The Design of Shallow-Draft Steamers for the British Empire, 1868–1906

ROBERT V. KUBICEK

"Gunboat diplomacy" is a shorthand description for the means by which the British imperial state in the 19th century imposed its will on weaker polities with navigable coastlines, rivers, and lakes. The negotiations, favorable treaties, and advantageous trading arrangements that flowed from these impositions have been minutely examined by scholars of British expansion and theorists of imperialism.[1] Some of the steam vessels employed to back the diplomacy of imperialism have been thoroughly examined, as well—for example, the navy's classic screw-driven gunboat, which typically drew 8–12 feet of water and was first developed for inshore work in the Black Sea during the Crimean War.[2] But the Admiralty and other government departments of the Victorian state used a variety of steam vessels—many of considerably less draft and fitted with other forms of propulsion—for numerous less-remarked-on but nonetheless important tasks. These shallow-draft vessels, the process by which they were chosen, and the uses to which they were put have not been systematically studied.[3]

DR. KUBICEK, professor of history at the University of British Columbia, did archival work for this article with the assistance of the Social Science and Humanities Research Council of Canada. He thanks the *Technology and Culture* referees and his colleague Fritz Lehmann for their helpful comments.

[1]See especially Winfried Baumgart, *Imperialism, the Idea and Reality of British and French Colonial Expansion, 1880–1914* (Oxford, 1982); David K. Fieldhouse, *Economics and Empire, 1830–1914* (London, 1973); Ronald Robinson and John Gallagher, *Africa and the Victorians: The Climax of Imperialism in the Dark Continent,* 2d ed. (London, 1981).

[2]Antony Preston and John Major, *Send a Gunboat; A Study of the Gunboat and Its Role in British Policy, 1854–1904* (London, 1967); Barry M. Gough, *Gunboat Frontier, British Maritime Authority and Northwest Coast Indians, 1846–1890* (Vancouver, B.C., 1984); David Lyon, *The Ship: Steam, Steel and Torpedos: The Warship in the 19th Century* (London, 1980), pp. 42–43.

[3]Preston and Major (n. 2 above), p. 191, exclude river gunboats from their elaborate analysis. For the selection and deployment of steam vessels for Asian and African rivers, ca. 1820–45, see Henry T. Berstein, *Steamboats on the Ganges, an Exploration in the History of India's Modernization through Science and Technology* (Calcutta, 1960), and Daniel R.

0040-165X/90/3103-0001$01.00

Sir Edward J. Reed (1830–1906), one of the best-known naval architects of the Victorian era, designed or surveyed numerous shallow-draft craft for British colonies and protectorates. But historians have neglected this part of Reed's long, controversial, and illustrious career, focusing instead on his work as the navy's chief constructor between 1863 and 1870, as inventor of the ironclad warship, as contributor to the development of the forerunner of the modern battleship, and as designer of warships for the governments of several nations. He also was a Liberal member of Parliament (1874–95, 1900–1905) and a frequent contributor to contemporary discussion on the construction and performance of steamships. His arrogance, "fiery" temperament, "prolific pen," and insistence on theoretical study rather than practice as the source of superior naval design stirred "violent opposition" to his career.[4] In 1906, Reed, though near death, felt compelled to defend his work designing ships for colonial administrations. In a paper he was too ill to present himself to the Institution of Naval Architects, he reviewed the specifications and performance of some seventy-five vessels that he had designed or whose construction he had supervised since 1885 for twenty-five British crown colonies and protectorates.[5] Almost all were destined for work in the tropics.

Reed's work contributed to the transfer of technology from the temperate industrialized to the tropical nonindustrialized regions of the world. As such it may be viewed, in Daniel Headrick's phrase, as the "geographic relocation of technology by Western experts."[6] Within that process, two interrelated sets of priorities and preferences determined the design and selection of colonial craft. One set, in which Reed played a key role, reflected the practices and policies of government departments of the London-centered Victorian state. The other set grew out of the needs and experience of colonial

---

Headrick, *Tools of Empire: Technology and European Imperialism in the Nineteenth Century* (New York, 1981), pp. 17–62.

[4]Stanley Sandler, *The Emergence of the Modern Capital Ship* (Newark, N.J., 1979), pp. 20–33; see also *Dictionary of National Biography, 1901–11:* 171–73; *Engineering* 82 (December 7, 1906): 770–72; and David K. Brown, *A Century of Naval Construction: The History of the Royal Corps of Naval Constructors, 1883–1983* (London, 1983), pp. 38–44.

[5]Edward J. Reed, "On Vessels Constructed for Service in Our Colonies and Protectorates," *Transactions of the Institution of Naval Architects* 48 (1906): 19–55, also reprinted in *Engineering* 81 (April 6, 1906): 462–70; Kenneth C. Barnaby, *The Institution of Naval Architects, 1860–1960: An Historical Survey of the Institution's Transactions and Activities over 100 Years* (London, 1960), pp. 238–39.

[6]Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850–1940* (New York, 1988), p. 10.

administrators pursuing their ambitions and responsibilities in the tropics. To determine whether Reed supplied these administrators with appropriate technology or, in his words, "types of vessels considered most suitable for their various services,"[7] this article addresses three interrelated themes. First, it considers how Reed, as a technical expert, was recruited and used by Whitehall. Second, it examines the rapidly changing small steamboat technology to which Reed and his associates had access. Finally, it surveys the many uses to which the vessels he designed were put within and on the frontiers of colonial jurisdictions.

Selecting and Designing Colonial Steamers, 1868–1870

Reed's work for the empire began much earlier than he indicated in his 1906 paper. In 1868, when he was still the Admiralty's chief constructor, he became the consulting naval architect and engineer to the Crown Agents for the Colonies. This agency acted as an economic and technical adviser to the Colonial Office and as a banker, broker, buyer, shipper, and contract negotiator for the crown colonies. A rather anomalous establishment, neither a government department nor a private firm, the Crown Agents nonetheless served an important function in arranging for the purchase and distribution of a number of the tools of empire, ranging from weapons to railways.[8]

The Crown Agents had been instructed to obtain a 400-ton, five-gun, paddle-wheel steamer for the Straits Settlements, one similar but on a smaller scale to an Admiralty vessel Reed had designed. For 3 percent of its cost or a sum of £500 he would design the vessel and supervise its construction.[9] The colonial governor wanted the ship to tour his jurisdiction, visit neighboring native states, service lighthouses, and run down local pirates.

Reed was also offered commissions during 1869–70 to select two other colonial steamers, one for Sierra Leone and the other for Ceylon. In the first instance, the Colonial Office had failed to obtain a suitable steamer to carry out government policy on the west coast of Africa. A parliamentary committee considered withdrawing the imperial factor from the region. Instead, the imperial presence would be made cheaper and more efficient by providing a chief governor with his own steamship at Sierra Leone. The vessel could carry troops and

[7]Reed, *Engineering* (n. 5 above), p. 462.

[8]Richard M. Kesner, "Builders of Empire: The Role of the Crown Agents in Imperial Development, 1880–1914," *Journal of Imperial and Commonwealth History* 5 (May 1977): 310–30.

