

Inventing the Military-Industrial Complex:
Torpedo Development, Property Rights, and Naval Warfare
in the United States and Great Britain before World War I

Dissertation

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By

Katherine Cranston Epstein, M.Phil.

Graduate Program in History

The Ohio State University

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Dissertation Committee:

Geoffrey Parker, Advisor

John Guilmartin

Jennifer Siegel

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Abstract

The warfare state is much older than the welfare state. For centuries, the relationship between militaries and the private manufacturing sector has been the most important point of interaction between the state and society. The naval-manufacturing relationship has even deeper historical roots: since warfare at sea has traditionally required much more sophisticated technology than warfare on land, nations have had to invest more money in navies in peacetime.

In the late nineteenth century, two developments transformed the naval-manufacturing relationship. First, the intense naval competition preceding World War I increased the pace of technological change and the need for peacetime investment in naval technology. Second, the Second Industrial Revolution transformed the manufacturing sector into the industrial sector, and it accordingly altered the nature of military and naval technology. Torpedoes were in the vanguard of both developments.

They played a significant role in the arms race before World War I because they threatened to revolutionize naval tactics and strategy. Navies realized that the tactical system built around capital ships primarily armed with big guns might give way to one built around smaller vessels primarily armed with torpedoes. At the strategic level, the ability of smaller vessels carrying torpedoes to sink larger ones made battle and blockade very risky. Given the potential of torpedoes to alter the metrics and application of naval

power, navies worked feverishly to develop them before World War I.

The sophistication of torpedo technology, however, complicated the task of turning potential into reality. Powered by fossil fuels and made with hundreds of small, steel, inter-changeable parts, torpedoes symbolized the Second Industrial Revolution at sea. Sending a torpedo prototype into mass production without adequately testing it beforehand would produce nightmares of assembly and operation. A robust research and development (R&D) infrastructure was therefore vital.

Torpedo development in the United States and Great Britain showed the two sides of the R&D coin. Despite the common depiction of a declining Britain and a rising United States in this period, Britain actually had a decided edge over the United States in naval-industrial R&D resources. This edge enabled it to perfect existing torpedo technology and test new technology, while the United States had to take technological gambles. It was R&D resources, not Yankee can-do spirit or John Bull conservatism, that accounted for the nature of technological change.

Although the two nations met with differing degrees of success, the effort to create an adequate R&D infrastructure profoundly changed the relationship between state and society in both the United States and Britain. Lacking the resources to develop adequate technology alone, the public and private sectors were forced to work together—but their collaboration raised fundamental and complex questions about the nature of property in relation to invention, and it imperiled the liberal political philosophy on which both nations were putatively founded.

Between their interaction with industrialization and the new relationship between the government and the private sector, torpedoes may be said to have helped put the

“industrial” and the “complex” in the military-industrial complex. Their story therefore belongs in larger narratives about the nature of technological change, industrialization, modern warfare, and national development.

Dedication

Dedicated to Mom, Dad, and Claire

Acknowledgments

It gives me great pleasure to acknowledge the assistance I received in researching and writing this dissertation.

My first thanks are due to those who helped me at the archives I visited. In England, the staff at The National Archives in Kew retrieved countless documents for me. I am also grateful to the archivists and librarians at the Hampshire Record Office, in Winchester; the Hartley Library of the University of Southampton, in Southampton; the Churchill Archives Center, Churchill College and the Vickers Archive, University Library, at the University of Cambridge, in Cambridge; the Tyne and Wear Archives, in Newcastle; the Liddell Hart Centre for Military Archives, in London; and the National Maritime Museum, in Greenwich.

At the naval base in Portsmouth, Jenny Wraight, the head librarian of the Admiralty Library, was gracious and helpful during my visits to the Naval Historical Branch. Iain Mackenzie answered my inane questions and ferried books back-and-forth between the Naval Historical Branch and the Royal Naval Museum, where the staff was also very friendly.

I visited several other archives in the Portsmouth area. George Malcomson hosted me on a brief visit to the HMS *Dolphin* Royal Navy Submarine Museum. Lieutenant Commander Bill Legg let me poke around the HMS *Collingwood* Communications and

Radar Museum and even gave me a tour of the base. Lieutenant Commander Brian Witts kindly did the same for me at HMS *Excellent*.

At the Brass Foundry in Woolwich, Jeremy Michell, Andrew Choong, and Graham Thompson created a convivial working environment.

In the United States, the staff at the National Archives and Records Administration in Washington, DC took my questions about obscure record groups in good humor and brought me many cart-loads of documents. The staff at the Navy Department Library, also in Washington, made it a congenial place to work on my short visits there.

At the Naval War College, where I viewed documents from the Naval Historical Collection, Dr. Evelyn Cherpak went to some trouble to procure the records of the Naval Torpedo Station for me, and then generously tolerated the boxes ringing the edges of her archives. Her company made my time in Newport much more pleasant. In addition, I am grateful to Dr. John Hattendorf for giving me a tour of the Naval War College Museum, including its torpedo exhibit. I would also like to thank Neil and the late Philippa Coughlan for their hospitality while I did research at the Naval War College.

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Generous financial support enabled me to research and write my dissertation. A Dean's Distinguished University Fellowship from the Ohio State University permitted me to focus on research without teaching responsibilities. An ABC-Clio Research Grant from the Society for Military History, a Caird Short-Term Research Fellowship from the National Maritime Museum, a Tomlin Fund grant from the Society for Nautical Research,

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I have been very fortunate in my education. Some people have their first great teacher in college; I had mine in kindergarten. I would particularly like to thank Betsy Emery, Bryan Jones, Leonard King, and Cynthia Peterson. Liz Hall was a long-time coach and mentor. I still treasure the eight years of Latin that I took with a trio of extraordinary teachers—Sean Mulholland, John Pepino, and Christine Vellenga—who gave me some my happiest moments in middle school and high school. Puckie Thomas taught me how to write and continues to inspire me with her devotion to the life of the mind.

In college, Dr. Jay Winter let me into his junior seminar on World War I as a sophomore in return for my volunteering to do the first presentation. I liked the class so much that I changed my major to history. Although shopping period is the bane of most Yalies' existence, it gave me a chance to check out Charlie Hill's course on International Ideas and Institutions on a whim, which set me on a course to taking Studies in Grand Strategy with him, Dr. John Gaddis, and Dr. Paul Kennedy. Grand Strategy was intellectually exhilarating, and I believe it was Charlie who suggested that I think about going to grad school to study military history further. I am glad he did.

