HMS Queen Elizabeth with *USS New York* in foreground.

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Naval Innovation

From Coal to Oil

By ERIK J. DAHL

Technology is often cited as a key aspect of the revolution in military affairs and a decisive factor in military operations today. A study of the transition by the Royal Navy from coal to oil, stimulated by First Lord of the Admiralty Winston Churchill and Admiral Sir John (Jacky) Fisher, reveals a more complex story. Although technological change was a great success—every navy soon switched to oil—it did not constitute a strategic advance for Britain. It was an achievement that represented a grave risk to a nation which possessed large coal reserves but no oil. This example suggests how technological innovations alone do not spark a revolution in military affairs.

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Twilight of a Technology

When Churchill went to Whitehall in 1911, coal was still the primary source of power for naval vessels. The Royal Navy had adopted oil for submarines and destroyers, and in most ships it was sprayed on coal to increase its combustion. But coal remained the principal fuel, especially for larger vessels like battleships. It was widely available, especially in Britain, where Cardiff coal mined in Wales was preferred by navies worldwide. Coal was accepted by marine engineers,

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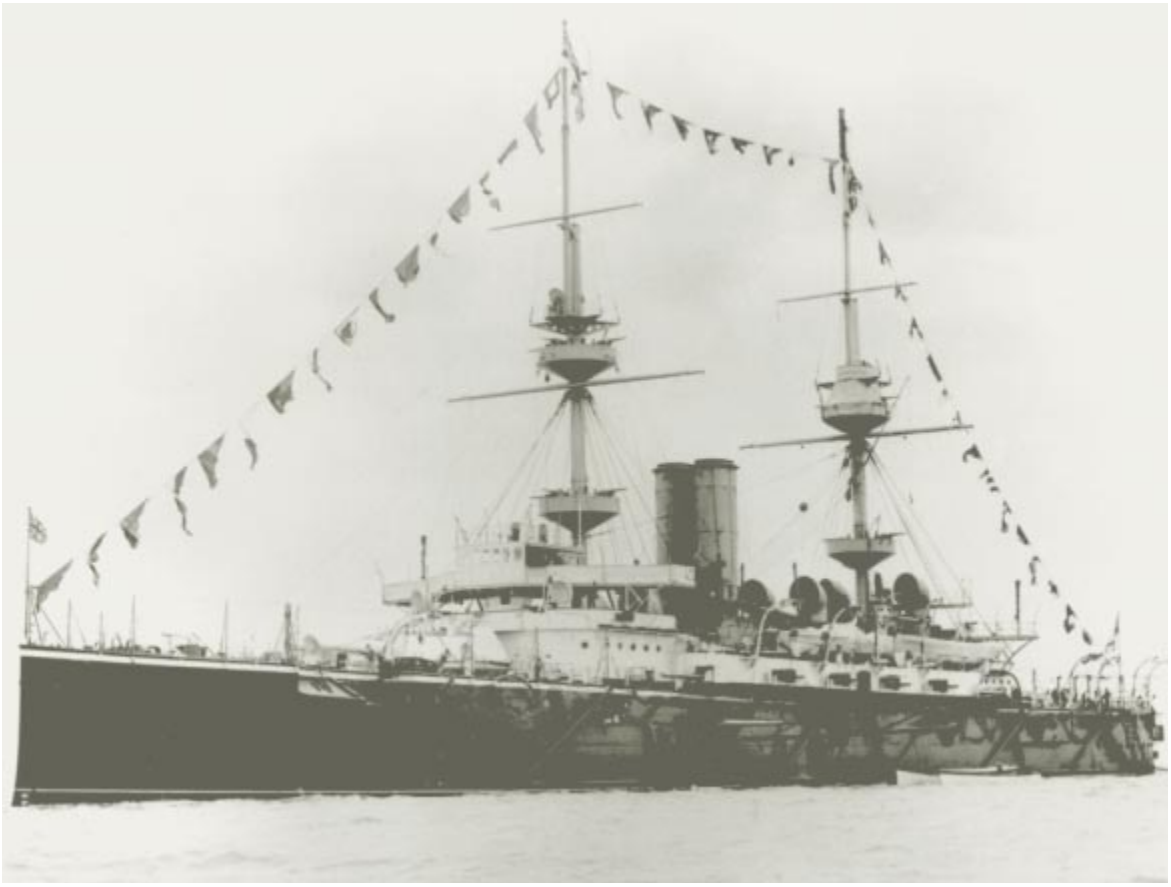

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HMS Illustrious, **coal-fired cruiser launched in 1896.**

and Britain had a global network of coaling stations. In addition, coal was inert and thus supplemented armor by reducing damage from shells exploding in coal storage bins.