[9]Reed to Crown Agents, June 9, 1868, Public Record Office (PRO), CO 273/23/6118.

its own armaments and thereby allow garrisons to be reduced as well as permit the chief administrator to supervise three other stations: the Gambia, Gold Coast, and Lagos.[10] He got the *Corra Linn,* a 170-foot, iron-hulled screw steamer drawing 11 feet. This vessel was found inappropriate; it drew too much water for Sierra Leone's estuaries and rivers and was underpowered, and its hull was subject to corrosion.[11]

With no expertise of their own, the Colonial Office and the Crown Agents had paid an officer of the Emigration Office with some knowledge of ships to select and fit out the *Corra Linn.* Its unsuitability no doubt convinced them that they needed better advice. From two shipbuilding firms, Money Wigram of Blackwall on the Thames and Lairds of Birkenhead near Liverpool, the agents obtained replacement offers based on the specifications of the *Corra Linn*'s captain. From John Dudgeon, another Thameside shipbuilding firm, they also got estimates of what it would cost to repair and alter the *Corra Linn.*[12] Then the Admiralty was asked whether Reed would give his advice and assistance. Naval officials had no objection if arrangements were made directly with Reed. He offered with "much pleasure" to give "prompt attention" to the matter for 2.5 percent "upon the cost of works designed, arranged or executed" under his supervision.

Colonial Office staff found the practice of payment by percentage on expenditures abominable and "a disgrace to a commercial country." Moreover, Reed, as the colonial secretary pointed out, was paid by the public for his whole time, and he should get only out-of-pocket expenses for work outside the naval dockyards. In the event, the office got Reed to accept a straight fee of £200, which was more than 2.5 percent of repairs and alterations but less than the same percentage of what a new steamer would cost.[13]

Reed's second commission involved a coastal steamer for Ceylon to carry cargo, cabin passengers, and troops. The Crown Agents had the firm of Money Wigram, which made the low bid to build the steamer for the Straits Settlements, review the specifications of Ceylon officials and come up with plans for a steamer for under £15,000. These the agents wanted Reed to vet, for his "well known ability and great experience in such matters" came cheaply. He would revise the shipbuilding firm's plans for 2 percent of the vessel's cost, or a fee

[10]John D. Hargreaves, *Prelude to the Partition of West Africa* (London, 1966), pp. 64–90.
[11]PRO, CO 267/294/8436.
[12]Crown Agents to Colonial Office, June 17, 1868, PRO, CO 267/296/6357.
[13]Admiralty to Colonial Office, November 2, 1868, PRO, CO 267/296/12168; Reed to Colonial Office, November 22, 1868, and minutes by Colonial Office staff, CO 267/297/12773; and CO 267/297/13832.

which was less than half what any other first-class naval architect would charge.[14]

Meanwhile, Reed drew up elaborate plans for a ship to be called *Pluto* to replace a vessel of the same name for the Straits Settlements. It was to be 437 tons, wooden-hulled, turned out with first-class fittings, and driven by a pair of 150-horsepower condensing engines with a wood-burning furnace supplying steam at 25 pounds per square inch. The lowest bid to build the vessel, which came from Money Wigram, was £22,000. Reed recommended the offer be accepted.

However, the price proved prohibitive. Local officials had budgeted £17,500 to include not only the price of the vessel but also of armaments and the cost of sailing it out. The Colonial Office, preoccupied with limiting expenditure, decided to find a cheaper alternative. Through a ship surveyor from the Board of Trade it found an apparent bargain. In 1866, a Glasgow builder, J. G. Lawrie, had begun an iron-hulled paddle wheeler for Australian river work that, if finished with the heavy plates stipulated, would draw more water than the buyer had specified. He canceled the order. Lawrie kept a £2,000 advance and the unfinished vessel. It was not as capacious as Reed's design nor was its hull of wood, but it drew only 6 rather than the 8 feet he had planned. The agents had the hull completed and engines by the Scottish firm of Blackwood and Gordon installed; the finished vessel sailed unarmed to the Straits Settlements for £14,130. The office, much to its chagrin, learned later that part of the price paid was stiff commissions of 7.5 percent charged by the Board of Trade official and the ship broker who set up the deal. The office was also disappointed by the ship's performance on its station, where it gave nothing but trouble.[15]

For West Africa, Reed recommended the *Corra Linn* be replaced by a wooden or composite copper-bottomed paddle-wheel steamer of 150 feet, 30 feet longer than Sierra Leone officials recommended. This vessel, the *Sherbro,* with 100–120-horsepower engines, would do 11 knots and cost £12,500.[16] While it was under construction, the captain and chief engineer of the *Corra Linn* complained about two specifications. To ensure that the hull would not be exposed to boring worms in tropical waters, they wanted its coppering 7 inches higher than provided. They were also surprised that Reed had not designed the paddle wheels to work independently of each other, a necessity,

[14]Crown Agents to Colonial Office, December 28, 1869, PRO, CO 54/449/14221.

[15]PRO, CO 273/42/11416; CO 273/52/9657; CO 96/115/1314.

[16]Armed and delivered, the vessel cost £15,856. The *Corra Linn,* secondhand, had cost £10,000.

they argued, in turning a ship in the narrow rivers of the African coast. The agents and the office accepted Reed's rebuttals. In dismissing the need for independently arranged paddle wheels, Reed argued that vessels the size of the *Sherbro* employed for river service "are never fitted for the Royal Navy in the manner suggested."[17]

Built by John White of Cowes and engined by the Thames firm of Humphrys Tennant, the *Sherbro* reached West Africa by early 1871. The vessel was not a success. A reorganization of responsibilities of British west coast officials meant that the senior administrator at Freetown did not need to use a steamship to visit the Gold Coast and Lagos. But the *Sherbro*'s length and draft—8 feet under minimum load—limited its effectiveness for river work even in the neighborhood of Freetown. Moreover, the vessel was very expensive to run and repair, and it had to be replaced.[18]

By then Reed had been forced to give up his consultancy for the Crown Agents. The Treasury objected to Reed's receiving fees from a government agency while fully employed in a government department. Reed's colleagues at the Admiralty also had second thoughts. They did not want him to superintend the construction of any ship whose design they had not officially approved.[19] Although prevented from providing the agents with advice for a fee, Reed was able to pick his successor. On his recommendation, John A. Welch, previously superintendent of the Admiralty construction yards for cruisers (and whose office had been abolished in an administrative shake-up), was employed to carry forward the design of the Ceylon steamer.[20]

The agents added several builders to a list of firms provided by Welch and asked them all to tender for a 160-foot, 446-ton, teak-hulled, screw-driven vessel to do 10 knots with 100-horsepower engines and a maximum draft of 10 feet. The bids exceeded the original estimates. The highest bid, £23,460, came from the Clyde

[17]PRO, CO 267/308/8970; and Reed to Colonial Office, February 11, 1870, CO 267/309/1621.

[18]PRO, CO 96/115/1314.

