National Historic Mechanical Engineering Landmark

Emery Rice T. V. Engine (1873)

U. S. Merchant Marine Academy
Kings Point, Long Island, New York
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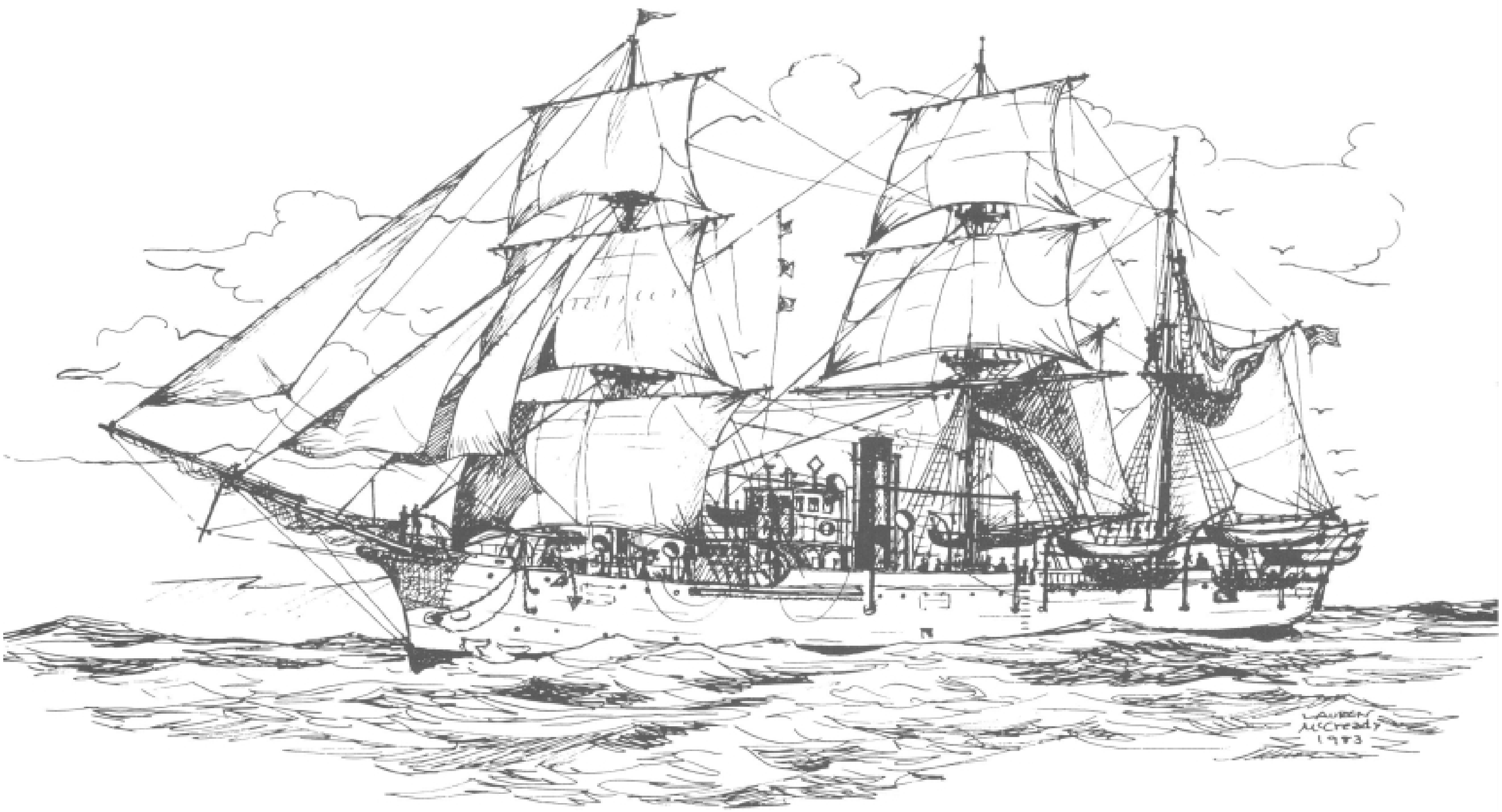
The American Society of Mechanical Engineers



