

Pennsylvania Coal and the Beginnings of American Steam Navigation

FOR more than thirty years before the Civil War, experiments were being carried on in the field of coal-powered steam navigation. Wood-burning steam vessels plying the vast network of inland waterways in the United States were viewed by both anthracite and bituminous coal producers of Pennsylvania as important potential consumers of mineral fuel. In the East there was considerable technical success in the adaptation of marine boilers to anthracite coal, and by the 1840's large amounts of Pennsylvania anthracite were being used. Steamboats on the river routes of the West, however, did not make the complete transition from wood to mineral fuel, despite fewer technological problems in burning bituminous coal under marine boilers.

Coal was really the first steamboat fuel used on western rivers; it was burned by the *New Orleans* on part of her maiden voyage in 1811-1812. Her owner and promoter, the young, ambitious Nicholas J. Roosevelt of New York, had carefully surveyed the Ohio-Mississippi River road in 1809. He had also collected a quantity of Ohio coal near Pomeroy, a point on the Ohio River about half-way between Pittsburgh and Cincinnati, to be used in refueling the steamboat which he hoped to build and launch as soon as he returned to Pittsburgh.¹ While the *New Orleans* did burn some Pittsburgh and Pomeroy coal, she also burned quantities of wood, for coal supplies along the Ohio in 1811-1812, with the exception of those at Pittsburgh and the cache at Pomeroy, were practically nonexistent. Many steamboats followed the *New Orleans* on the Ohio, Mississippi, and Missouri, the three great river arteries of the West, but the common use of bituminous coal in these steamboats was hampered and delayed by a number of practical problems not faced by eastern vessels.

¹ C. H. Ambler, *A History of Transportation in the Ohio Valley* (Glendale, Calif., 1932), 113, 121.

River steamboats in the West rarely carried wood supplies for more than one day's run. Weight was the main consideration, since sand bars, low water, half-submerged driftwood islands and other hazards of western river navigation made it imperative that steamboats maintain a shallow draught. In the early days, when population was sparse, the usual practice of steamboat captains was to send crews ashore to cut wood from the timberlands near the banks of the river. As the population increased, and the timberland was claimed by settlers, the cutting of wood for steamboat fuel became an important industry for people living along the river banks.² This proved to be a more satisfactory system, for the wood usually was seasoned and so burned better than the green timber secured by boat crews. The best wood was resinous pine found along the lower Mississippi and was much preferred by boat captains when passing through that section of the country. Still, captains had to be on the alert for sly riverbank merchants who would sell them green timber of any kind if they had the chance. A story reflecting this particular situation appeared in a Cincinnati paper in 1845.

A Mississippi steamboat captain called to a wood merchant on shore:

"What wood is that?"

"Cord wood," came back the answer.

"How long has it been cut?" asked the captain.

"About four feet," replied the wood merchant.³

Limited amounts of wood cargo and suitable wood fuel were complicated further by increased costs during the twenty years before 1860. Timber became less plentiful along the banks of the Ohio and central Mississippi as the forests retreated before the axe, the farm, and the town. Steamboats placed an additional burden on the forested areas. Small and medium-sized river steamers burned from twelve to twenty-four cords of wood a day; the large boats consumed as much as fifty to seventy-five cords for every twenty-four hours running time.⁴

The substitution of bituminous coal for wood fuel would seem to have been the logical and practical answer to the shrinking forests of

² L. C. Hunter, *Steamboats on the Western Rivers. An Economic and Technological History* (Cambridge, Mass., 1949), 264-265.

³ *Cist's Weekly Advertiser* (Cincinnati), Oct. 15, 1845.

⁴ Hunter, *Steamboats on the Western Rivers*, 266.

the Ohio Valley. While in this period the soft coal of Pennsylvania had become a welcome substitute for wood fuels in the factories, mills, and homes of Cincinnati, Louisville, St. Louis and other western river towns, it did not completely supplant the use of wood under the boilers of the riverboats.⁵ In spite of increased utilization of soft coal, full transition from wood to mineral fuel was still not completed by 1860. The reasons were apparent in the unsolved problems of supply, weather, price, type of cargo and, in general, the peculiarities of western river navigation.

Until 1840, the western Pennsylvania coal trade was not too well developed. Coal supplies on the lower Ohio, even at Cincinnati and Louisville, were scarce and expensive. Thus, much of the Ohio run was made on wood. During the next two decades, from 1840 to 1860, the coal trade from the Pittsburgh, Monongahela, and Youghiogheny regions increased. The development of mines along the Ohio and its lower tributaries also added to available bituminous coal supplies in the valley. With the growth of the western coal trade came extended use of Pennsylvania coal in Ohio steamboats. Difficulties in supply still remained, however, tending to hamper complete reliance on bituminous coal as steamboat fuel. Not the least of these difficulties was the weather.

John Randolph of Roanoke is said to have described the Ohio River as "frozen up" one half the year and "dried up" the other half. While not conforming to the description, the great river, flowing nearly a thousand miles from Pittsburgh to its juncture with the Mississippi at the southern tip of Illinois, was subject to the vagaries of weather. Ice and drought hampered river traffic at times and affected coal supplies for steamboats. In periods of low water the smaller, shallow-draught steamboats could leave the wharves of Pittsburgh and other Ohio River ports before the "coal boat rise." Coal boats were great box-like affairs, as bulky as the cargo they carried. Loaded to the gunwales, they not only drew considerable water, but needed high water for safe handling in tow. Floating ice was another hazard for these cumbersome craft; they were difficult enough to maneuver when the river was ice-free. Before the coal

⁵ For examples of the use of Pennsylvania bituminous coal in manufacturing and home heating in Ohio River towns, see *Cist's Weekly Advertiser*, 1845-1851, and *Pittsburgh Gazette*, 1856-1857.

fleets could be floated downstream, the river steamers were already underway, taking advantage of early thaws or relatively high water following a drought. This meant that cargo steamers often used the water routes before the down-river towns had replenished their coal supplies. Steamboats leaving the wharves at Pittsburgh, where coal was always in supply, had no difficulty in securing mineral fuel for a few cents a bushel. But steamers seldom carried more than enough fuel for a day's run. For a medium-sized vessel this was approximately one hundred and fifty bushels of bituminous coal. A heavier fuel cargo was the exception; despite the cheapness of coal, large amounts increased the draught of the ship which added to the hazards of river navigation, and lessened the weight of goods which could be carried to the next town.⁶

Because of the scarcity or the uncertainty of bituminous coal supplies on the rivers of the western country, steamboats were seldom equipped to burn coal as their only fuel. Bituminous coal required a smaller firebox and finer grate bars than wood to ensure efficient combustion.⁷ As a compromise, a medium-sized firebox was used, which sacrificed combustion efficiency but was large enough to burn both wood and coal. The soft coal was kept at the base of the fire and the wood scattered on top. Furnaces were fired by alternate layers of coal and wood. A very hot fire resulted, and steam could be produced quickly. Many steamboat engineers, however, preferred wood to the inexpensive soft coal, since wood was a clean fuel and did not necessitate frequent cleaning of the flues.⁸ Also, bituminous coal soot pouring from the stacks of the steamboats was particularly annoying to passengers.