I am grateful to Dr. Alex Roland, of Duke University, for suggesting that I look into torpedoes. In the midst of flailing around for a dissertation topic, I met Dr. Roland at

the 2007 West Point Summer Seminar and wrote to him asking if he had any suggestions on topics. He graciously replied with several ideas, one of which was torpedo development, saying that he had seen little on the subject. Thus a dissertation was born.

When I was just beginning to think about my topic, I paid a visit to Dr. Jon Sumida at the University of Maryland. Not knowing what to expect from a Clausewitz scholar who studied the Royal Navy as a hobby (I thought), I found Jon full of enthusiasm and support for the idea. He was the person who really got me excited about my topic, and he often restored my spirits when they flagged. Jon smoothed the way for me at archives and was exceedingly generous in sharing documents (including a complete set of the Annual Reports of HMS *Vernon*, the Royal Navy's torpedo school, and several "Paper[s] prepared by the Director of Naval Ordnance and Torpedoes for the Information of his Successor") and advice—without pressuring me to agree with his interpretations of the sources. He carefully read and commented on a draft of my dissertation. I am grateful to him for setting high standards and doing his best to help me reach them.

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Dr. Frederick Milford—author of a series of articles on American torpedo development, engineer, and Columbus resident—graciously read a draft of Chapter 3 of my dissertation and discussed it with me on his front porch.

I would like to thank several of my professors at Ohio State. Dr. Alan Beyerchen was one of the reasons I came here. His class on historiography and conversations with him have been stimulating and helped to shape my understanding of historical study. Dr. John Guilmartin has forgotten more than I will ever know about military history, and as a member of my dissertation committee, he read and commented on a draft of my dissertation. Dr. Jennifer Siegel also graciously served on my dissertation committee, in which capacity she heroically read and commented on two drafts of my dissertation.

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Kate Epstein
Columbus
July 2011

Vita

2004.....	B.A. History <i>summa cum laude</i> , Yale University
2004–present.....	Phi Beta Kappa
2004–2005.....	Gates Cambridge Scholarship
2005.....	M.Phil. International Relations, University of Cambridge
2005–2006.....	Roy A. Koenigsnecht Graduate Alumni Fellowship, The Ohio State University
2005–2008.....	Dean’s Distinguished University Fellowship, The Ohio State University
2008.....	Society for Military History ABC-Clio Research Grant
2008.....	Society for Nautical Research Tomlin Fund Grant
2008.....	National Maritime Museum Caird Short-Term Research Fellowship
2008.....	Mershon Center for International Security Studies Grant, The Ohio State University
2008–2009.....	U.S. Naval Historical Center Rear Admiral John D. Hayes Pre-Doctoral Fellowship
2008–2009.....	International Security Studies Pre-Doctoral Fellowship in Security Studies, Yale University
2009–2010.....	Graduate Teaching Associate, Department of History, The Ohio State University
2010–2011.....	Bradley Foundation Fellowship

Publications

Review of David Edgerton, *Warfare State: Britain, 1920–1970*, in *International Journal* 62:4 (Fall 2007)

“Imperial Aims: Leo Amery’s Air-mindedness, 1873–1945,” *Journal of Imperial and Commonwealth History* 38, no. 4 (December 2010): 571–598

Fields of Study

Major Field: History

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Abbreviations Used in the Notes

Adm	Admiralty
ACNTS	Assistant Commander of the Naval Torpedo Station, Newport, RI, United States
ADNO	Assistant Director of Naval Ordnance, Admiralty
ADT	Assistant Director of Torpedoes, Admiralty
AL	Admiralty Library, Portsmouth, England
ART	Annual Report of the Torpedo School (H.M.S. <i>Vernon</i>)
ASRGF	Assistant Superintendent of the Royal Gunpowder Factory
Asst	Assistant
AsstSecNav	Assistant Secretary of the Navy
B	Box
BB*	
BBB*	
BF	Brass Foundry, Woolwich, England
BuOrd	Bureau of Ordnance, Navy Department
CINC	Commander in Chief
CIO	Chief Intelligence Officer, Navy Department
CNTS	Commander of the Naval Torpedo Station, Newport, RI, United States
CoO	Chief of the Bureau of Ordnance, Navy Department
CSOF	Chief Superintendent of Ordnance Factories
Ct. Cl.	Court of Claims
DeptNav	Navy Department
DNO	Director of Naval Ordnance, Admiralty
E	Entry
F	Folio
<i>FDSF</i>	<i>From Dreadnought to Scapa Flow</i> (book by Arthur Marder)
FY	Fiscal Year
GBP	Great Britain Patent
IoO	Inspector of Ordnance
JAG	Judge Advocate General, Navy Department
M	Microfilm
NARA	National Archives and Records Administration, Washington, DC, United States
NMM	National Maritime Museum, Greenwich, England

NTS	Naval Torpedo Station, Newport, RI, United States
NHC	Naval Historical Collection, Newport, RI, United States
SC	Ship's Cover
SecAdm	Secretary of the Admiralty
SecNav	Secretary of the Navy
SRGF	Superintendent of the Royal Gunpowder Factory, Woolwich, England
SRNTF	Superintendent of the Royal Naval Torpedo Factory, Greenock, Scotland
P	Page
PP	Pages
PQ	<i>Principal Questions dealt with by the Director of Naval Ordnance</i>
R	Reel
RCAI	Royal Commission on Awards to Inventors
RG	Record Group
RGF	Royal Gunpowder Factory, Woolwich, England
RNC	Royal Naval College, Greenwich, England
RNTF	Royal Naval Torpedo Factory, Greenock, Scotland
T&W	Tyne and Wear Archives, Newcastle, England
TDC	Torpedo Design Committee
TNA	The National Archives, Kew, England
USP	United States Patent
V	Volume
VA	Vickers Archive, University of Cambridge Library, Cambridge, England
VG**	
VR**	

*At NARA, in RG74/E25 (BuOrd official files), the box numbering restarts twice. I adopted "B" to apply to the first series, "BB" to apply to the second series, and "BBB" to apply to the third series.