The Back-Acting Engine of the T. V. EMERY RICE

This engine of the training vessel T. V. EMERY RICE was constructed in 1873 and began its long career in the USS Ranger, an iron gunboat rigged as three-masted barque and commissioned in 1876. With 1909, the RANGER was transferred to the Massachusetts Nautical Training School and was successively known as ROCKPORT, NANTUCKET and BAY STATE. The ship was again renamed in 1942 to honor Captain Emery Rice, an 1897 graduate of the Massachusetts Nautical Training School who served with distinction in both the Spanish-American War and World War I.

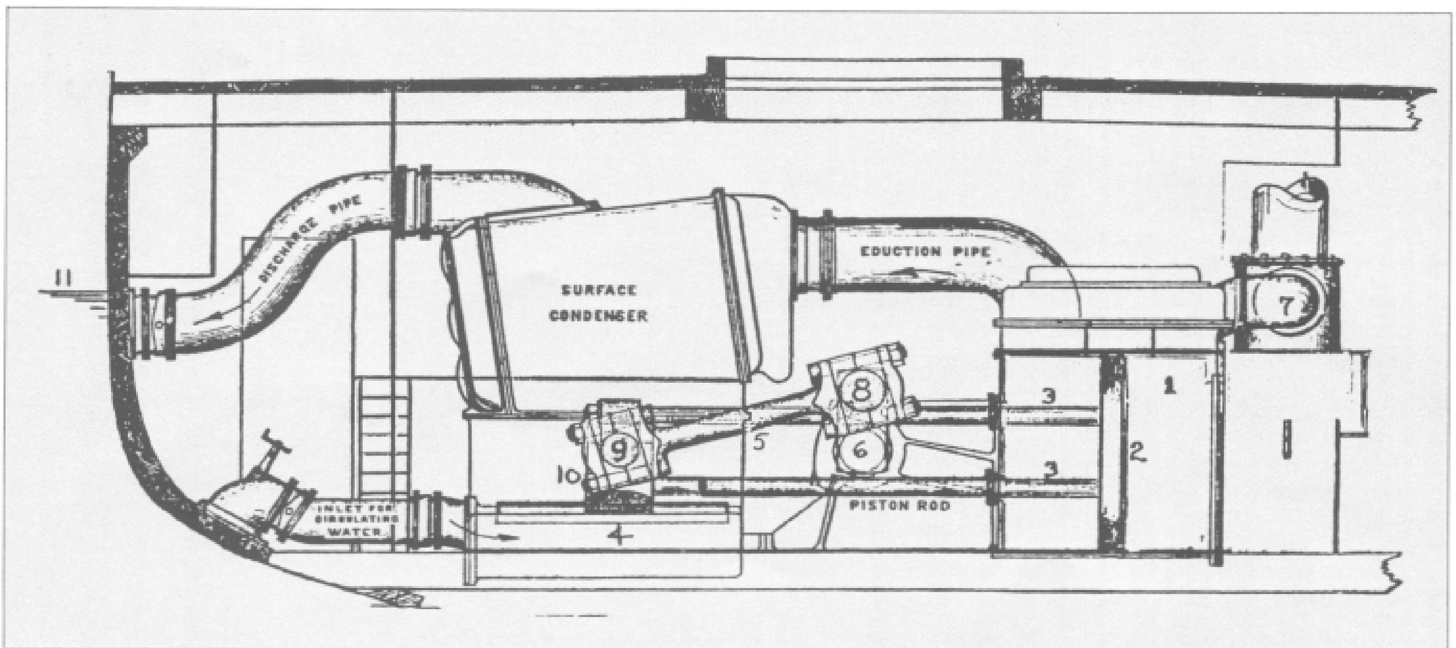
The engine is that rare thing, an actual machine from the past, an artifact not scrapped after being outmoded. By memorable foresight, the engine was saved when the iron hull that carried it was sent to the breakers in 1958. It represents a typical naval engine of the nineteenth century during the time of momentous change: sail was giving way to steam, iron hulls replacing the "wooden walls," and the entire character of naval engagements transformed as new guns and armor plate came into their own.