[19]Minutes on Crown Agents to Colonial Office, December 28, 1869, PRO, CO 54/449/14221; Admiralty to Colonial Office, March 8, 1870, CO 54/459/2517.

[20]Crown Agents to Colonial Office, July 11, 1870, PRO, CO 54/459/7442. Through a lengthy apprenticeship, long experience, and in-house examinations, Welch had become what was then called a naval draughtsman. The term was a misnomer, for such persons had the skills and did the work of a naval architect, which required them to calculate weight, center of gravity, draft, trim, and stability as well as draw up plans and specifications. See Great Britain, *Parliamentary Papers,* "Report of [the] Entry, Training and Promotion of the Professional Officers of the Dockyards, and in the Department of the Controller of the Navy," 1883 (277), XVII, 46–48.

firm of J. and G. Thomson. Money Wigram, which had provided the original specifications that Welch modified for the tender, was the low bidder at £17,600. This bid was about £1,500 more than the original estimate because Welch had reworked the design of the hull.[21]

He also chose the ship's engines. Money Wigram recommended simple, low-pressure machinery by Humphrys Tennant and Company. But Welch convinced the agents and the office that similar but more costly equipment by John Penn of Greenwich, perhaps the best-known engine builder of the day, who provided much machinery for Admiralty ships, was better. He also deflected the suggestion of Ceylon officials that compound engines be tried. They had learned that the Peninsular and Oriental Steam Navigation Company had sharply reduced fuel costs using such engines in its deep-sea vessels and wanted a "full enquiry into the subject with the view of adopting that principle of Engines for the new Steam vessel about to be built for the Island Service, should it be found more serviceable in regard of durability, simplicity of working and economy of fuel, than the ordinary low pressure, condensing Engines. . . ."

But Welch preferred to go with what was proved. He doubted the savings in fuel consumption claimed for compound engines and stressed evidence that they were not reliable. Moreover, he put the question to the engine builders themselves. The firms of Humphrys Tennant and John Penn, as well as another London establishment, Maudslay and Sons, offered to provide compound engines at more expense. But reservations expressed by Penn and Humphrys Tennant buttressed Welch's preferences: "The saving in fuel," reported Penn and Company, "over the plan we originally sent in, will be about 10 to 15 percent, but in the former case although the Engines were on the expansive principle the pressure on the Boilers was only 30 lbs., and we think it may perhaps be worth consideration whether for the sake of this saving it would be worth while adopting this kind of Engine for Colonial purposes as the wear and tear is greater with steam at 60 lbs., than at 30 lbs., and would require more care on the part of the Engineers." Humphrys Tennant concurred: "The high pressure at which it is proposed to work the boilers is also an objection in our opinion as sufficient time has not yet elapsed since their introduction of high pressure boilers to enable us to judge of their durability—we know they require more repairs than those working at low pressure, and for a hot climate like Ceylon where the care of the boilers

[21]PRO, CO 54/459/7442.

practically devolves upon native firemen we cannot recommend their adoption."[22]

The Colonial Office initially balked at the cost of the Ceylon steamer. Robert Herbert, a senior official, told the agents that he thought a suitable secondhand boat could easily be found.[23] The agents countered that a secondhand boat would need repairs sooner and that repairs were very expensive and difficult to carry out in Ceylon. They also claimed that it was essential that the hull of a vessel working the eastern seas be coppered teak, which was easily maintained and more comfortable for passengers. Very few such vessels were available. In the end the Colonial Office accepted the agents' arguments, and Ceylon got a new steamer, the *Serindib,* in September 1871.

The contribution of Reed and Welch in the design and selection of steam vessels for colonial service in the tropics in the late 1860s and early 1870s had two notable aspects. First, although they apparently came cheap, their designs were actually very expensive. Reflecting their Admiralty background, they wanted to build very strong, well-finished vessels. Second, they preferred to go with proved rather than new technologies. Welch, for example, opposed compound engines in the early stage of their adaptation to marine work, and Reed continued to opt for wooden hulls. Though their clients complained about cost and raised questions about materials and machinery, they accepted what Reed and Welch recommended.

What alternatives were available? British shipbuilders were satisfying the cost-conscious private sector with innovative vessels that exploited several new technical developments. Metallurgical breakthroughs led to ever-larger and more powerful ships constructed by ever-larger and more specialized firms.[24] But several shipbuilders also adapted technical advances to produce specialized shallow-draft vessels. Some installed compound engines in river steamers for tropical work.[25] Some equipped such vessels with high-pressure boilers. By the late 1870s steel was widely used for boiler shells and occasionally for

[22]Master Attendant of colonial vessels to Ceylon Colonial Secretary, Colombo, February 21, 1870, and other enclosures in ibid.

[23]PRO, CO 54/459/2517.

[24]Sidney Pollard and Paul L. Robertson, *The British Shipbuilding Industry, 1870–1914* (Cambridge, Mass., 1979), pp. 84–87.

[25]For example, between 1868 and 1874 the Glasgow firm of Robert Duncan built seven paddle steamers for a British company operating in Burma that were supplied with compound engines by Rankin and Blackmore, Greenock. H. J. Chubb and C. L. D. Duckworth, *Irrawaddy Flotilla Company Limited, 1865–1950* (Greenwich, London, 1973), p. 79.

vessel hulls.[26] Surface condensers, which provided clean, fresh water instead of dirty or salt water, also prolonged boiler life.

One of the leaders in small-vessel production was the Thameside firm of Yarrow and Hedley. From 1866 it had built numerous steam launches that were, in effect, scaled-down versions of larger ocean-going vessels. But Yarrow and Hedley also built craft whose draft relative to their length and breadth was extraordinarily shallow. As early as 1871, for private firms working on the Amazon River, the firm was turning out 85-foot paddle wheelers, with Bessemer steel plates one-eighth of an inch thick, that drew only 21 inches.[27] Shortly thereafter, it designed a version of the stern-wheel river steamer. Instead of a wooden hull and beam engine, which were characteristic of sternwheelers in the United States, these were of steel with inclined or horizontal direct-acting machinery.[28] The hull was often constructed in watertight sections so that it could be shipped abroad for assembly on the spot. These sections were bolted or riveted and pressed together to give added rigidity by the placement of the boiler well forward and the engines aft. By 1877 Yarrow had built such vessels up to 120 feet in length, not only for Latin American waters but for the East Indies and even for the operations of the Hudson's Bay Company in Canada.[29]

In ships of very shallow draft, if conventionally arranged propellers were to be fully immersed, they must be of small diameter and thus of limited propelling power. Hence these vessels were normally fitted out with either side or stern wheels. However, John Thornycroft, another Thameside company that specialized in small craft, built in

[26]For an illuminating study of when affordable and dependable steel products came to be widely used, see J. F. Clarke and F. Storr, *The Introduction of the Use of Mild Steel into the Shipbuilding and Marine Engine Industries* (Newcastle, 1983).

[27]*Engineering* 11 (April 14, 1871): 269–70.