For years western coal producers tried to convince steamboat operators that bituminous fuel should be used exclusively. Cost, space, and weight were stressed as its advantages. Still the problem of dependable supply remained, and wood continued to supplement mineral fuel in western steamboats. Linked with the supply problem was the type of cargo carried. The soot and sparks which poured from

⁶ Hunter, *Steamboats on the Western Rivers*, 267; *Pittsburgh Gazette*, January through February, 1854, and December, 1856; L. C. Hunter, "Seasonal Aspects of Industry and Commerce Before the Age of Big Business," *Smith College Studies in History*, XIX (1933-1934), 15.

⁷ Cannelton, *Perry County, Indiana, etc.* (Louisville, Ky., 1850), 80-81.

⁸ Hunter, *Steamboats on the Western Rivers*, 266.

the stacks of a steamboat burning bituminous coal endangered deck-stowed cargo. The cleaner, less dangerous wood fuel was, for this reason, preferred in the cotton trade.⁹

As late as the mid-fifties, coal firms were complaining that while western steamboats used bituminous coal, wood was still an important part of their fuel.¹⁰ In 1855, Wheeling, West Virginia, an important coal center, opposing the railroad between Baltimore and Columbus, argued that she would become a "mere wooding station for steamboats" should the proposed railroad by-pass her.¹¹

On the Great Lakes, mineral fuel for steam navigation had greater success. Pennsylvania, Ohio, and some Illinois coals were introduced on the lakes in the late forties. Small quantities of Pennsylvania anthracite and Blossburg semibituminous coal found their way to Buffalo, and larger amounts of bituminous coal came to Lake Erie from Mercer and Lawrence counties in northwestern Pennsylvania. Canal and later railroad extensions brought Pennsylvania coal to the cities of Erie and Cleveland. A major factor in the construction of both the Erie extension of the Pennsylvania Canal and the Cleveland and Pittsburgh Railroad was the coal trade, with particular emphasis on the potential consumption of lake steamers.¹²

By the mid-fifties, steamboats on the Great Lakes were using large amounts of Pennsylvania and Ohio bituminous coal because, unlike the river steamers of the West, they had little concern for shallow draught. Not weight but space and steaming range were the first considerations in taking on fuel. One ton of coal was equivalent to more than three cords of wood and took up much less space; additional coal supplies gave the steamers greater range in their trips. Lake steamers also burned huge amounts of wood, and the cost of wood was high. The *Chicago Tribune* commented in 1848 that the steamboat *Empire* burned seven hundred cords of wood between

⁹ *Cist's Weekly Advertiser*, Aug. 1, 1851. "The fuel used in the *Magnolia* is, when running up stream, and in the cotton trade, yellow pine; and down stream cottonwood, ash and cypress; when running down, in the Louisville and New Orleans produce trade, Pittsburg coal is used, with the yellow pine wood. . . ." *Journal of the Franklin Institute*, LVI (1853), 259.

¹⁰ Prospectus of the Pittsburgh and Youghiogheny Coal Company (1856), W. J. Palmer Papers, Colorado State Historical Society.

¹¹ Ambler, 203.

¹² W. M. Roberts, "Report on the Erie Extension to the Board of Canal Commissioners," *Pennsylvania House Journal*, II (1840), Appendix, 273-274. See also *Annual Reports of the Cleveland and Pittsburgh Railroad, 1849-1856*.

Chicago and Buffalo. The boat made thirteen trips each season, which meant that forty wood cutters destroyed two hundred and thirty-four acres of timber at a cost of \$10,000 for wood and wages. In 1848, there were fifteen other such first-rate steamers on the upper lakes.¹³ This wholesale destruction of timberland, together with mounting costs, beckoned the bituminous coal trade of Pennsylvania and Ohio. The price of bituminous coal at Cleveland and Erie averaged between \$2.50 and \$3.00 per ton, while at Buffalo it was \$4.00 per ton. Small shipments of Illinois coal found along the Illinois and Michigan Canal began coming into Chicago in 1849-1850. Steamboat engineers considered Illinois bituminous coal useless, however, for the sulphur content was so high that grates and boilers suffered damage.¹⁴

Pennsylvania coal also found a market in Canadian lake ports and was used by some Canadian steamers. In 1853 the *Cleveland Herald* estimated the entire consumption of the lake region to be three hundred thousand tons.¹⁵ Better than half of this amount came from Pennsylvania. The mines in Mercer County that year shipped more than one hundred thousand tons to Erie. Lawrence County the year before had started small shipments amounting to ten thousand tons, and additional supplies reached Cleveland via the Cleveland and Pittsburgh Railroad. Within the decade, the Pittsburgh, Fort Wayne and Chicago Railroad pushed through to Lake Michigan and served as a connecting link between the Pittsburgh-Monongahela coal fields and the lakes. By 1860 Pennsylvania bituminous coal shipments to lake ports had increased to more than a quarter of a million tons a year.¹⁶ That one third of this amount was burned as fuel by lake steamers would be a conservative estimate. But, like the river steamboats of the West, the lake steamers still supplemented their coal fuel with wood, primarily because of the problem of inadequate and unreliable supplies.

While steamboats rode the water lanes of the western country or moved from port to port over the Great Lakes, the eastern portions

¹³ *Niles' National Register*, LXXIII (Dec. 20, 1848), 394.

¹⁴ R. C. Taylor, *Statistics on Coal* (Philadelphia, 1855), 312-313.

¹⁵ *Ibid.*, 313.

¹⁶ Production tables in H. N. Eavenson, *American Coal Industry* (Pittsburgh, 1942), 464, 472, 491, 493, 496.

of the nation, touched by the Pennsylvania anthracite trade, showed an early interest in the use of hard coal for river and Long Island Sound steamers. Anthracite coal firms led the way in the encouragement of anthracite steam navigation. Two companies, in particular, were instrumental in stimulating the technical advancement which led to anthracite-burning steamboats. The first company was not completely successful in its experiments, but showed the way to the second company, which, with the aid of the mechanical genius of an extraordinary preacher and educator, achieved success and gained great profits in marketing fuel for steamboat consumption.