In this engine we have the real hardware—not pallid engravings or faded photos without a sense of scale—to show how things were near the end of a once vital development naval steam power that would soon be overwhelmed by a combination of advancing technologies.

The RANGER was one of the four last iron ships to be built. The next ships, again four, authorized in 1883, were of steel and mark the beginning of the "American Steel Navy." Of this lot, two of the three cruisers (all had ram bows), carried engines similar to "ours," while the third, the only twin-screw vessel, was fitted with two compound overhead-beam engines. The fourth ship, a dispatch vessel, was driven by a vertical compound. All in all, it was quite a power spectrum reflecting mixed opinions of the time.

This engine—the type is called "back-acting" in the United States and "return connecting-rod" in England—has all the parts of a conventional reciprocating engine that are adroitly re-arranged to form a compact horizontal compound engine. The new configuration is distinguished for being short as well as low, enabling it to lie athwartship over the keel and drive the propeller shaft directly. The arrangement of the parts is necessarily unconventional, for while the crossheads are in their expected locations, the two cranks are not. Instead of being beyond the crossheads, the cranks are quite close to

Principal parts of a back-acting engine of the period say 1855–1875. (adapted from *The Marine Steam Engine* by Sennett and Oram, London, 1915). 1–Cylinder; 2–piston; 3 and 3–two piston rods, the upper and far one being over the crankshaft 6 and the near rod passing under, with the crank turning between the rods; 4–crosshead guide; 5–connecting rod; 6–crankshaft; 7–steam inlet; 8–crankpin; 9–wrist pin; 10–crosshead; 11–waterline.



their cylinders. The connecting rods reach back or "return" from the crossheads to couple to the crank pins. To allow this, the usual single piston rods were dispensed with, and replaced by two off-center piston rods in the L. P. and an equivalent yoke from the H. P., all straddling the crankshaft. Although somewhat cramped, the arrangement does allow connecting rods of reasonable length to keep the lateral thrusts on the crosshead guides within bounds.

The fore-and-aft crankshaft is in the middle of the engine, the cylinders being to starboard with the high pressure forward. The attached condenser, salt-water circulating pump, and the air and condensate pump—are to port. The condenser lies over the crossheads and pumps, the latter being driven from the lower piston rods. All is mounted on a very massive iron frame that also carries the crankshaft main bearings. The total weight of the engine is 61 tons, and it is some 20 ft wide with fore and aft length of 10 ft, height about 6 ft.

The cylinders of 28.5 and 42.5 in bores with common stroke of 42 in are served by D-slide valves having Stephenson link motion supplemented by Meyer's Riding Cutoff for precise control of cutoff. Reverse is by steam ram, backed by handwheel and screw, and hand levers. Pistons and cylinder liners are of bronze, and the 9-in diameter crank-shaft is a one-piece forging. The glands of piston and pump rods, inaccessible when running, are toothed and engage worm gears on reach-rods terminating on the control platform to permit adjustment when the engine is operating. Bronze, not Babbitt metal, bearings are featured. The engine was designed by the Bureau of Steam Engineering of the U. S. Navy Department and constructed by John Roach & Son of Chester, Pennsylvania.

There was a 9-in propeller shaft that was interrupted by a "sailing clutch" allowing disengagement of the four-bladed, 12-ft diameter propeller of 17.5-ft pitch. With 64 rpm, the engine of 560 ihp gave the 175-ft, 1020-t ship a speed of 10 kn. Steam was furnished at 80 psig by four coal-burning, hand-fired Scotch boilers with natural draft, and the normal condenser vacuum was 26 in of mercury.