[28]The steamer in the United States evolved in navigational conditions similar to what British colonial authorities encountered in the tropics: uncharted rivers with flows and bottoms that altered dramatically and with few repair and docking facilities. British shipbuilders, used to the placid rivers and good docking arrangements of the home country, ignored the American technology. Only one, e.g., incorporated the beam engine, commonly used in American river steamers, in its designs. Why British builders did not exploit American designs is discussed in Norman S. Russell, "On American River Steamers," *Transactions of the Institution of Naval Architects* 2 (1861): 105–27; and in "The Western River Steamboat," *Engineering* 62 (July 31, 1896): 141–42. Both British and American firms operating in the rivers and on the coast of China initially preferred American steamers. But by 1869 they opted for British-built iron-hulled steamers. See Edward K. Haviland, "American Steam Navigation in China, 1845–1878," *American Neptune* 16 (October 1956): 255–59.

[29]*Engineering* 24 (December 7, 1877): 432–33.

1875 a successful 63-foot twin-screw vessel for work on the Nile. Its screws were set in arched indentations in the ship's hull; though the indentations were partly above the waterline, they filled with water when the propellers revolved.[30]

New Designs for New Jurisdictions, 1878–1886

The design and production of the specialized shallow-draft vessel, operating in uncharted waters where it had minimal access to maintenance, boomed in the 1880s. Attempting to extricate General Gordon from Khartoum, the imperial state turned to private industry, which hurriedly provided more than twenty such steamers for the Nile in 1884–85. Yarrow built five sternwheelers and Thornycroft five screw-tunnel vessels. And John Elder (later the firm of Fairfield) of Clydeside got a contract for fourteen stern-wheel gunboats.[31] Most of these craft were deployed too late to be a factor in the failed rescue attempt, but in the next decade they helped prepare the way for conquest of the Sudan.

Meanwhile, firms specializing in shallow-draft craft serviced numerous nations and interests. Some built ships for agents of King Leopold of Belgium, who pegged out an empire for himself in central Africa. Forrestt and Son of Limehouse built a steam launch for a Belgian expedition in 1880. Edwards and Symes of Cubbit Town, another Thameside firm, built a sternwheeler in 1884 on the design of the engineer-in-chief of the Belgian government for the Association Internationale du Haut Congo of Brussels, a front for Leopold's designs. Thornycroft also built a steamer for work on the Zaire River. Called *Peace,* propelled by screws in tunnels, and drawing only 12 inches, it was for missionary service. The Clyde builder, William Denny and Brothers, produced the first of numerous sternwheelers for the Irrawaddy Flotilla Company in 1882. The French government in 1884 had five stern-wheel gunboats constructed for use on the rivers of Indochina. These followed a design developed by Yarrow. Russians and Latin Americans, in integrating hinterlands into their empires, also purchased numerous river craft.[32]

Colonial authorities under the supervision of the Colonial Office, concerned with patrolling the peripheries of their jurisdictions and

[30]Ibid., 75 (April 10, 1903): 498–500.

[31]Evidence of profit is seldom available, but Messrs. Elder charged the Admiralty £60,000 for ten gunboats while their costs were less than £29,000. Cost and Order Book, Strathclyde Regional Archives, Glasgow, UCS2/73/1 ff. 28–30.

[32]*Engineering* 29 (June 18, 1880): 475; ibid., 37 (January 18, 1884): 63; ibid., 25 (May 18, 1883): 463–64; "Small Light-Draught Twin-Screw Steamers for Service of the Argentine Republic," ibid., 34 (August 25, 1882): 198; ibid., 37 (January 11, 1884): 37;

strengthening their administrations, also perceived the need for more and better shallow-draft craft. Before Reed was reemployed, the Crown Agents continued to use Welch on an occasional basis as a naval consultant. In 1878 he was called in to consider the specifications of purpose-built steamers for Lagos, one to cross its notorious bar, the other to work the extensive adjacent shallow lagoons—or, if possible, one that would combine both functions. The design process began with specifications for a bar steamer, roughly worked out by the engineer in charge of government vessels at Lagos who adapted plans he saw in an engineering periodical of a ship built in Britain for the Portuguese government. The Lagos governor also had a say and was concerned that he get a boat of sufficiently shallow draft and with suitable cabin arrangements by which he could move easily and in style through the network of lagoons within and beyond his jurisdiction. The office, of course, had cost as a first priority. Perhaps a steamer already on the station could be patched up and made to do. But its staff also made design suggestions. One civil servant, for example, seemed partial to flat-bottomed—or "tea-tray"—instead of V-shaped hulls.[33]

In producing designs to meet these varied guidelines, Welch had to be concerned with several factors; three were particularly crucial. One was draft, which colonial authorities wanted set ideally at 2 but not more than 3 feet. But this might not be sufficient for the vessel to cope with rough water on the bar or in the roadstead beyond. In addition, if the ship was not seaworthy it would have to be shipped out in pieces or sections and assembled on the shores of the lagoon. A second concern was propulsion. Should it be by side wheels or stern wheels, or single or twin screws? A third concern was the material for the hull—should it be wood, iron, or steel? Engine choice was not a problem; Welch wanted the light, durable, and proved machinery of John Penn.

Welch thought a ship to serve both bar and lagoon work was possible, but he much preferred one for each purpose: ". . . for the rough work over the Bar would require a Vessel of deeper draught, and better hold in the water, than can be given to a Vessel required for working in the shallow water of the Lagoons."[34] He also preferred a V-hulled side-wheeler. He did not think engines and boilers could be incorporated into a flat-bottomed vessel if cabins were to be fitted

---

Chubb and Duckworth (n. 25 above); George Rickard, "Light Draught River Steamers," *Transactions of the Institution of Naval Architects* 36 (1895): 216–33.

[33]PRO, CO 147/35/12409 /36/1210; minute by Robert Meade, April 2, 1878, CO 147/36/3939.

[34]Welch to Crown Agents, June 3, 1878, PRO, CO 147/36/7046.

forward. Ignorant of its proved use for shallow-draft work in tight quarters, he pronounced the " 'stern wheel' [to be] no good, except to work in straight canals" for he thought there "would be a complete loss of power in backing astern" and this would lead to "bad steering." To enable his craft to navigate out to West Africa and do occasional bar work he designed it to have a draft of 3 feet, the maximum allowed by the colony's specifications.

When the work went to tender the office required bids on both Welch's design and a design for a vessel which could be "sent abroad in sections to be re-erected in the Colony," so it could "judge of their relative costs."[35] One of three bids received was from a company that had built light-draft vessels for Africa. This was the Thames firm of Edwards and Symes. Its bid, which provided for Penn engines, was recommended both by Welch and by the steam vessel engineer at Lagos. The firm offered to build a tea-tray-hulled vessel for £4,250 and reassemble it at Lagos for an additional £900, or construct Welch's vessel capable of sailing out for £4,950. However, a lower bid came in from another Thames firm, R. and H. Green of Blackwall, which would assemble a ship at Lagos for £900 and build it for £3,900 or construct one of Welch's design for £3,900. Faced with these figures, the Crown Agents and the Colonial Office opted for Welch's side-wheeler but at the lower bid.[36]

This 126-foot, 30-horsepower, wood-hulled vessel named *Gertrude* arrived in Lagos in June 1879 after a voyage out of thirty-seven days.[37] Shallow-draft vessels had short life spans on the West African coast because able staff to run them was difficult to obtain and keep alive and because at that time no ship repair facilities were available. Nonetheless, *Gertrude* did "remarkably good service" for more than six years before it wore out and local officials called for a sternwheeler to replace it.