**At NARA, RG74/E26 (semi-official BuOrd files) is especially quirky, and my abbreviations are therefore especially quirky. They are:

- B1B/VR (B[ox] 1, B[ound papers], V[olume] R[ed])
- B1B/VG (B[ox] 1, B[ound papers], V[olume] G[reen])
- B1L (B[ox] 1, L[oose papers])

References to these files appear only in Chapter 5.

Introduction

Beneath the Surface

This is a work about torpedoes, historical methodology, and the emergence of the modern state.

Torpedoes were a crucial weapon before and during World War I, but they have received little attention from historians. Before helping to imperil the Allied war effort, torpedoes created a revolution in naval tactics, strategy, and the very metrics of naval power. Because the so-called “dreadnought revolution” dominates historians’ understanding of the pre-war period, however, torpedoes have been neglected. Repairing this neglect requires more than a narrative about torpedo development: it also requires a different understanding of how to study naval history. This work offers both.

Through torpedoes, it also explores a transformation in the relationship between the state and society for the purposes of waging war in the industrial age. Torpedoes—not steamships—are the quintessential symbol of the Second Industrial Revolution at sea. Their development required the creation of a new weapons procurement paradigm, characterized by state investment in new technology during the experimental stage rather than by the purchase of finished products. The new paradigm in turn created difficulties about intellectual property rights, the proper limits of state power, and the balance

between civil liberties and national security—all issues which remain pressing today.

This work makes several points:

- First, that torpedoes were just as important as capital ships and big guns in pre-war naval history.
- Second, that we must define the “military-industrial complex” more precisely and date it earlier than is customary.
- Third, that the military-industrial complex has crucial implications for property rights and classical liberal political philosophy.
- Fourth, that the dynamics creating the military-industrial complex were international—meaning that the United States and Great Britain were not exceptional.
- Fifth, that our understanding of pre-World War I naval history is gravely incomplete.
- Sixth, that we cannot correct our misunderstanding without repairing our methodology.

The first six of these points may be said to relate to the “what” of history, and the seventh to the “how.” The last is the most important, because the quality of the process used determines the quality of the conclusions reached. The dependence of ends on means is evident throughout the existing literature.

American Naval Historiography

Torpedoes do not fit into the conventional wisdom on pre-World War I American naval history. Most historians agree that the U.S. Navy, having languished for almost two decades after the Civil War, began a renaissance in the early 1880s. The old wooden navy gave way to the steel “New Navy,” armed with modern rifled breech-loading guns. The first steel ships were cruisers, followed by small battleships intended for coast defense, but the Navy was building large ocean-going battleships by the early 1900s. Symbolically marking the transition from the old navy to the new, Alfred Thayer Mahan published *The Influence of Sea Power upon History* in 1890, arguing that commerce warfare was

ineffective and that great nations needed concentrated fleets of battleships to seek command of the sea through decisive battle. The Spanish-American War and imperial growth in the late 1890s and early 1900s impelled the United States to put Mahan's vision into practice. As historic rivalry with Britain gave way to rapprochement in the 1890s, the United States focused its new naval strategy against Germany in the Caribbean and Japan in the Pacific. While the Navy centralized its fleets, analogous administrative centralization occurred in the Navy Department, in which the Secretary of the Navy oversaw eight Bureaux. The Naval Advisory Boards, aide system, Naval War College, and Office of Naval Intelligence gave the Secretary new weapons to combat the power of the decentralized Bureaux. Although the literature contains a disagreement over the value of the battleship strategy that emerged in the 1890s, both sides treat it as a watershed in American naval history.¹ This narrative of American naval history has also crept into broader studies of American defense and foreign policy before World War I.²

These large-scale overviews of the subject draw on five main specialist approaches. The first, epitomized by William Braisted and William Still, examined the

¹ For positive takes on the battleship strategy, see Harold Sprout and Margaret Sprout, *The Rise of American Naval Power, 1776–1918* (Princeton: Princeton University Press, 1939); Paulo Coletta, *A Survey of U.S. Naval Affairs, 1865–1917* (Lanham: University Press of America, 1987), 9–52; Stephen Howarth, *To Shining Sea: A History of the United States Navy, 1775–1991* (New York: Random House, 1991), 231–43. For a negative take, see Kenneth Hagan, *This People's Navy: The Making of American Sea Power* (New York: The Free Press, 1991), 176–227, 389–90. See also Robert Albion, *Makers of Naval Policy, 1798–1947*, ed. Rowena Reed (Annapolis: Naval Institute Press, 1980), 6–13, 205–19.

² See, e.g., David M. Pletcher, *The Awkward Years: American Foreign Relations under Garfield and Arthur* (Columbia: University of Missouri Press, 1962), 116–36; Walter LaFeber, *The New Empire: An Interpretation of American Expansion, 1860–1898* (Ithaca: Cornell University Press, 1963), 58–60, 93, 121–27, 229–41; James Abramson, *America Arms for a New Century: The Making of a Great Military Power* (New York: The Free Press, 1981), 20–9, 47–8, 120–3; Thomas Misa, *A Nation of Steel: The Making of Modern America, 1865–1925* (Baltimore: Johns Hopkins University Press, 1995), 95–96; Paul A. C. Koistinen, *Mobilizing for Modern War: The Political Economy of American Warfare, 1865–1919* (Lawrence: University Press of Kansas, 1997), 26–47.

Navy from a high-level strategic and even diplomatic perspective.³ The second, which includes the work of John Reilly, Robert Scheina, and Ivan Musicant, was technological history focusing mainly on the evolution of capital ships.⁴ A more recent strand within technological history was more self-consciously theoretical; it includes the work of William McBride and William Thiesen.⁵ The third approach, exemplified by Peter Karsten and Robert O’Connell, was socio-cultural history which tended to present naval officials in a highly unfavorable light.⁶ Fourth, historians have written biographies of a few famous naval officers generally considered to be “reformist” or “progressive,” like Stephen Luce, Alfred Thayer Mahan, Bradley Fiske, William Sims, and George Dewey, generally ignoring the mass of less famous officers.⁷ Finally, historians have studied the two organizations most closely associated with the administrative centralization that supposedly accompanied the American naval renaissance, namely, the Naval War College

³ William R. Braisted, *The United States Navy in the Pacific, 1897–1909* (Austin: University of Texas Press, 1958) and *The United States Navy in the Pacific, 1909–1922* (Austin: University of Texas Press, 1971); William N. Still, *American Sea Power in the Old World: The United States Navy in European and Near Eastern Waters, 1865–1917* (Westport: Greenwood Press, 1980).