But coal also had disadvantages. Moving it from shore to ship, and aboard ship, was dirty and strenuous work that required extensive manpower. As Churchill noted, "the ordeal of coaling ship exhausted the whole ship's company. In wartime it robbed them of their brief period of rest; it subjected everyone to extreme discomfort."[1] It was virtually impossible to refuel at sea, meaning that a quarter of the fleet might be forced to put into harbor coaling at any one time. Providing the fleet with coal was the greatest logistical headache of the age.

Oil offered many benefits. It had double the thermal content of coal so that boilers could be smaller and ships could travel twice as far. Greater speed was possible and oil burned with less smoke so the fleet would not reveal its presence as quickly. Oil could be stored in tanks anywhere, allowing more efficient design of ships, and it could be transferred through pipes without reliance on stokers, reducing manning. Refueling at sea was feasible, which provided greater flexibility.

Oil erased the drawbacks of a solid fuel. As Churchill noted, "the advantages conferred by liquid fuel were inestimable." But he also recognized that a switch would be difficult to implement: "To change the foundation of the navy from British coal to foreign oil was a formidable decision in itself." Finding and securing sources of oil threatened to be the most difficult part of the venture:

The oil supplies of the world were in the hands of vast oil trusts under foreign control. To commit the navy irrevocably to oil was indeed to take arms against a sea of troubles. . . . If we overcame the difficulties and surmounted the risks, we should be able to raise the whole power and efficiency of the navy to a definitely higher level; better ships, better crews, higher economies, more intense forms of war power—in a word, mastery itself was the prize of the venture.[2]

Opposing the transition was the weight of naval tradition, magnified by loss of the strategic advantage of large coal supplies in Britain. This position was voiced in 1904 by Lord Selborne, the First Lord of the Admiralty: "The substitution of

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German battleship *Posen*, powered by mixing coal and oil.

oil for coal is impossible, because oil does not exist in this world in sufficient quantities. It must be reckoned only as a most valuable adjunct."[3]

Supporting change was Admiral Fisher, the First Sea Lord from 1904 to 1910, and friend and advisor to Churchill during his tenure as First Lord of the Admiralty. Fisher, who dominated the Royal Navy in his day, was renowned for many innovations in administration and engineering, including *Dreadnought*-class battleships. An early supporter of oil as fuel, he wrote in 1902, "It is a gospel fact . . . that a fleet with oil fuel will have an overwhelming strategic advantage over a coal fleet."[4] Fisher admitted with pride that he was known as an "oil maniac" as early as 1886.[5]

the Royal Navy regarded the shortage of trained sailors as its worst long-term problem

Fisher described such advantages as the ability to replenish at sea and the smaller amount needed to produce the same amount of energy as coal. He reported that a new Russian battleship burned oil alone and that "at one stroke, oil fuel settles half our manning difficulties! We should require 50 percent less stokers."[6] Personnel savings were also critical to the Royal Navy, which regarded the shortage of trained sailors as its worst long-term problem.

Although Fisher was unable to push the senior service over the precipice during his tenure as First Sea Lord, he found Churchill an important ally since their first meeting in 1907. When Churchill became First Lord, Fisher wrote to a friend describing Churchill in the extravagant terms common in his correspondence: "So far every step he contemplates is good, and he is brave, which is everything! Napoleonic in audacity, Cromwellian in thoroughness."[7] Fisher regularly peppered Churchill with advice on a variety of naval matters.[8]

One requirement, Fisher told Churchill, was that the *Queen Elizabeth*-class battleships be built as a fast division, able to outmaneuver and cross the T of the German fleet. In 1912, Fisher wrote to Churchill, "What you do want is the superswift—all oil—and don't fiddle about armour; it really is so very silly! There is only one defence and that is speed!"[9]