The ship that became the EMERY RICE in 1942 led an eventful life, and as a training ship was the tutor of thousands. At the start of her naval career when the USS RANGER, the ship was in service with the Atlantic and Pacific fleets and spent many years on magnetic survey duty along the western coasts, crossing the equator countless times. In 1909 she was transferred to the Massachusetts Nautical Training School as the USS ROCKPORT, the old name being assigned to a new battle cruiser in 1917. A year later, now as the USS NANTUCKET, she was given patrol service with the First Naval District but with maintenance of her training duty. With war over, the ship was again released to the School. The year 1941 had her under the name BAY STATE. Finally, in July 1942, she was transferred to the newly founded Merchant Marine Academy at Kings Point and given her last name, EMERY RICE, at the urging of Vice Admiral Richard R. McNulty, who in ordering the ship to Kings Point kept her on the active list. Age and 1944 brought retirement from sea duty that she might display her memories as Museum Ship.

The ship herself was scrapped in 1958, but the engine escaped disaster and was put into storage because of the efforts of Karl Kortum, Curator of the San Francisco Maritime Museum (now National Maritime Museum). Kortum calls it "the largest marine steam engine of its period existing anywhere." Some 25 years later, now Rear Admiral Patterson of the Academy became aware of the historic engine and bent every effort to get the engine back to Kings Point that it might become the focal point of the Marine Engineering Hall of the Academy's Museum. Patterson was also a key figure in saving the World War II Liberty Ship JEREMIAH O'BRIEN, the last steaming survivor of a once great fleet, a ship that was designated a National Historic Mechanical Engineering Landmark in September of 1984 in San Francisco. The work of guiding the rehabilitation of the EMERY RICE engine fell to retired Rear Admiral Lauren S. McCready.

A fuller account of the low-profile engines of yester-century holds enough surprises to be of interest. The engine of 1873 that gave faithful service from 1876 to 1944 relates to the period 1840–1880 that was marked by many events in a time of transition. In particular, steam power was making its way aboard the sailing ship, both on fighting vessels and merchantmen. Of two possible methods of propulsion, the paddlewheel and the screw propeller, the first was fairly obvious, whereas the screw propeller was in the early stages of being reduced to practice with clear indication of being a relatively high-speed element.

With few exceptions, the earliest steam merchant vessels had sidepaddle wheels. Straightforward and easily constructed, the requirement of low speed for the paddlewheels was compatible with that of the vertical-cylinder stationary steam engines with large oscillating beams that had been serving industry from the early 1700s. For shipboard use such engines were readily re-configured and easily adapted to the high paddle-shaft located below the weather deck. Power requirements were substantial, but low steam pressure because of the state of the boiler art made for large cylinders and massive engines standing well above the water line, some projecting through the weather deck.

Naval vessels had to cope with design parameters associated with possible damage by enemy guns. It was bad enough to have masts and sails exposed to shot, but to have highly vulnerable paddle-boxes and above-waterline machinery was out of the question. The submerged and relatively small screw at the stern was in protected position, and the engine had to be compact and sheltered by being below the waterline. This location was vital, for while the fighting ships of the forepart of the 19th century had wooden hulls more than a foot in thickness, iron plate armor would not be pioneered until the Civil War (1861–1865). The old battle tactics involved trying to disable the enemy with broadsides of solid shot delivered at point-blank range above the waterline, and then boarding him.