⁴ John Reilly and Robert Scheina, *American Battleships, 1886–1923: Predreadnought Design and Construction* (Annapolis: Naval Institute Press, 1980); Ivan Musicant, *U.S. Armored Cruisers: A Design and Operational History* (Annapolis: Naval Institute Press, 1985).

⁵ William McBride, *Technological Change and the United States Navy, 1865–1945* (Baltimore: Johns Hopkins University Press, 2000); William Thiesen, *Industrializing American Shipbuilding: The Transformation of Ship Design and Construction, 1820–1920* (Gainesville: University Press of Florida, 2006).

⁶ Peter Karsten, *The Naval Aristocracy: The Golden Age of Annapolis and the Emergence of Modern American Navalism* (New York: The Free Press, 1972); Robert O’Connell, *Sacred Vessels: The Cult of the Battleship and the Rise of the U.S. Navy* (Boulder: Westview Press, 1991). Ronald Spector’s *Professors at War: The Naval War College and the Development of the Naval Profession* (Newport: Naval War College Press, 1977) takes a more neutral view.

⁷ For example, John Hattendorf and John Hayes, eds., *The Writings of Stephen B. Luce* (Newport: Naval War College Press, 1975); Paolo Coletta, *Admiral Bradley A. Fiske and the American Navy* (Lawrence: Regents Press of Kansas, 1979); Elting Morison, *Admiral Sims and the Modern American Navy* (Boston: Houghton Mifflin, 1942); William Livezey, *Mahan on Sea Power* (Norman: University of Oklahoma Press, 1981); Ronald Spector, *Admiral of the New Empire: The Life and Career of George Dewey* (Baton Rouge: Louisiana State University Press, 1974); James C. Bradford, ed., *Quarterdeck and Bridge: Two Centuries of American Naval Leaders* (Annapolis: Naval Institute Press, 1997). An exception to the rule of ignoring all but a few officers is Stephen Stein, *From Torpedoes to Aviation: Washington Irving Chambers and Technological Innovation in the New Navy, 1876–1913* (Tuscaloosa: University of Alabama Press, 2007).

and the Office of Naval Intelligence.⁸

With few exceptions, the existing literature relies on an inadequate source base. It exploits published documents, like congressional committee hearings and the annual reports of the Secretary of the Navy; the personal papers of certain high-ranking “reformist” officers; and records from the Office of the Secretary of the Navy. Three major groups of sources are conspicuously absent from this list. One is the records of the Navy Department bureaux. The failure to consult them is particularly problematic given the general agreement among naval historians that the bureaux, rather than central bodies, drove the development of the American Navy in this period. McBride, for instance, did not cite a single record from the four major technological bureaux in his book on *Technological Change and the United States Navy*.⁹ The second major absence in the sources is the personal papers of all but a few famous reformers. The third is the tactical, as opposed to the strategic, sections of the reports published by the War College every summer. In fairness, one exception to these critical comments should be noted: Norman Friedman, who carried out extensive archival research, including Bureau records and the War College tactical papers, for his magisterial series of books on American naval vessels and technologies.¹⁰

⁸ Jeffrey Dorwart, *The Office of Naval Intelligence: The Birth of America's First Intelligence Agency, 1865–1918* (Annapolis: Naval Institute Press, 1979); Karsten, *The Naval Aristocracy*; Spector, *Professors at War*; John Hattendorf, B. Mitchell Simpson, III, and John Wadleigh, *Sailors and Scholars: The Centennial History of the U.S. Naval War College* (Newport: Naval War College Press, 1984). The only works to treat naval administration at large are Albion, *Makers of American Naval Policy*, and Charles Paullin, *Paullin's History of Naval Administration, 1775–1911: A Collection of Articles from the U.S. Naval Institute Proceedings* (Annapolis: Naval Institute Press, 1968).

⁹ McBride relied primarily on R[ecord]G[roup] 45 (Naval Records Collection) and RG 80 (Office of the Secretary of the Navy). Completely absent from his notes are RG 19 (Bureaux of Construction and Repair, Steam Engineering, and Equipment) and RG 74 (Bureau of Ordnance).

¹⁰ Norman Friedman, *U.S. Destroyers: An Illustrated Design History* (Annapolis: Naval Institute Press, 1982); *U.S. Aircraft Carriers: An Illustrated Design History* (Annapolis: Naval Institute Press, 1983); *U.S.*

In addition to archival weaknesses, most of the existing literature also displays a flawed conceptual approach. Historians' obsession with battleships and commitment to a whiggish narrative of American naval progress, characterized by fleet and administrative centralization, has blinded them to other crucial stories. Despite the enormous growth in naval expenditures before World War I, no one has undertaken a serious study of how the United States paid for its navy. Frederick Harrod's *Manning the New Navy* is the only study of the crucial personnel question.¹¹ There are no published monographs devoted to such key technologies as fire control or signaling, for instance, while Nicholas Lambert's unpublished doctoral dissertation remains the best work on American submarine development.¹² Only articles, not monographs, have been published on torpedo development. Frederick Milford's article on pre-World War I American torpedoes is solid but does not use the relevant bureau records.¹³ E. W. Jolie's history of American torpedoes contains minimal analysis and occasional errors, while the articles by Barbara

Naval Weapons: Every Gun, Missile, Mine and Torpedo Used by the U.S. Navy from 1883 to the Present Day (Annapolis: Naval Institute Press, 1983); *U.S. Cruisers: An Illustrated Design History* (Annapolis: Naval Institute Press, 1984); *U.S. Battleships: An Illustrated Design History* (Annapolis: Naval Institute Press, 1985); *U.S. Small Combatants, Including PT-Boats, Subchasers, and the Brown-Water Navy: An Illustrated Design History* (Annapolis: Naval Institute Press, 1987); *U.S. Submarines since 1945: An Illustrated Design History* (Annapolis: Naval Institute Press, 1994); and *U.S. Submarines through 1945: An Illustrated Design History* (Annapolis: Naval Institute Press, 1995).

¹¹ Frederick Harrod, *Manning the New Navy: The Development of a Modern Naval Enlisted Force, 1899–1940* (Westport: Greenwood Press, 1978).