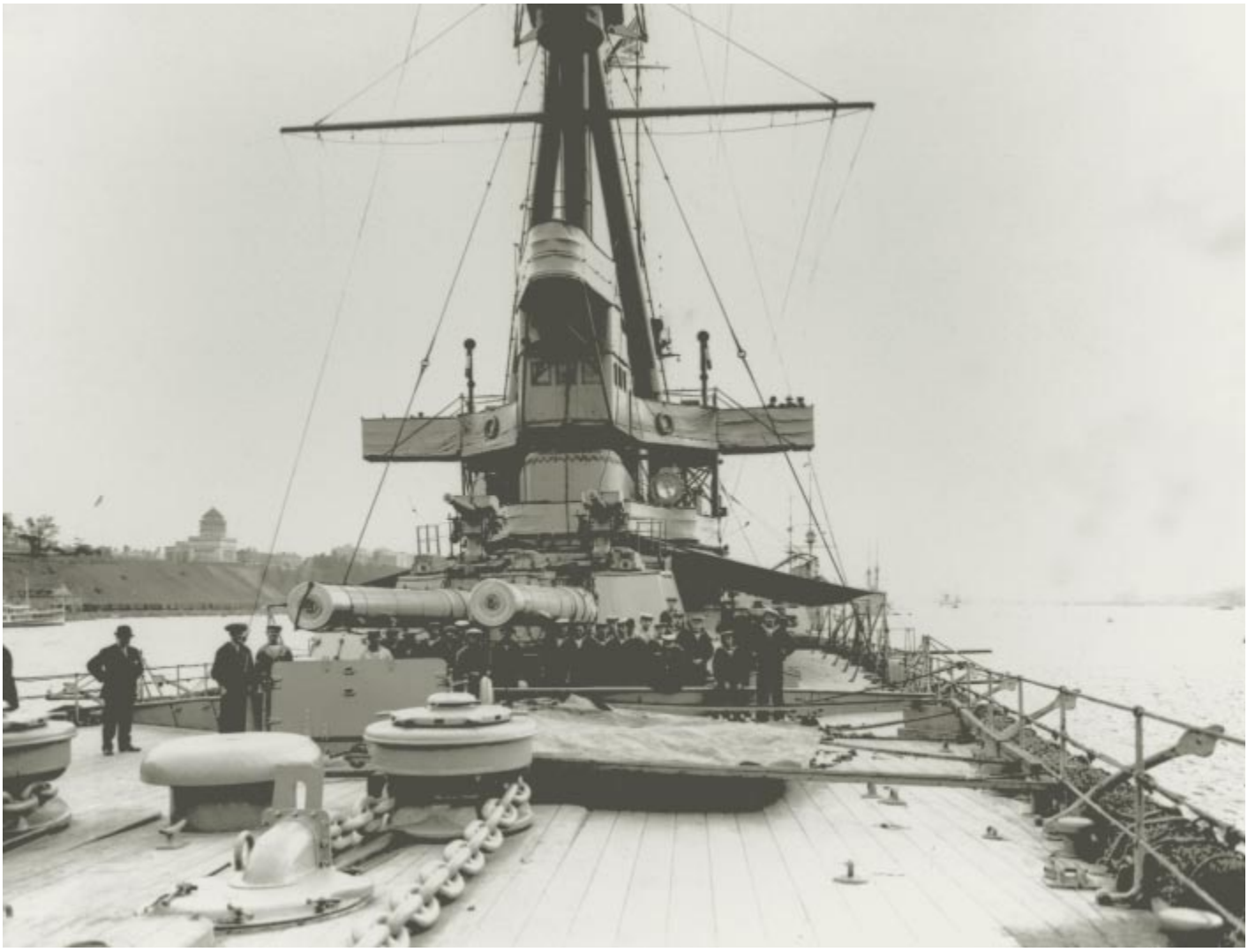
The war college was asked how much speed a fast division would need to outmaneuver the German fleet. The answer was 25 knots, or at least four knots faster than possible at the time. Churchill concluded, "We could not get the power required to drive these ships at 25 knots except by the use of oil fuel." This was enough for him.

Queen Elizabeth-class battleships were built to burn oil only. Once this decision was made, Churchill wrote, it followed that the rest of the Royal Navy would turn to oil:

The fateful plunge was taken when it was decided to create the fast division. Then, for the first time, the supreme ships of the navy, on which our life depended, were fed by oil and could only be fed by oil. The decision to drive the smaller craft by oil followed naturally upon this. The camel once swallowed, the gnats went down easily enough.[10]

But building oil-fired ships was only part of the exercise; it was also necessary to secure a supply and solve storage and transport problems. To meet these challenges Churchill established a royal commission. With Fisher as chairman, the commission eventually published three classified reports confirming the benefits of oil. It judged that ample supplies of oil existed but urged that a storage capacity be built in peacetime to ensure sufficiency in time of war.

