourgois, "Etudes sur l'application de l'hélice à la marine militaire," *Nouvelles Annales de la Marine* 5 (1851):363, 368; Dislère, *Croiseurs*, pp. 15-16.

The Program of 1846

In 1846 the navy was impelled to act on the idea of mixed propulsion when a combination of pressures, mainly from Parliament, forced the navy to reexamine its overall policy and, as a part of this, to produce a compromise between sail and steam. Since the crisis of 1840 Parliament had become increasingly unhappy over the state of the navy. During the 1830's both Parliament and the successive governments had been firm believers in minimizing government expenditure, and the result had been that the government had itself held the navy budget below the amount required by the various fleet programs, while Parliament had sometimes imposed additional cuts. After about 1837 it became clear that the navy was not only failing to meet the requirements of its fleet programs, but was actually declining in the numbers of both battleships and frigates. Soon afterwards a series of crises began converting more and more deputies to a belief in the need for a strong navy. In the early 1840's the budget commission of the Chamber of Deputies began dropping hints to the government that the limitations imposed on the navy budget by the executive were no longer welcomed by the legislative and for the budget of 1844 the government took the hint and, for the first time in memory, submitted a request for funds that fully covered the navy's estimated needs for the year.[1] The following year it was able to add additional funds to begin building up a war reserve of

[1] Budget, 1844, p. 145.

raw materials, particularly timber.[1] But by this time the decline in the sail navy was so evident that Parliament was no longer satisfied with just holding the line against further deterioration. In addition the deputies were beginning to lose some of their affection for steam. The various innovations of the early 1840's and the debates over a number of important details, such as how to arm steamers, indicated that the nature of the true steam warship was far from being decided upon and that it would be imprudent to be in too great a hurry to abandon the sail navy, or even to weaken it.[2]

In his budget for 1846 the Minister of Marine, Vice Admiral Baron Ange-Réné-Armand de Mackau, proposed a plan for bringing the navy up to strength in seven years, using the funds of the normal budget.[3] If this move was intended to head off parliamentary criticism it did not work, for the budget commission of the Chamber of Deputies called on him to hasten efforts to regain the level required by the ordinances of 1837 and 1842, if these, particularly the latter, still reflected the navy's needs.[4] The main challenge, however, came on the floor of the

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[1] Budget, 1845, p. 151.

[2] Reports to the Chamber of Deputies, 6 June 1844, P.V. Députés, 1844, 8:298-99; 27 June 1844, P.V. Députés, 1844, 10: 184-85; 20 May 1845, P.V. Députés, 1845, 7:542-44.

[3] Budget, 1846, p. 766; Mackau in Chamber of Deputies, 21 June 1845, P.V. Députés, 1845, 12:186-87.

[4] Report to the Chamber of Deputies, Budget for 1846, 20 May 1845, P.V. Députés, 1845, 7:494.

Chamber of Deputies when a member submitted a motion demanding a full investigation by the government into the state of the navy and a special report to Parliament. He asserted that the government was violating the will of the chambers by cutting back on the size of the active forces (a move taken in 1843 in an effort to retreat from the abnormally high levels reached in the crisis of 1840), and he deplored the fact that, to send a few ships to Africa for anti-slavery patrols, the government had had to request extraordinary funds to build and operate the ships. Mackau made the best of the situation, and after making it clear that he would have resisted an investigation by Parliament (which would have raised the political issue of confidence in the government), stated that he did not have the slightest objection to making it himself and, in order to end the matter, would agree to provide the report.[1]

Mackau soon perceived the advantages of his position. He had, in effect, been given an "opportunity to fix the opinion of the Chambers and the nation on the real needs of the navy in the present circumstances and on the extent of the sacrifices needed to provide them regularly each year."[2] His report, presented to the king in December 1845, therefore included not only

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[1]Lacrosse and Mackau in Chamber of Deputies, 21 June 1845, <u>P.V. Députés</u>, 1845, 12:181-83, 187-88.

[2]Baron Ange-Réné-Armand de Mackau, Minister of Marine, "Rapport au Roi: Compte rendu de l'établissement maritime en France depuis 1820. Sa situation présente. Vues du gouvernement pour l'avenir," <u>Ann. Mar.</u>, no. 95 (1846), p. 5.

a review of the current state of the navy and a historical explanation of its decline but also a complete program for the navy of the future that updated and replaced all previous fleet plans, including those of 1845 (for steamers), 1837 and 1820.

To produce this program, Mackau had to tackle the problem of steam and sail, since the program would necessarily define the relative importance of the two in the new Fleet. Mackau sought to avoid dissention by including in the program as much as possible of the ideal fleet of each group--the sailing fleet of Portal for the advocates of sail and the steam fleet of the Central Superior Commission on Steam Vessels for the steam enthusiasts. The sailing fleet was to consist of the forty battleships and fifty frigates that had been standard since the days of Portal. Only twenty of the battleships were to be afloat, as in the 1837 program, but the number of frigates afloat was to be raised to forty from twenty-five. This left twenty battleships and ten frigates to be maintained essentially complete on the ways. Mackau also maintained the reserve of sixteen frigates in a partially completed state, but reduced the corresponding reserve of battleships from thirteen to four, stating that the progress of steam made it prudent not to build up too big a reserve of these expensive ships. For the steam navy, Mackau adopted without change the one hundred steamers recommended by the Central Superior Commission in 1845 and approved in the ordinance of November 1845.[1]

[1]Ibid., pp. 62-65.

The resulting program definitely left sail in the dominant position in the navy. The retention of a strong force of forty battleships meant that the contention of Joinville and his supporters that the days of fleet actions were over had been rejected. This indicated that the large steamers in the program would not be the primary combatant force in European waters as Joinville had intended, but would carry out missions in support of those of the sailing fleet. However the program still had a lot to offer the steam enthusiasts, for the steam navy was far from having reached the figure of one hundred steamers and the official adoption of that figure left it much room for additional growth.

In addition to the hundred steamers, the report of the Central Superior Commission of 1845 had also recommended the use of mixed propulsion for battleships and frigates; and Mackau duly included a few of these in his program. He planned to provide, as a first step, auxiliary machinery for four battleships, four frigates and four corvettes, the total power of all twelve ships being 1520 horsepower. These ships were to be suitable for use either in the battle fleet or overseas. Makau did not put much emphasis on these ships, but they ultimately proved to be a more important basis for compromise between sail and steam than the numerical balance in the program between the sail and steam fleets. For the first time a fleet plan included a type of ship intermediate between sail and steam, and on the need for which both sail and steam advocates were agreed. The

mixed-propulsion compromise appealed to the advocates of sail because it maintained the existing naval doctrines and the existing capital ship essentially unchanged. It appealed to the steam enthusiasts because their doctrines required such ships for use overseas and, even more important, because it opened to them a whole new field of activity--the sail navy itself. The mixed-propulsion ships were included in the program as part of the sail navy, not as a separate category, and if the idea worked, there seemed no reason why the use of mixed-propulsion should not eventually spread to the entire sailing fleet. However in the mixed-propulsion ships proposed by Mackau the role of steam was severely limited: the horsepower of the different classes, if assumed to be proportional to size, works out to only about 220 for the battleships, 100 for the frigates, and 60 for the corvettes.[1]

The reactions to Mackau's program were varied. Joinville wrote privately to Mackau to congratulate him on it, adding that "I do not doubt that this work will have as its effect to open the eyes of all to all we have to do to constitute our naval force."[2] For him, and undoubtedly for many other officers, the details of the program were less important than the principle of establishing and maintaining a respectable program free of

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[1]Mackau, "Etablissement maritime," p. 79.

[2]Joinville to Mackau, 5 January 1846, Mackau papers, A.N., 156-AP-I-50.

legislative interference. Some, however felt that Mackau had given up too much in settling for only forty battleships, and especially in giving up most of the reserve of battleships under construction.[1] However the big surprise for Mackau must have been the reaction of the commission appointed by the Chamber of Deputies to examine his proposals, for this group began making big revisions, mostly reductions, in the program.

The parliamentary advocates of steam were well represented on this commission--out of proportion, as it turned out, to their numbers in the Chamber. Its members included three admirals, all of whom opposed the strategic ideas behind existing French naval policy which called for maintaining a strong battle fleet, backed by a large number of completed ships on the building ways, whose main purpose was to fight major fleet actions. One of these men, Rear Admiral C.-C.-E. Hernoux, the president of the commission, was also one of the most vigorous supporters of steam in the Chamber.[2] In its report the commission stated that France should rely primarily on frequent and rapid offensive strikes against the enemy instead of on fleet actions, and stated it would have preferred to see more steamers in the program.[3] It

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[1] Mackau in Chamber of Deputies, 17 April 1846, <u>P.V. Députés</u>, 1846, 6:49-50.

[2] Lieutenant de vaisseau Gomart, "L'Escadre d'évolutions en Mediterrané de 1840 a 1848" (Thesis, Ecole de Guerre Navale, 1936-37), pp. 44-45. Hernoux had also been aide-de-camp to Joinville since 1837.

[3] Report to the Chamber of Deputies, 1 April 1846, <u>P.V. Députés</u>, 1846, 4:152.

did not increase the number of steamers, but made major reductions in the sailing fleet, cutting four battleships plus most of the reserve of incomplete battleships and frigates. It claimed that the reduction in the number of frigates was possible due to the fact that the navy used primarily smaller ships on the stations, but it cut these as well, from 180 to 136, explaining that steamers should be able to replace these. The only increase in the strength of the sail navy came when the commission recommended maintaining twenty-four battleships afloat instead of twenty. The effect of these changes was to reduce the total program from 93 million to 73 million francs.[1] Mackau acquiesced to one reduction after another, hoping each would be the last, but balked at the reduction in the number of battleships and vowed to carry the fight to the floor of the Chamber.[2] He did so, and after a long debate the Chamber unanimously agreed to restore all of the large ships (except the reserve of partially-completed ships) and all of the funds cut by the commission.[3]

The most interesting part of the commission's proceedings, however, was that relative to the twelve mixed-propulsion ships, for in discussing these it changed considerably the compromise between sail and steam proposed by Mackau. The

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[1] Ibid., pp. 174-75, 180-85.

[2] Mackau in Chamber of Deputies, 14 April 1846, P.V. Députés, 1846, 5:72-74.

[3] Ann. Mar., no. 95 (1846), pp. 594-98; Chamber of Deputies debate, 17 April 1846, P.V. Députés, 1846, 6:41-42, 45.

commission did not believe that France should engage in large fleet actions, and thus had little interest in the purpose of mixed propulsion as proposed by the navy (giving large ships reserve mobility in emergencies, particularly in case of dismasting during a fleet action or attack by steamers). It felt instead that steam had changed the nature of maritime warfare by greatly increasing the ability of naval forces to attack enemy coasts, or to defend their own. In concluding its report the commission indicated what it felt should be the three elements of French naval strategy, with their relative priority:

> We want a navy appropriate to the genius of the country, to its real needs, conceived in a systematic idea which lends itself first to the vigorous defense of the vast extent of our coasts; then to bold aggression, near or distant; finally, if necessary, to conducting an active and sustained war.[1]

These ideas echoed those offered by the steam enthusiasts during the period from 1840 to 1844, and were sanctioned by the fact that the British had already acted on them. One of the main British responses to the clamor of 1844 had been to begin the conversion in late 1845 of four old battleships and four old frigates (whose construction dated back as far as 1807) to steam "blockships" or "guardships." These did not conform to the initial concept of mixed-propulsion ships, as their engines were larger and displaced more of the supply of stores and provisions

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[1] Report to the Chamber of Deputies, 1 April 1846, P.V. Députés, 1846, 4:203; Hernoux in Chamber of Deputies, 16 April 1846, P.V. Députés, 1846, 6:23. See also Enquête, 1849, 2:72.

than could be tolerated in seagoing ships; but as they were only designed to operate near Britain, primarily in the approaches to her ports, this did not matter. (In France, Dupin pointed out that they still could easily get as far as Lisbon under steam and thus were a potential threat to French ports.)[1] In addition their small size relative to newer ships and their age meant that they would not be suitable for use in the line of battle, even in European waters. The French commission proposed imitating the British and putting engines into some of the oldest battleships afloat, which would be used as floating batteries for coast defense. The power of their engines would be increased from the 220 horsepower requested by the minister to 500 horsepower, at the expense of a large proportion of the ships' provisions and seakeeping qualities.

Mackau, who was quite pliant during the hearings, agreed to the idea, but he must have run into a barrage of criticism the moment he returned to the ministry. The sail advocates could not have wanted to see their battleships turned into floating forts, while the proposed ships would not satisfy the steam enthusiasts, who tended to want much higher speed, coupled with a strong ram, for harbor-defense ships. In addition, the proposal wrecked an important part of Mackau's proposed compromise between sail and steam by taking the mixed-propulsion ships

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[1]Report to the Chamber of Peers (by Charles Dupin), 15 June 1846, Ann. Mar., no. 96 (1846), pp. 65-68.

out of the battle fleet. Therefore, when Mackau returned to the hearings the next day, he proposed an improvement on the commission's idea. He pointed out that one could not use old weak hulls for coast defense ships--these required the strongest hulls available and thus should be new ships. Instead, he argued, if 500-horsepower engines were put into new battleships, these would not only be superior coast defense ships but could also be used as fleet units in European waters. (Their lack of stores would prevent their being sent overseas.) This compromise pleased everyone and was adopted, but the commission noted that these ships would have too deep a draft to be used as coast defense ships in some shallow estuaries (including the Seine), and added to the program two special shallow-draft floating batteries with engines of 400 horsepower.[1] As a result of this action the horsepower of each mixed-propulsion type was roughly doubled compared with the navy's original request--the battleships rose to 500 horsepower, the frigates to 250 and the corvettes to 120.[2]

Parliament thus brought about an important alteration in the compromise between sail and steam, changing it to the advantage of steam. The navy had asked for ships with weak engines intended for use in the battle fleet or overseas,

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[1] Hernoux and Mackau in Chamber of Deputies, 16 and 17 April 1846, P.V. Députés, 1846, 6:30, 44-45; Report to the Chamber of Deputies, 1 April 1846, P.V. Députés, 1846, 4:142, 175-80, 185.

[2] Ibid., pp. 178-80, 185.

Parliament had asked for ships with strong engines intended for use for coast defense, and they had compromised on ships with strong engines capable of operating with the battle fleet in European waters or along the coast. The result was a real compromise--the new ships were neither true sailing ships nor true steamers, but contained enough of the advantages of each to be able to carry out a wide range of missions and at the same time to indicate which advantages, those associated with sail or those associated with steam, were in the long run of greater importance.

The whole program, of which these ships were only a small part, became law on 3 July 1846, and the fleet organization implicit in it was incorporated into a royal ordinance in November 1846, which also restored to the navy the authority to maintain a reserve of partly-completed ships.[1] The new "legal" fleet consisted essentially of Portal's sailing fleet of forty battleships and fifty frigates, plus the one hundred steamers that had been agreed upon in 1845.[2] The program was designed to give France the forces needed to maintain two fleets of twelve battleships each, one in the Atlantic and one in the Mediterranean, which, it was hoped would be able not only to defend French interests in both areas but perhaps even to

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[1] C.A., 5 November 1846, A.N., Marine BB8-875.

[2] <u>Ann. Mar.</u>, no. 94 (1846), pp. 913-15.

exploit some temporary British weakness and inflict a major defeat on her.[1]

During its debate on the ordinance of November 1846 the Council of Admiralty made one small change in language which symbolized, better than anything else, what the navy had been through since Portal's fleet program had been incorporated into a royal ordinance in 1824. The 1824 ordinance and the original draft of the 1846 ordinance read "The naval forces of the kingdom . . . shall consist of . . ." The Council changed this to read, "The strength of the naval forces of the kingdom . . . shall be increased in the interval of time fixed by the law of 3 July 1846 to . . ." Boucher protested that the original draft, which he had written, was more faithful to the 1824 ordinance, but Mackau retorted, "that was a mistake, for you see that things change these days." Change had finally become a factor to be taken into account by the Council, and it no longer dared determine the definitive form of the fleet, as it had in 1824, but only its form for the present and for the immediate future, in this case, seven years. It also made another concession to change, and added language enabling the ministry to modify the categories of ships and their standard armaments if progress indicated a need to do so.[2]

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[1]Mackau in Chamber of Deputies, 17 April 1846, P.V. Députés, 1846, 6:46.