The Lehigh Coal and Navigation Company began experimental trials with anthracite in the steam boilers of tow boats for coal barges as early as 1826, when the Lehigh coal trade was scarcely six years old.¹⁷ In 1831 the Lehigh company purchased a wood-burning steamer, the *Pennsylvania*, for further experiments. The grates of the firebox were altered to burn coal and the boat was put into operation. For several years the *Pennsylvania*, using anthracite fuel, towed coal arks on the Delaware River between Philadelphia and Coal Haven near Trenton. It took the small vessel nearly an hour to get up steam for the thirty-three-mile trip, but the amount of fuel saved by using anthracite instead of wood made up for this slowness.¹⁸ The steamboat used three tons of coal per round trip of sixty-six miles, at half the cost of wood, and could tow three sets of Delaware coal arks carrying a total coal load of four hundred tons.¹⁹ The *Pennsylvania* soon had a "sister ship," the *Convoy*. By 1839 the board of managers of the Lehigh Coal and Navigation Company reported to the stockholders with satisfaction on the gradual introduction of their anthracite as steamboat fuel on the Delaware and Hudson rivers and Long Island Sound.²⁰

The dozen years between the first experiments with anthracite in eastern steamboats and the Lehigh company's report were marked

¹⁷ Josiah White to Gov. Joseph Ritner, July 11, 1837, The Historical Society of Pennsylvania.

¹⁸ Hazard's *Register of Pennsylvania*, VIII (1831), 15; XIV (1834-1835), 144. The length of time it took to raise steam aboard the *Pennsylvania* indicates that the technology of marine boilers was in its infancy.

¹⁹ *Ibid.*

²⁰ *Report of the Board of Managers of the Lehigh Coal and Navigation Company* (Jan. 14, 1839), 32.

by concern among steamboat operators over the growing scarcity and rising cost of wood. This concern was reflected in the many attempts to adopt anthracite fuel in marine boilers and ensure maximum operating efficiency. New York steamboats consumed an estimated two hundred thousand cords of pine wood during an eight-month running season in 1828. Philadelphia's steamboats, ferries, and factories used one hundred and fifty thousand cords.²¹ Some of the supply came from the pine lands of the Carolinas, but most of it was cut from the shrinking pine barrens of southern New Jersey. At the turn of the century in 1800, before the advent of the steam engine in factories and steamboats, Jersey pine lands, then considered unfit for agriculture, were worth six to ten cents per acre. Steam revolutionized the land value of this wooded region, which was close to Philadelphia and, by sea, not far from New York. Within a generation the price of an acre of pine timber had risen to six dollars and threatened to go higher as labor costs mounted and the demand for quick-burning, resinous pine wood increased with factory and steamboat development.²² Steamboat men, like factory owners employing stationary steam engines, looked about for a cheaper substitute fuel.

The stationary steam engine began using anthracite coal in 1825. But with the exception of the *Pennsylvania* and the *Convoy* which operated on short runs, and then not too efficiently, and scattered experiments in New York, steamboat engine designs lagged behind those of the stationary engines in the use of anthracite fuel. The steamboat engine was more powerful and more complex than the stationary engine. While the stationary engine was simple to operate and maintain, running at a fairly uniform rate with few excessive pressures, steamboat machinery often was overtaxed and had to react quickly to signals from the bridge. It was imperative that steam pressure be maintained, controlled, and altered during a run in order to maneuver the boat. Thus, a strong, hot fire under the boilers was necessary at all times. When anthracite was tried in boats that burned wood, it proved inefficient, for the flames of the coal did not extend high enough from the deep firebox to have a telling effect on the boilers. While this was also the basic problem in stationary engines, it was a greater problem in steamboats because of the con-

²¹ *Niles' Weekly Register*, XXXIV (Aug. 2, 1838), 352.

²² *Philadelphia Saturday Bulletin*, reprinted in the *Miners' Journal*, Aug. 1, 1829.

stant demands for quick, ready steam. The problem of reliable and adequate coal supplies was voiced by the Pottsville *Miners' Journal* in 1827 as being the only reason why anthracite had not been adopted by steamboats. The argument was invalid.²³ Eastern river and Long Island Sound steamers did not adopt anthracite as their common fuel until 1838–1840. Adequate supplies of Pennsylvania anthracite had been available along the Delaware and Hudson rivers and in the coastal towns and cities from Baltimore to Boston since 1833. The delay in the use of anthracite in eastern steam vessels was not so much a problem of supply as a problem of technology.

While the Lehigh company wrestled weakly with the problem of the utilization of anthracite as fuel for steamboats, another coal firm, with the persistence born of prospective profits, became the leader in the large-scale introduction of anthracite fuel for steamboats, and particularly for those on the Hudson River and Long Island Sound. This was the Delaware and Hudson Company, which mined and shipped Pennsylvania anthracite from the Lackawanna Valley to the port of New York via the Delaware and Hudson Canal and the Hudson River. Lackawanna coal ignited more readily than the heavier anthracite of the Lehigh and Schuylkill areas. Beginning with its first shipments, the company believed that its lighter anthracite was excellent steam coal for stationary engines and told stockholders that Lackawanna coal “. . . will, ere long become the most favored article for the same purpose in steamboats.”²⁴

Little was accomplished in the introduction of Lackawanna coal aboard steamboats until 1831 when the company noted that three ferry concerns on the East River and one on the Hudson River used Lackawanna with “entire success,” and that two or three coastwise steamers out of New York burned its fuel.²⁵ The next year a new vessel, the *David Brown*, was constructed to burn Lackawanna coal. It was hoped that the boat could make the passage from New York to Charleston without touching any intermediate port to refuel.²⁶

²³ *Miners' Journal*, Dec. 1, 1827. For another misleading statement concerning the unavailable supplies of Pennsylvania anthracite for steam vessels, see D. B. Tyler, *Steam Conquers the Atlantic* (New York, 1939), 128.

²⁴ *Delaware and Hudson Company Annual Report* (1828), 4.

²⁵ *Ibid.* (1832), 5–6.

²⁶ *New York Evening Post*, reprinted in J. C. Emmerson, Jr., ed., *Steam Navigation in Virginia and Northeastern North Carolina Waters, 1826–1836* (Portsmouth, Va., 1949), 217.

The Delaware and Hudson Company realized that improvements were necessary in anthracite steamboat engines if eastern vessels were to adopt Lackawanna coal in place of pine wood, and that the phrase, "entire success," had been premature. The company expended some of its own funds to alter the fireboxes and grates in one of the East River ferries and sent free coal for experimental purposes to the Walnut Street Ferry in the spring of 1831.²⁷ The board of managers also delivered coal to the steamboat *Victory* for trial runs between New York and Hartford. The company's untiring efforts to promote the use of Lackawanna anthracite in steamboats became well known among steamboat men of the eastern coast.²⁸

For four years the Delaware and Hudson Company supported measures which it anticipated would bring Lackawanna coal into common use aboard steamboats. These were years of constant disappointment, for no inventor had designed a marine boiler which could be heated effectively by anthracite. At last the discouragement was transformed into bright optimism. The man responsible for the change was none other than the remarkable Dr. Eliphalet Nott, president of Union College for sixty-two years, clergyman, prohibitionist, lecturer of note, and holder of more than a score of patents on anthracite stoves for home heating and cooking. In 1835 Nott designed tubular boilers for the ferryboat *Essex*, which ran from Cortland Street Wharf to Jersey City. The boilers consisted of a number of malleable iron tubes, each one and a half inches in diameter and three feet in length. The tubes were installed vertically in a chamber seven feet long, seven feet high, and three and a half feet wide. The furnace was placed alongside the chamber or boiler containing the tubes and was fired by large lumps of Lackawanna coal.²⁹ The problem of producing a flame to create steam to propel the boat was solved by blowers which injected air into the bottom of the firebox. The *Essex* had two of these boilers. Newly equipped, the boat made a trial run on March 16, 1835, on the Hudson and around New York harbor, traveling in all about forty or fifty miles. "The success was complete, and we believe satisfied all on board that the

²⁷ Delaware and Hudson Company Minute Books, Mar. 22 and May 12, 1831.