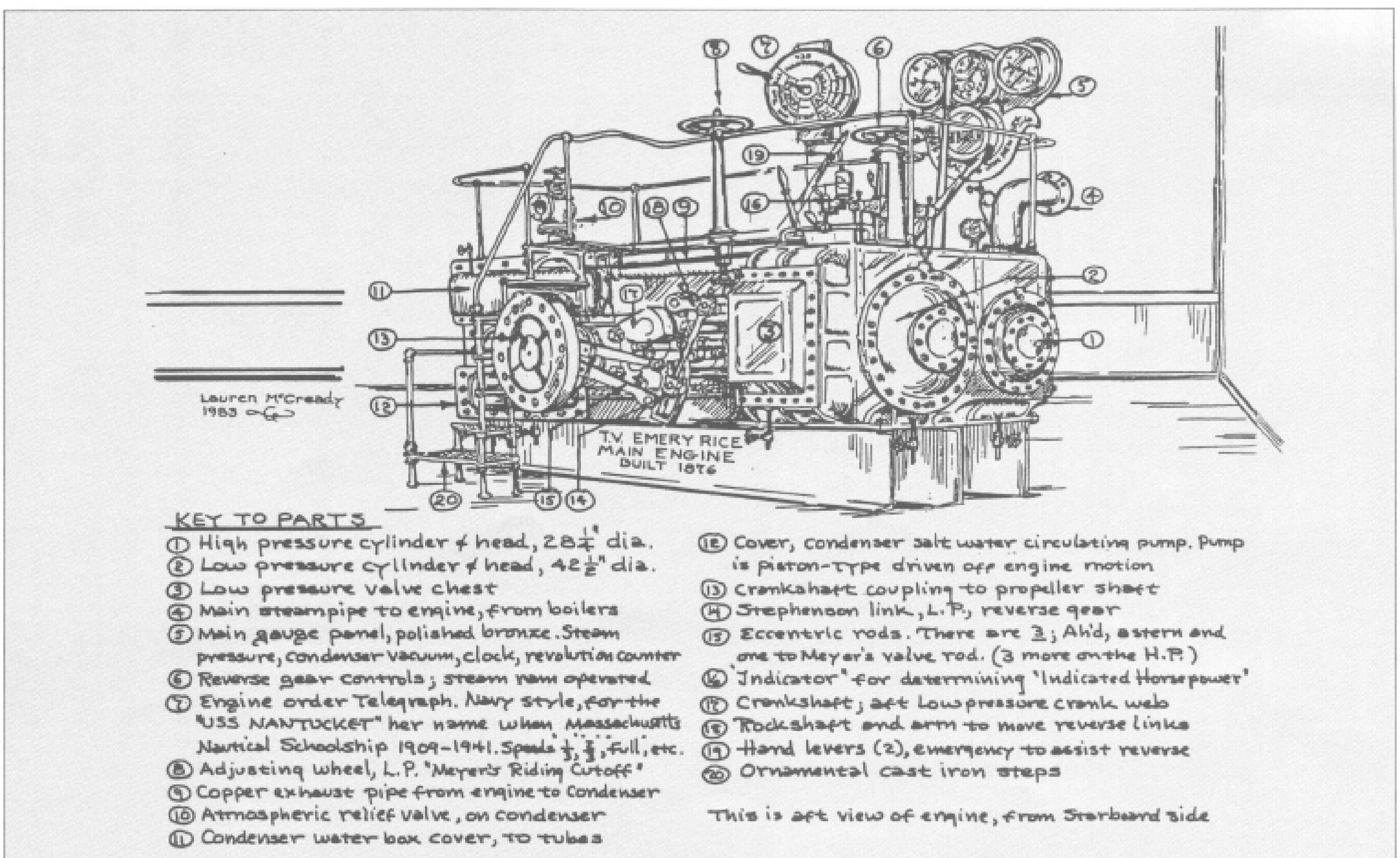
The world's first screw-steam warship with propulsion machinery and boilers entirely below the waterline was the USS PRINCETON commissioned in 1843. She was a creation of John Ericsson, best known for the USS MONITOR of the Civil War, and Captain Robert Stockton of the U.S. Navy. The 164-ft vessel of 954-t displacement was ship-rigged. Space does not permit description of the quite unique horizontal two-cylinder engine lying just above the keel, a type dubbed "vibrating piston," "vibrating pendulum" or "semi-cylinder" in which the "pistons," really long rectangular vanes oscillating about a long edge in semi-cylinders, were linkage-connected to a crank on the propeller shaft swinging a six-bladed screw of 14-ft diameter. Supplementing incomplete data with cautious guesses, a calculation seems to show about 250 ihp for a speed of 7 knots. The ship was employed with the Home Squadron from 1845 to 1847, doing duty in the Gulf of Mexico and even on the California coast during the Mexican War. Sent next to the Mediterranean Station, she was broken up upon her return in 1849. Ericsson engined the USS MONITOR (1861) and later Monitor types with low-profile, horizontal, two-cylinder engines with conventional pistons also having linkage connections between pistons and screw shaft. Unfortunately, a closer look at these unusual engines (sometimes called bizarre) that found use in only the United States and Sweden, Ericsson's native land, is impossible here.