¹² Christopher Havern has written an excellent master's thesis on American fire control ("A Gunnery Manqué: William S. Sims and the Adoption of Continuous-Aim in the United States Navy, 1898–1910" (Master's Thesis, University of Maryland, 1995)), and Timothy Wolters has written an equally good doctoral dissertation on American signalling ("Managing a Sea of Information: Shipboard Command and Control in the United States Navy, 1899–1945" (Ph.D. Diss., Massachusetts Institute of Technology, 2003)). On submarines, see Lambert, "The Influence of the Submarine upon Naval Strategy" (Ph.D. Diss., University of Oxford, 1992). Gary Weir's *Building American Submarines, 1914–1940* (Washington: Naval Historical Center, 1991) has strengths—including some use of RG 19, the Bureaux of Engineering and Construction and Repair records, and awareness of McNeill's thesis of "command technology," discussed below—but it is weakened by an over-simplified explanation of naval opposition to submarines (see p. 6) and, judging by the endnotes, an absence of research in RG 74, the records of the Bureau of Ordnance, which played a major role in submarine development.

¹³ Frederick Milford, "US Navy Torpedoes—Part One: Torpedoes through the thirties," *The Submarine Review* (April 1996).

Moe and Bruce McCandless on American torpedoes are short and superficial.¹⁴ Richard Glasow's unpublished "Prelude to a Naval Renaissance" is the only study of guns in the key transitional period of the 1870s, and one of the only works from any period to draw on the relevant bureau records.¹⁵ Kurt Hackemer's *The U.S. Navy and the Origins of the Military-Industrial Complex, 1847–1883* (2001) and Benjamin Franklin Cooling's *Gray Steel and Blue Water Navy: The Formative Years of America's Military-Industrial Complex, 1881–1917* (1979) are the only two systematic studies of the rapidly growing nexus between Navy and business, but both focus on ship-building, and the latter, while seminal, is seriously weakened by lack of research in the relevant bureau records.¹⁶ There are several other works on ship-building and steel as components of the naval-industrial complex, but none on other components.¹⁷

The approaches and research agenda of most historians are caught in a vicious feedback loop: problems with the former feed problems with the latter, and vice-versa. For instance, Edward Miller wrote in the introduction to his famous study of American naval war planning against Japan that he would deal with "the larger aspects of planning"

¹⁴ E. P. Jolie, *A Brief History of U.S. Navy Torpedo Development* (NUSC Technical Document 5436, 15 September 1978); Barbara Moe, "The Impact of the Invention of the Torpedo on the U.S. Navy," *Oceans Proceedings* 1 (2003): 61–67; Bruce McCandless, "The Howell Automobile Torpedo," *USNI Proceedings* (October 1966): 174–76. For instance, Jolie stated that the 5-meter Whitehead Mark I and II torpedoes were longer versions of the 3.55-meter Mark I and II torpedoes, when in fact they entirely different types (p. 19).

¹⁵ Richard Glasow, "Prelude to a Naval Renaissance: Ordnance Innovation in the United States Navy During the 1870s" (Ph.D. Diss., University of Delaware, 1978).

¹⁶ Benjamin Franklin Cooling, *Gray Steel and Blue Water Navy: The Formative Years of America's Military-Industrial Complex, 1881–1917* (Hamden: Archon Books, 1979); Kurt Hackemer, *The U.S. Navy and the Origins of the Military-Industrial Complex, 1847–1883* (Annapolis: Naval Institute Press, 2001).

¹⁷ See David B. Tyler, *The American Clyde: A History of Iron and Steel Ship-building on the Delaware from 1840 to World War I* (Newark: University of Delaware Press, 1958); Dean C. Allard, "The Influence of the United States Navy upon the American Steel Industry, 1880–1900" (Master's Thesis, Georgetown University, 1959); Johannes R. Lischka, "Armor Plate: Nickel and Steel, Monopoly and Profit," in *War, Business, and American Society: Historical Perspectives on the Military-Industrial Complex*, ed. Benjamin Franklin Cooling (Port Washington: Kennikat Press, 1977), 43–58; Thomas R. Heinrich, *Ships for the Seven Seas: Philadelphia Shipbuilding in the Age of Industrial Capitalism* (Baltimore: Johns Hopkins University Press, 1997); and Thiesen, *Industrializing American Shipbuilding*.

and not with “tactical plans,” because the latter “were almost nonexistent”—and he failed to use the extensive War College records dealing with tactical planning (such as the suggestively titled “Battle Plan No. 1”).¹⁸ Similarly, Robert Love’s conviction that Mahan’s emphasis on concentrated battlefleets was a key turning point in American naval history led him to write that this principle “always” applied for Mahan and ignore the many ways in which Mahan qualified it.¹⁹ Viewing capital ships as the defining aspect of the “American naval revolution,” Walter Herrick mis-identified the inventor of the torpedo as “Arthur” Whitehead.²⁰ Because many historians think they can do naval history by focusing on strategy and battleships alone, they do not look for the primary sources that illuminate other issues; and because they do not look for the sources that illuminate other issues, they do not realize how important these issues are.

British Naval Historiography

Any account of the literature on British naval history before World War I must begin with the work of Arthur Marder, who established the conventional wisdom on the subject. Marder’s reputation as the leading scholar rests on two monographs: *The Anatomy of British Sea Power*, covering 1880 to 1905, and published in 1940; and the first volume of *From the Dreadnought to Scapa Flow*, covering 1904 to 1914, and

¹⁸ Edward Miller, *War Plan Orange: The U.S. Strategy to Defeat Japan, 1897–1945* (Annapolis: Naval Institute Press, 1991), 3. Note that Miller contradicts himself on the next page, writing that “In Phase II [of the plan]... the two battle fleets would meet in a cataclysmic gunnery engagement which American dreadnoughts would win.”

¹⁹ Robert Love, *History of the U.S. Navy, 1775–1941* (Harrisburg: Stackpole Books, 1992), 371. For Mahan’s qualifications, see Jon Sumida, *Inventing Grand Strategy and Teaching Command: The Classic Works of Alfred Thayer Mahan Reconsidered* (Baltimore: Johns Hopkins University Press, 1999), 42–49, 67–76.