The final step was finding a source, and toward that end a delegation went to the Persian Gulf to examine oil fields. Two companies were the likely choice of supply: the powerful Royal Dutch Shell Group and smaller Anglo-Persian Oil Company. After considerable maneuvering, and largely through Churchill's encouragement, the government decided to maintain competition in the oil industry and ensure supplies by investing directly in Anglo-Persian. The government acquired 51 percent of company stock, placed two directors on its board, and negotiated a secret contract to provide the Admiralty with a 20-year supply of oil under attractive terms.



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***HMS Inflexible* on Hudson River, 1910.**

Military-Oil Complex

Other factors were involved in the switch to oil beyond the efforts of Fisher and Churchill. Private industry helped develop ships and engine designs. As Hugh Lyon wrote, "The use of oil fuel would not have been possible without the pioneering work of such British firms as Wallsend Slipway on the design of suitable and economic burners. The Admiralty did do some research itself, but the main bulk of the investigations that were conducted in Britain were the work of private industry."[11] This argument is similar to that advanced by William McNeill, who described the period from 1880 to World War I as a "runaway technological revolution." It was largely the result of "command technology" in which government planners urged industry to innovate. In the case of the Royal Navy, for example, the Admiralty—largely due to Fisher—set specifications for engineers but did not actually design the ships and guns.

The growing oil industry also played an important part. Peter Padfield sees the efforts of private firms, especially Anglo-Persian, as "a good example of the way in which British command of the sea, exercised through her world system, allowed her to exploit commercial opportunities which in turn increased her command."[12] Padfield argues that Anglo-Persian, acting as part of the British Empire, pushed the switch to oil, which drove the Royal Navy to seek higher speeds.

Although Fisher and Churchill had close personal and professional relations with senior oil executives, their correspondence reveals that military and strategic concerns, and not commercial motives, were at the root of the switch. Fisher, for example, worked closely with leaders of major companies but rejected offers to sit on corporate

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U.S. Fleet, Guantanamo Bay.

boards. He also did not have favorites, praising and supporting each competitor at different times. The Burmah Oil Company, for example, was an early supplier to the Admiralty, beginning in 1904 when Fisher was First Sea Lord, and was the forerunner to Anglo-Persian. Fisher also wrote flattering accounts of the chiefs of Anglo-Persian's archrival, Shell, including a description of Henri Deterding as "Napoleonic in his audacity and Cromwellian in his thoroughness."[13]

widespread experimentation and development of fuel oil had shown the technology was feasible

Race to the Future

Beyond the efforts of the main actors and pressures of industry and commerce, it appears that several broader historical factors in the years leading up to World War I made the time right for Britain to adopt oil. One factor was the growing Anglo-German naval race. But just as critically, by this time several decades of widespread experimentation and development of fuel oil had shown that the technology was feasible. It appeared Britain ran the risk of being left behind.

The Italian navy led the way in experimenting with oil starting in 1890, and by 1900 most of its torpedo boats were oil burning. The mixed-firing method of spraying oil on coal was routine by the early 1900s, and a liquid fuel board in the United States recommended using oil as a standalone fuel in 1904. The first oil-burning American destroyer, *USS Paulding*, was commissioned in 1910, and by 1911 the *USS Nevada*-class battleship was planned for solely oil as fuel.

By 1912 oil technology was relatively well understood. But there was no particular race to develop oil-fueled warships, and in 1914, despite the advantage of oil, only America joined Britain in moving far in that direction. The United States had ample supplies. But Fisher received regular reports that the Germans were developing oil.

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***HMS Dreadnought* underway.**

To innovate and maintain a lead over an enemy was Fisher's goal. He cautioned Churchill in 1912: "The luxuries of the present are the necessities of the future. Our grandfathers never had a bathroom . . . you have got to plunge for three years ahead!" A letter from Fisher demonstrates both his concern over German developments and excessive rhetoric:

The one all pervading, all absorbing thought is to get in first with motor ships before the Germans! Owing to our apathy during the last two years they are ahead with internal combustion engines! They have killed 15 men in experiments with oil engines and we have not killed one! And a . . . fool of an English politician told me the other day that he thinks this creditable to us.[14]

This combination of concerns expressed by Fisher—that development was inevitable, an enemy was working on it, and Britain must stay in the lead—had been present in the earlier development of the *Dreadnought*-class battleship. In 1910 he wrote "Like the planet Neptune, the discovery of the dreadnought was inevitable, but luckily we saw her in the heavens before the other chaps and got our unparalleled lead! Thank God!"[15]