What was wanted was a more maneuverable ship capable of 10 knots with a draft well below 3 feet. Local officials knew that a private company operating on the Niger was having "great success" with paddle wheelers of 2.5-foot mean draft that could speed 10 knots and that had boilers forward and engines and paddles aft: "Some such ship as one of these might . . . meet . . . requirements for lagoon work, the lower deck being made serviceable for soldiers and crew, the upper deck for the accommodation of officers. It would also have the

[35]Welch to Crown Agents, April 5, 1878, and Colonial Office to Crown Agents, April 8, 1878, CO 147/36/3939.

[36]Colonial Office to Crown Agents, June 29, 1878, PRO, CO 147/36/7046.

[37]With armaments and the expense of navigating it to its station, the vessel cost £5,792.

advantage of having the paddle floats protected against sunken stakes or snags, not possessed by the 'Gertrude.' "[38]

Reed and His Critics, 1885–1900

To obtain a ship to replace the *Gertrude,* the Colonial Office turned to Reed, who had already been rehired in 1885 to design a vessel for work at the Gold Coast. Controversy plagued both undertakings. For the Gold Coast, a ship to cope with Atlantic swells along its exposed coastline was required at an estimated cost of £9,000. It was also expected to move administrators and troops to Lagos from Cape Coast Castle. Named *Governor Maclean,* the vessel was completed in 1886 at a cost of £13,000, exclusive of armaments and Reed's £350 fee. In rehiring Reed as their consulting naval architect the Crown Agents had arranged a fee schedule that featured a sliding percentage that decreased as the project cost increased; it provided for a fee of 2.5 percent on works costing between £12,000 and £20,000.[39]

Reed chose wood for the hull. Gold Coast officials preferred wood and the Admiralty had also obtained good results using wooden-hulled side-wheelers for survey and reconnaissance work on the West African coast. The ship drew 6 feet of water. It had return-tube boilers operating at 100 psi and surface-condensing inverted diagonal compound engines linked to twin screws that drove the vessel at 11 knots. Built and engined by the Barrow Shipbuilding Company of Barrow-in-Furness, then a small company concentrating on naval contracts, it had excellent accommodation for "a superior dignitary and his staff" and a troop deck to carry 100 men, but little cargo capacity. When members of the Gold Coast legislature learned of the *Governor Maclean*'s cost of construction, that the vessel would be expensive to operate, and that Lagos would not share these expenses, they refused to take delivery. After trying unsuccessfully to get other tropical jurisdictions to purchase it, the Colonial Office had to sell the vessel to private interests for £6,000, less than half the original cost.[40]

Though Reed claimed later to have been the first to design stern-wheel vessels for service in Africa,[41] this was not actually the case. As noted above, numerous sternwheelers for both governments and companies had been designed and built in the late 1870s and

[38]Acting Administrator Frederick W. Evans to Colonial Office, September 23, 1886, PRO, CO 147/57/19151.

[39]PRO, CO 96/194/19263; Reed complained he made no money because the fee was too low. Reed to the Crown Agents, November 1, 1898, PRO, CAOG 10/36.

[40]*Lloyd's Register* for 1894–95 reported the steamer, renamed *Carenero,* operating in Venezuelan waters.

[41]Reed to Crown Agents, June 5, 1896, PRO, CO 147/108/12759.

early 1880s. Reed's first design of this class of boat was not completed until 1887 and was for the Indian government service in Burma.[42] Moreover, while others were using Siemens steel for their hulls, his first sternwheeler for Africa called for iron.

Built and engined by Lairds, the vessel was to operate in the Lagos lagoon. Since it was too large to be put on board an oceangoing steamer and too fragile to steam out, its iron plates were shipped separately and riveted together at Lagos. On the basis of carrying out similar work in India, Reed calculated that it could be erected in three months. With no riveters available locally and attempts to train Africans to do the job unsuccessful, skilled workmen were imported from Liverpool. Fever and alcohol abuse led to considerable absenteeism. In the end a dozen European workmen used 60,000 rivets and took fourteen months to erect the hull and install machinery.[43]

The *Margaret* was operational in April 1889. Including armaments and erection expenses, it cost £10,670. The 125-foot vessel was powered by compound surface-condensing engines and drew 2.5 feet. Within seven and a half years it was worn out—the boilers seriously impaired and the hull in very bad condition. The governor also complained of its "defective" accommodation, with only two small cabins, on the upper deck, that were close to the funnel and extremely hot. He thought that Lairds, which had no previous experience in building such vessels, should not have been used. A replacement vessel, he wrote, should be supplied by Yarrow; specialists in this line of work, they had already produced a flat-bottomed sternwheeler for the French colonial service on the West African lagoons.[44]

Maud replaced *Margaret* in 1897. Lairds was not the builder, but neither was Yarrow. The Scottish firm of Bow, McLachlan, which promised to build a stronger hull than Yarrow, provided *Maud* at a price much cheaper than Fairfield of Clydeside proposed. As Reed admitted, "Some considerable difficulty having been encountered in the Colony re-erecting the Margaret . . . the Maud was constructed in sections, each section being rivetted up complete, and the whole temporarily bolted together to ensure all being fair and in line." However, "it was not considered desirable to insure the expense of completing the vessel sufficiently to carry out trials in this country."[45]

[42]Reed's work for the Indian government also included two larger steamers for river and coastal work of more than 200 feet in length and drawing about 10 feet. *Engineering* 41 (June 25, 1886): 615; ibid., 47 (December 13, 1889): 687.

[43]PRO, CO 147/67/2156 /71/13402.

[44]PRO, CO 147/71/13401; Reed, *Engineering* (n. 5 above), p. 469; PRO, CO 147/ 105/ 14178; Sir Gilbert Carter to Colonial Office, March 14, 1896, CO 147/104/7827.

[45]Reed, *Engineering* (n. 5 above), p. 465.

In the event, the 130-foot steel sternwheeler, with compound surface-condensing engines supplied by the builder, drew 3 feet and cost £11,000.

Maud too was a disappointment. Users complained of flimsy woodwork, leaking plates, defective steering, excessive vibration, and poor speed. One governor called it a "decided failure." Colonial Office staff agreed and wished the Crown Agents would get another naval architect.[46] Defects were to some extent remedied by the efforts of local engineers who, for example, installed extensive bracing to cut down vibration.