²⁰ Walter R. Herrick, Jr., *The American Naval Revolution* (Baton Rouge: Louisiana State University Press, 1966), 37. Hagan repeated the error in *This People’s Navy*, 187.

published in 1961. Leading lights have hailed his work, singling out his archival access and research for praise. According to John Keegan, Marder's "standards of archival research and organization of material ... defy betterment."²¹ Sir Michael Howard called Marder's work "a monument of scholarship worthy of its subject," noting also that Marder had "persuaded the Admiralty to give him access to their documents long before they were officially released."²² Likewise, Marder's entry in the *Dictionary of National Biography* commented that "[i]t would be difficult to fault Marder's published work" and mentioned his "access to materials not readily available to earlier historians of the First World War."²³ In the foreword to Marder's festschrift, Lord Mountbatten acclaimed "his outstanding historical work" and "his international reputation as a modern naval historian of the highest calibre."²⁴ In major studies of pre-war British defense policy, Samuel Williamson and Paul Kennedy relied heavily on Marder for their interpretation of naval policy, and historians still revere Marder's work.²⁵ Given such professional imprimatur, Marder's ideas unsurprisingly found their way into popular imagination, as evidenced by

²¹ John Keegan, *The Face of Battle* (New York: Penguin, 1976), 27.

²² Michael Howard, "Leading Seaman," review of *From the Dreadnought to Scapa Flow*, Vol. 5, *Victory and Aftermath*, by Arthur Marder, *Times*, 21 June 1970, clipping in DAN 563 (H. E. Dannreuther papers), NMM.

²³ John Horsfield, "Marder, Arthur Jacob (1910–1980)," in *Oxford Dictionary of National Biography*, ed. H. C. G. Matthew and Brian Harrison (Oxford: OUP, 2004), <http://www.oxforddnb.com.proxy.lib.ohio-state.edu/view/article/54711> (accessed May 3, 2010).

²⁴ Lord Louis Mountbatten, Foreword to *Naval Warfare in the Twentieth Century*, ed. Gerald Jordan (London: Croom Held, 1977).

²⁵ Samuel Williamson, *The Politics of Grand Strategy: Britain and France Prepare for War, 1904–1914* (Cambridge: Harvard University Press, 1969), 15–18, 43–46, 50–51, 68–69, 103–9, 194–95, 238–40, 361–62; Paul Kennedy, *The Rise of the Anglo-German Antagonism, 1860–1914* (London: Allen and Unwin, 1980), 251–52, 260, 272, 279, 444, 451–52. For evidence of Marder's continuing hold, see Matthew Seligmann, "New Weapons for New Targets: Sir John Fisher, the Threat from Germany, and the Building of HMS *Dreadnought* and HMS *Invincible*, 1902–1907" and "Switching Horses: The Admiralty's Recognition of the Threat from Germany, 1900–1905," *International History Review* 30, no. 2 (June 2008). Paul Haggie also relied on Marder for "The Royal Navy and War Planning in the Fisher Era," in *The War Plans of the Great Powers, 1880–1914*, ed. Paul Kennedy (London: George Allen & Unwin, 1979), 118–32.

Robert Massie's *Dreadnought*, for instance.²⁶

Marder advanced five major theses. First, he argued that by 1903 the Royal Navy had become more concerned about the threat from Germany alone (as opposed to the threat from Germany in alliance with France or Russia) than about any other threat.²⁷ In his words, the Anglo-German naval antagonism was the “Ariadne’s thread” of the decade or so before World War I.²⁸ Second, he argued that John (“Jackie”) Fisher, the powerful First Sea Lord from 1904 to 1910, redistributed the fleet, by pulling ships from foreign stations to concentrate them in home waters, as a response to the German threat.²⁹ Third, Marder placed the construction of the *Dreadnought* type of battleship at the center of reforms carried out by Fisher.³⁰ Fourth, he argued that Fisher was obsessed with materiel to the exclusion of strategy.³¹ Finally, he argued that from 1904 until the outbreak of war in 1914, strategic and tactical thinking in the Royal Navy was essentially static: the Royal Navy sought to re-enact Trafalgar against Germany, decisively defeating the German

²⁶ Robert Massie, *Dreadnought: Britain, Germany, and the Coming of the Great War* (New York: Random House, 1991).

²⁷ Arthur Marder, *The Anatomy of British Sea Power: A History of British Naval Policy in the Pre-Dreadnought Era, 1880–1905* (Hamden: Archon Books, 1964; first edn. 1940), 465: “By the autumn of 1902 ... public opinion, the government, and the Admiralty were as one in viewing the German fleet as a potential menace far greater than the fleets of the Dual Alliance.”

²⁸ Arthur Marder, *From the Dreadnought to Scapa Flow: The Royal Navy in the Fisher Era, 1904–1919*, vol. 1, *The Road to War, 1904–1914* (London: Oxford University Press, 1961) [hereafter *FDSF I*], vii.

²⁹ Marder, *The Anatomy of British Sea Power*, 491: “A redistribution of British naval strength was long overdue. The German navy menace galvanized the Admiralty into action.” See also Marder, *FDSF I*, 40–43.

³⁰ Marder, *The Anatomy of British Sea Power*, Chapter 27. In this chapter, Marder treats the battlecruiser *Invincible* as an afterthought—20 pages on *Dreadnought* versus 2 paragraphs on *Invincible*. He treated the battlecruiser more seriously when he returned to the subject in *FDSF I* (Chapter 3, Section E), but clearly still regarded it as less important than the dreadnought.