[2]C.A., 5 November 1846, A.N., Marine BB8-875.

The program of 1846 changed the direction of the development of steam navigation in the French navy. Previously the emphasis had been on developing an independent steam navy, while subsequently the emphasis was on giving the sail navy some of the benefits of steam. Over the short run this was a setback for steam, which was no longer to be allowed to develop its full technological potential but was instead to be limited by the space and weight available in sailing ships. But over the long run it was a triumph, for it ended the direct confrontation between sail and steam which until then had kept steam out of the battle line and gave steam the chance to overwhelm its rival by the easiest and most effective manner--by absorbing it.

Joinville Tests Military Steamers at Sea

Ultimately the hope of the planners of 1846 was that auxiliary steam would provide a way of combining the advantages of sail and steam in a single hull, but in the interim the same combination could be approximated by a technique which had been discussed theoretically for several years but never tried by the French: using steamers to tow sailing battleships. Once again Joinville was the pioneer. His career brought him to the command of the Squadron of Evolutions (the new name for the Mediterranean fleet) at the very time that the program of 1846 was being debated, and he saw his new position as an opportunity to use existing steamers, imperfect as they were, to put the new ideas into practice for the first time.[1]

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[1] Joinville, Vieux Souvenirs, p. 279.

Previously the main function of the Squadron of Evolutions had been to train its personnel in precision maneuvering under sail, particularly in the art of navigating together, in all weather, in the very close order that was required in order to keep the line intact in battle. They drilled in simultaneously getting underway, reefing and changing sails, firing the guns, and in every other aspect of seamanship and military manoeuvre.[1] Until 1846 steam had not figured in these exercises, since the fleet had consisted entirely of sailing ships, except for one steamer, or at the most two, whose mission was to maintain communications with the fleet's base at Toulon. During the 1840's exceptions had been made and steamers included in the fleet for special operations such as the Moroccan expedition of 1844, usually to assist battleships in coastal navigation and shore bombardments, but the French had not yet tried integrating them into its permanent battle fleet.[2]

After receiving word of his assignment to command the Squadron of Evolutions, Joinville called at the ministry and requested that its composition be changed so that he could study the problems encountered by several steamers navigating together as a squadron or in company with a sailing fleet for an extended time.[3] He had his way, and for 1846 the strength of the Squadron

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[1] Gomart, "Escadre d'évolutions," pp. 41-42.

[2] Ibid., p. 49.

[3] Joinville to Minister of Marine, 8 May 1846, A.N., Marine BB4-614.

of Evolutions was set at seven battleships and four paddle steamers. Three of the steamers were to conduct the experiments, while the fourth was to maintain the traditional communications with Toulon.[1]

Joinville took command of the fleet on 7 May 1846 and took his ships to sea later in the month. He was able to conduct several exercises, and at one point took the steamers out by themselves for twenty-four hours of day and night maneuvers. He found these highly interesting, as they revealed some of the new opportunities and the new problems raised by maneuvering naval forces mechanically instead of by the wind.[2] His experiments were then cut short by the inevitable demands on his fleet for unanticipated missions--his steamers were first assigned to transport troops between France and Algeria, and his sailing fleet was then called to Tunis and Tripoli to make the annual demonstration in favor of the Bey of Tunis against his nominal suzerain, the Sultan of Turkey. Joinville later regained control of some of his steamers, and, while carrying out various diplomatic missions, he found that he could make good use of them by having them tow the battleships whenever the fleet was in transit from one place to another and the winds were unfavorable. In

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[1] Minister of Marine to Joinville, 28 April 1846, A.N., Marine BB4-614.

[2] Joinville to Minister of Marine, 30 May 1846, A.N., Marine BB4-644; Gomart, "Escadre d'évolutions," p. 51; Joinville, Vieux Souvenirs, p. 279.

experiments with this in August he found that Descartes (540 horsepower) could tow two battleships together at 5-1/2 knots against a light breeze, while Asmodée (450 horsepower) could tow two at 4.4 knots. When the breeze freshened three of the battleships were cast off and made 8.7 knots under sail, but Asmodée kept the fourth under tow and was able to tow her at 4 knots directly into the wind.[1]

The crisis over the marriage of one of Joinville's brothers to a Spanish princess in late 1846 cut short the activity of the Squadron of Evolutions, which was kept near Toulon instead of carrying out a planned cruise into the Atlantic. It also showed that the French experiment with steam had come none too soon, for a similar British mixed sail and steam squadron, first formed on an experimental basis earlier in 1846, appeared at Lisbon with eight battleships and three steamers shortly after the crisis broke.[2]

Joinville was generally satisfied with his experiments--while they showed that existing steamers had serious defects (Asmodée's hull was grossly overweight, while Descartes's machinery broke down every time she tried to go slower than four knots or to back down), they also showed that even these

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[1] Joinville to Minister of Marine, 17 August 1846, A.N., Marine BB4-644.

[2] Bartlett, Britain and Sea Power, p. 226; Gomart, "Escadre d'évolutions," p. 52.

imperfect ships could be of the greatest use to a fleet.[1] The main conclusion reached by Joinville, primarily due to his unplanned experiences during the fleet's transits, was that henceforth no battle fleet would be complete unless each battleship had its own steamer to tow it if needed. Back in Paris at the end of October 1846, Joinville recommended modifying the composition of the squadron for the 1847 season from seven battleships and four steamers to six of each: while there would be one battleship less, he argued that the fleet would be much more compact and, in his opinion, stronger. (The British arrived at the same conclusion after their experiments in 1846, and decided that their experimental squadron in 1847 was to have five battleships and five steamers.)[2] When Joinville saw Mackau the minister objected on administrative grounds to the extensive reshuffling of battleships requested by Joinville (who wanted two three-deckers in place of three two-deckers). However Joinville then ran into Guizot in the hallway outside Mackau's office, and Guizot agreed that the government could accept the difficulties (financial and otherwise) involved in the change.[3] The Squadron of Evolutions for 1847 thus consisted

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[1] Joinville to Minister of Marine, 3 August 1846, A.N., Marine BB4-644; Touchard ("Officier d'ordonnance" to Joinville) to Minister of Marine, 11 September 1846, A.M. Marine 7DD1-56.

[2] Bartlett, Britain and Sea Power, p. 227.

[3] Joinville to Mackau, 31 October 1846, Mackau papers, A.N., 156-AP-I-50.

of six battleships and six steamers, the latter being added in order to "continue on a larger scale the experiments which were begun last year on the use of these ships, as tugs for battleships or as an independent military force."[1] A seventh steamer was also provided to maintain communications between the fleet and Toulon.

The squadron's operations during 1847 were even more broken up by special missions than in 1846. It does not appear that Joinville was ever able to assemble his steamers in one place at one time, a situation he deplored bitterly as it deprived the fleet of the speed steam could give it, both in its normal operations and in its response to crises or to special orders, as well as depriving him of the chance to develop a set of tactics for steamers, either as a separate group or in company with a sailing fleet.[2] As in the previous year, Joinville was able to make some demonstrations of the capabilities of a mixed sail and steam fleet despite his lack of ships. The best occasion arose when he was again ordered to send some ships to Tunis. He sent a compact group of two battleships and two steamers, which made the trip from Malta in fifty-three hours, during which the battleships were under tow for forty-four hours and unable even to set a sail for thirty-one hours.

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[1]Director of Personnel (Movements) to Minister of Marine, 23 February 1847, A.N., Marine BB1-92.

[2]Joinville to Minister of Marine, 14 May 1847, A.N., Marine BB4-644.

The commander of the force noted that such sudden appearances of battleships would undoubtedly give the Bey's enemies much to think about.[1] The ships were soon withdrawn, but a steamer remained at Tunis and was clearly capable of calling a similar squadron back again if needed. At the end of the year, returning from La Spezzia to Toulon, Joinville rejoiced at the sight, unprecedented until then, of an entire battle fleet moving in a calm with a speed of seven knots, the battleships being under tow of the steamers.[2]

One other trial was also conducted during this period, on the initiative of an officer on a distant station. The commander of one of the transatlantic packets, which was now in naval service on the west coast of Africa, put a floating target into the water and then pretended to fight it in the way prescribed for paddle steamers--end-on. He found that, even against a target with no capability for evasive movement, he was only able to hold the end-on position for a very short time, as the wind forced him to back down periodically to keep away from the target, and paddle steamers did not steer well while backing. During that time he was only able to get off an insignificant number of rounds from his bow guns, which he felt, would have done little damage to a strongly-armed opponent.[3]

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[1] Commanding Officer, Iéna, to Joinville, 1 August 1847, A.N., Marine BB4-644.

[2] Gomart, "Escadre d'évolutions," p. 55.

[3] Ann. Mar., no. 100 (1847), pp. 699-700.

Boucher seized the opportunity to abolish the protective coal bunkers which Joinville had caused to be placed before and abaft the machinery. These took up a lot of space, caused stability problems and, he reported, were designed for a mode of combat that now appeared to be impractical.[1]

Building Mixed Propulsion Battleships

The value of paddle steamers as combatant ships was therefore more doubtful than ever, while their use as tugs for battleships, although most interesting as an experiment, was also clearly only a very imperfect expedient. The navy therefore intensified its efforts to develop the most promising alternative: the mixed-propulsion ships of the 1846 program. On 24 November 1846 the minister decided to begin conversion of two battleships and two frigates and construction of one floating battery at once, and on 9 December the ministry ordered the ports to prepare plans for the hulls and Indret to prepare plans for the engines.[2]

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[1]Ports to Minister, 21 September 1847, A.M., Marine 1DD1-122.

[2]Ports to Minister, 24 November 1846, A.M., Marine 1DD1-109; Maritime Prefect of Rochefort to Minister of Marine, 21 December 1846, A.M., Marine 7DD1-71; Maritime Prefect of Lorient to Minister of Marine, 16 December 1846, A.M. Marine 7DD1-52. The floating batteries (named Protecteur and Tonnant) did not get beyond the design stage. Complicated plans involving use of iron hulls, iron armor and rams were submitted, and before all of the technical problems could be sorted out the revolution of 1848 made construction of the ships financially impossible. Ports to Minister, 24 November 1846, A.M., Marine 1DD1-109; C.T., 23 June 1847, A.M., Marine BB8-1120; C.T., 29 March 1848, A.M., Marine BB8-1122; C.T., 28 July and 17 November 1847, A.M. Marine BB8-1121.

The problems that the French navy faced in executing this program were enormous. Major technological advances were involved, both in the design of the screw propeller and in its installation in the ships. The French relied on information from Britain wherever possible, but at times it was not available, for even the British had not resolved some of the problems. The result was that the plans for the ships relied to a great extent on French experiments and on French ingenuity. The solutions did not come easily--the design process took over three years, from late 1846 to early 1850. But the final success showed the degree to which France had achieved mastery both of steam technology and of mechanical engineering in general.

The French navy made an early effort to develop some theoretical knowledge concerning the screw propeller. During 1844 and 1845 a French naval officer, Ensign Siméon Bourgois, had carried out trials with various screws in a launch at Indret, and his report (published at his own expense) made such a favorable impression that his proposal to set up a program of trials on a larger scale was immediately accepted.[1] A special ship (_Pélican_, 120 horsepower) was ordered in September 1845 to be built for the trials, and most of the numerous proposals for different model screws that the navy received from inventors

[1] C.T., 17 May 1845, A.M., Marine BB8-1118; Ports to Minister, 3 July 1845, A.M., Marine 1DD1-95; Ports to Minister, 8 September and 22 December 1845, A.M., Marine 1DD1-99.

during this period were passed along to Bourgois for inclusion in his trial program.[1] The project was given high priority, and extensive methodical trials were carried out between 1847 and 1849.

Of more immediate value, however, for the mixed-propulsion program were the trials begun in 1846 with the French navy's first two large screw steamers, Pomone and Chaptal. The design and construction of these pioneering ships have already been discussed: Pomone was a mixed-propulsion frigate of 220 horsepower begun in 1842, while Chaptal was a pure steamer of the same power begun in 1844. In ordering these ships the navy had managed to get the contractors for the machinery to guarantee the proper operation of the screws and a specified minimum speed for the ships, thus transferring all the risks of developing the new technology in these specific cases from the navy to the contractors. The precaution turned out to have been wise from the navy's point of view, for, just as in England, a number of mistakes were made and each contractor had to replace his screw at least once and make numerous other modifications in his machinery.

Of the many problems examined during these trials, one may serve as an example: the question of the relative position of the screw and the rudder. Many of the early screw steamers,

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[1] C.T., 15 December 1845 and 10 January 1846, A.M., Marine BB8-1119. See also Bourgois, "Application de l'hélice," pp. 357-430.

including _Chaptal_, followed what has become the normal system and had the rudder abaft the screw, where its effect was magnified by the water from the screw rushing past it. However _Pomone_ was given another system which had been used successfully by John Ericsson and recommended by his agent, Count Rosen, in which two rudders were placed, one on each side of the propeller shaft, _in front_ of the screw. When _Pomone_ went out for her first trials in August 1846, her crew found that she was almost impossible to steer while under steam.[1] Suspicions deepened when, three months later, _Pomone_ made the trip from Lorient to Cherbourg under sail (her screw having been removed for modifications) and steered perfectly. The ministry fired off instructions to two French naval officers then in Britain to report on the relative position of the screw and rudder in British screw steamers. In the meantime _Pomone_'s screw had been reinstalled, and she and _Chaptal_ ran joint trials (attended, predictably, by Joinville) on 29 and 30 December. Once again _Pomone_ was almost unmanagable under steam, while _Chaptal_ steered without the slightest difficulty.[2] The evidence seemed overwhelming that the arrangement in _Chaptal_ was the correct one, especially when the French officers in England reported that nearly all British

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[1] Bonard to Minister of Marine, 29 August 1846, A.M., Marine 7DD1-164/5.

[2] Maritime Prefect of Cherbourg to Minister of Marine, 30 December 1846, A.M., Marine 7DD1-164/5; Maritime Prefect of Cherbourg to Minister of Marine, 31 December 1846, A.M., Marine 7DD1-11.

screw steamers also used her system.[1] The stern of Pomone was therefore torn apart and rebuilt with the rudder abaft the screw. Both ships had many other problems during 1847 (Chaptal at one point broke her propeller shaft), but in January 1848 both ships ran completely successful trials and were reported ready for service in February.[2] The navy was particularly pleased with Pomone, both because of the significance of her trials for the mixed-propulsion concept and because of the British effort to imitate her in their Amphion. French engineers reported proudly that the French ship was faster than the British and carried more guns and stores, and that the British had been so discouraged by Amphion's trials that they had deferred the conversion of four old frigates into harbor-defense screw blockships.[3]

The next problem that the navy faced in the construction of its new mixed-propulsion ships was the design of their machinery. It found that there were two main ways being used in England to design screw machinery: one could either connect an engine with high RPM directly to the propeller shaft, or one could connect an engine with low RPM to the shaft through a set

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[1]Ports to Minister, 27 January and 8 February 1847, A.M., Marine 1DD1-122; C.T., 3 February 1847, A.M., Marine BB8-1120.

[2]Maritime Prefect of Cherbourg to Minister of Marine, 12 February 1848, A.M., Marine 7DD1-164/5.