Complaints were also rebutted by Reed, who claimed that anyone who had experience with light-draft steamers would know that they exhibited vibrations in unexpected places, no matter how carefully staying might have been considered in their design. *Maud* only confirmed this common experience. "The science of the subject does not at present enable us to foresee precisely either [their] amount or locale." If such was the case, then trials in England seemed necessary. It was, as Colonial Office staff noted, very risky to do otherwise.[47]

Responding to Client Demand

Reed was also called on to design or supervise the selection of a number of steam launches. These craft, initially scaled-down versions of larger vessels, had evolved since the 1860s in a variety of forms.[48] With a length of 40–80 feet, with wooden, composite, iron, or steel hulls, with boiler pressures that varied considerably, and with simple, compound, or even triple-expansion engines, some were driven by side wheels but most by single or twin screws. They were cheap, mobile in tight quarters, and versatile. They probed very shallow waters, towed boatloads of troops into action, secured buoys, provided lesser administrators with their own means of transportation, and served senior officials when the colonial steamer was laid up. They also made sure that customs duties, the main source of local revenue, were paid on goods entering or exiting colonial waterways. On occasion they raised revenue by transporting people and goods or towing commercial vessels.

Reed planned or surveyed some forty steam launches between 1885 and 1906. He designed three similar vessels for police work in British

[46]Sir George Denton to Colonial Office, April 26, 1899, PRO, CO 147/142/13039; minute by Reginald Antrobus, October 23, 1899, CO 147/144/27425.

[47]Report by Reed with Crown Agents to Colonial Office, November 18, 1898, and minute by Edward Wingfield, December 28, 1898, PRO, CO 147/138/26060.

[48]Cf. *Engineering* 61 (April 7, 1871): 255; Chubb and Duckworth (n. 25 above), pp. 46–51.

Guiana. One of these, the *Ismay,* featured a 40-foot coppered teak hull, single screw, compound surface-condensing engines, and return-tube boilers, and was built by Cochran and Company of Birkenhead. His favorite builder for steam launches was, however, the noted Cowes yacht builder J. S. White. This firm constructed the *Alexandra,* specially built for cargo, passenger, and administrative work on the rivers of Sierra Leone. Launched in 1902, the steel twin-screw 80-foot vessel drew 3 feet, 9 inches and was driven by compound self-condensing engines.[49]

One unusual launch that Reed failed to mention in his presentation to the Institution of Naval Architects was the *Otto,* one of six launches built for the colony of Lagos in 1899. A German-built launch, the *Daddy,* owned by a Lagos merchant, had been hired for imperial service in the Niger River. Its performance so impressed the governor of Lagos that he wanted a replica for his fleet. Obtaining the *Daddy*'s specifications from its builder, Heinrich Bradenburg Steimwarder of Hamburg, Reed designed a more elaborate vessel. On the request of the Lagos administration, the Crown Agents invited Shuttleworth of Erith to tender on it. Their bid of £2,100 delivered in London was considerably higher than what the *Daddy* cost. So the Colonial Office had the original design re-tendered. The Hamburg firm that built the *Daddy* was low bidder at £140 less than British competitors. The new vessel would be delivered at Lagos for £1,750. "It appears," complained a Colonial Office official, "that even in shipbuilding Germany can outbid our people. This is no dbt the result of trades unionism."[50] The *Otto* arrived in Lagos in July 1894. It was built of iron and about 50 feet long; its compound engines had no condenser.

Another steam launch Reed did not mention was the *Ilo,* which arrived in the Lagos colony in 1899. Only 35 feet long, the teak-hulled, screw-driven boat cost £885 delivered. Built by Forrestt and Son (now with yards at Wyvenhoe, Essex), its design annoyed the governor. Such a vessel, he said, should steer from the bow in snag-filled rivers; but the *Ilo* steered from the stern, and the helmsman had to stand on tiptoe to see over the cabin. The colony had not provided detailed specifications, but he thought the expert, in this case Reed, should have known better.[51]

[49]Reed, *Engineering* (n. 5 above), p. 470.

[50]Minute by Augustus Hemming, October 6, 1893, PRO, CO 147/92/16979. It came to be office policy to have the agents purchase foreign manufacture for the colonies if savings were substantial. See circular of August 25, 1903, CO 273/304/23875.

[51]Sir William MacGregor to Colonial Office, September 12, 1899, PRO, CO 147/144/27425.

Mounting complaints about the cost and performance of steamboats supplied to the colonies prompted the Colonial Office to force a set design procedure on the agents, their naval architect, and colonial authorities to ensure that durable, purpose-built vessels were provided. "The only remedy," remarked a senior office staff member, "is to make the Crown Agents responsible. They and their naval architect must make it their business to foresee the kind of treatment which launches will receive in a West African Colony . . . and to point out, if the specifications furnished by a Colony . . . are incomplete or inconsistent, that more [information] is wanted, and not to assume, as they appear to do, that what is suitable for other places will do in W. Africa."[52] To satisfy the Colonial Office, the Crown Agents got Reed to draw up a three-page form to be completed by the colonial client.

Reed was not, however, optimistic that the form would stop complaints. Colonial personnel often did "not see the full effects of their own proposals. . . ." Those who submitted requisitions were "frequently superseded before the boats are delivered. . . ." The purposes for which the boat was to be used might not be sufficiently stated. Poor performance, the result of "bad or unskillful use," was "sometimes imputed to defective design or constructions as the best way out of a local difficulty. . . ."[53] Reed did, however, attempt to instruct his clients about some of the pitfalls he faced in meeting their needs. Invariably his colonial clients wanted vessels of very shallow draft. But this requirement must, he said, increase the difficulty of satisfying other conditions. It demanded lighter construction, faster engine speeds, and hence more expensive and complex machinery and a larger vessel. Such specifications added substantially to the cost and subsequently required more exacting maintenance. It was, therefore, important to allow for the deepest draft possible in the circumstances.

In 1901, Reed's requisition form was sent to five Asian and Indian Ocean colonies (Ceylon, Straits Settlements, Hong Kong, Mauritius, Seychelles) as well as to four West African colonies with the instruction that it be carefully followed. Filling out forms was no substitute, however, for testing vessels in Britain before shipment. Two shallow-draft cargo boats for the Northern Nigerian government, the *Kampala* and the *Karonga,* were given trials in 1901 because, as Reed observed, "previous experience with similar boats had indicated that it was worth while to incur the additional cost of completing the vessel

[52]Minute by Antrobus, February 20, 1900, PRO, CO 147/152/314.
[53]Reed to Colonial Office, August 30, 1900, PRO, CO 96/385/9930.

sufficiently in this country to allow of speed and other trials being carried out. . . ."[54]

Reed likely wished that two steamers he designed for operations on Lake Victoria had also been given trials before shipment, for their performance had again embroiled him in controversy and impugned his expertise. These sister vessels, the *Winifred* and *Sybil,* were designed for passenger and cargo service. One hundred and fifty feet long, they were supposed to carry 150 tons of cargo and 20 tons of fuel (wood or coal) on a minimum draft of 6 feet. With no other means to get them overland to the lake than human porterage, they had to be designed so they could be carried in manageable pieces. The vessels' hulls and machinery were temporarily erected in the builder's yards. Then "every part of the work was carefully marked before being dismantled" and shipped in more than 3,000 pieces or packages for each vessel along with "full and detailed plans and instructions" for assembly.[55] At their destination the ships were reassembled under the supervision of engineers employed in the building of the Uganda Railway, then snaking its way from the East African coast to Lake Victoria.