²⁸ *Ibid.*, May 12, 1831; *Miners' Journal*, July 9, 1831, and May 12, 1832; Delaware and Hudson Company Minute Books, Feb. 6, 1834.

²⁹ *American Railroad Journal*, IV (Mar. 21, 1835), 85.

desideratum of generating steam by anthracite coal aboard steamboats has at length been attained," reported the *New York Journal of Commerce*.³⁰

The Delaware and Hudson Company received the news of the *Essex* experiment with a great deal of satisfaction and reported to its stockholders that a new era soon would dawn in the Lackawanna coal trade.³¹ The board of managers had good reason to rejoice. Its members had followed Dr. Nott's experiments with interest. A few days prior to the *Essex* run they had drawn up a tentative agreement with H. Nott and Company, a leading stove manufacturing firm controlled by Dr. Nott, which had sponsored the development of Dr. Nott's Patent Anthracite Tubular Boilers and had provided the capital necessary for their construction at Stillman's Novelty Works in New York. The agreement between the two firms stated that if Nott and Company succeeded in running a steamboat on the Hudson from New York to Albany at a speed equal to the other river boats, the Delaware and Hudson would supply the vessel with five thousand tons of coal each year for six years at four dollars per ton, or less, should prices drop.³² The price of four dollars was approximately half the average retail price of anthracite on the New York market in 1835.³³ Should the tests fail, the coal firm would have the option to purchase the boiler patent at a fifty per cent discount. A few days after the *Essex* experiment, the clause concerning the option was altered, and H. Nott and Company agreed to sell the boilers to the Delaware and Hudson at twenty per cent discount to equip one steamboat. The patent rights, however, were retained by the stove company.³⁴ The success of the *Essex* had convinced Nott of the promise of his invention.

A year later, on June 23, 1836, the steamboat *Novelty*, equipped with new and improved Nott anthracite tubular boilers, cast off from Chambers Street Wharf in New York. It was six o'clock in the morning. On board was a sleepy but expectant "party of gentlemen, consisting of the managers of the Delaware and Hudson . . . and

³⁰ *Journal of Commerce*, Mar. 18, 1835.

³¹ *Delaware and Hudson Company Annual Report* (1835), 6.

³² Delaware and Hudson Company Minute Books, May 6, 1835.

³³ *House Executive Document*, 38th Cong., 1st Sess. (1863-1864), VI, 362-401.

³⁴ Delaware and Hudson Company Minute Books, May 6, 1835.

others," including, of course, Dr. Nott.³⁵ The *Novelty* was a large steamboat, more than two hundred and fifty feet long. She contained twelve Nott boilers and four furnaces fed by Lackawanna anthracite, with steam blowers to stimulate combustion. The trip to Albany took twelve hours, which was considered good time. Philip Hone, first president of the Delaware and Hudson, and keen observer of the men and events of his era, made the trip. He wrote in his diary that day: "Dr. Nott has succeeded completely in the invention, which establishes certainly that coal will succeed wood in all our steamboats, and the Delaware and Hudson Company will hereafter be able to sell all the coal they can bring down the canal at an advanced price."³⁶ Hone estimated that a steamboat the size of the *Novelty* would have consumed forty cords of pine wood at six dollars a cord, whereas the coal consumption amounted to twenty tons at a maximum of five dollars per ton. Hone had good reason to be encouraged.

Anthracite coal was to be of great value not only to Hudson River steamboats, but to Long Island Sound steamers. Much of the deck space heretofore cluttered with bulky wood fuel could be cleared for cargo and passengers. Anthracite was a clean fuel and sparks were few. Large sound steamers burned more than sixty cords of wood per trip between New York and Providence and could not carry the entire fuel load. A supply sloop was picked up off Fisher's Island at the end of Long Island Sound and the steamer took on wood for the rest of the trip while underway at reduced speed.³⁷ This was dangerous and sometimes impossible in rough water, as well as expensive in money and lost time. Anthracite coal would eliminate this refueling problem.

The predicted dawn of a new era in the Lackawanna coal trade did not appear for a few years. When it did come, it surpassed all expectations. The Delaware and Hudson intensified its campaign for adoption of coal in steamboats, but the conversion of boilers from wood to coal was expensive in spite of the attraction of future fuel savings. It was not until 1840 that the company regarded its efforts as completely successful. Lackawanna coal was being accepted on an increasing scale by steamboats on the Hudson and along the New

³⁵ Allen Nevins, ed., *The Diary of Philip Hone* (New York, 1927), I, 214.

³⁶ *Ibid.*, 215.

³⁷ R. G. Albion, *The Rise of New York Port* (New York, 1939), 159.

England coast.³⁸ To meet the growing demand for coal, the Delaware and Hudson Canal was widened and deepened to permit forty-five-ton coal boats to pass. The eighteen-mile railroad was double-tracked from the mines to Honesdale at the head of the canal. By 1844 the company had increased its tonnage fifty per cent on the canal and one hundred per cent on the railroad, and still was pressed to satisfy the market at the peak of the season. In 1840 it was estimated that eastern steamboats used one hundred and fifty thousand tons of anthracite coal.³⁹ Much of this was supplied by the Delaware and Hudson. There is no doubt that the primary reason for the increased sales of the company was the use of Lackawanna coal by eastern steamers.⁴⁰

Steamboats on the Delaware River also adopted anthracite as their fuel during the forties. Here, the Lehigh Coal and Navigation Company should be given credit for running the first anthracite steamboats. But the Lehigh Company, like the Schuylkill County operators, was busy supplying domestic and industrial demands in the thirties and encouraging the use of anthracite in home, factory, and blast furnace. The successful campaign for the use of anthracite in steamboats was conducted by New York, not by Philadelphia.

In 1800 it was nine days by sloop from New York to Albany. In 1850 the trip was made by anthracite steamboat in as many hours. To Americans of the time, the nation stood on the threshold of new and even greater discoveries in transportation. Those who looked back into the years could say with Philip Hone, "What wondrous changes have occurred in our day and generation!"⁴¹

The beginning of transoceanic steam navigation was marked by the experimental voyage of the *Savannah* in 1819, a ninety-eight-foot vessel. Built in New York the year before, equipped with a steam engine constructed in Morristown, New Jersey, and boilers made in Elizabeth, she originally was destined for the run between New York and Savannah. The Panic of 1819 put an end to the coastwise career of the new ship, and her owners, the Savannah Steamship Company,

³⁸ *Delaware and Hudson Company Annual Report* (1841), 4-5; *Niles' National Register*, LVIII (May 2, 1840), 229; (June 13, 1840), 240.