[3]Cros, "Considérations," pp. 32-33. Three of the frigate blockship conversions were in fact cancelled, the ships later being converted to steam during the Crimean War.

of gears which would increase the number of revolutions transmitted to the screw.[1] Both systems had their theoretical advantages and disadvantages, and for a while the navy was unable to decide between them. In March 1847 Indret proposed an engine which, by using high RPM and several recent innovations in engine design, would develop 650 horsepower and give a battleship a speed of seven knots.[2] The Council of Works was frightened by the audacity of this design, and ordered Indret to submit new plans with conventional Watt-type low-speed engines connected to the propeller shaft through gearing, and to accept whatever speed such an installation would produce for the ship.[3] However the next step proved to be not back to the drawing board but back to England. By this time the British had over thirty screw steamers under construction, and during the second half of 1847 the French sent to Britain the two constructors most closely connected with the mixed-propulsion project to find out what design principles they were using.[4] They learned,

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[1] Enquête, 1849, 2:144. The function of these gears was the exact opposite of that of modern reduction gears, which connect the propeller to a turbine rotating at a much higher speed.

[2] Director of Indret to Minister of Marine, 22 March 1847, A.M., Marine 7DD1-71.

[3] C.T., 31 March, 21 April and 23 June 1847, A.M., Marine BB8-1120; Moll (Indret) to Minister of Marine, 20 March 1848, A.M., Marine 7DD1-143; C.T., 1 December 1847, A.M. Marine BB8-1121.

[4] Ports to Minister, 12 July 1847, A.M., Marine 1DD1-122.

among other things, that for low-speed ships, with speeds similar to the French battleships, the British were connecting the engines directly to the propeller shaft instead of using gearing. As a result the Council of Works reversed itself and allowed the use of direct-drive, although it still forbade the use of some of the other novelties in Indret's original plan.[1] Once the specifications for the engines were agreed upon, Indret was able to design them without much difficulty, and in May 1848 its plan for the machinery for both the battleships and the frigates were approved by the Council of Works.[2]

The final, and the most difficult, problem in producing the mixed-propulsion ships was to incorporate the screw propeller and the engines into the sailing-ship hulls, which were already sitting essentially complete on the building ways. One reason for the magnitude of the problem was that the ships had resulted, not from design studies in the ministry, but from a compromise between the ministry and Parliament backed by only the most cursory calculations. Parliament had demanded high horsepower (fixed by the ministry in November 1846 at 540 for the battleships and 350 for the frigates), while the navy demanded ships that could stand in the line of battle and maneuver with sailing ships, which, it felt, precluded lengthening the hulls or making

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[1] C.T., 24 November 1847 and 1 December 1847, A.M., Marine BB8-1121.

[2] Memorandum by Moll (Indret), 20 March 1848, A.M., Marine 7DD1-143; C.T., 8 May 1848, A.M., Marine BB8-1122.

any other changes in the ships besides the inevitable reductions in provisions and stores.[1] Realizing the difficulty of the job facing its constructors, the ministry gave them the greatest possible leeway in drawing up their initial plans.[2] These, submitted between March and June 1847, did not even meet the few conditions set by the ministry: the engineer at Rochefort, where one battleship was to be converted, provided only 480 horsepower and wanted to widen his ship, while the engineer at Toulon, Dupuy de Lôme, who was to convert the other battleship, abandoned the idea of a conversion altogether and proposed building a new ship to a radically different design.[3] These proposals were rejected, but they did provide enough information for the Council of Works to set more exact design specifications for the ships in June 1847. In the battleships, four months' supply of provisions and spares and three months' supply of water were to be sacrificed along with 250 tons of ballast in order to provide space and weight (900 tons) for the machinery and the coal. (This left the ships with provisions for two months, water for one, and 70 tons of ballast.) The original hull dimensions, as well as the size of the crew and the armament,

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[1] Enquête, 1849, 2:140.

[2] Ports to Minister, 24 November 1846, A.M., Marine 1DD1-109.

[3] C.T., 9 June 1847, A.M., Marine BB8-1120. The ship proposed by Dupuy de Lôme had a brilliant future under the name Napoléon and is discussed in the next chapter.

were under no circumstances to be tampered with, although the rig was to be reduced slightly. The frigates were to be designed along similar lines, taking into account recent experiences with Pomone.[1]

By the end of 1847 neither the designs for the engines nor those for the hulls had yet been agreed upon, and the conversion program was therefore reduced from two battleships and two frigates to one of each. (The ships involved were also changed.)[2] However the total soon rose back to three ships, when a proposal, first made in November 1846, to put an engine into an old ship scheduled for overhaul at Toulon was approved in April 1848.[3] (A 450-horsepower engine for this ship was ordered from Benet of La Ciotat in June.)[4] Progress on the hulls continued to be plagued by program changes, however. In May 1849 it was found that large screw ships could not be built

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[1]C.T., 30 June 1847, A.M., Marine BB8-1120.

[2]Maritime Prefect of Lorient to Minister of Marine, 13 June 1849, A.M., Marine 7DD1-239; Ports to Minister, 2 May 1849, 7DD1-114. Ulm replaced Turenne at Rochefort and Entreprenante replaced Vengeance at Lorient. The conversion of Fleurus at Toulon and Persévérante at Brest were dropped.

[3]Maritime Prefect at Toulon to Minister of Marine, 11 November 1846, A.M., Marine 7DD1-34; Maritime Prefect at Toulon to Minister of Marine, 19 August 1847, A.M., Marine 7DD1-187/8; C.T., 29 March 1848, A.M., Marine BB8-1122; Ports to Minister, 24 April 1848, A.M., Marine 7DD1-34.

[4]In soliciting the order for this engine, Benet reported that "since the revolution of February they had not drawn back from any sacrifice to keep their workers at work," but that their normal source of orders, other private firms, had dried up. Ports to Minister, 16 June 1848, A.M., Marine 7DD1-34.

at Rochefort due to the method then used to launch ships there,[1] while it was also found that the hull of the old ship at Toulon was too rotten to be worth converting.[2] A ship at Cherbourg, _Austerlitz_, was therefore designated for conversion in lieu of the one at Rochefort, while a new ship under construction at Toulon, _Charlemagne_, was designated to receive the engine ordered from Benet.[3]

Design work on the hulls could finally start in earnest, but it soon produced additional problems. In October 1849 the Council of Works considered a complaint from the constructor working on _Austerlitz_ that there were four major errors in the Council's specifications: the reductions in the supplies of

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[1] The technique of launching ships at Rochefort involved allowing the ship to slide down the ways and across the river, where she would be stopped when her stern jammed into the mud on the opposite bank. The current would then swing her around and free her from the mud so she could be towed to a pier. The effect of this on a screw installation, located aft below the waterline, can well be imagined. Ports to Minister, 2 May 1849, A.M., Marine 7DD1-114.

[2] Maritime Prefect of Toulon to Minister of Marine, 16 April 1849, A.M., Marine 7DD1-34.

[3] Ports to Minister, 2 May 1849, A.M., Marine 7DD1-114; C.T., 19 May 1849, A.M., Marine BB8-1124 (on _Austerlitz_); Ports to Minister, 2 May 1849, A.M., Marine 7DD1-34; C.T., 5 May 1849, A.M., Marine BB8-1124 (on the old ship at Toulon, _Nestor_). _Castiglione_ was originally designated on 12 May 1849 to be converted in place of _Nestor_, but _Charlemagne_ was designated in her place in early June. _Charlemagne_ was known as _Hector_ until 2 April 1850. Considerable design work had been done on the hulls of _Nestor_ and the ship at Rochefort (_Ulm_), although no final plans had been approved: C.T., 5 July 1848, 25 November 1848 and 18 April 1849 (on _Nestor_), 29 March 1848 and 28 February 1849 (on _Ulm_), A.M., Marine BB8-1122 to 1124.

provisions and water did not produce the saving of either space or weight anticipated by the Council, while the seventy tons of ballast left by the Council were insufficient to guarantee the ship's stability and the lines of the stern were too full for use with a screw propeller. The constructor's recommendation was to lengthen the ship 3.66 meters amidships. Toulon reported similar problems with Charlemagne and also wanted to lengthen that ship.[1] The Council had to admit that there were problems in its specification, but rejected out of hand the proposed solution:

> Austerlitz, fitted with a purely auxiliary steam engine, must above all and in the most absolute way remain a line of battle ship of the second rank. In consequence, any modifications of a nature to compromise in any way her nautical qualities as a sailing ship must peremptorily be repulsed.[2]

Instead, the Council had to modify its specifications, and it reluctantly allowed a reduction in the coal supply which, it hoped, would not drop below six days' supply.[3]

Within a month the constructor working on Austerlitz was back again with a new problem. He had exchanged plans with the engineer who was building the 650-horsepower engines for the ship at Indret, and they had found that there was no way to get the engines into the hull. The only way out that they could

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[1] C.T., 20 and 24 October 1849, A.M., Marine BB8-1125.

[2] C.T., 20 October 1849, A.M., Marine BB8-1125.

[3] Ibid.

find was to eliminate two of the four cylinders, thus reducing the power of the machinery to 325 horsepower. Once again the Council of Works, meeting in December 1849, had to acknowledge the problem, but rejected the proposed horsepower, stating that they wanted either a ship with the strongest possible engines that could be put into an existing hull, which appeared to be about 500 horsepower, or a purely auxiliary engine of no more than 150 horsepower. Since only about a tenth of the 650-horsepower engine had been built, Indret reported that it could be converted into a two-cylinder engine of 500 horsepower which would fit into Austerlitz, and the Council approved this compromise.[1]

The problem with Austerlitz prompted Indret to look at the situation with regard to the frigate, and they found that here too the engine (now rated at 400 horsepower) would not fit into the hull. In this case the engine was further advanced (a third built) than the one for Austerlitz and could not be altered in the same way so as to get it into a frigate hull. Its power could, however, be increased to 450 horsepower, and it was decided to do this and put it into a battleship.[2] On

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[1] C.T., 8 December 1849, A.M., Marine BB8-1125; Ports to Minister, 24 December 1849, A.M., Marine 7DD1-114; Bourgois, "Application de l'hélice," p. 371.

[2] Ibid. Design work on the hull of the frigate had not advanced far: plans had been rejected by the Council of Works on 11 July 1849 and no new ones had yet been submitted. C.T., 11 July 1849, A.M., Marine BB8-1125.

22 February 1850 Jean Bart, building at Lorient, was designated to receive this engine, and the initial French mixed-propulsion program finally attained its definitive form.[1] It provided three battleships: Austerlitz, Charlemagne and Jean Bart, which, together with Pomone, would provide a compact mixed-propulsion battle squadron.

The deliberations over Austerlitz resolved the last remaining technical problems, and thereafter work on the ships progressed rapidly. In January 1850 the plans for the conversion of Charlemagne were approved, and those for Jean Bart, which almost exactly duplicated Charlemagne were approved in April.[2] Everything seemed to be in order when a communication from Cherbourg later in 1850 made the ministry realize that none of the decisions arrived at by the Council of Works in 1849 concerning the hull of Austerlitz had reached the builder of that ship.[3] Almost a year was thus lost in her construction (her plans were approved by the Council of Works on 22 January 1851), and Charlemagne thus reaped the honors of being the first to be launched (on 16 January 1851) and to reward her creators with a successful series of trials.

The British experience with mixed-propulsion battleships closely paralleled the French, with one exception. The ability

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[1] Ports to Minister, 22 February 1850, A.M., Marine 7DD1-81.

[2] C.T., 26 January 1850 and 6 April 1850, A.M., Marine BB8-1126.

[3] C.T., 25 September 1850, A.M., Marine BB8-1127.

to send fleets overseas was considerably more important for the British than for the French: for the French it was simply a matter of retaining the capability to conduct a particular form of warfare, while for the British it was a question of defending an existing empire as well as a large merchant marine. The British were therefore reluctant to accept the reduction in stores and provisions involved in the conversion of existing hulls to steam, and preferred to build new hulls for their mixed-propulsion ships.[1] These, however, were simply imitations of sailing ship hulls lengthened sufficiently (about forty feet) to permit retaining some of the provisions and stores that would have been lost in a conversion. Otherwise they were very similar to the French mixed-propulsion conversions, as they had the same artillery and the same steam power (generally 600 horsepower). The first of these, James Watt, was ordered in April 1847, but the British apparently encountered some of the same design problems as did the French and did not complete the plans for the class until July 1849. The first British mixed-propulsion battleship actually built to these plans was Agamemnon, which was launched in May 1952, over a year after the French Charlemagne.[2]

However the British did not reject the idea of conversions altogether, since, while these were limited in their capabilities,

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[1] Brodie, Sea Power in the Machine Age, pp. 73-74.

[2] Surveyor's Submission Letter Books numbers 12-14 (1847-1852), ADM. 88:12-14.

they had the advantage of being economical in that they made use of existing hulls. In January 1848 the Admiralty ordered the installation of some engines that already existed in three battleships and one frigate. However by July all four of these conversions had been cancelled, due partly to design problems and partly to the fact that the ships could not be spared from active service long enough to be converted. In November 1848 they tried again, and ordered an existing engine of 350 horsepower to be put into the smallest battleship then under construction, Sans Pareil. This ship was launched in March 1851, two months after the French Charlemagne, but gave such trouble during trials that ten of her guns had to be removed and her engines had to be replaced by a new set of 400 horsepower before she could be accepted for service.[1]

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The British experience helps to indicate the magnitude of the French achievement in constructing their mixed-propulsion ships. It shows that the French had drawn even with Britain in steam technology, both chronologically and in engineering skill. The first mixed-propulsion frigates (Pomone in France and Amphion in Britain) were built simultaneously, and the first mixed-propulsion battleships (excluding the British blockships, which were not designed to stand in the line of battle) were also built at the same time. (The French ship, Charlemagne, was

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[1] Ibid.; "Theseus, late R.N.," "Our Screw Steam Navy," Colburn's United Service Journal and Naval and Military Magazine, no. 359 (1859), pp. 237-46.

actually completed before the British Sans Pareil.) The French still relied on information from Britain whenever they could in their work with screw technology, and in fact in late 1846 they increased their efforts in this direction by deciding to maintain at least one engineer in permanent residence in Britain at all times, instead of depending on periodic visits.[1] However they found that the British did not have many of the answers, for both countries were in fact working on the same problems at the same time. The French therefore had to go beyond the methods they had used in introducing paddle steamers into France (which had consisted mainly of reproducing British ideas and mechanisms in France), and solve most of the technical problems themselves. In doing so they made some egregious blunders, but then so did the English. The final product of their efforts, Charlemagne and her sisters, were every bit as successful as the British ships, indicating that by 1852 the French had developed the ability to pursue the development of steam technology independently of Britain.

The main feature of the period around 1846, however, was the development of the principle of mixed-propulsion, which was the basis of the design of these ships and which was also the basis for a compromise between sail and steam. The screw propeller made it possible to combine steam propulsion and traditional

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[1]Ports to Minister, 13 December 1846, A.M., Marine 1DD1-117. The resident engineer was recalled as an economy measure after the revolution of 1848: Enquête, 1849, 2:554.

tactical and strategic ideas by installing small engines in existing sailing ships. This technological compromise was imposed on the navy as a policy compromise in 1846 when the minister of marine, himself under pressure from Parliament, included some of these mixed-propulsion ships in a new fleet program. Parliament increased the horsepower of these ships and to some extent changed their characteristics, but they still represented a compromise that required concessions from the advocates of both sail and steam, and ended the confrontation between them that had developed during the early 1840's.

CHAPTER VII

DUPUY DE LOME'S NAPOLEON AND THE FINAL TRIUMPH OF STEAM, 1847-1852

The final adoption of steam power for capital ships in Britain and France followed somewhat different patterns. In Britain the steam capital ship evolved as the logical consequence of the mixed-propulsion compromise, but in France that compromise was obscured by a separate innovation, the fast battleship Napoléon, designed by Dupuy de Lôme; and the steam capital ship was finally adopted only after one last round in the battle between sail and steam. By designing this ship, Dupuy de Lôme also demonstrated that France had matched or even surpassed Britain in the ability to make major innovations involving the use of steam technology.

In the short run the mixed-propulsion compromise was a setback for steam. Steam was no longer to develop unhindered by other considerations, but was now enclosed in a sailing ship hull, where its role was limited by the need to retain essentially unchanged the ship's original armament, crew and speed under sail. But its mere introduction, in any form, in a battleship proved to be the decisive step, for, once given its chance, steam soon demonstrated its advantages and, one by one, broke

down the various obstacles to its further development. In the long run, therefore, the mixed-propulsion compromise made possible the final triumph of steam over sail, and in the easiest possible way--by absorbing it.