Soon it was discovered the ships' draft when loaded was 7.5 feet, or 18 inches over specification. Colonial authorities charged Reed had been careless. In fact, the re-erectors had apparently added more cement to the inside of the hull as well as additional deck accommodation not called for in his design. Moreover, the ships had been overloaded with cargo and coal. A Royal Engineer who happened to be in Uganda looked into the matter and calculated the overdraft to be only 6.5 inches. This did not satisfy Reed, who argued that neither the re-erectors nor the investigator was a naval architect or marine engineer and they were, therefore, incapable of following plans or assessing performance.[56]

Not all Reed's efforts triggered controversy. Innovative technology, appropriate methods to adapt it to particular purposes and conditions, and tests to assess performance produced a state-of-the-art vessel for the Niger River. Steamboats had penetrated the confusing channels of its delta and navigated its shifting sandbars and sharply fluctuating flows since the 1830s. Numerous types of vessels had been tried and found wanting. As late as 1896 two of the Royal Navy's tunnel-screw river gunboats, diverted from part of a consignment for work on the Nile, had quickly become unserviceable. Sternwheelers

[54]Reed, *Engineering* (n. 5 above), p. 465.
[55]Ibid., p. 464.
[56]Ibid.

purpose-built for the Royal Niger Company had more success. One of these, the *Empire,* was purchased from the company by colonial authorities when they assumed administrative burdens from the chartered company in 1900.[57] But Frederick Lugard, the assertive Northern Nigerian high commissioner who had used both the naval gunboats and the company sternwheelers, wanted something more appropriate and prestigious.

It took "a considerable amount of correspondence, extending over several months," before Reed could reconcile Lugard and his staff "to the limitations that I, as one subject to the laws which govern naval architecture, was compelled to place upon their desires."[58] The result was the *Corona* (figs. 1, 2). Built in 1903, its draft, with fuel, crew, and stores aboard, was 2 feet. Accommodation allowed Lugard to travel in style with a substantial staff. Their quarters were on the upper deck with the governor's oak-paneled quarters forward. "Native engineers" and crew were located aft on the main deck. Housing for the European captain and two engineers, on a short deck above the upper deck, completed accommodation clearly based on occupational and racial segregation. Triple-expansion surface-condensing engines were supplied with steam from water-tube boilers operating at 180 psi. Not only did the vessel have some of the most up-to-date machinery then employed for small, shallow-draft craft; it also featured twin screws housed in tunnels. These allowed shallow draft and in this instance evidently achieved maneuverability even in moving astern. They also had the advantage of needing less weighty and more economical machinery while providing greater speed, in this case 10.28 mph.

The ship's builder, Forrestt and Son, as well as the constructor of its engines, Plenty and Son of Newbury, Berkshire, had already provided a similar vessel for work in British East Africa and a sternwheeler for the Niger. Even so, after the *Corona* was launched, "a careful series of trials" (as Reed put it) were carried out. Moreover, to avoid vibration, "a point which was considered of much importance," the engines were carefully balanced and "special attention" paid to "the pillaring and bracing of the ship's structure." Finally, after trials, the vessel's upper structure was packed in its hold, and a tug towed it to the Niger delta.[59]

[57]See Robert V. Kubicek, "The Colonial Steamer and the Occupation of West Africa by the Victorian State, 1840–1900," *Journal of Imperial and Commonwealth History* 18 (January 1990): 9–32.

[58]Reed, *Engineering* (n. 5 above), p. 467.

[59]Ibid.; *Engineering* 77 (January 29, 1904): 156–57.

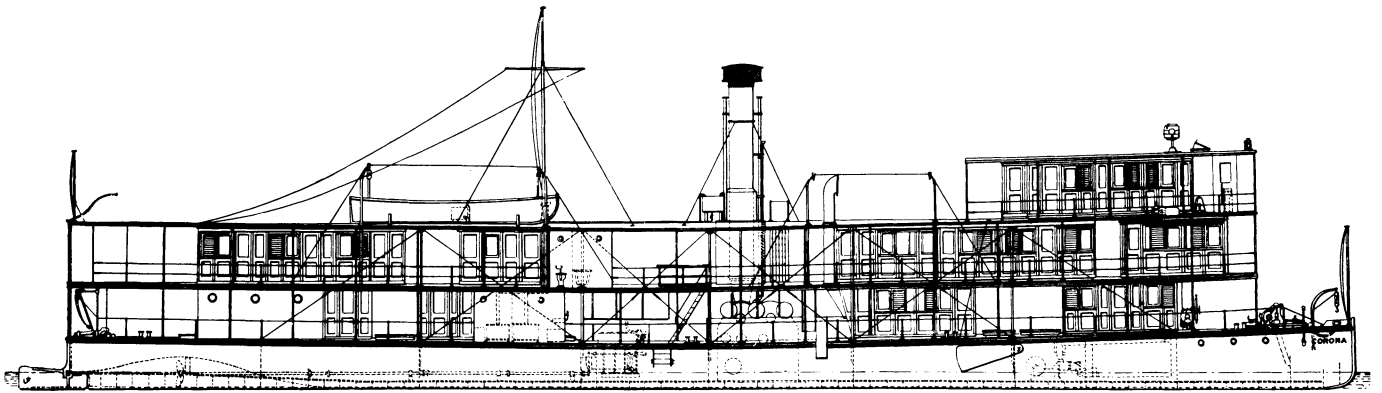

FIG. 1.—Plan of colonial river steamer *Corona*, built in 1903 for the high commissioner of Northern Nigeria and designed by Sir Edward J. Reed, showing tunnel screws, a form of propulsion first applied successfully by the firm of Alfred Yarrow in the 1870s. (From *Engineering* 77 [January 29, 1904]: 157.)