³⁹ *Ibid.*, LXVI (1844), 281.

⁴⁰ *Fisher's National Magazine*, I (August, 1845), 220.

⁴¹ Nevins, II, 905.

decided to sell the vessel abroad. It was therefore economic necessity and little else which prompted the first crossing of the Atlantic by a ship using auxiliary steam power. To raise the steam both coal and wood were taken aboard.

The *Savannah* found no purchasers in Europe and returned to the United States to be sold at auction. On both crossings the engine had been used very little. Most of the voyage had been made by sail, and so discouraging had been the reports about her auxiliary steam power that the engine was dismantled and sold to a New York factory. The *Savannah* spent the remainder of her days as a coastwise sailing ship.⁴²

After this initial endeavor, Americans did not attempt to brave the Atlantic with steam-powered vessels for more than twenty years. It was the British who led the way in Atlantic steam navigation, but even their endeavors did not mature until the late thirties when the *Sirius* and the *Great Western* plodded across the sea to New York, where they received gala receptions. The *Sirius* burned more than four hundred and fifty tons of British bituminous coal on her maiden voyage. The *Great Western* burned Welsh bituminous coal. On later voyages she experimented with Pennsylvania anthracite, though not too successfully, for she soon reverted to bituminous coal. The *Liverpool*, another early British steamship, burned samples of American anthracite.⁴³ Though the press reported satisfaction with anthracite, British steamships consistently used bituminous coal. Many owners complained of "inferior" American coals and, despite the duty, established fuel depots in United States ports for British coal. It was not until Maryland Cumberland coal, an excellent bituminous steam fuel, became available in quantity during the 1850's that British steamships, especially the Cunard Line, took advantage of American coal on a large scale.⁴⁴

The United States clung to sail. For a decade after the initial successes of the British there were no American experiments in ocean steam navigation. Reluctance to enter this field had nothing to do with the amount of coal available, for the market could have been

⁴² Tyler, 7-13.

⁴³ Hazard's *United States Commercial and Statistical Register*, I (July 10, 1839), 34.

⁴⁴ *DeBow's Review*, n.s., I (1853), 476; *Thirty-fourth Annual Report of the President and Directors to the Stockholders of the Baltimore and Ohio Railroad Company* (1860), 23-24, herein after referred to as *Annual Report*, B. & O.

supplied by the anthracite producers. The United States lacked both capital and public confidence to encourage the immediate founding of steamship lines to compete with Britain. Early but futile efforts of some farsighted businessmen, including Nicholas Biddle, met with a cool reception. At this time, too, the energies of the Delaware and Hudson were absorbed in introducing anthracite aboard river steamboats. The company paid little attention to the possibilities of a new market until the fifties when ocean steam navigation had matured.⁴⁵ Even more damaging to the development of American ocean steam navigation were the swift and graceful clipper ships which caught the imagination of the public. Blinded by the scudding spray of these "greyhounds of the sea," investor, builder, and patron firmly believed in the enduring triumph of sail over steam.

Coal producers of the Lehigh and Schuylkill regions, however, showed considerable interest in the potential market for anthracite aboard ocean steamers.⁴⁶ Word drifted to Philadelphia that the owners of the *Great Western* considered anthracite superior steamship fuel. The Philadelphia *North American*, a zealot in the cause of Pennsylvania economic sectionalism, jumped to the conclusion that the state soon would become the source of all fuel energy for steamers standing out of American ports. "The giant Pennsylvania . . . her bowels . . . filled with . . . coal," was favored by God as "the repository of untold wealth and blessings."⁴⁷

Those engaged in the anthracite trade were jealous of the general preference of bituminous coal for the new ocean steamers. A mysterious tragedy at sea soon presented them with ammunition to fire at the opposition. On March 11, 1841, the British steamship *President* left New York bound for England. She was never seen again. The mysterious disappearance of the vessel and the one hundred and ten persons aboard provoked endless speculation in the press. Benjamin Bannan's Pottsville *Miners' Journal* recalled that the *President* carried bituminous coal in her bunkers. Bituminous coal, said the paper, was susceptible to spontaneous combustion. The ship "probably" took fire and went down somewhere in mid-ocean. And this was not

⁴⁵ *Delaware and Hudson Company Annual Report* (1852), 4.

⁴⁶ *Report of the Board of Managers of the Lehigh Coal and Navigation Company* (Jan. 14, 1839), 32; *Miners' Journal*, Oct. 23, 1841.

⁴⁷ *North American*, reprinted in Hazard's *United States Register*, I (Sept. 25, 1839), 215.

all. The *Journal* went on to relate that the *British Queen*, the *Great Western*, and two Boston steamers had had fires in their bunkers, but the facts had been withheld from the public.⁴⁸ These serious charges were caught up immediately by other newspapers. Some felt that spontaneous combustion did or could occur, but most of the papers saw through the bias of the anthracite trade organ. The *New York Herald* and the *Philadelphia Ledger* were particularly vehement in their criticism of the *Miners' Journal*. This attitude ". . . might be expected," retorted Bannan, "from a prostituted and venal press," but the honor of Pottsville was offended when the *Boston Transcript* called the thriving center of the Schuylkill coal trade "a back-country village."⁴⁹ Benjamin Bannan quoted a dozen instances of spontaneous combustion in vessels carrying bituminous coal. Not only had steamships experienced these unwelcome disasters, but sailing ships carrying soft coal as ballast found the fuel a fire hazard. Scientific opinion was brought to bear in support of the *Journal's* arguments, and the paper even went so far as to demand laws prohibiting the use of bituminous coal in steamships using American ports.⁵⁰

The public became genuinely concerned over these tales. By October, 1841, American passenger travel aboard British steamships burning bituminous coal had become noticeably light.⁵¹ For a time, fear of fire at sea drove many back to sailing vessels. Over the years, ideas were advanced to solve the problem of spontaneous combustion of bituminous coal piles aboard ship, but no concrete solution was reached.⁵² As long as steamers carried bituminous coal in enclosed spaces the danger was always present. The fears in the public mind gradually dispersed when no major disasters proved traceable to the menace of bituminous fuel. The anthracite press abandoned the issue in 1842. When Cumberland bituminous coal from Maryland mines gained ascendancy in steam navigation, the *Miners' Journal* again

⁴⁸ *Miners' Journal*, July 24, 1841.

⁴⁹ *Ibid.*, Aug. 7, 1841.

⁵⁰ *Ibid.* The Philadelphia *North American*, a high tariff, proanthracite paper, supported some of the charges against bituminous coal piles in yard bunkers and storage areas. *Ibid.*, Sept. 11, 1841. The Philadelphia Gas Works was annoyed with this problem for many years.

⁵¹ *Ibid.*, Oct. 2, 1841, and Dec. 11, 1841.