This proved to be the experience of the British. All the steam battleships built by the British during the 1850's were basically mixed-propulsion ships, in which many features of sailing battleships were retained. They still offered a considerable range in characteristics, varying from new ships which were longer than their sail equivalents and which had relatively high steam power (generally 600 horsepower for two-deckers), to converted ships which were lengthened only slightly if at all and which had relatively low power (generally 400 horsepower). The more powerful ships were almost invariably found to be much more satisfactory under steam than the others (even a small increase in horsepower produced major improvements in performance), and, surprisingly, they also turned out to be better under sail.[1] Even more important, fleet commanders found that the mobility of the steamers offered such great operational advantages that the reduction in their ability to make long cruises was all but forgotten. All the pressures were therefore in favor of more horsepower, and during the 1850's this crept up in British ships. By the end of the decade, when

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[1]"Theseus," "Our Screw Steam Navy," pp. 237-46.

the advent of the ironclad interrupted the development of wooden battleships, the standard two-decker in the British navy was being built with 800 horsepower, while two three-deckers were under construction with engines of 1000 horsepower.

Dupuy de Lome's Fast Battleship

This pattern of gradual evolution towards increased steam power was not, however, followed in France. Instead it was short-circuited, at the very beginning, by the initiative and imagination of one man, assisted by the right contacts and by a little luck. In 1847 a brilliant young naval constructor, Dupuy de Lôme, saw that technology was capable of providing something much better than a mixed-propulsion battleship, and he designed and submitted plans for the ship towards which technical evolution was just beginning to lead: the world's first true steam capital ship.

Since becoming an officer in the Naval Construction Corps in 1839, Dupuy de Lôme had concentrated his attention on innovations and what they could do for the steam navy. His study on iron hulls which made his reputation in 1844 was followed by several designs for screw steamers in which he developed new principles of hull design that would enable engineers to get the maximum advantage out of the screw propeller.[1] He thus went

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[1] Dupuy de Lôme, "Exposé des modifications apportées au plan du Caton," dated 1 November 1843, A.M., Marine 7DD1-130; Maritime Prefect of Toulon to Minister of Marine, 29 October 1845 (enclosing Dupuy de Lôme's plans for Sentinelle), A.M., Marine 7DD1-84.

beyond many of his contemporaries, who were content simply to put the screw in hulls designed for use with sails or with paddle wheels.

Dupuy de Lôme was a firm supporter of the steam navy, and his projects quickly brought him to the notice of Joinville, who valued his ability and helped him at crucial points in his career.[1] In return, Dupuy de Lôme espoused the theories concerning the steam navy contained in Joinville's article of 1844. He felt, however, that the debate over this article had raised a problem that had to be resolved before the steam navy could realize its full potential: it had nothing that could stand up to a capital ship (the sailing battleship) in a fair conventional fight. Until it did, the arguments of the steam enthusiasts could not be expected to make much progress against conservative opinion both inside and outside the navy. In addition, there were more substantive reasons why the problem had to be solved. The main strategic role of the steam navy as seen by Joinville and his supporters was to enable France to land troops at any point along the enemy coastline, using surprise and speed to offset any enemy advantage in conventional naval forces. This might well work, but existing steamers were so vulnerable to shot that, if a few enemy battleships happened along during the operation, the carnage might well become appalling. Dupuy de Lôme feared, in fact, that the chance of something going wrong, and the heavy losses to be expected if it did, might

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[1] Joinville, Vieux Souvenirs, pp. 244, 279-80.

prevent such operations from even being tried. What was needed was ships that could accompany the expeditionary force and keep enemy battleships out of the landing area by engaging them in a conventional battle. Sailing battleships could not do this, for if a steam fleet were forced to remain in company with a sailing escort force it would lose the mobility that was its chief asset, and landing operations would once again be dependent on the wind. Hence the steam navy needed its own capital ship, which would combine the high speed under steam (and the limited supply of provisions) characteristic of steamers with armament and hull strength equivalent to those of sailing battleships.

Such ships would also have other uses. Even without an accompanying landing force they could make prompt and precisely-timed descents on a given point along the coast, either as a political demonstration or as a military operation. (Mixed-propulsion ships could not be relied upon to do this as their horsepower was not sufficient to make them fully independent of the wind.) They could also protect fast steamer convoys between France and Algeria or conduct fast sweeps along that vital route to keep it open in time of war. Finally they would have a tactical advantage in a naval engagement due to their guaranteed superiority of speed over any other capital ship, either sail or mixed. Like other steamers they would, however, be limited to European waters due to their limited supply of provisions. The overseas stations would thus remain the province of sail.[1]

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[1]Memorandum by Dupuy de Lôme, April 1847, A.M., Marine 7DD1-143; Cros, "Considérations sur le materiel de notre flotte," p. 40; Enquête, 1849, 2:141-42.

Dupuy de Lôme's first effort to solve this problem came in early 1845. His approach at this time was to compensate for the battleship's superiority over the average steamer in artillery and hull strength through the use of several recent technological innovations. The ship he proposed was basically a screw frigate with high speed and a relatively generous coal supply. Since the engines of such a ship could not be put below the waterline, he proposed protecting them with a 90 millimeter thick armor belt, 2.4 meters wide, which ran all around the ship at the waterline and which rose amidships to cover the gun battery as well. The weight of this armor would be compensated for by making the hull of iron instead of wood. Dupuy de Lôme hoped that this protection would allow the ship to stand up under enemy fire while it shot its opponent to pieces with its twenty-eight large guns. This project, submitted on 20 February 1845, led to some tests of armor, but was not pursued, partly due to the novelty of armor and partly to the continued distrust of iron hulls.[1]

The ministry's dispatch of 9 December 1846 ordering the ports to prepare plans for the conversion of some sail battleships then on the building ways to mixed-propulsion ships gave Dupuy de Lôme another opportunity to express his ideas about steam capital ships. He acknowledged that conversions made good

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[1]Baxter, pp. 60-62; Olivier Guihéneuc, "Les origines du premier cuirassé de haut mer à vapeur: Le plan de Dupuy de Lôme en 1845," Revue Maritime, no. 100 (1928), pp. 459-82.

financial sense, since something had to be done with all those half-finished sailing ship hulls. However these conversions held little interest for him as an engineer since the sailing-ship hulls with their blunt ends could only make very imperfect use of the screw, and, worst of all, they could never provide the answer to the problem of the steam capital ship since the hulls did not have room for both the high-powered engines and the ample coal supply that were required to make them fully independent of the wind.

But what if he were permitted to build a new ship from the keel up, specially designed to meet his own specifications? He felt he could design a hull with space for the engines and the coal, along with the correct hull lines for use with the screw propeller. Best of all, he found that the technological advances in steam engine design made during the 1840's allowed him to put the engines completely below the waterline. This freed him from the need to use armor to protect the engines and to compensate for its weight with the various other technical gimmicks of his 1845 plan. There was, in fact, no reason why, above the waterline, his ship could not simply be a regular battleship, with the usual rows of artillery and heavy timber sides, and thus capable of slugging it out in the classic manner with any other battleship of its rank. This ship, pure steamer below the waterline, pure battleship above it, was the world's first true steam capital ship, for it essentially added the advantages of steam to the combatant characteristics of the

standard capital ship of its day. Dupuy de Lome called it a _vaisseau rapide_ or fast battleship, thus contrasting it with the other two types of capital ships, mixed-propulsion and sailing battleships.[1]

Therefore, while other engineers worked on the mixed-propulsion conversions, Dupuy de Lome drew the plans for his fast battleship. For her hull he took the hull plans of one of the transatlantic packets of the 1840 program, enlarged them until the ship had the beam of a second-rank battleship, and then removed a section amidships to bring the length back down to that of the packet. He thus got both the hull capacity of a battleship and the hull lines at the bow and stern of a steamer. Into this space he fitted an engine of 900 horsepower and coal for twelve days' steaming at full power, plus the two months of provisions and other supplies that had been stipulated for the mixed-propulsion conversions. Above the waterline he made the ship as similar as possible to the standard third-rank battleship, with ninety guns divided between two covered batteries and the open spar deck. The major visible difference was that Dupuy de Lôme's project had only half the sail area of the normal ninety-gun battleship. He reasoned that the coal supply of his ship could last up to forty days if she cruised at her most economical speed (eight knots), and, since she had only sixty days' provisions, she would have little occasion to use her sails

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[1] Memorandum by Dupuy de Lôme, April 1847, A.M., Marine 7DD1-143.

unless the engines broke down. Since steam was to be the prime motive force in the new ship, and since a heavy rig would interfere with it from the point of view of both weight and wind resistance, he therefore greatly reduced the rig in his project. To reassure the timid, however, he pointed out that the ship's stability was good enough to permit carrying practically the full rig of the standard third-rank battleship, and that the rig could therefore be increased later if found necessary.[1]

Predictably, the ship's rig was, in fact, substantially increased prior to completion, and in appearance this revolutionary ship became practically indistinguishable from her sailing consorts except for her two smokestacks (which were retracted unless in use) and her extra length. The radical difference between her and a sailing battleship became visible only if one went below decks, or if one did the next best thing and looked at a comparison of the weights of the items carried inside Dupuy de Lôme's ship and a sailing battleship of identical displacement (5050 tons), the standard three-decker (see Table 2).

While the comparison in Table 1 of a mixed-propulsion frigate (Pomone) with a similar sailing frigate (Erigone) showed changes to only a couple of figures, this comparison in Table 2 of the two battleships shows that the inclusion of 1600 tons of machinery and coal forced Dupuy de Lôme to alter radically almost every characteristic of the traditional battleship except armament

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[1] Ibid.; C.T., 26 May 1847, A.M., Marine 7DD1-143.

TABLE 2

FAST STEAM BATTLESHIP COMPARED WITH SAILING BATTLESHIP

	3-decker sail battleship	Dupuy's fast battleship
Comparative weights (in tons)		
Artillery	560.1	460.5
Anchors, ground tackle	139.7	77.6
Masts, rigging, sails	252.4	68.0
Boats	23.7	22.0
Various supplies	91.6	38.6
Cooking objects	14.3	16.0
Wood for stowage	27.0	5.0
Crew and belongings	109.0	80.0
Provisions	920.0 (Provisions and Water)	122.0
Water		72.0
Ballast	350.0	0.0
Coal	--	1100.0
Engines and boilers	--	504.0
Total of above (excluding hull proper)	2487.8	2565.7
Total ship (including hull)	5050	5052
Comparative dimensions (in meters)		
Length	63.00	71.30
Beam	16.41	16.22

SOURCES: C.T., 14 July 1847, and memorandum by Dupuy de Lôme, April 1847, A.M., Marine 7DD1-143. These differ slightly concerning Dupuy's ship.

and appearance in designing his fast battleship. Nothing could show better the essential difference between a mixed-propulsion conversion and a true steamer, or more fully reveal the radical nature of Dupuy de Lôme's proposal.

Debating and Approving Dupuy's Design

Dupuy de Lôme's plan was forwarded to Paris by the port authorities at Toulon on 12 May 1847 with an endorsement that enthusiastically recounted its features and concluded that "before the end of 1848 we could have afloat a remarkable ship, which would be an entirely French creation and not an imitation or a copy of foreign ships." (The author of this endorsement was himself an innovative naval constructor who had proposed building an armored floating battery in 1844.)[1] But Dupuy de Lôme had every right to expect a cool reception by the councils in Paris, which had asked for conversion plans, not for a massive new project. In fact, a proposal similar in many ways to Dupuy de Lôme's met just such a reaction at this very time. In June 1847 Rochefort's chief constructor submitted plans for the battleship to be converted there, and at the same time also submitted plans for a screw frigate which, like Dupuy de Lôme's project, had full steam power (800 horsepower) and would have to be built from the keel up as a new ship. The Council of Works told him in no uncertain terms that the construction of such a ship would depart completely from the terms of the conversion program sent out by the minister and that the navy had too much

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[1] Endorsement by A. Vincent dated 12 May 1847 on Dupuy de Lôme's memorandum of April 1847. A.M., Marine 7DD1-143.

invested in its sailing ships, especially those still on the building ways, for it not to try to make use of them before building new ships to essentially different designs.[1]

But, thanks to proper contacts and to good luck, this was not the reaction that Dupuy de Lôme's project received. Dupuy de Lôme was on very good terms with Joinville, and apparently kept him fully informed concerning the details and the progress of his project. Joinville lobbied intensively in the ministry for the project, so much so that his advocacy was mentioned in an official report.[2] In addition, Joinville seized an opportunity to expedite consideration of the project. At the time Dupuy de Lôme's project arrived in Paris (around 18 May) there was no minister of marine, since Mackau had resigned over a colonial issue on 9 May and his successor did not arrive in Paris until 20 May.[3] In the interim the navy portfolio was held by Guizot, and, according to Joinville (whose account is unfortunately highly inaccurate), he (Joinville) and Dupuy de Lôme called on Guizot and talked him into using his signature to override the naval bureaucracy and order immediate construction of the ship.[4] Actually all that Guizot's signature ordered was the

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[1] C.T., 9 June 1847, A.M., Marine 7DD1-143; Dislère, Croiseurs, p. 20n. The constructor at Rochefort was V. Sabattier.

[2] Ports to Minister, 2 June 1847, A.M., Marine 7DD1-143; Joinville, Vieux Souvenirs, p. 280.

[3] Mackau advised Joinville of his resignation on 16 May: Mackau to Joinville, 16 May 1847, A.N., 156-AP-I-50.

[4] Joinville, Vieux Souvenirs, p. 280. It is interesting to recall that Guizot had overridden the navy on behalf of Joinville in at least one other case (the composition of the Squadron of Evolutions for 1847).

immediate consideration of the project by the Council of Works, but this conspicuous support from the prime minister and a prince of the blood put Dupuy de Lôme in an extremely strong position when dealing with the navy's bureaucrats.

His plan was first examined by the Council of Works on 26 May 1847. This council at once found what it felt were grave design defects in the machinery: while Dupuy de Lôme had calculated its power at 900 horsepower, the council calculated it at 300 horsepower! This would have been enough to cause the peremptory rejection of any other project, but the council simply told Dupuy de Lôme to go and redesign his engine, and when this was done to come back and they would examine the rest of the project.[1]

The main deliberation of the Council of Works on Dupuy de Lôme's fast battleship came on 14 July 1847. Dupuy de Lôme was called to Paris to participate in the proceedings, and in the days before the meeting he was quizzed by committees of the council on all aspects of the project. The committees approved of most of his plan but recommended changes in several major details and, most important, recommended deferring construction of the ship until practical experience had been gained with large screw propeller installations in the trials of Pomone and Isly. In the meeting with the full council on 14 July the report of the committees was read, and then Dupuy de Lôme was

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[1]C.T., 26 May 1847 and Ports to Minister, 2 June 1847, A.M., Marine 7DD1-143.

allowed to speak. He made such an extraordinary impression on the council that every change recommended by the committees save one (raising the horsepower to 960 at the expense of two days' coal) was rejected. In its report the council stated that it was more important to retain the initiative in the introduction of this new type of ship than to wait for practical experience with the screw frigates and, from a strictly technical viewpoint, they recommended immediate construction of the ship on an experimental basis.[1]

By this time momentum was clearly working in favor of Dupuy de Lôme's project, and most officials in the central administration were backing it. In June Boucher, the Director of Ports, reported that he personally favored the ship (although he felt precautions should be taken in her plans so that some use could be made of her if she were a failure as designed):

> At the present time, and when on all sides and in all countries men are straining their ingenuity to find new combinations preferable to those now existing, it does not seem to me to be appropriate for the administration to draw back from efforts that could bring important results and to limit itself to imitating timidly that which is done abroad.[2]

The most important endorsement came from the Council of Admiralty, which had been asked, after the Council of Works had resolved the technical problems (except for the engines) to give its opinion on whether it was advisable to introduce such a ship

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[1] C.T., 14 July 1847 and Ports to Minister, 14 August 1847, A.M., Marine 7DD1-143.