³¹ Marder, *FDSF I*, viii-ix: “The entire period was ... one in which *matériel* considerations bulked somewhat larger than the more ‘sublime’ aspects of naval warfare, strategy, and tactics. Fisher was the father of the *matériel* school. It is, then, hardly a misnomer to call the 1904–19 period the Fisher Era in the Royal Navy.”

battlefleet by the old tactic of crossing the “T” and bringing superior gunfire to bear.³²

For other historians, the plausibility of Marder’s interpretation depended on the perception that he had the evidence necessary to support it. Marder not only took pains to create the impression that he had exhausted the relevant primary sources, but he also encouraged the view that the Admiralty had granted him privileged access. In the preface to *The Anatomy of British Sea Power*, for instance, Marder characterized the work as

the first reasonably complete study of British naval policy in all its ramifications in the vital pre-dreadnought era. In addition to poring through every scrap of published material and innumerable organs of public opinion, it has been my good fortune to be permitted to see various unpublished materials of the first importance. These materials have never before been utilized in any published work.³³

He struck similar notes in the preface to the first volume of *From Dreadnought to Scapa Flow*, writing that it was, “like its predecessor, based on a mass of unpublished material, virtually all published works of any value to the subject, Parliamentary papers, *Hansard’s Parliamentary Debates*, the leading newspapers, periodicals, and professional journals, and correspondence and interviews with officers and civilians having first-hand knowledge of the subject.”³⁴ Marder thanked the Lords Commissioner of the Admiralty for access to the Admiralty Record Office, where Admiralty papers remained until their release to the Public Record Office, and he singled out, among others, the former Head of the Admiralty Record Office. The obvious implication of these acknowledgements was that Marder had enjoyed privileged access to Admiralty records. This effectively deterred

³² See especially Marder, *FDSF I*, Chapter 12. To wit: “The genius of most of the Navy’s leaders in the Fisher era did not shine in the field of tactics. Especially was this Fisher’s blind spot” (395); “On one fundamental tactical objective only was there general agreement—from whatever formation, to cross the ‘T’, that is, to steam across the head of the enemy’s line” (400).

³³ Marder, *The Anatomy of British Sea Power*, v.

³⁴ Marder, *FDSF I*, vii.

scholars who wished to follow in his footsteps so long as the Admiralty still held the records, while the lack of indexing of many important files at The National Archives continued to hamper scholars even after the Admiralty surrendered the records.³⁵

Marder further hindered subsequent scholarship by failing to provide adequate citations. In the introduction to *The Anatomy of British Sea Power*, he warned, “The Admiralty archival material will not be cited in reference footnotes in this work.”³⁶ Similarly, in the introduction to the first volume of *From Dreadnought to Scapa Flow*, he acknowledged that “[i]t has, unfortunately, not been possible to indicate the source of some of the documents cited in footnotes.”³⁷ Marder also remarked that in service of “telling a story,” he had decided “to eliminate the impedimenta of scholarship like the meticulous acknowledgment for every word that has been borrowed.”³⁸ In effect, Marder demanded that scholars accept his interpretation on trust.

A few scholars have not done so. Instead, they went back to the archives and

³⁵ This is especially true of ADM 1 (Admiralty Secretariat files), 116 (Admiralty case files), and 137 (files for the official history of World War I). ADM 1 consists of boxes which contain docket. The dockets in each box are often unrelated to each other; for instance, a docket on uniform buttons might be next to a docket on gunnery contracts. Unfortunately, the finding aids at The National Archives are box-level, not docket-level. Researchers can also consult the original Admiralty digests in ADM 12, but these provide only an approximate idea of which box a docket might be in, and no guarantee that the docket survived “weeding”—that is, the destruction of records deemed to be relatively unimportant “weeds.” The only way to find out what dockets are in the boxes, therefore, is to order the boxes one by one. As for ADM 116 and 137, they contain files that otherwise would have ended up in ADM 1, but there is no index for either record group and no way of knowing in advance which of the three record groups contains files on a given subject. ADM 116, like ADM 1, is organized according to the date of the latest paper in the file, meaning that important papers on the pre-war period exist in volumes filed with those from the interwar period—for instance, ADM 116/3408–12, which contain papers from 1886–1913, is surrounded by case files from the 1920s and 1930s. ADM 137 is arguably even worse, since its creators bound the volumes as they found the papers left by the official historians, without reorganizing them. Thus, as with ADM 1, the only way to discover the contents of ADM 116 and 137 is to order the files one by one. ADM 1 contains roughly 2,500 boxes covering the decade before World War I, ADM 116 contains some 2,500 case files which must be checked for that period, and ADM 137 contains nearly 5,000 volumes. The scale of the task is formidable, to say the least.

³⁶ Marder, *The Anatomy of British Sea Power*, v.

³⁷ Marder, *FDSF I*, xi-xii.

³⁸ Marder, *FDSF I*, viii.

produced an alternative, amply documented interpretation, which is much more persuasive than Marder's. Ruddock Mackay made the first contribution in 1973, when he published *Fisher of Kilverstone*.³⁹ Unlike Marder, Mackay gave serious consideration to Fisher's tenure as Commander in Chief of the Mediterranean Fleet from 1899 to 1902, two years before he became First Sea Lord. By re-orienting attention from the North Sea (where the threat was Germany) to the Mediterranean (where the threats were France and Russia), Mackay challenged a key aspect of Marder's interpretation, namely, that Fisher was obsessed with the German threat and the search for decisive battle in the North Sea.

Building on Mackay, Jon Sumida published *In Defence of Naval Supremacy* in 1989, followed by several major articles.⁴⁰ Sumida challenged Marder's interpretation in several ways. First, he argued that the primary motive affecting British naval policy in the three decades before World War I was not political—namely, the rise of the German threat—but financial, specifically, the need to reduce naval spending. Second, he argued that Fisher was less concerned with the German threat to Britain in home waters than with the Franco-Russian threat to Britain's global imperial interests, especially its trade. Finally, as a corollary to these twin emphases on finance and the protection of global

³⁹ Ruddock Mackay, *Fisher of Kilverstone* (Oxford: Clarendon Press, 1973). It should be noted that Mackay has distanced himself from Sumida's and Lambert's work, even though his own work is far more compatible with theirs than with Marder's. See, e.g., the annotated bibliography of Mackay's entry on "John Fisher" in the *Oxford Encyclopedia of Maritime History*, ed. John Hattendorf (Oxford: Oxford University Press, 2007), which ignores Sumida's work and minimizes the importance of Lambert's.

⁴⁰ Jon Sumida, *In Defence of Naval Supremacy: Finance, Technology, and British Naval Policy, 1889–1914* (Boston: Unwin Hyman, 1989); "The Quest for Reach: The Development of Long-Range Gunnery in the Royal Navy, 1901–1912," in *Military Transformation in the Industrial Age*, ed. Stephen D. Chiabotti (Chicago: Imprint, 1996), 49–96; "A Matter of Timing: The Royal Navy and the Tactics of Decisive Battle, 1912–1916," *Journal of Military History* 67 (January 2003): 85–136; and "Expectation, Adaptation, and Resignation: British Battle Fleet Tactical Planning, August 1914–April 1916," *Naval War College Review* 60, no. 3 (Summer 2007): 101–22.

commerce, he gave a new account of Fisher's shipbuilding policy which de-emphasized the importance of battleships in favor of battlecruisers.