As indicated, Ericsson's pioneer linkage engine found little application abroad, and aside from the Monitors, little in this country. A parallel development of low-profile naval engines took place in England, and it is from this that "our" engine derives, called "return connecting-rod" in Britain but "back-acting" in the United States.

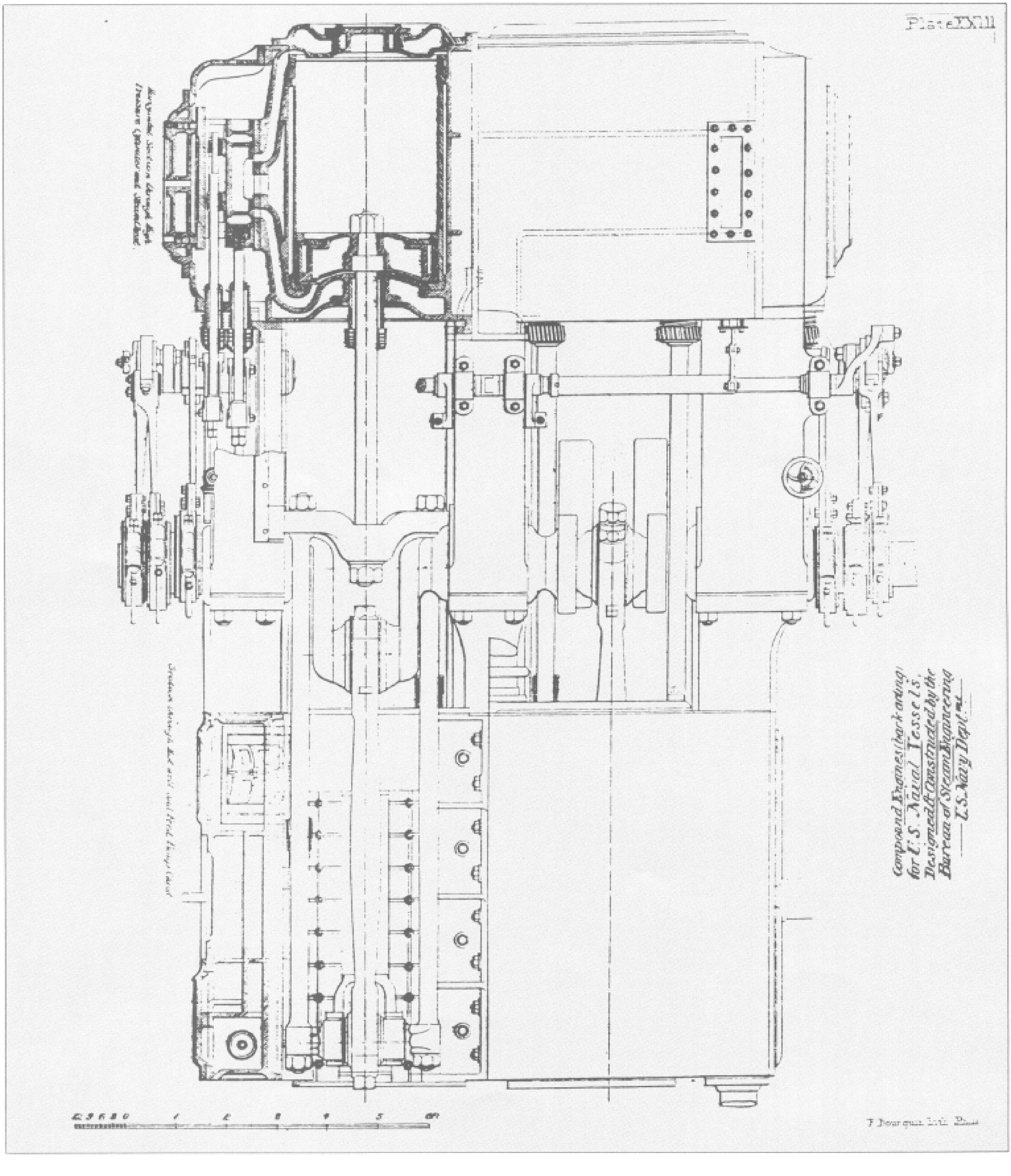
In England, the cumbrous beam engine with its Watt parallel-motion guidance of the piston rod was giving way to much tidier crosshead machines, the crosshead being mounted in a frame ("steeple") over the traditional vertical cylinder, the piston rod emerging from the top of the cylinder as it always had. The vertical cylinder remained popular because the piston weight, considerable with large-bore cylinders compensating for the low-pressure steam, did not contribute a substantial friction force as it would were the cylinder horizontal, nor did cylinders and pistons wear oval. On such vertical engines, the crankshaft was re-located between the cylinder and crosshead, possible because the central piston rod was replaced with a form that avoided interference, thus allowing the connecting rod to "return" to the crank near the cylinder: these were then return connecting-rod engines. Such a stationary engine of the 1840s when laid on its side served the naval purpose very well, the cylinders being horizontal, athwartship and mounted over the keel to have the crankshaft in line with the propeller shaft, attaining a direct drive in addition to achieving a properly low profile. It is from the prototype introduced to the British Navy in 1844 by the well-known firm of Maudslay & Field that the EMERY RICE ex-RANGER engine derives.