Ironically, Fisher's information was faulty in the case of oil, and Germany did not develop oil as quickly as Britain or the United States. Germany used mixed firing in a major combatant for the first time in 1909 and did not use all-oil firing for surface combatants until after World War I. Nonetheless, it was a combination of the general level of oil development and the threat of German advances that pushed Britain to change despite the loss of the coal advantage. The transition itself quickly became recognized as the right decision, and the new fuel became universally used in naval design in a few years. In 1919 *Jane's Fighting Ships* announced that "the geared turbine and 'all oil' fuel system have secured a distinct success."

Fortunes of Conflict

Although the British navy did gain a speed advantage, particularly since Germany did not develop oil until after World War I, the change did not appear to be a deciding factor in the conflict. At the same time, the Royal Navy suffered from oil shortages, particularly in 1917 when attacks on submarine tankers began to tell. For a time British ships were forced to stay in harbor as much as possible and destroyers were held to a speed of 20 knots.

The switch to oil neither sparked a naval revolution nor delayed Britain's naval decline. In part its historical significance may have been overshadowed by development of the dreadnought. It

German battleship *Nassau,* launched 1908.

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may also be that World War I gave little opportunity for innovation, and by World War II every navy had adopted oil, neutralizing gains. This explained, as Michael Handel stated, why technological advantages may be short-lived. "The general availability of new technologies to all participants in a war cancels out the advantage that might otherwise be realized from greater knowledge and control. When both sides have telephones, radios, radars, high-speed computers, or [remotely piloted vehicles], no one has the advantage (that is to say, when all other things are equal)."[16]

Moreover, limitations may relate to a common complaint leveled by historians, that Fisher focused on the material over the strategic. He is blamed on one point in particular. Paul Kennedy, discussing the lose of ascendancy by the Royal Navy over the army before World War I, explained that "energetic and farsighted though the First Sea Lord was in so many ways, he was no great strategist and had crushed all moves to create an effective naval staff."[17]

The transition from coal to oil was symptomatic of the broader limitations of leadership of the navy by Fisher and Churchill: it was a significant innovation but not a strategy. It improved the warfighting capability of the Royal Navy but didn't change the way wars were fought.

The transition from coal to oil in the Royal Navy came about through a variety of factors. Fundamentally, it was a technological phenomenon waiting to happen. Britain, the United States, and a few other nations had been experimenting with oil, and its advantages were generally known. In the event, Britain and the United States made the change at about the same time. But in Britain the strategic risks were great enough to require the skill of both Fisher and Churchill to accomplish the change. The Anglo-German naval race—particularly reports that Germany was developing oil as fuel more quickly—provided the final impetus. **JFQ**

NOTES

[1] Winston S. Churchill, *The World Crisis,* Vol. 1 (New York: Scribner's, 1923), p. 134.

[2] Ibid., pp. 133–36.

[3] P. K. Kemp, ed., *The Papers of Admiral Sir John Fisher,* Vol. 1 (London: The Navy Records Society, 1960), p. 81.

[4] Arthur J. Marder, ed., *Fear God and Dread Nought: The Correspondence of Admiral of the Fleet Lord Fisher of Kilverstone*, Vol. 1 (London: Jonathan Cape, 1952), p. 220.

[5] John Fisher, *Records* (London: Hodder and Stoughton, 1919), p. 202.

[6] Marder, *Fear God,* p. 235.

[7] Ibid., p. 430.

[8] Ibid., p. 402.

[9] Ibid., p. 426.

[10] Churchill, *The World Crisis,* pp. 133, 136.

[11] Hugh Lyon, "The Relations Between the Admiralty and Private Industry in the Development of Warships," in *Technical Change and British Naval Policy 1860–1939,* edited by Bryan Ranft (New York: Holmes and Meier, 1977), p. 49.

[12] Peter Padfield, *The Battleship Era* (New York: David McKay, 1972), p. 203.

[13] Fisher, *Records*, p. 201.

[14] Marder, *Fear God*, p. 426.

[15] Ibid., p. 332.

[16] Michael Handel, *War, Strategy and Intelligence* (London: Frank Cass, 1989), p. 21.

[17] Paul M. Kennedy, *The Rise and Fall of British Naval Mastery* (London: The Ashfield Press, 1976), p. 234.