⁵² *Journal of the Franklin Institute*, XXXIV (1842), 420-421; LIII (1852), 419; *The Mining Magazine*, III (1854), 567.

took up the cry. Ten years after its first attacks, the paper informed its readers that not all bituminous coal was liable to spontaneous combustion, but Cumberland was, and it would be better to “. . . ship aboard a powder magazine” than a vessel carrying most brands of bituminous coal.⁵³

In the fall of 1841 the steamship *Clarion* was launched in New York. She was equipped with anthracite boilers and the Ericsson propeller. The *New York Herald* atoned for its earlier attitude by noting a British Admiralty report on fires caused by spontaneous combustion of bituminous coal in East India steamers. The paper then praised anthracite as an excellent fuel for ocean steam navigation. “It has long been urged by grave authorities, that nature has imposed an effectual barrier to prevent the United States from competing with Great Britain in steam navigation, owing to the scarcity and inferior quality of our bituminous coals.” The trial run of the *Clarion* illustrated the “absurdity of this opinion,” said the *Herald*. Anthracite would become the steamship fuel of the future! Pennsylvania anthracite had the ability to produce steam efficiently and economically, and with an absence of smoke. Steamers burning bituminous coal could be tracked for seventy miles at sea long before their hulls were visible because of the black coal smoke trailing along the horizon. In time of war this would make the bituminous coal-burning warship inferior to the vessel burning anthracite. The article concluded by expressing regret that the two new United States war steamers, the *Mississippi* and the *Missouri*, had been designed to burn only bituminous coal.⁵⁴ The regret was shared by anthracite operators in the Schuylkill region, and since there was a lack of American bituminous steam coal on the east coast, it was thought the two warships would have to depend on foreign supplies.⁵⁵

Anthracite interests looked to the future and hoped that ocean steamship lines would realize the numerous advantages of hard coal as a safer, cleaner, more economical fuel. More freight and less coal could be carried by a ship burning anthracite. Passenger packets would be able to eliminate sparks and odors which plagued travelers

⁵³ *Miners' Journal*, Mar. 29 and Apr. 5, 1851.

⁵⁴ Reprinted in Hazard's *United States Commercial and Statistical Register*, V (Oct. 20, 1841), 253.

⁵⁵ *Miners' Journal*, Oct. 30, 1841.

aboard ships using soft coal. War steamers would have a greater cruising range. The day would come when all ocean steamers would burn Pennsylvania anthracite! "What a vast field for its consumption," chorused the anthracite operators.⁵⁶ The chorus was lost in the sea wind. At that time only a few ocean steamers were built to burn anthracite. It was not until the succeeding decade that American ocean steamers used Pennsylvania hard coal in large enough quantities to be considered an important market. Even more discouraging was the fact that in the 1840's the few attempts made by American business to enter transoceanic steam navigation were unsuccessful.

The first American steam packet since the *Savannah* to make the round-trip voyage from the United States to England did not stand out of New York harbor until 1845. This ship, the *Massachusetts*, took seventeen and a half days to cross the Atlantic. Most of the crossing was made under sail, although her captain asserted a few years later that eleven days were made under steam. The bunkers simply did not carry enough coal for that long a trip. The *Massachusetts* was not a profitable venture. Competition with British steamships and American clippers forced the owners to sell her to the United States Army. Used as a troop transport during the Mexican War, she was transferred to the Navy Department upon the establishment of peace in 1848.⁵⁷

A year before the maiden voyage of the *Massachusetts*, the American steam vessel *Midas* rounded Cape Horn bound for Hong Kong. Her boilers were in such poor condition when she arrived off the China coast that she made the return voyage under canvas.⁵⁸ Two steamship lines, one to Bremen and the other to Havre, each boasting two ships, were granted subsidies by Congress in 1847 and 1848, but proved a disappointment to all, including their respective founders, Edward Mills and Mortimer Livingston. They simply did not possess the speed to "drive the Cunarders off the ocean." Cunard's ships, running from England to Boston and then, later, to New York, were the steam-queens of the sea. It was particularly galling to the Pennsylvania anthracite interests that the coal burned

⁵⁶ *Ibid.*, Oct. 23, 1841.

⁵⁷ *Scientific American*, X (Oct. 28, 1854), 51; *Journal of the Franklin Institute*, LVI (1853), 57.

⁵⁸ *Scientific American*, X (Oct. 28, 1854), 51.

by the Cunarders was not from their mines. Indeed, in the first few years of the Cunard Company, their vessels did not burn American coal of any kind. Instead, sailing ships brought supplies of soft coal from Liverpool to the Cunard docks at Boston and to the newer piers across the Hudson at Jersey City.⁵⁹

These early beginnings in American ocean steam navigation did little to enhance the Pennsylvania coal market. It was not until the appearance of the ill-fated Collins Line in 1850 that Pennsylvania anthracite gained a steady customer in transatlantic shipping. Collins first experimented with Dauphin semibituminous coal from the Susquehanna Valley and found it superior to Cumberland coal from Maryland.⁶⁰ The line's four steamers, *The Atlantic*, *Pacific*, *Arctic*, and *Baltic*, soon turned to the readily available Pennsylvania anthracite and found it more satisfactory. Collins steamers burned Pennsylvania anthracite on their voyages from New York to Liverpool, and Welsh coal on their return trips.⁶¹ B. F. Isherwood, chief engineer, United States Navy, studied the steam log of the *Arctic* and stated that the Welsh coal burned on return voyages was "the Welch [*sic*] coal of similar chemical composition," meaning, of course, that it was Welsh anthracite.⁶² The Cunard steamers were still burning Welsh bituminous coal on their voyages from England to the United States, but had abandoned the expensive procedure of sending coal supplies to this country for the return trips. Instead, Cunard began using Cumberland bituminous coal which, by that time, was shipped in large quantities from Baltimore to the northern seaports.⁶³

It was this Maryland bituminous coal which became anthracite's competition in transatlantic steam navigation. Cunard ships, whose boilers were not constructed to burn anthracite, considered it superior to Virginia or Nova Scotia soft coal and equal to Welsh bituminous. Those who supported the Cumberland interests claimed that it was superior to anthracite in producing steam. The Collins steamer *Pacific* made several fast runs with Cumberland coal and for a short time the company leaned toward the Maryland product.

⁵⁹ Albion, 324-326.

⁶⁰ Taylor, 80-81.

⁶¹ *Ibid.*, 85; *Miners' Journal*, Feb. 12, 1853.

⁶² *Journal of the Franklin Institute*, LVI (1853), 41.

⁶³ Taylor, 85; *Miners' Journal*, Feb. 12, 1853.