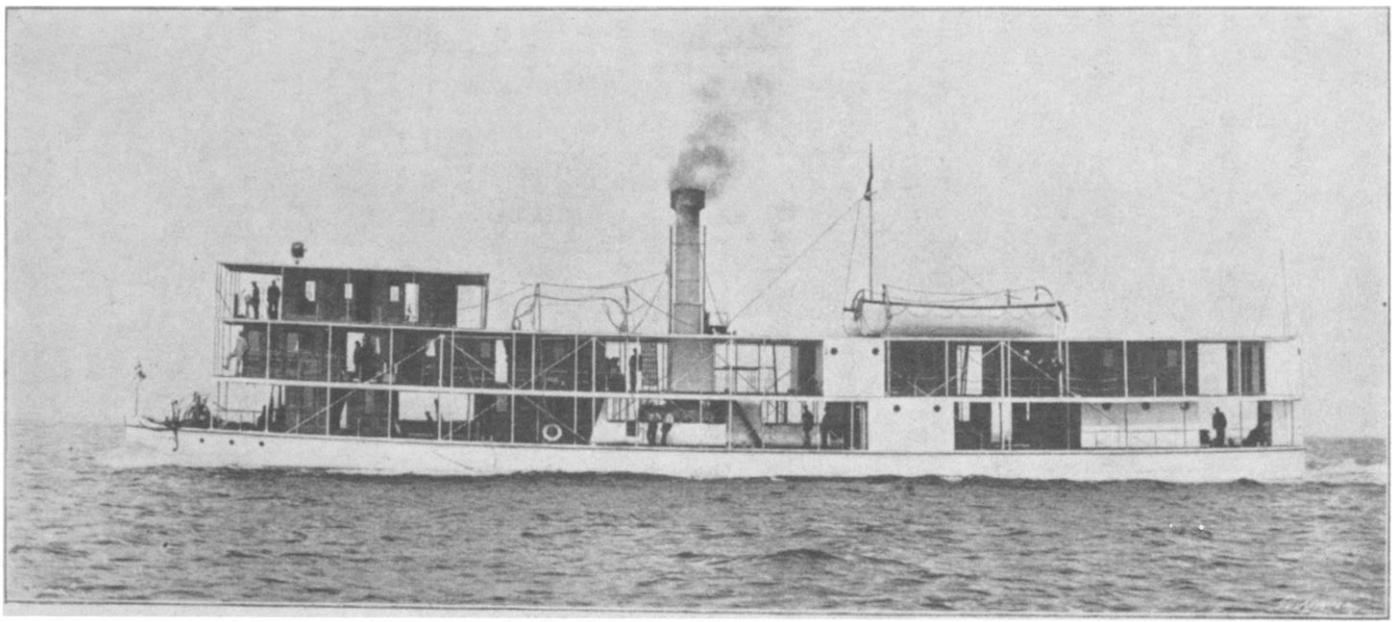

FIG. 2.—The 160-foot colonial river steamer *Corona* during steam trials in 1903, showing location of accommodation on main, upper, and wheelhouse decks. (From *Engineering* 77 [January 29, 1904]: 156.)

Reed's Contribution

During the late 19th century, the shallow-draft steamer became an exceedingly useful tool of European powers as they contended for status, imposed their will on local polities, and administered their jurisdictions in tropical Africa and Asia. In employing one of Victorian Britain's preeminent naval architects to provide them with a cheap and efficient version of this tool, the imperial factor—the Colonial Office, its administrative agents on the spot, and the Crown Agents—were not well served. They seldom got the most appropriate technology available. The Colonial Office was itself partly to blame. Though committed to providing steamboats to crown colonies and protectorates, it was also dedicated to economy. By insisting on minimal expenditures, it created false economies. The Colonial Office also allowed the agents to follow ad hoc design procedures. Only when complaints from local authorities reflected adversely on the office did it formalize arrangements. Neither the Colonial Office nor the Crown Agents made an effort to institute a system of tendering that would enhance the possibility of getting the best ship for the least expenditure.

Faced with a bewildering set of choices as steamship technology changed rapidly, these Whitehall departments sought expert advice. Reed, the expert they employed, proved neither very innovative nor conscientious in fulfilling his task. He made little effort to design vessels well suited to inshore, river, and lake work on remote tropical stations. He was, of course, frustrated by the financial constraints within which he had to operate. But it should also be remembered that he was primarily a specialist in the design of deep-water warships. Colonial authorities blamed him unfairly for their inability to keep steamers well maintained. But he did not pay much attention to the demanding conditions under which the ships he designed must operate. Uncharted waters, corrosive heat and humidity, and inadequate maintenance made for frequent breakdowns and a short operating life. Only when goaded by complaint and pressed by influential and knowledgeable officials would he adapt his skills and knowledge to the special task at hand. Reed prided himself in his use of applied theory rather than rule-of-thumb experience to predict performance, strength, stability, and displacement.[60] But there is no

[60]See Reed, "On the Advances Made in the Mathematical Theory of Naval Architecture [since 1860]," presented in July 1897 to an International Congress of Naval Architects and Marine Engineers, *Engineering* 64 (1897): 106–7, 215–16, 239–40, 272–74.

evidence to suggest that he developed such applications to arrive at the most appropriate scantlings for the shallow-draft craft he designed.

In directing work to British shipbuilders, Reed seemed partial to firms such as John S. White, located in southern England, which did considerable work for the Admiralty. Yet not only were Clydeside firms such as William Denny and Brothers with abundant experience in shallow-draft craft for tropical work passed over,[61] so too were the two Thames River establishments most equipped and skilled to meet such requirements. The firms of Alfred Yarrow and John Thornycroft were leaders in designing and producing sternwheelers and tunnel-screw vessels for the Admiralty as well as foreign governments. They also produced for the private sector, suggesting that their product was not prohibitively expensive.[62] But Yarrow built none of the vessels Reed described in the defense of his work. Thornycroft built only two, a lifeboat for Mauritius in 1903 and a passenger and cargo vessel for coastal work off Trinidad in 1905.[63] Significantly, these were constructed after colonial complaints had forced the Colonial Office to formalize the process of design selection.

The combination of the Colonial Office, the Crown Agents, and the eminent naval architect as expert yielded very indifferent success in providing suitable shallow-draft craft for the tropical colonies of the British Empire. On the other hand, advice from local clients, the authorities in the crown colonies, and protectorates to which Reed belatedly or reluctantly responded, was often not as impractical or uninformed as he suggested. Observing specialized craft operated in or near their jurisdictions by the private sector or the agents of other imperial powers, who possessed a good deal of practical experience in

[61]The renowned firm may have been passed over because one of its directors, John Denny, was a member of Parliament (1895–1905), which prevented the private company from tendering for Admiralty contracts and, presumably, other government work. See John Lyon, ed., *The Denny List* 4 (Greenwich, London, 1976), Appendix 4: 51.

[62]Philip Banbury, *Shipbuilders of the Thames and Medway* (Newton Abbot, Devon, 1971), pp. 278–86, 296–303. Yarrow moved to the Clyde in 1907, a development that underlined the decline of the Thames as a major shipbuilding site. Since Parliament was petitioned by the river's builders for assistance, it is likely that Reed as an MP would have been urged to divert business to them. However, since his consulting business was located in London and he was feeling underpaid by the Colonial Office for his services, he had little incentive to seek builders further afield.

[63]Reed, *Engineering* (n. 5 above), p. 469. At the time Reed wrote his paper on steam vessels for the colonies, Thornycroft was completing construction of two very light-draft launches he had designed to be propelled by internal combustion engines for service in southern Nigeria. Ibid., p. 466, and *Engineering* 81 (March 9, 1906): 308.

their operation, colonial officials had much to say about what was most appropriate. As in the case of advice from Nigerian administrators, Reed belatedly used specifications provided from local experience to enhance the utility of his designs. Though he was not one to admit it, Reed, the metropolitan expert, learned a good deal about the performance of shallow-draft steamboats from the experience of local officials. These men on the spot, well known in the literature on empire for disregarding the policies of Whitehall and Westminster, were also in this instance dissatisfied with the tools an eminent Victorian expert designed for their use.