[2] Ports to Minister, 2 June 1847, A.M., Marine 7DD1-143.

in the fleet in view of its potential impact on naval strategy and tactics and its immense cost. The council, after meeting on 2 and 8 November 1847, recommended proceeding with the project despite its cost, and indicated the two reasons that had made the greatest impression on it:

> . . . The progress of the navy is closely tied with that of the industrial arts which are developing with great activity. . . . It is, consequently, indispensable that we make a point of following the course of this progress, by knowing how to make for this purpose considerable expenditures, even with the probability that some of them will remain unfruitful.
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> . . . The sense of our needs imposes on us the duty to possess war steamers of high speed that can assure us in case of maritime war prompt and sure communications with Algeria.[1]

Having made this decision the council urged the ministry to proceed with the project as quickly as possible. It wanted to wait until the Council of Works was satisfied with the engines before ordering the construction of the ship, but expressed the desire that this delay be as short as possible. It felt that "we must hurry so that others may not get the same idea and deprive us of the merit of the initiative." For this reason, and also probably with military secrecy in mind, it warned the ministry to take steps so that "the general description, the details and the purpose of this construction do not fall into the domain of publicity." The response of the minister was to include the ship among those to be built during 1848 with the

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[1]C.A., 2 and 8 November 1847, A.M., Marine 7DD1-143.

provision that nearly two-thirds of the work on her (a very high amount) be done before the end of that year.[1]

The project was to go through one more trial before final success, however. On 24 November the Council of Works examined Dupuy de Lôme's new plans for the engines, drawn, this time, in collaboration with the director of Indret, and again rejected them. This was at least in part Dupuy de Lôme's fault, for he had included in his design a number of features that the council had objected to earlier in the year.[2] Nonetheless, by the beginning of 1848 the project showed every sign of becoming bogged down in a debate over engine design. This time it was rescued on 11 January 1848 by a proposal from the Director of Ports that, in view of the amount of work to be done before the end of the year, the hull should be started at once even though the engine plans were not ready. (Joinville was in Algeria at this time and had no role in this proposal.)[3] The minister approved, and on the same day sent to Toulon the directive ordering construction of the ship. The engines were finally approved by the Council of Works in May 1848.[4]

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[1]Ibid.; Ports to Minister, 1 November 1847, A.M., Marine 7DD1-143.

[2]C.T., 24 November 1847, A.M., Marine 7DD1-143.

[3]Ports to Minister, 1 November 1847, A.M., Marine 7DD1-143; Joinville, Vieux Souvenirs, p. 292.

[4]Maritime Prefect at Toulon to Minister of Marine, 18 January 1848 and C.T., 18 May 1848, A.M., Marine 7DD1-143.

The intervention of the Director of Ports turned out to have been crucial, for a little over a month later the revolution of 1848 broke out. The Second Republic was not hostile to the navy as such, but was very short of funds and made strenuous efforts to keep down expenditures.[1] In this atmosphere projects that had not actually been put in motion tended to die unrealized. Such was the fate of two additional ships that the Council of Admiralty had recommended building at the same time that it approved the construction of Dupuy de Lôme's fast battleship. It had asked that the ministry lay down at once two steam screw frigates with fifty guns and a speed equal to Dupuy de Lôme's battleship. Plans for such ships remained under discussion through June 1848, but the revolution of February 1848 ended any chance of building them. They suffered from an additional disability in that they did not originate in the mind of a man like Dupuy de Lôme, who could free himself from the influence of the past if it suited his purpose, but were the result of efforts of two navy committees to combine Dupuy de Lôme's new ideas with several old ideas that they could not bear to give up. Feeling that frigates were essentially overseas cruisers and would need sails, the Council of Admiralty laid down the stipulation that these fast steam frigates also be as fast under sail as the best French sail frigates, and the Council of Works declared that to guarantee this the hulls of

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[1] No money was paid out under the program of 1846 after 1849. Budget, 1850, pp. 307, 313; Budget, 1851, pp. 309, 313; Budget, 1852, pp. 330-31.

the new ships would have to be exact copies of the hulls of successful sailing frigates. Under these conditions the designers could provide only four days' coal and three months' provisions and could not make the hull lines suitable for the screw propeller, results that were as ludicrous as Dupuy de Lôme's were elegant. A pure steam alternative was considered in June, but died from lack of funds.[1]

It has been suggested that the July Monarchy planned to name Dupuy de Lôme's fast battleship Prince de Joinville, but the proposal was never made officially and the ship was still without a name when, in early April, the first Minister of Marine of the Second Republic named her Vingt-Quatre Février.[2] Joinville reported that he was amused, in a bitter sort of way, when, shortly after her launch (which took place on 16 May 1850), the ship was renamed Napoléon.[3] She ran her trials in early 1852, and her performance exceeded even the fondest hopes of her designer.

The design and construction of Napoléon represented the final stage in the introduction of steam technology in the French navy, for two reasons. First, it completed the structure of the

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[1] C.A., 2 and 8 November 1847, A.M., Marine 7DD1-143; Ports to Minister, 30 November 1847, A.M., Marine 1DD1-122; C.T., 19 January, 29 March, 5 April and 7 June 1848, A.M., Marine BB8-1122; Dislère, Croiseurs, p. 20.

[2] Ports to Minister, 3 April 1848, A.M., Marine 7DD1-143. The name Prince de Joinville is reported in "Répertoire des navires de guerre français," Triton, no. 77 (1966), p. 19.

[3] Joinville, Vieux Souvenirs, p. 281.

steam navy. Beginning in 1829 with Sphinx, which was equivalent in function to a sailing brig, the steam navy had developed categories of ships capable of taking over the functions of each of the main combatant categories of sailing warships. The first steam corvette in the French navy, Lavoisier, of 1838, was followed by the first steam frigate, Gomer, in 1841, and the process was now complete with the development of a steam capital ship. Napoléon had the essential attribute of a sailing battleship (the capital ship of its day) in its strong hull and strong artillery, and also had all the attributes of a steamer. No sailing ship could survive confronted by such a ship, and the ultimate triumph of steam was thus assured. Second, the success of Napoléon showed that the French had achieved complete mastery of steam technology. Her design and construction actually involved two major innovations: the concept of the ship and the design of her hull were entirely novel; and her 960-horsepower engine, designed by Dupuy de Lôme and an engineer at Indret, was not only the biggest engine by far yet built in France, but also exceeded in size the largest engine in the British navy (an 800-horsepower paddle engine). The future showed even more conclusively the magnitude of the French achievement, for during the 1850's France actually took the lead in developing new ideas in marine technology. Led by Dupuy de Lôme, they first introduced iron armor for ships in five floating batteries built in 1855 for the Crimean war, and

they then incorporated this armor into the first seagoing capital ship, Gloire, in 1858.[1]

Mixed Propulsion Superseded

The acceptance of high steam power as in Napoléon for future battleships did not come at once, however. Napoléon did not run trials until 1852, and before then the radical nature of her design raised grave doubts as to her eventual success. In addition, the decision to build her tended to undercut the compromise between sail and steam represented by the mixed-propulsion battleship. The advocates of sail were bound to feel that if the steam navy was to have its ideal battleship, why shouldn't they? By 1849 officers who remained attached to the sail navy had adopted as their ideal battleship the one proposed by Mackau to Parliament in 1846--a ship with a small steam engine which retained all the characteristics of a sailing ship, including the ability to make prolonged cruises overseas.

The magnitude of the movement in favor of such ships might have remained concealed from us, had not the National Assembly ordered a massive investigation of the navy in 1849 during which a large number of naval officers and naval constructors were interviewed. The Commission of Inquiry found that the mixed-propulsion battleships then under construction had a key attribute of a true compromise: they pleased nobody. A few witnesses defended them as experiments, but none felt that such

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[1]The early phases of the revolutions in ordnance and armor are ably discussed in Baxter, Ironclad.

ships should have a large place in the fleet of the future. They had neither enough endurance to please the advocates of sail, nor enough speed under steam to please the advocates of steam.[1] *Napoléon* was defended by several witnesses, and others were willing to concede that the navy needed some ships of this type to carry out special missions near France.[2] But the opinion of the overwhelming majority of the witnesses was that the capital ship of the future would be a sailing battleship with auxiliary steam power capable of providing not over four knots' speed.[3]

Even this concession to steam had its risks. One senior officer pointed out that the screw propeller involved a new organization of shipboard personnel and of the military equipment inside the ship, and wanted to avoid making any more changes for the next ten years:

> . . . for all these trials and all these upheavals cost an infinite amount of money and hold the spirit in an uncertainty which prevents our sailors from becoming attached to that which they have in their hands.
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> Sailors like the ship on which they find themselves; today one sees them breaking loose from that attachment, and that comes from nothing else but this perpetual state of change that we are in.[4]

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[1] *Enquête, 1849*, 2:178, 374.

[2] *Enquête, 1849*, 2:72, 140, 176, 344, 525. See also Cros, "Considérations," pp. 34-35; E. de Moras, "Quelques documents sur le matériel flottant des marines française et anglaise, *Nouvelles Annales de la Marine* 2 (1849):380.

[3] *Enquête, 1849*, 1:180; 2:71, 176, 178, 298, 300, 344, 374, 392, 399, 439, 697; 3:17.

[4] *Enquête, 1849*, 2:71.

A senior naval constructor (who had been quite active in the development of the steam navy) feared the unexpected technical problems that might arise from the mass conversion of battleships to steam:

> We already know that steamers, which in general have little depth of hold, are less comfortable to live in for their crews, in that they preserve with more difficulty their provisions due to the heat which spreads into all parts of the hold. Can we say in a certain way what will be the effect of the introduction of a steam engine in the very bottom of the hold of a battleship, manned by a very numerous crew and carrying five or six months of stores; prudence dictates not being in too much of a hurry to make a general decision.[1]

Faced with the progress steam had already made, however, these doubts had to be set aside. For several years the theory of the sailing battleship with a small steam engine dominated French naval construction policy. (There were also budgetary reasons for this: the fiscal problems that followed the revolution of 1848 led Parliament and the government to cut off funds for the execution of the program of 1846 after only two of the seven installments had been paid and to reduce the navy's budget drastically. The navy was thus severely limited in the types and numbers of new ships that it could afford.)[2] In June 1849 Lieutenant Siméon Bourgois, who had carried out the screw propeller experiments in Pelican, showed that that ship, which only had 120 horsepower, could tow the largest battleship in the French navy at four knots. He then followed this demonstration by

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[1] Enquête, 1849, 2:143.

[2] Budget, 1851, p. 309; Budget, 1852, p. 331.

submitting plans for the installation of a 120-horsepower engine in an existing battleship.[1] The ministry encouraged further work on the project, and in December 1849 asked the constructors in the ports to submit proposals for fitting all four ranks of battleships with engines capable of giving them a speed of 4-1/2 knots at most. This was to be accomplished primarily by reducing the water supply by half (this amount could be compensated for by adding a distilling apparatus). The supply of provisions was not to be reduced below six months, and the rig, armament and crew were not to be changed in any way.[2] The ultimate result was that in early 1851 the three-decker Montebello was ordered to be fitted with engines of 140 horsepower.[3] Design work also began in 1850 and 1851 on two new classes of sailing battleships, a large three-decker and a small two-decker, each of which was to be fitted with a small steam engine.[4]

Thus before any French steam battleship ever got to sea, France was building three types: the compromise mixed-propulsion

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[1] C.T., 9 June 1849, A.M., Marine BB8-1124; Bourgois, "Application de l'hélice," pp. 371-78, 384-87.

[2] C.T., 28 November 1849, A.M., Marine BB8-1125.

[3] C.T., 22 July 1850, 26 February 1851, 28 May 1851, and 24 January 1852, A.M., Marine BB8-1127, 1128 and 1130.

[4] Bretagne and Desaix (120 guns): C.A., 23 January 1851, A.N., Marine BB8-879; C.T., 25 June 1851 and 22 October 1851, A.M., Marine BB8-1128 and 1129; Maritime Prefect of Cherbourg to Minister of Marine, 8 December 1851, A.M., Marine 7DD1-15. La Tour d'Auvergne (74 guns): C.T., 27 February 1850, 25 June 1851 and 21 January 1852, A.N., Marine BB8-1126, 1128 and 1130; C.A., 5 June 1850, A.N., Marine BB8-879.

type (Charlemagne), and an example of each of the extremes (the high-power Napoléon and the low-power Montebello). The question of steam propulsion for capital ships would thus be resolved in France not by gradual evolution but by comparative trials.

In the space of a few months, the trials settled the question once and for all. It was clear even before the trials began that Montebello's performance under steam, even if it came up to expectations, would be very undistinguished; and critics claimed that in a headwind or heavy sea she would be so slow that she would not be able to steer.[1] Then came the trials of Charlemagne and Napoléon. Late in 1851 Charlemagne, whose designers had expected perhaps seven knots under steam, clocked an unhoped-for 9.4 knots, while also turning in a most creditable performance under sail at over eleven knots. Napoléon's success was even more spectacular. In her trials, which took place in mid-1852, her maximum speed turned out to be not the ten to eleven knots anticipated but over thirteen knots, and in concluding her trials she made the trip from Toulon to Ajaccio, Corsica, at an average speed of 12.4 knots. Her maneuverability and seakeeping qualities were also found to be excellent, and as a bonus she turned out to be extremely fast and handy under sail as well.[2]

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[1] C.T., 10 July 1850, A.M., Marine BB8-1127; Cros, "Considérations," pp. 34-35. See also C.T., 9 July 1851 and 21 January 1852, A.M., Marine BB8-1129 and 1130.

[2] Commandant de Balincourt and Pierre Le Conte, "La Marine française d'hier: VI: Vaisseaux mixtes," Revue Maritime, no.

Transforming the Battle Fleet, 1852-1857

Overnight the attitude in the ministry changed: while its efforts between 1849 and 1851 had been to conserve as many of the features of sailing ships as possible in its capital ships, now all it could think of was getting as much steam power as possible into the battle fleet. In addition to the proof of the technical feasibility of steam battleships, several other factors combined in 1852 to herald a new period of activity for the French navy. On 2 December 1851 Louis Napoleon put an end to the Second Republic, and under a strong executive the navy began to receive more money for shipbuilding.[1] The return of a Bonaparte to absolute power in France also aroused old fears in England, which expanded into full-blown naval scares in 1852 and 1853.[2] These events made a new naval program possible, and confirmed the view that Britain was still the power against which France's naval preparations should be directed. In May 1852 the Minister of Marine transmitted to the Council of Admiralty the strategic ideas on which he felt the new building program should be based, and these included many arguments previously advanced by the steam enthusiasts:

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159 (1933), pp. 346-47 and no. 160 (1933), pp. 483-84.

[1] C.A., 22 and 29 May 1852, A.N., Marine BB8-853 (secret volume); Budget, 1853, pp. 159, 547.

[2] Bartlett, Britain and Sea Power, pp. 277-93; Brodie, Sea Power in the Machine Age, pp. 58-69.

> It would no longer be a question, in effect, in case of war with Britain, of sending overseas numerous fleets, but instead of compensating for the material inequality of forces by speed in movements and in expeditions; it is a question of making preparations to deal rapid and sure blows against British commerce, and always to keep hanging the threat of a descent on the coasts of the United Kingdom. For that, large ships equipped with a heavy armament, carrying a large number of armed men and capable of carrying out rapidly and unexpectedly a landing on a specific point on the coast--such is for France the truly effective way of obtaining great advantages. Battleships and frigates with high speed and battleships equipped with an auxiliary engine of sufficient size seem . . . the best of all combinations.[1]

The new policy explicitly excluded any further construction of sailing ships, and, implicitly, with them, of sailing ships with weak engines such as Montebello. Instead a crash program to give the battle fleet maximum steam power was begun. Existing hulls were to be converted along the lines of Charlemagne, which represented the most powerful battleship that could be produced from existing hulls without major lengthening (which was regarded as being too expensive to be worthwhile except in a few special cases). New battleships were to be built on the plans of Napoléon, the fastest steam battleship then afloat. In 1852 alone preparations were made to start five fast battleships and seven powerful mixed-propulsion conversions, and more soon followed.[2] (The British responded by ordering eleven conversions between August and November 1852.)[3]

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[1] C.A., 22 May 1852, A.N., Marine BB8-853.