When B. F. Isherwood carefully analyzed the steam log of the *Pacific*, he reported that her speed was due to the excellent weather conditions during the crossing and not to the superior qualities of the fuel, and advocated the continued use of anthracite in the Collins steamers.⁶⁴ The line took his advice until shipwreck and financial failure brought it to a tragic end. From that time on, transatlantic steamship traffic was concentrated in the hands of European concerns, whose ships' boilers were not designed to burn anthracite. These ships did use Cumberland coal, however, and some Pennsylvania soft coals which found their way to the seaboard in the late fifties.⁶⁵

In the ten years before the Civil War, a market for Pennsylvania hard coal was nevertheless secured in the United States Caribbean and coastal trade. More than half the steamers plying these waters used Pennsylvania anthracite in whole or in part, while steamships out of New Orleans usually burned Pittsburgh bituminous coal. Anthracite was shipped to Havana and to Nicaragua to supply steamers on the Caribbean run,⁶⁶ and was even sent around the Horn, or across the Isthmus and north to Acapulco and to California ports to feed the boilers of steamers on the Pacific coast.⁶⁷ The annual anthracite consumption of all vessels was estimated to be a quarter of a million tons.⁶⁸

The use of steam and coal by ocean shipping gradually placed sail in a subordinate position. In time, the merchant steamer would drive even the sleek clipper from the seas. But the story of the development of the American steam navy took no such glorious course and lagged behind private shipping interests in the utilization of steam propulsion.

Advocates of steam-powered war vessels were few in the service of the United States Navy. Most of the older officers resisted steam navigation, a trend which was to continue for a decade beyond the Civil War. Shades of the sea victories in the War of 1812 haunted

⁶⁴ *Journal of the Franklin Institute*, LVI (1853), 400-401.

⁶⁵ *Annual Report, B. & O.*, 23-24. Congress cut off subsidies to the Collins Line in 1858.

⁶⁶ *DeBow's Review*, I (1853), 476.

⁶⁷ *Cannelton, Perry County, Indiana, etc.*, 69.

⁶⁸ *DeBow's Review*, I (1853), 476. The exact estimate was 200,000 tons for forty-six steamers in 1853. Capt. Charles Wilkes, USN, *Report on the Examination of the Deep River District, North Carolina* (1858), 26.

the memory and blurred the vision of the men who loved the sailing ships. Not only naval officers, but high government officials showed disdain for steam navigation. President Van Buren evidenced little interest and some hostility to the development of naval steamships. The President's attitude was magnified in the stand taken by the Secretary of the Navy, James Kirke Paulding, who looked upon steamships as "sea monsters." After the launching of the Navy's first steam vessel, the *Fulton*, in 1837, there would have been little progress had not some public concern shown itself in Congress over the construction of steam navies by England and France. In 1839 Congress authorized the construction of three more steam vessels.⁶⁹

The former captain of the *Fulton* returned from Europe that same year. Captain Matthew C. Perry, remembered for his famous expedition to Yedo Bay, was one of the foremost pioneers in the history of steam navigation in the United States Navy. His European tour had been devoted to the study of steam engineering in the navies of England and France, and on his return, his technical knowledge and experience contributed largely to the design and construction of two of the three steamships completed in 1842.⁷⁰ These were the *Mississippi* and *Missouri*, whose boilers were equipped to burn bituminous coal—a fact deplored and lamented by the *Miners' Journal* and the *New York Herald*.⁷¹ The two frigates, each two hundred and twenty-nine feet long, possessed small auxiliary steam engines. It was obvious that the ships were meant primarily for sail. The extension of the Baltimore and Ohio Railroad to Cumberland coincided with the launching of the vessels in 1842 and made the Cumberland coal of western Maryland available to the east coast. Seventeen thousand bushels were purchased by the Navy Department for the two steamers.⁷²

At this time the Navy Department also sent requests to anthracite operators for samples of coal to be sent to the Navy Yard at Washington, D. C., and to other naval establishments on the Atlantic

⁶⁹ Harold and Margaret Sprout, *The Rise of American Naval Power, 1776-1918* (Princeton, N. J., 1946), 112.

⁷⁰ *Ibid.*, 114.

⁷¹ Hazard's *United States Commercial and Statistical Register*, V (Oct. 20, 1841), 253; *Miners' Journal*, Oct. 30, 1841.

⁷² *Niles' National Register*, LXII (1842), 112.

and Gulf coasts and on the Great Lakes. The sample shipments of no less than two tons each, were to be forwarded at the expense of coal operators with a statement of the coal's origin and time of extraction.⁷³ The anthracite had to be tested in stationary engines in the Navy Yard since it could not be burned by the new steamers. But the Schuylkill interests were delighted, and the *Miners' Journal* voiced confidence in the federal government's drive on fuel economy by proclaiming, ". . . now that the Rubicon is passed they can have every proof of the efficiency and superiority of anthracite over any other."⁷⁴

The third ship to be built under the Act of 1839 was the first screw-driven warship in any navy in the world. Behind the construction of this vessel were three men—Captain Robert F. Stockton of Princeton, New Jersey; John Ericsson, inventor of the submerged screw propeller; and Abel P. Upshur, Secretary of the Navy, a staunch supporter of the steam navy idea.⁷⁵ Built at the Philadelphia Navy Yard and launched in 1844, the *Princeton* was to come into national focus and to be remembered by students of American history for reasons totally different from her revolutionary design. On her tragic cruise up the Potomac shortly after her launching, her new cannon, the "Peacemaker," exploded and ended the lives of six persons, among whom were the Secretary of the Navy, Thomas W. Gilmer, and Abel P. Upshur, now Secretary of State. It was an ironic twist of events when the shattered fragments of an exploding gun aboard the newest steam vessel of the Navy snuffed out the life of Upshur. He had been in the front ranks of the few men who campaigned for technical progress and modernization in the Navy of the United States. The glory of the *Princeton* was dimmed in the public eye, but she was recognized as the leader in naval engineering by England and France. Not only was she equipped with the screw propeller, but her boilers had been built to burn Pennsylvania anthracite. In 1845 she proved the excellence of Pennsylvania hard coal in speed tests, and, during the Mexican War, used anthracite successfully when operating in the blockade of Vera Cruz.⁷⁶

⁷³ *Miners' Journal*, Apr. 23, 1842; *The Pennsylvanian*, May 21, 1842.

⁷⁴ *Ibid.*

⁷⁵ Sprout, 125.

⁷⁶ *Journal of the Franklin Institute*, LVI (1853), 43-50.

While Upshur was still Secretary of the Navy, complaints were received by his department concerning the coals procured to service the new bituminous coal-burning vessels. The Navy commissioned Professor Walter R. Johnson, a prominent engineer and fuel analyst, to determine the best coal for naval use. Ability to raise steam, durability of grate bars, and a dozen other properties were analyzed by the scientist and his staff in a specially constructed laboratory. Johnson experimented with forty-one samples of coal, nine of which were Pennsylvania anthracite; foreign coals also were analyzed. His famous, controversial report to the Navy Department was issued in 1844, a few months after the deaths of Upshur and Gilmer.⁷⁷ Johnson himself admitted that his experiments were by no means conclusive, but to his satisfaction he had scientifically proved that the most efficient coal for naval steam vessels was Maryland Cumberland from the Atherson and Templana mines.⁷⁸ As a result of his findings, the Navy continued to burn Cumberland coal, and even the *Princeton* was eventually converted to burn this fuel.