This type had its day and disappeared toward the end of the nineteenth century as advances in the armor-plating of ship's hulls gave protection to multi-cylinder vertical engines having vastly greater power and more convenience than the low engines sprawled across the keel.

Main engine of T. V. EMERY RICE.



Top view of compound back-acting engine with yoked piston rod on high-pressure cylinder to left, and two piston rods under and over the crankshaft on the low-pressure cylinder. (*Modern American Marine Engines, Boilers and Screw Propellers,* Emory Edwards, Philadelphia, 1881).



The type was little known because of its limited naval-vessel application, land engines not suffering from the strictures of space dictated by the beam of a ship. It is found in older "Manuals of Marine Engineering," but not in the usual books dealing with power plants. England's Science Museum (London) displays eight models of return connecting-rod engines of British warships of the period 1855–1876, the scales ranging from 1:8 to 1:18. One of those ships, H.M.S. MONARCH (1868) had a two-cylinder engine of 120-in. bore and 4.5-ft stroke. The engine indicated 7800 hp at 64 rpm on boiler pressure of 31 psi, or an mep of about 20 psi. A subsequent refit gave the ship a vertical triple expansion engine. The only surviving back-acting engine seems to be that of the EMERY RICE.

That the engine is here at all is because of the efforts of the key figures mentioned earlier. With the engine at hand, the next phase, that of meaningful presentation, is a costly and time-consuming task consequent to the administration of diverse restoratives in doses large and small. Heartening support from marine-related industry and individuals in the form of money, materials, donations of services and reduced-cost contracts has been salutary. The long roster of the generous is marked by Captain Leo Berger's gift of $100,000 for the Hall of Marine Engineering bearing his name. Another principal contributor, STEAMCO, INC., assumed the extensive task of complete restoration of the engine that suffered the unkind experience of casual storage for over a quarter-century. And as salient contribution must be added the efforts of the many, the volunteer workers concerned with the needful, tedious and dirty jobs.

The Long Island Section of the American Society of Mechanical Engineers gratefully acknowledges the efforts of all who cooperated on the designation of the T. V. Emery Rice engine as a National Historic Mechanical Engineering Landmark, particularly Professor Richard S. Hartenberg, ASME History and Heritage Committee, who wrote this brochure, and Rear Admiral Lauren S. McCready, USMS (Ret.) and Captain Charles M. Renick, USMS, U.S. Merchant Marine Academy.

The T. V. Emery Rice Engine is the 80th National Historic Mechanical Engineering Landmark to be designated since the program began in 1973. In addition 18 International and 8 Regional Landmarks have been recognized by ASME. Each represents a progressive step in the evolution of mechanical engineering, and each reflects an influence on society.

The landmarks program illuminates our technological heritage and serves to encourage the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians, and travelers, and helps establish persistent reminders of where we have been, where we are, and where we are going along the divergent paths of discovery.

For further information contact ASME, Public Information Dept., 345 East 47th St., New York, N.Y. 10017, 212-705-7740.

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