[2] C.A., 6 September 1852, A.N., Marine BB8-853; C.T., 7 July 1852, 27 November 1852, 12 January 1853, A.M., Marine BB8-1131 and 1132; Ports to Minister, 7 March 1853, A.M., Marine 1DD1-197.

[3] Surveyor's Submission Letter Book number 14 (1851-1852), ADM. 88-14.

The navy of the Second Empire found that little stood in the way of the execution of this program. The doubts concerning the usefulness of steam that had blocked its use for so long were now all but dissipated. Meanwhile the navy's engineers had proven their mastery of steam technology and their ability to produce major innovations in it when necessary. The only doubtful area was France's ability to produce large numbers of steam engines, for events during the late 1840's showed that the industrial base built up with the navy's encouragement was still far from secure. One problem was the lack of corporate organization of many firms--both Hallette and Cavé were family businesses, not corporations, and their continuity would necessarily be put into jeopardy by the death or retirement of their founders. In the case of Hallette this happened in 1846 when Alexis Hallette died and was succeeded by his son, who had the firm incorporated.[1] However the new management did not get a chance to prove itself, for in the same year, 1846, the entire mechanical industry was imperiled when excessive speculation, especially in railroad stocks, led to a crash on the Bourse. Orders from private companies (especially the railroads) for steam engines dried up, and some firms began to run out of operating funds.[2] By late 1846 Hallette could not meet its payroll and tottered on the edge of bankruptcy. The navy tried to help the firm by securing Cabinet approval for a scheme that allowed

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[1] Daumas, "Mécaniciens autodidactes," p. 315.

[2] Jardin and Tudesq, La France des notables, 1:237-38.

it to advance funds to the company despite laws to the contrary, and then tried to bolster up the firm with an order for a new engine.[1] The government was successful in keeping the plant operating through the winter and in preventing unemployment that could have had serious political consequences, but the last two engines built by Hallette for the navy were of inferior quality, and the firm closed for good in 1848.[2]

Soon afterwards Cavé's plant also fell victim to the same problems, financial difficulties and lack of corporate organization. Cavé must have had some financial problems after 1846, for he received no further navy orders while he had to struggle with defects in the 650-horsepower machinery he was building for the screw frigate Isly which ultimately proved insurmountable. (He was rescued from this situation in 1853 when the government ordered a big battleship engine from him, the profits from which were to permit him to build new machinery for Isly.)[3] Cavé was still solvent when his family convinced him to retire in 1853, but there was no member of his family qualified to direct the firm and it had to be turned over to a corporation which ruined it through poor management within two years. The plant was dismantled and the equipment sold piece by

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[1] Ports to Minister, 26 November 1846, A. M., Marine 1DD1-109.

[2] Ports to Minister, 31 January 1847, 6 and 9 March 1847, A.M., Marine 1DD1-122; Cros, "Considérations," pp. 102-103.

[3] C.T., 2 February 1853, A.M., Marine BB8-1132.

piece.[1] In 1853 a French industrialist, Philip Taylor, wrote that there were only two private establishments in France that could produce powerful engines, presumably the one he himself had just set up and Schneider's firm at Le Creusot.[2]

However the French industrial base, while not nearly as strong as that in England, turned out to be there when needed, after all. The navy could always turn to Indret, which became the leading French producer of engines for large navy ships in the 1850's. Schneider also remained one of the navy's largest suppliers, while two new major firms soon appeared to take the place of Hallette and Cavé. Mazeline at Le Havre, who had made his debut in the 1840's with the engine for Pomone, became one of the navy's biggest suppliers in the 1850's; while a number of small firms near Marseilles, including Philip Taylor, who had received navy orders in the 1840's, combined to produce a new giant firm located at La Seyne, the Forges et Chantiers de la Mediterrané.[3] These firms were better located than their predecessors, being in important commercial ports instead of in the interior, and they also proved to be much longer-lived: while Mazeline closed in 1870, his plant was purchased and re-opened by the Forges et Chantiers de la Mediterrané, which

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[1] Jonveaux, "Cavé," pp. 72-73.

[2] Bartlett, Britain and Sea Power, pp. 291-92.

[3] Benet's yard at La Ciotat became the engine factory of the French national merchant shipping company, the Messageries Imperiales (later Nationales).

continued to operate both the Le Havre and La Seyne sites into the twentieth century.[1] Indret and the three major private firms provided the engines for twenty-four of the thirty-three wooden battleships built or converted during the 1850's. Of the rest, five were built in the navy's ports, one by Cavé, and three in England, as part of an arrangement arising out of the Crimean War.

Thus by 1852 the success of the high-powered steam battleship was assured. France had developed the type as a result of Dupuy de Lôme's leap of the imagination in 1847, while the British were steadily evolving towards it. The main types of British and French wood steam battleships built after the Crimean War were, in fact, practically identical to each other: all were 90 gun two-deckers, and while the French retained an advantage in steam power (900 horsepower to 800 for the British), this was not always reflected in the speed of the ships. This battle line was supported by a steadily growing fleet of large screw frigates and smaller screw corvettes and avisos, all of which took over the functions of their sail and mixed-propulsion equivalents as quickly as they could be built.

However the decisions of 1852 did not change the fleet overnight, and, in practice, sailing ships continued to form an important part of the navy. They might have continued to do so for quite some time, had not the Crimean War proved once and for all the impotence of a sail fleet faced with a fleet that

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[1] Anthiaume, Construction, p. 420.

had steamers. In that war the Russian navy, which included forty-two sail battleships but no screw battleships or frigates, achieved some initial successes against the Turks, but abandoned the seas without a fight when Britain and France entered the war, and ultimately found no better use for its ships than to sink them as blockships in the entrances to its ports. The French felt they could see the reason why. If the Russian fleet had tried an offensive, the least change in wind could have stopped it, while a calm would have immobilized it. If it had ventured far from its base, an Allied steam fleet could have cut off its line of retreat or even attacked its base before it could return to defend it. If it had engaged the Allies in battle, the superior Allied mobility would have given them an overwhelming tactical advantage that no superiority in artillery or training in sail could have compensated for. The French also learned through their own experiences in the war: their squadron of sail battleships in the Baltic had been a constant hinderance to the British squadron, which had been made up primarily of steamers; while the winter storms in the Black Sea had also repeatedly proved the advantages of steam in carry-out a prolonged campaign.[1] In 1857, in both Britain and France, official reports signalled the end of the age of sail, the British

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[1] F.-A. Hamelin, Minister of Marine, _Rapport de Son Excellence M. le Ministre de la Marine à l'Empereur sur la transformation de la flotte_ (Paris, 1857), pp. 3-4.

agreeing with the French statement that "any ship which was not equipped with a steam engine could not be considered a ship of war."[1]

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[1] Ibid., p. 7. The British opinion, given by the First Lord of the Admiralty in the House of Commons, is cited in Brodie, Sea Power in the Machine Age, p. 73.

CHAPTER VIII

CONCLUSION

The French navy had to come a long way from Voyageur of 1818 to reach Napoléon of 1852. In retrospect one can see what the French achieved during this period: starting from scratch, they created a steam navy, complete with the technological and industrial base and the doctrines and organization needed to support it. But this was not what the navy had set out to do, and even in 1852 it was far from clear that this was what it had done. Instead the navy had been caught up in an extremely complex process, partly of its own making, partly beyond its control, which carried it farther than any reasonable observer could have at first thought possible.

The introduction of steam technology in the French navy was a single series of closely related events, but for analytical purposes one can look at it as having consisted of three separate processes. Of these perhaps the most obvious, and the one according to which this work has been organized, was that by which steamers took over the military functions of sailing ships. The most remarkable feature of this process was that, despite the great advantages offered by steam propulsion, it was

introduced into the fleet only with the greatest hesitation. This hesitation was due to the fact that there were numerous technical problems with the early steamers (of which only a handful have been discussed here), and also to the fact that the early steamers, due to their vulnerability to gunfire and to their need to refuel frequently, were unsuited to either of the forms of naval warfare then contemplated, fleet actions and overseas cruising. Steamers were initially used only for special missions in which their primary advantage, dependable mobility, outweighed all other considerations. During the 1820's they were used in the colonies and as harbor tugs in the naval ports; and in the 1830's they went to sea in large numbers on scheduled naval and postal packet lines. In the late 1830's some thought was given to extending these uses to the fleet, where steamers could carry orders or tow battleships into position for combat, but these ideas were not put into practice due to technical problems and to the fact that the sailing fleet was carrying out its missions successfully without steamers.

This attitude changed, however, when in the Middle East crisis of 1840 the activities of the French sail navy failed to have any moderating effect on the hostile foreign policy of the British. By this time steamers were large enough to have some serious military value, and a transatlantic packet program had just been decided upon that would give France fourteen steamers of the largest size. The result was a great increase in interest in the military use of steamers during the early 1840's;

and by 1845, thanks largely to the Prince de Joinville and his followers, the steam navy had received an organization parallel to that of the sail navy and a complete set of strategic and tactical doctrines. However these ideas proved too radical for their day and steam finally entered the fleet, not through confrontation with the sail navy, but through a compromise with it, the mixed-propulsion compromise which formed part of the naval program of 1846. This compromise, in turn, was made possible by a technological innovation, the screw propeller. Thereafter the advantages of steam led it to prevail slowly but steadily over sail, though in France this evolution towards steam was, to a degree, short-circuited by the introduction of Dupuy de Lôme's fast battleship, Napoleon.

Less obvious, but perhaps more important from the general historian's point of view, was the second process involved in the introduction of steam technology in the French navy: the introduction of this technology into France. This process was an example of technological diffusion, since at first steam technology came entirely from England. The navy had an important role in this process and, in addition, approached it with a deliberation and determination that were totally unlike its ambivalence toward the military use of steam. The reason for this difference was that, from the very beginning, navy officials agreed that, while the capabilities of existing steamers might be limited, the long term potential of steam at

sea was practically unrestricted. This, plus a belief that France must not fall behind England in learning about and using the new technology, guaranteed that the navy would take a strong interest in the introduction of steam technology in France. This was shown from the start, in the navy's production of Africain and Voyageur and its interest in the progress of Comte Donzelot, and it continued unabated during the period. The actual intervention of the navy in the process was brought about by the failures of most of the engines built by French firms for naval steamers during the experimental period of the 1820's, which showed that the French firms did not have either the capital or the expectation of profits that would enable them to expand their capabilities. The navy reasoned that only the government could support the initial cost of outfitting a large factory and developing the new technology, including the inevitable expensive initial mistakes, and it therefore initiated a deliberate program designed to provide France with the industrial base she would need to produce large marine steam engines. It first established its own factory at Indret in the late 1820's, both to supply engines to the navy and to act as a center for importing steam technology from England. It then nurtured several of the larger private French engine builders (notably Cavé, Hallette and later Schneider) during the 1830's with repeated orders for engines for both naval and packet steamers, enabling them to expand their facilities and gain valuable experience with the new technology. The packet program of 1840 led to massive investments of funds both in Indret and

in private firms, and largely completed the process of giving France the capability of building engines as large as any made in England. During the 1840's private industry in France was able to provide most of the navy's needs, enabling the navy to reduce the role of Indret in the production of its engines and to cease buying engines abroad.

The third process is closely tied to the second, but is worth distinguishing from it as it represents a higher stage of technical development than the imitation which is characteristic of the early stages of diffusion. This process adds invention and innovation to imitation and involves the ability, not simply to copy foreign machinery, but to improve on foreign models and to design one's own models. The French navy was slow in developing these capabilities. It was unable to design successful engines in France during the 1820's, and toward the end of that decade it adopted the practice of buying British engines as models and keeping informed concerning changes in British technology through periodic visits by French officers to Britain. This practice became official policy in 1832, and for most of the 1830's steam engine design in the French navy remained frozen, being based on the engine of _Sphinx_ which had been built in Britain in 1828. When the size of marine engines increased at the end of the 1830's, the French continued to rely on British designs--while they tried to develop their own models of 220- and 450-horsepower engines, the ones they bought in England proved to be much more satisfactory.

The crisis of 1840 caused the French navy to decide to break this dependence on Britain, despite the costs and risks of doing so. The navy increased the number of engineers sent to visit Britain, but after 1840 it bought no more engines there as models (although the Post Office bought one small one). This happened at a time when the British were introducing major improvements in marine engine technology--direct-acting engines and tubular boilers--along with iron hulls for ships; and during most of the 1840's French engineers struggled simply to keep up with the English. However they succeeded, and, in the case of the screw propeller, they showed the ability to carry out a major program of technological development essentially on their own. Finally, with Dupuy de Lôme's _Napoléon_, they showed the ability to make major innovations in the new technology, for this ship was not only a new type of warship, but also had an engine of the largest size (960 horsepower), completely designed and built in France.

The introduction of steam technology in the French navy thus combined the three processes of change in military technology, diffusion of that technology from Britain to France, and the development in France of the ability to make innovations in that technology. The first of these processes resulted in the creation of a steam navy in France. But the last two processes were necessary prerequisites to the first, for without an industrial and technological base the navy would not have been able to count on having the new technology available in time of need. The navy saw this clearly--more clearly, in fact, than it saw

any immediate need for large numbers of steamers. Thus, while it took an ambivalent attitude towards the introduction of steam in the fleet, it took an early interest in introducing and developing steam technology in France.

In doing this the navy not only satisfied its own needs, but also intervened at a crucial point in the general economic development of France. The steam engine industry was one of the foundations of the industrial revolution, and the navy made deliberate and persistent efforts to develop it in France. Some idea of the importance of these efforts may be gained from the few statistics that are available (some of which are collected in Appendix B). Navy orders accounted for a significant part of the output (measured in horsepower) of the major steam engine manufacturers. As of 1842, as has been seen, a third to a half of the work of the three largest firms, Cavé, Hallette and Schneider, had been for the navy. However the size of the navy's engines was more important than their quantity, for only large engines could provide the technical challenges and financial incentives needed to cause private manufacturers to make significant increases in their productive capabilities. In the size of its engines the navy was far ahead of the rest of France. When it first ordered engines of 160 horsepower, the largest engines in the French merchant marine were about half that size. (Land-based engines were probably further behind, as they tended to be smaller, though much more numerous, than marine engines.) The same was true each time the navy increased the power of its

engines, to 220, 320 and 450 horsepower. It was still true in 1850. In that year the navy was building an engine of 960 horsepower for Napoléon and several in the 450 to 650 horsepower range, while the merchant marine included only three steamers of 320 horsepower and four others of over 200 horsepower (all Rhône river steamers incapable of going to sea), out of a total of three hundred steamers.[1] The deliberate policy of the navy, and the size of the engines that it ordered, were a key factor in the expansion of the French steam engine industry, and it thus appears that naval needs played an important, and hitherto underestimated, role in the introduction of the industrial revolution into France. At the same time, some of the problems faced by the navy reflected some of the weaknesses of heavy industry in France, which remained long after France had achieved mastery of steam technology.