The gradual growth of the steam navy to sixteen vessels by 1853, and the successful use of anthracite in coastwise and transoceanic steam navigation reopened the fuel controversy in naval circles. Congress instructed the Secretary of the Navy to obtain a new report from Engineer in Chief Charles B. Stuart. Stuart submitted his report to the secretary in February, 1852, and in the spring of that year elaborated some of his findings in a letter addressed to the chairman of the Committee on Naval Affairs.

Professor Johnson's experiments of the preceding decade were literally torn to ribbons by Stuart's practical findings. The coals used in the Navy tests were Cumberland bituminous and Schuylkill Valley white-ash anthracite. Emphasizing throughout his letter that valid comparative tests could only be made with fuels as they were delivered to the ships, stored in the bunkers, and brought out for use,

⁷⁷ *Senate Document* No. 386, 28th Cong., 1st Sess., i-xi. One of the many ways in which these experiments differed from previous tests was in the amount of coal used. Johnson utilized several hundred pounds of each kind in every test. Marcus Bull, many years before, in conducting his experiments, had used only a pound or two of each type of coal. *Ibid.*

⁷⁸ *Ibid.*, 599-600. The report was voluminous. When published, it contained more than six hundred pages. It was submitted to the Senate by John Y. Mason, Secretary of the Navy; the Senate considered it important enough to order ten thousand copies printed and distributed throughout the United States. *Ibid.*

Stuart criticized Johnson's limited experiments. Johnson had used, at the most, no more than half a ton in each laboratory test and in a boiler which was not used by naval steam vessels. Stuart used hundreds of tons in marine boilers under actual steaming conditions over a period of time. He found Cumberland coal to be more expensive than anthracite, costing about \$1.50 more per ton at the New York Navy Yard. Since Cumberland coal was friable, a portion of it always crumbled into unusable powder in the process of loading and handling, thus increasing the real cost of the fuel. It was also liable to spontaneous combustion, a hazard of great concern aboard naval craft. In comparison, the initial cost of anthracite was not only less, but the hard coal was easier to handle and not liable to spontaneous combustion. Under cruising conditions, it had been proven to be one-third more effective than Cumberland coal in getting up steam and sustaining it.

Stuart also pointed out that a ship could steam two-thirds longer with anthracite. Because of its smaller bulk more of this coal could be taken aboard, a factor of great importance to the Navy, for it meant longer periods at sea without refueling. Smoke from the stacks of bituminous coal-burning naval vessels could be tracked for miles at sea before their hulls were visible, and their positions could thus be easily determined by enemy ships. Anthracite not only threw out less smoke, but fewer sparks, minimizing the danger of fire. The intense heat of anthracite made copper boilers impractical, however, and, in closing, Stuart recommended iron boilers whenever possible. The chief engineer's report was confirmed by observations made by B. F. Isherwood, who had studied the use of Pennsylvania and Welsh anthracite on a cruise to Liverpool, as well as by earlier British experiments which had reported anthracite's superiority over bituminous coal in naval vessels.⁷⁹

The controversy was by no means settled by Stuart's findings, but the Navy leaned toward anthracite fuel from Schuylkill County from 1852 through the Civil War. It should be pointed out, however, that prior to the Civil War steam was regarded merely as an auxiliary power to sail, to be used in battle maneuvers, in calm, or in entering or leaving port. The war demonstrated the many practical advan-

⁷⁹ *Senate Executive Document No. 74, 32nd Cong., 1st Sess., 1-14; Journals of the Franklin Institute, LIII (1852), 418-419; LIV (1852), 217-228; LV (1853), 40-41.*

tages of steam-powered vessels during the tedious blockading operations by the Union. *The Official Records of the Union and Confederate Navies* is filled with letters, orders, and dispatches regarding coal supplies for northern ships and the difficulties experienced in securing coal by the proud, destructive commerce raiders of the Confederacy.⁸⁰

Most of the coal used by the Union Navy came from Pennsylvania mines. The majority of this tonnage was anthracite brought by sailing sloop from New York or Philadelphia to coaling stations or lighters along the eastern coast, Cuba, and the Gulf coast of Florida.⁸¹ In 1867, the well-known economist and convert to protective tariff policies, Henry C. Carey, bemoaning the financial losses of anthracite coal operators, no doubt exaggerated anthracite's part in the war. Still his words are worth quoting: "But for Pennsylvania anthracite . . . the cause of the North would this day be 'the lost cause.'"⁸² "Pennsylvania," continued Carey, "alone in the possession of anthracite, . . . furnished nearly all the motive power that maintained the blockade."⁸³

Although there was strong dependence on steam during the Civil War, the Navy returned to canvas with the peace. By 1870, under Navy regulations, steam power was to be used only when absolutely necessary. Captains were required to enter in their log books in red ink the reasons for starting their engines.⁸⁴ Admiral Porter, staunch defender of fighting ships of wood and canvas, was bitterly opposed to Isherwood, chief of steam engineering.⁸⁵ The admiral even suggested that a means of enforcing the regulation of less steam and more sail would be to charge the cost of the coal consumed against the commanding officer's pay.⁸⁶

For a few years after the Civil War, Pennsylvania coal lingered in the shadow of sentiment and sail. The day of the American steam navy was still to come.

⁸⁰ For examples, see *Official Records of the Union and Confederate Navies in the War of the Rebellion* (Washington, D. C., 1894), Ser. I, I, 156, 477, 479, 560-561, 647; II, 82-117, 257-259, 353-354, 625, 627.

⁸¹ *Ibid.*

⁸² "Letter Sixth," H. C. Carey to Sen. Henry Wilson, Sept. 10, 1867, *Works of Henry C. Carey* (Philadelphia, 1867), XXIX, 28-29.

⁸³ "Letter Seventh," *ibid.*, 32-33.

⁸⁴ Sprout, 167.

⁸⁵ J. T. Morse, Jr., ed., *The Diary of Gideon Welles* (Boston, 1910), III, 283.

⁸⁶ Sprout, 168.

The beginnings of American steam navigation were years of transition. From the shallow-draught steamboat on western rivers to the large steamers of the Great Lakes and coastal waters of the United States, the significant source of energy steadily became coal. By 1840 America had entered what the journals of the day called the "Coal Age." In the succeeding quarter of a century positive progress was shown in steam navigation through fuel experimentation, technical improvements in marine machinery, and aggressive marketing techniques. The story of steam navigation in America is entwined in the history of a plentiful natural resource. Most of the mineral fuel produced for market before 1865—indeed, eighty per cent of it—came from Pennsylvania mines. The utilization of coal, and more specifically, Pennsylvania coal, proved to be the key which unlocked the wonders and treasures of steam navigation in the United States.

Hartwick College

FREDERICK M. BINDER