With the successful introduction of steam technology, the first of the modern revolutions in maritime technology was essentially complete. But marine technology never returned to an extended period of equilibrium, such as it had experienced before 1815. Hardly had the wooden steam battleship been accepted as the capital ship of the future when it was overthrown by a new revolution--the one in naval artillery. This revolution was in fact brewing during the entire period discussed here: Paixhans had shown as early as 1824 that new types of artillery were capable of devastating existing wooden ships. However the

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[1] Enquête, 1849, vol. 3, annexe 12.

implications of his experiments were evaded by the world's navies until technology and experience showed a way to respond to them and still maintain the seagoing capital ship as the core of naval forces. The way was finally indicated during the Crimean War, when it was found that iron armor, capable of keeping out the largest projectiles, could be mounted on the side of a ship. In 1858 Dupuy de Lôme produced plans for the first armored seagoing capital ship, Gloire, and in a few years the wooden battleship was as obsolete as the sailing battleship. But now not only the mobility of a warship (its engines) but also its offensive strength (its guns) and its defensive strength (its armor) were dependent on industrial technology; and constant advances in that technology, which kept shifting the advantage back and forth between the offensive and the defensive while producing larger and more powerful engines, have kept warship technology in a state of flux ever since. Today mobility at sea, both on and below the surface, is provided by nuclear reactors as well as by steam boilers, the offensive is represented by the aircraft and the missile instead of the gun, and electronic gadgets have replaced armor as a ship's main defense; but the race between the three goes on and, as of now, the achievement of a new equilibrium in naval technology to replace the one overthrown by the introduction of steam seems more improbable than ever.

APPENDIX A

FRENCH FLEET PROGRAMS, 1820-1846

TABLE 3

FRENCH FLEET PROGRAMS, 1820-1846

	1820-1824	1827	1837	1842	1845-1846
Battleships					
1st rank	10	10	10	10	10
2nd rank	10	10	10	10	10
3rd rank	15	15	15	15	15
4th rank	5	5	5	5	5
Frigates					
1st rank	17	17	17	17	15
2nd rank	17	17	17	17	20
3rd rank	16	16	16	16	15
Corvettes					
Covered Battery	5	5	8	8	20
Open Battery	5	5	12	12	} 20
Corvette-avisos	10	10	10	10	
Brigs					
Large	30	30	30	30	30
Small	15	15	20	20	20
Small sailing vessels	15	15	50	50	30
Other small	(as required)		--	--	--
Transports	(as required)		50	50	16
Steamers					
450-600 HP	--	--	--	20	10
320-400 HP	--	--	--	} 20	20
220-300 HP	--	--	--		20
150-200 HP	--	24	40	} 30	30
0-120 HP	--	6	--		20
Steam floating batteries	--	--	--	--	2
TOTAL	170	200	310	340	328
Proportion of above to be kept complete on ways					
Battleships	--	1/3	1/2	1/2	2/5
Frigates	--	1/3	1/2	1/2	1/5
Additional reserve on ways, about half-built (not included above)					
Battleships	--	13	13	13	as required
Frigates	--	16	16	16	as required

SOURCES: 1820-24: Ann. Mar., no. 59 (1836), pp. 55-61. 1827: Budget, 1829, p. 24; Budget, 1831, p. 20. 1837: Ann. Mar., no. 62 (1837), pp. 221-30. 1842: Ann. Mar., no. 77 (1842), pp. 412-15. 1845-46: Ann. Mar., no. 89 (1945), pp. 949-51 (steam only); Ann. Mar., no. 94 (1846), pp. 913-15 (steam and sail).

APPENDIX B

STEAM ENGINES IN FRANCE, 1819-1851

TABLE 4

STEAM ENGINES IN FRANCE, 1819-1851

Year (31 Dec.)	NAVY # of Ships	NAVY Total HP	NAVY Largest Engine	POST OFFICE # of Ships	POST OFFICE Total HP	POST OFFICE Largest Engine
1819	2	64	32			
1820	2	64	32			
1821	2	64	32			
1822	2	64	32	1	30	30
1823	5	304	80	2	80	50
1824	5	304	80	2	80	50
1825	5	304	80	2	80	50
1826	5	312	80	2	80	50
1827	5	440	160	2	80	50
1828	9	892	160	2	80	50
1829	10	1052	160	2	80	50
1830	11	1212	160	0	0	0
1831	12	1372	160			
1832	14	1572	160	1	60	60
1833	19	2492	160	3	160	60
1834	16	2652	160	3	160	60
1835	16	2780	160	4	320	160
1836	21	3480	160	13	1760	160
1837	24	3860	160	13	1760	160
1838	25	4260	220	13	1760	160
1839	30	5120	220	13	1760	160
1840	32	5500	220	13	1760	160
1841	37	6700	450	13	1760	160
1842	46	9600	450	16	2160	160
1843	61	14660	450	23	3600	220
1844	71	16080	540	24	3760	220
1845	73	16960	540	24	3760	220
1846	78	17980	540	23	3690	220
1847	88	20190	540	22	3700	220
1848	101	22960	650	20	3380	220
1849	105	24350	650	20	3380	220
1850	110	26510	960	17	3020	220
1851	112	27480	960	3	420	150

TABLE 4--Continued

Year (31 Dec.)	MERCHANT MARINE # of Ships	Total HP	Largest Engine	LAND-BASED # of Ships	Total HP	Largest Engine
1819						
1820						
1821						
1822						
1823						
1824						
1825						
1826						
1827	64	1894	80			
1828						
1829						
1830						
1831						
1832						
1833	75	2635		947	14746	
1834	82	2724	140	1132	15741	
1835	100	3863	140	1448	19126	
1836	105	4148	140	1749	23411	120
1837	124	5408	180	1969	26187	
1838	160	7493	180	2125	28902	
1839	225	11297		2547	35779	
1840	211	11422		2591	34350	
1841	227	11856	180	2807	37296	
1842	229	11794		3053	39010	
1843	242	12748		3369	42514	
1844	238	12789		3645	45780	
1845	259	18050		4114	50187	
1846						
1847						
1848						
1849	300	21816	320			
1850						
1851						

SOURCES: Navy and Post Office: Compiled from Appendix C. Merchant Marine, 1827: Tourasse and Mellet, Essai, pp. 16-22. Merchant Marine, 1833-45: France, Ministère des Travaux Publics, de l'Agriculture et du Commerce, Direction générale des ponts et chaussées et des mines, Compte rendu des travaux des ingénieurs des mines, 1846, p. 93, and C.R. Constructeurs, 1841-43, p. 239. Merchant Marine, 1849: Enquête, 1849, vol. 3, annexe 12. Land-based, 1833-45: Travaux des ingénieurs des mines, 1833-45. (A detailed breakdown of the data on land-based engines for 1835 and 1836 can be found in A.N., F14-4233, Documents 1 and 2.)

APPENDIX C

LIST OF THE FRENCH STEAM NAVY, 1818-1852

LIST OF THE FRENCH STEAM NAVY, 1818-1852

Key to the list (column numbers in parentheses)

(1) Name of ship. All ships in official lists between 1 January 1819 and 1 January 1852 (1 January 1850 for those below 120 horsepower) are included. Ships which were cancelled before receiving names are listed as "N."

(2) Date construction scheduled to start, or actually started, whichever came first. As some of these schedules were made up one or two years in advance, program changes (column 7) could occur before these dates. Dates in parentheses for the transatlantic packets are those of their permanent assignment to the navy.

(3) Date construction actually started.

(4) Date launched. Engines usually installed immediately after launch.

(5) Date deleted from list of effective warships.

(6) Final disposal. A date indicates date sold or scrapped. "Lost" indicates loss from any cause. "Canc" indicates cancelled. "Navy" and "Mesg" indicate postal packets transferred to the Navy or to the Messageries Nationales respectively. Where a word occurs in column 6, the date of the change referred to is that in column 5, while subsequent naval service is given in column 7.

(7) Builder of hull. Major program changes, changes in name and miscellaneous notes follow below the builder's name. Only major changes in horsepower are shown. "HP" indicates horsepower. "Merc" indicates mercantile.

(8) Builder of engines.

(9) Nominal horsepower.

I. Avisos (Second Class)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Early, paddle								
VOYAGEUR	1818	1818	1819	1826		Lorient	/Périer	32
AFRICAIN	1818	1818	1819	1827		Lorient	/Périer	32
CAROLINE	1822	1823	1823	1833		Rouen	/Manby	50
						(ex GALIBI 1824) -renamed LOUISE 1828		
COUREUR	1822	1823	1823	1837		Rouen	/Manby	80
RAPIDE	1822	1823	1823	1834	1840	Rouen	/Aitken	80
SERPENT	1824		1826	1833		Rouen	/Manby	40
Later, paddle								
REQUIN	1826	1827	1828	1835		Brest	/*	32
						(*Engine from VOYAGEUR)		
VILLE DU HAVRE	1828			1834	1843	Purchased		100
REMORQUEUR	1830	1830	1832	1832		Cherbourg	/Pelletan	40
RAMEUR	1830	1830	1831	1831		Cherbourg	/Dumoulin	60
AFRICAIN	1830	1830	1832	1838		Indret	/Indret	40
N	1830			1831	Canc	Cherbourg		80?
N	1830			1831	Canc	Cherbourg		80?
BRASIER	1832	1832	1833	1854		Toulon	/Fawcett	100
FLAMBEAU	1832	1832	1837	1861	1880	Brest	/*	80
						(*Engine from PELICAN)		
COURSIER	1836	1836	1836	1843		Indret	/Indret	60
EREBE	1836	1836	1837	1849		Indret	/Maudslay	60
GALIBI	1840	1840	1841	1854		Brest	/Sudds	80
VOYAGEUR	1840	1841	1841	1864	1872	Indret	/*	80
						(*Engine from old RAPIDE)		
RAPIDE	1840	1840	1841	1859	1859	Indret	/Indret	60
ALECTON	1840	1840	1843	1853		Cherbourg	/Beslay	60
VEDETTE		1841	1842	1856	1856	Indret	/Indret	120
						(ex COMTE D'EU 1844)		
ERIDAN	1842	1842	1843	1846	Lost	Cavé	/Lorient	60
SERPENT	1843	1843	1843	1854		Cavé	/Cavé	30
BASILIC	1843	1843	1843	1854	1865	Cavé	/Cavé	30
ANTILOPE	1844			1851		Purchased		60
CHACAL	1844			1862	1862	Purchased		60
LIAMONE	1844			1862	1866	Purchased		60
RUBIS	1844			1862	1865	Purchased		60
VAR	1844			1854	1882	Purchased		70
ANACREON	1844	1845	1846	1859	1859	Indret	/Indret	120
						(ex PASSE PARTOUT 1845) (ex ANACREON 1844)		
N	1845			1844	Canc	Brest		80
N	1845			1844	Canc	Lorient		80
AVERNE	1847	1847	1848	1878	1880	Indret	/Indret	100
GUET N'DAR	1847	1847	1848	1854	Lost	Guibert	/Guibert	20

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Later, paddle--cont'd								
DAIM	1847	1848	1849	1877	1885	Gache	/Gache	120
FLAMBART	1848	1848	1849	1856	1861	Nillus	/Nillus	120
BISSON	1849	1849	1850	1871	1914	Lorient	/Lorient	100
						(ex TANTALE 1850)		
GALILEE	1849	1849	1851	1868	1890	Lorient	/Lorient	100
Postal packets, paddle								
HENRI IV	1822			1830		Purchased		30
DUC DE BORDEAUX			1823	1830		Rouen	/Aitken	50
COURRIER	1832			1847		Purchased		60
POSTE			1833	1847		Cherbourg	/Fawcett	50
ESTAFETTE			1833	1847		Cherbourg	/Fawcett	50
AJACCIO			1842	1850	Navy	Benet	/Pihet	120
						-Navy until 1871-1871		
BASTIA			1843	1850		Chaigneau	/Mazeline	120
DAIM			1847	1855	Navy	Chaigneau	/Schneider	150
						-Navy until 1878-1878		
						-Navy name: CHAMOIS		
BICHE			1846	1855	Navy	Chaigneau	/Schneider	150
						-Navy until 1858-Lost		
						-Navy name: ANTILOPE		
Postal packets, screw								
NAPOLEON			1842	1850	Navy	Normand	/Barnes	120
						-Navy until 1890-1903		
						-Navy name: CORSE		
FAON			1847	1855	Navy	Normand	/Penn	120
						-Navy until 1878-1882		
Screw (Navy)								
SALAMANDRE	1843	1846	1847	1871	1871	Toulon	/Benet	120
PASSE PARTOUT	1845	1845	1846	1868	1870	Indret	/Indret	120
						-to Post Office 1850		
						-returned 1855		
PELICAN	1846	1846	1847	1873	1885	Indret	/Indret	120
ARIEL	1847	1847	1848	1873	1875	Toulon	/Benet	120
MARCEAU	1850	1850	1852	1871	1903	Cherbourg	/Indret	120
DUROC	1850	1851	1852	1856	Lost	Cherbourg	/Cherbourg	120
Mixed-propulsion schooner								
PINGOUIN	1844	1844	1844	1856	1856	Chaigneau	/Mazeline	30

(1)	(2)	(3) (4) (5) (6)	(7)	(8)	(9)
Mixed-propulsion corvette-avisos					
BICHE	1846	1846-1848-1868-1868	Malo	/Mazeline	120
SENTINELLE	1846	1846-1848-1869-1877	Chaigneau	/Mazeline	120
		II. Avisos (first class)			
Early, paddle					
NAGEUR	1826	1826-1827-1838-	Cherbourg	/Manby	160
SOUFFLEUR	1826	1826-1828-1834-1865	Cherbourg	/Aitken	160
PELICAN	1826	1826-1828-1834-1865	Lorient	/Gengembre	160
Standard type (and two purchased units), paddle					
SPHINX	1827	1828-1829-1845-Lost	Rochefort	/Fawcett	160
CASTOR	1827	1829-1831-1853-1865	Indret	/Martin	120
CROCODILE	1827	1829-1832-1856-1856	Indret	/Indret	160
VAUTOUR	1827	1830-1834-1863-1866	Indret	/Indret	160
ARDENT	1829	1829-1830-1860-1881	Brest	/Frimot	160
CHIMERE	1829	1831-1833-1861-1871	Indret	/Cavé	160
			(ex 80-HP 1831)		
SALAMANDRE	1829	1831-1833-1835-Lost	Indret	/Cavé	160
			(ex 80-HP 1831)		
FULTON	1830	1832-1833-1867-1867	Rochefort	/Hallette	160
PHENIX	1830	-1831-Canc	Indret		160
STYX	1832	1832-1834-1867-1867	Indret	/Indret	160
PHARE	1832	1833-1835-1865-1866	Indret	/Indret	160
			(ex 80-HP 1832)		
METEORE	1833	1833-1833-1867-1872	Rochefort	/Hallette	160
RAMIER	1833	-1849-1878	Purchased		150
ECLAIREUR	1833	-1834-Lost	Purchased		150
PAPIN	1834	1834-1836-1845-Lost	Indret	/Fenton	160
CERBERE	1834	1834-1836-1864-1866	Indret	/Indret	160
TARTARE	1834	1834-1836-1867-1867	Indret	/Cavé	160
ACHERON	1835	1835-1835-1869-1872	Indret	/Hallette	160
ETNA	1835	1835-1836-1847-Lost	Indret	/Cavé	160
COCYTE	1835	1835-1837-1867-1875	Indret	/Indret	160
PHAETON	1836	1836-1837-1849-	Indret	/Hallette	160
TONNERRE	1836	1836-1838-1859-1877	Indret	/Cavé	160
EUPHRATE	1837	1837-1839-1862-1862	Indret	/Indret	160
BRANDON	1837	1837-1839-1841-Lost	Lorient	/Vilback	160
GRONDEUR	1838	1838-1839-1860-1875	Lorient	/Sudds	160
GREGEOIS	1838	1838-1839-1865-1865	Cherbourg	/Indret	160
TENARE	1838	1838-1840-1861-1861	Toulon	/*	160
			(*Engine from NAGEUR)		

(1)	(2)	(3) (4) (5) (6)	(7) (8)	(9)
Postal packets, paddle				
SESOSTRIS		-1835-1851-Navy	Cherbourg/Hallette	160
			-Navy until 1861-1895	
TANCREDE		-1836-1851-Mesg	Brest /Miller	160
SCAMANDRE		-1836-1851-Mesg	Rochefort/Maudslay	160
RHAMSES		-1836-1848-Lost	Cherbourg/Cavé	160
MENTOR		-1836-1851-Mesg	Toulon /Bury	160
LICURGE		-1836-1851-Mesg	Lorient /Fenton	160
LEONIDAS		-1836-1851-Mesg	Brest /Miller	160
EUROTAS		-1836-1851-Mesg	Rochefort/Maudslay	160
MINOS		-1836-1847-1847	Lorient /Indret	160
DANTE		-1836-1846-1846	Lorient /Indret	160
PERICLES		-1842-1848-Lost	Toulon /Benet	160
TELEMAQUE		-1844-1851-Mesg	Toulon /Benet	160
Later, paddle (navy)				
BRANDON	1843	1844-1846-1867-1867	Lorient /Lorient	160
AUSTRALIE	1843	1844-1844-1867-1876	Chaigneau/Mazeline	160
NARVAL	1843	1843-1844-1875-1877	Benet /Benet	160
SOLON	1844	1844-1846-1867-1879	Indret /Indret	160
DAUPHIN	1844	1844-1847-1868-1868	Guibert /Gache	180
PETREL	1844	1844-1846-1855-Lost	Malo /Babonneau	180
REQUIN	1844	1846-1847-1862-1874	Coureau /Gache	180
EPERVIER	1846	1846-1847-1857-Lost	Guibert /Babonneau	180
MOUETTE	1846	1846-1847-1867-1867	Taylor /Taylor	200
			(ex 80-HP 1845)	
HERON	1846	1846-1847-1871-1874	Guibert /Cavé	200
			(ex 80-HP 1845)	
GOELAND	1846	1846-1848-1872-1887	Guibert /Gache	200
			(ex 80-HP 1845)	
PHENIX	1846	1846-1848-1871-1874	Malo /Nillus	200
ECLAIREUR	1844	1846-1847-1868-1868	Indret /Indret	200
			(ex 220-HP 1846)	
			(ex 160-HP 1845)	
PROMETHEE	1847	1847-1848-1868-1868	Indret /Indret	200
			(ex 220/300-HP 1846)	
MILAN	1848	1848-1849-1865-1865	Cherbourg/Mazeline	200
			(ex screw 1848)	
Screw				
MEGERE	1849	-1848-Canc	Rochefort	200
			(possibly paddle)	
MEGERE	1851	1852-1853-1875-1901	Rochefort/Rochefort	200
LUCIFER	1851	1852-1853-1874-1887	Rochefort/Rochefort	200
AIGLE	1852	1852-1853-1858-Lost	Cherbourg/Cherbourg	200
			-renamed EPERVIER 1858	

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

III. Corvettes (Second class)

Standard type, paddle

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAVOISIER	1836	1836	1838	1865	1887	Indret	/Indret	220
						(ex 160-HP 1835)		
VELOCE	1836	1836	1838	1860	1860	Rochefort	/Fawcett	220
CAMELEON	1837	1837	1839	1858	1865	Rochefort	/Indret	220
						(ex 160-HP 1836)		
GASSENDI	1837	1837	1840	1865	1866	Indret	/Indret	220
						(ex 160-HP 1837)		
PLUTON	1838	1838	1841	1854	Lost	Brest	/Schneider	220
ARCHIMEDE	1841	1841	1842	1853	1868	Brest	/Schneider	220
						(ex 450-HP 1840)		
MONGE #1	1841			1841	Canc	Rochefort		220
						(ex 160-HP 1840)		

Transatlantic packets, paddle

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PHOQUE	(1845)	1841	1842	1855	1878	Indret	/Stehelin	220
ESPADON	(1845)	1841	1842	1852		Indret	/Pauwels	220
ELAN	(1845)	1841	1843	1851		Indret	/Stehelin	220
CAIMAN	(1845)	1841	1843	1854	Lost	Indret	/Pauwels	220

Postal packets, paddle

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ALEXANDRE			1843	1851	Mesg	Chaigneau	/Hallette	220
EGYPTUS			1843	1851	Mesg	Benet	/Benet	220
LOUQSOR			1843	1851	Mesg	Coureau	/Pauwels	220
NIL			1843	1851	Mesg	Coureau	/Pauwels	220
OSIRIS			1843	1851	Mesg	Benet	/Benet	220
CAIRE			1843	1851	Mesg	Lorient	/Cavé	220

Later, paddle (navy)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CASSINI	1841	1843	1845	1863	1869	Lorient	/Schneider	220
						(ex 320-HP 1840)		
TITAN	1842	1843	1844	1868	1896	Toulon	/Cavé	220
NEWTON	1844	1845	1848	1857	Lost	Cherbourg	/Cavé	220
						(ex 320-HP 1844)		
						(ex 220-HP 1843)		
COLIGNY	1843	1845	1850	1888	1889	Rochefort	/Rochefort	300
						(ex 450-HP 1843)		
EUMENIDE	1846	1846	1848	1887	1907	Chaigneau	/Hallette	300
GORGONE	1846	1846	1848	1869	Lost	Chaigneau	/Hallette	300
TANGER	1846	1847	1849	1874	1889	Brest	/Indret	300
TISIPHONE	1846	1847	1851	1872	1875	Lorient	/Lorient	300
LABORIEUX	1847	1847	1848	1861	1879	Rochefort	/Rochefort	220
SOUFFLEUR	1847	1847	1849	1887	1888	Indret	/Indret	220

(1)	(2)	(3) (4) (5) (6)	(7) (8)	(9)
Screw				
CHAPTAL	1840	1844-1845-1862-Lost	Cavé /Cavé	220
			(ex paddle 1842)	
			(ex 450-HP 1840)	
			(ex 160-HP 1839)	
CATON	1843	1844-1847-1874-1875	Toulon /Schneider	260
			(ex paddle 1843)	
			(ex 160-HP 1843)	
LUCIFER	1849	-1848-Canc	Cherbourg	300
			(possibly paddle)	

IV. Corvettes (first class)

(1)	(2)	(3) (4) (5) (6)	(7) (8)	(9)
Early, paddle (covered battery)				
CUVIER	1840	1841-1842-1848-Lost	Lorient /Miller	320
			(ex 450-HP 1840)	
			(ex 300/400-HP 1839)	
Standard type, paddle (open battery)				
PRONY	1844	1845-1847-1861-Lost	Brest /Indret	320
			(ex SOCRATE 1846)	
			(ex 220-HP 1843).	
COLBERT	1843	1845-1848-1867-1867	Cherbourg/Indret	320
			(ex 220-HP 1843)	
CATINAT	1844	1845-1851-1880-1885	Rochefort/Rochefort	400
			(ex 450-HP 1843)	
BERTHOLLET	1849	1850-1850-1866-1866	Rochefort/Schneider	400
			(probably ex screw 1848)	
Screw (open battery)				
COMTE D'EU	1844	1844-1846-1882-1914	Normand /Schneider	320
			-renamed PATRIOTE 1848	
			-ren. REINE HORTENSE 1853	
			-ren. CASSARD 1867	
ROLAND	1843	1845-1850-1870	Toulon /Mazeline	400
			(ex paddle 1845)	
			(ex 450-HP 1843)	
			-ren. REINE HORTENSE 1852	
			-ren. ROLAND 1853	
MONGE	1847	-1848-Canc	Toulon	400
			(ex 600-HP screw frigate 1847)	
PHLEGETON	1849	1850-1853-1868-1868	Cherbourg/Indret	400
LAPALCE	1850	1850-1852-1879-1880	Lorient /Schneider	400
PRIMAUGUET	1850	1850-1852-1877-1886	Brest /Mazeline	400

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Screw (covered battery)								
D'ASSAS	1851	1852	1854	1878	1922	Lorient	/Indret	400
DU CHAYLA	1852	1852	1855	1875	1890	Lorient	/Lorient	400
						(ex VOLTA 1855)		
V. Frigates								
Early, paddle								
INFERNAL	1838	1840	1843	1861	Lost	Rochefort	/Indret	450
						(ex 320-HP 1840)		
						(ex 220-HP 1839)		
Standard type, paddle								
DESCARTES #2	1838	1840	1844	1867	1867	Rochefort	/Rontgen	540
						(ex GOMER #1 1841)		
						(ex 160-HP 1839)		
VAUBAN #2	1838	1840	1845	1865	1867	Lorient	/Rontgen	540
						(ex ASMODEE #1 1841)		
						(ex 220-HP 1839)		
SANE #1	1842			-1841	-Canc	Cherbourg		450
VAUBAN #1	1842			-1841	-Canc	Lorient		450
DESCARTES #1	1842			-1841	-Canc	Rochefort		450
TAMERLAN	1844			-1844	-Canc	Rochefort		540
GODEFROI	1844			-1844	-Canc	Lorient		540
Converted transatlantic packets, paddle								
GOVER #2	(1841)	1840	1841	1868	1868	Rochefort	/Fawcett	450
ASMODEE #2	(1841)	1840	1841	1865	1865	Rochefort	/Fawcett	450
SANE #2	(1841)	1840	1847	1859	Lost	Cherbourg	/Indret	450
MOGADOR	(1841)	1840	1848	1878	1880	Rochefort	/Schneider	650
						(ex MONGE #2 1844)		
Transatlantic packets, paddle								
DARIEN	(1848)	1841	1842	1869	1869	Cherbourg	/Cavé	450
						-merc.NEW YORK 1847-48		
ULLOA	(1848)	1841	1842	1865	1902	Cherbourg	/Cavé	450
						-merc.MISSOURI 1847-48		
CHRISTOPHE COLOMB	(1848)	1841	1843	1868	1878	Brest	/Cavé	450
						-merc.PHILADELPHIE 1847-48		
CANADA	(1848)	1841	1843	1871	1878	Brest	/Schneider	450
						-merc.UNION 1847-48		
MAGELLAN	(1846)	1841	1843	1879	1884	Brest	/Cavé	450

Transatlantic packets, paddle--cont'd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CARAIBE	(1845)	1840	1842	1847	Lost	Lorient	/Schneider	450
ELDORADO	(1846)	1841	1843	1871	1875	Lorient	/Indret	450
CACIQUE	(1846)	1840	1843	1869	1869	Lorient	/Indret	450
GROENLAND			1843	1844	Lost	Rochefort	/Hallette	450
MONTEZUMA	(1845)	1841	1843	1863	Lost	Rochefort	/Hallette	450
PANAMA	(1845)	1841	1843	1871	1896	Rochefort	/Hallette	450
ALBATROS	(1845)	1841	1844	1879	1880	Rochefort	/Schneider	450
LABRADOR	(1845)	1841	1842	1871	1878	Toulon	/Schneider	450
ORENOQUE	(1845)	1841	1843	1878	1880	Toulon	/Schneider	450

Special small type, paddle (navy)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CAFFARELLI	1843	1845	1847	1867	1882	Brest	/Indret	450
						(ex PLATON 1846)		
						(ex 320-HP 1844)		
						(ex 220-HP 1843)		

Regular type, screw

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ISLY	1846	1846	1849	1872	1875	Brest	/Cavé	650
N	1852			1853	Canc	--		(34 guns)
N	1852			1853	Canc	--		(34 guns)

Mixed-propulsion frigate

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
POMONE	1842	1842	1845	1877	1887	Lorient	/Mazeline	220

VI. Floating Batteries

Floating batteries (screw)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TONNANT	1847			1848	Canc	Brest		450
PROTECTEUR	1847			1848	Canc	Lorient		450

VII. Battleships

Steam battleship (screw)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
NAPOLEON	1848	1848	1850	1876	1884	Toulon	/Indret	960
						(ex 24 DE FEVRIER: 1850)		

Mixed-propulsion battleships

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CHARLEMAGNE	1849	1850	1851	1882	1882	Toulon	/Benet	450
AUSTERLITZ	1849	1851	1852	1872	1894	Cherbourg	/Indret	500

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mixed-propulsion battleships--cont'd.								
JEAN BART	1850	1850-	1852-	1869-	1869	Lorient	/Indret	450
MONTEBELLO	1851	1851-	1852-	1867-	1889	Toulon	/Indret	140
						(launched as sail 1812)		

SOURCES: _Budget, 1820_ to _Budget, 1852_. (Each contains an official fleet list among its appendices.) France, Ministère de la Marine, _Liste de la Flotte_, 1850-1922. (Some information from this series kindly provided by Dmitri D. Selesneff.) Information on engines is from A.N., C-879, Document 16; _C.R. Constructeurs 1841-43_, pp. 249-52; and correspondence in A.M., Marine 1DD1.

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Archives and Special Collections

Archives de la Marine

Call numbers from this series are preceded by the word "Marine." This series is physically split: parts are located in the Service Historique de la Marine at Vincennes ("A.M."), and parts are located in the Archives Nationales at Paris (A.N."). The following sections were consulted:

AA Acts of the sovereign authority

BB General Services

BB1 Reports and decisions of the Office of Movements (A.N.)

BB4 Campaigns, expeditions, etc. (A.N.)

BB5 Movements of ships (Registers, etc. A.N.)

BB7 Foreign navies (BB7-1 to 11: A.M.)

BB8 Papers of the Office of the Minister and various commissions

BB8-824 to 900: Council of Admiralty (Conseil d'Amirauté, abbreviated C.A. Location: A.N.)

BB8-1106 to 1165: Council of Works (Conseil des Travaux, abbreviated C.T. Location: A.M.)

CC Personnel

CC7 Dossiers relating to individual officers. (A.M.)

DD Materiel

1DD1 Outgoing correspondence of the Office of Naval Construction (including the Office of Steam Vessels). The documents examined were primarily the "decisions": reports sent by the Director of Ports (since these offices were under his jurisdiction) to the Minister and approved by him (abbreviated "Ports to Minister in the footnotes). (A.M., transferred from A.N. 1974.)

4DD1 Contracts (4DD1-1 to 6: A.M.)

7DD1 Dossiers relating to individual ships no longer in the navy. Primarily incoming correspondence and reports. (A.M.)

8DD1 Plans of ships (A.M.)

GG Miscellaneous

GG1 Memoirs and projects (A.M. and A.N.)

GG2 Personal papers (A.M. and A.N.)

Bibliothèque de la Marine

The navy library is located in the Service Historique de la Marine at Vincennes. Its manuscript collection includes an untitled memoir by Baron Jean-Marguerite Tupinier (Director of Ports, 1823-1842).

Archives Nationales, Paris ("A.N.")

C Records of national assemblies (Parliament)

C-717 to 905: Records relating to bills and hearings

C-1010: Records of the Parliamentary investigation of the navy of 1849-51

C-2744 to 2777: Petitions

F Administrative Documents (Ministries)

F12 Commerce and Industry

F14 Public Works

F20 Statistical documents

AP Private Papers

156-AP: Mackau family

Archives Nationales: Section Outre-Mer, Paris ("A.C.")

Senegal

Senegal I-5 to 6: General correspondence

Senegal XVI-43: Local naval station, 1817-1865

Martinique

Martinique 143-1284: Documents on Comte Donzelot

Guyane (French Guiana)

Guyane A11-03: Correspondence of the governor

Guyane F1-09 Colonization

Guyane F5-01 Mana

Guyane P1-2 Missions of Ships

Bibliothèque Nationale, Paris ("B.N."): Brochures

Comité des intérêts métallurgiques

Circulaire du 15 février 1840 (no. 1) (B.N.: V-35150)

Circulaire du 24 mai 1840 (no. 4) (B.N.: V-35150)

Comité des constructeurs de machines

Compte rendu des travaux du Comité des constructeurs de machines (1840-1841) (B.N.: V-13681)

Ibid., (1842-43) (B.N.: V-13682)

Ibid., (1843-45) (B.N.: V-13683)

Public Record Office, London

ADM.: Admiralty Papers

ADM. 3: Minutes

ADM. 88: Surveyor's Submission Letter Books, especially numbers 10 through 14 (1841-1852)

ADM. 180: Progress Books (ships, 1792-1872)

Naval Library, Ministry of Defence, London

The Naval Library holds some bound manuscript records, including an untitled series of annual manuscript navy lists.

Official and Semi-Official Serial Publications

Chamber of Deputies

France, Sénat et Chambre des Députés. Archives Parlementaires de 1787 à 1860. (Ends in 1839.)

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France, Ministère du Commerce et des Travaux Publics, Direction générale des ponts et chaussées et des mines. Compte rendu des travaux des ingénieurs des mines (1833 and 1835).

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