Important though Sumida's conclusions were, the methodology by which he reached them was even more important. Sumida's notes confirm that he looked at sources to which Marder's notes do not refer, and Sumida asked questions that Marder clearly never considered. Taking a seemingly arcane piece of technology (gunnery fire control), Sumida showed how important it had been to naval officials and thus how important it should be to historians. He linked his highly technical account of fire control to major changes in tactical thought, overturning Marder's depiction of tactical stagnation. To substantiate his interpretation, he used sources like a two-inch-thick docket in the Admiralty Secretariat files entitled "Gunnery: Effects on ... possibility of concentration of fire &c. of new developments in Fleet Tactics"—whose title alone belied Marder's assertion that the Royal Navy made "[n]o effort... to co-ordinate tactics and gunnery."⁴¹ Not stopping at technical and tactical issues, Sumida offered significant new insights into the origins of World War I, British grand strategy, the structure of the state, and the relationship between the state and society. In effect, Sumida did not so much argue within an existing paradigm as create a new one, redefining the relevant archival base and the research agenda.

Nicholas Lambert significantly extended Sumida's work in a series of major articles and in *Sir John Fisher's Naval Revolution*, published in 1999.⁴² Where Sumida

⁴¹ The full title of the docket was "Gunnery: Effects on a) plotting for range, b) rate of change of bearing & range, c) possibility of concentration of fire &c. of new developments in fleet tactics," ADM 1/8051, TNA. Marder, *FDSF* I:401.

⁴² Nicholas Lambert, "Admiral Sir John Fisher and the Concept of Flotilla Defence, 1904–1909," *Journal of Military History* 59, no. 4 (October 1995): 639–60; *Sir John Fisher's Naval Revolution* (Columbia:

took fire control as his point of entry into larger questions, Lambert used the submarine, which formed the centerpiece of a strategy known as flotilla defense. Instead of seeking decisive battle against the Germans in the North Sea, Lambert argued, Fisher sought to use mines and torpedo craft—submarines and destroyers—to deny the North Sea, the Channel, and the Mediterranean to enemy vessels. This strategy of denial and control of the sea was financially sustainable, whereas command of the sea through battleships was not. Fisher linked his strategy of flotilla defense to an offensive strategy centered on battlecruisers and new communications equipment, which would enable the Admiralty to track merchant shipping and direct battlecruisers against it. This revolutionary scheme of command and control was known as the War Room System, after the room at the Admiralty where an unprecedented amount of operational decision-making power was concentrated.⁴³ Far from being a strategic dullard, Fisher was a strikingly original, even brilliant, strategist. Lambert's addition of flotilla defense and the War Room System complemented and strengthened Sumida's emphasis on battlecruisers, financial factors, and the Admiralty's continuing commitment to imperial defense. Lambert also ranged more widely than Sumida into domestic politics and Cabinet-level decision-making, substantiating his interpretation with verifiable citations.

Torpedoes played a large role in Sumida's and Lambert's interpretation, and their work remains the best existing source of information on British torpedo development.

Marder is unreliable: he reversed the chronology of two important inventions in torpedo

University of South Carolina Press, 1999); "Strategic Command and Control for Maneuver Warfare: Creation of the Royal Navy's 'War Room' System, 1905–1915." *Journal of Military History* 69, no. 2 (April 2005): 361–410.

⁴³ Lambert, "Strategic Command and Control for Maneuver Warfare: Creation of the Royal Navy's 'War Room' System, 1905–1915," *Journal of Military History* 69, no. 2 (April 2005): 361–410.

technology, the gyroscope and the superheater, and vaguely attributed further development to “the process of mechanical progress.”⁴⁴ Early treatises like C. W. Sleeman’s *Torpedoes and Torpedo Warfare* (1889), G. E. Armstrong’s *Torpedoes and Torpedo-Vessels* (1896), and Murray Sueter’s *The Evolution of the Submarine Boat, Mine, and Torpedo* (1907) are useful but dated, and do not draw on confidential records. Edwyn Gray’s *The Devil’s Device* and *Nineteenth-Century Torpedoes and their Inventors* are worthy starting points, but they are more popular than academic, with such poor notes that it is often impossible to retrace his research.⁴⁵ Peter Bethell produced a generally sound (and amusing) series of articles on torpedo development in 1945–1946, but they have occasional errors, and in any case contain few footnotes.⁴⁶ Geoff Kirby’s work on early torpedo development is superficial and riddled with errors.⁴⁷ Mark Briggs’ article covers only the Royal Navy’s initial adoption of the torpedo, up to 1873, and Alan Cowpe’s strong chapter on British torpedo development goes up to only the 1890s.⁴⁸ While Sumida and Lambert are invariably reliable on torpedo development, it was not their primary focus, and their work leaves ample room for a study focusing on the subject.

⁴⁴ Marder, *The Anatomy of British Sea Power*, 356.

⁴⁵ Edwyn Gray, *The Devil’s Device: The Story of Robert Whitehead, Inventor of the Torpedo* (Annapolis: Naval Institute Press, 1991; first edn. 1975); *Nineteenth Century Torpedoes and their Inventors* (Annapolis: Naval Institute Press, 2004).

⁴⁶ Peter Bethell, “The Development of the Torpedo,” Parts 1–7, *Engineering* 159–61 (25 May 1945 to 15 Mar 1946). For instance, Bethell said that the first gyroscopes acquired by the U.S. Navy were angled gyroscopes, when in fact they were not (p. 11), and certain details in his account of superheater development were wrong (p. 13).

⁴⁷ Geoff Kirby, “A History of the Torpedo: The Early Days,” *Journal of the Royal Navy Scientific Service* 27, no. 1 (January 1972): 30–55. To give just two examples, Kirby dated the Royal Navy’s introduction of angled gyroscopes to 1900, when in fact it did not occur until 1912 (p. 37); and he credited the Armstrong dry superheater as the first effective superheater, when in fact Leavitt’s superheater was the first (p. 43).

⁴⁸ Mark Briggs, “Innovation and the Mid-Victorian Royal Navy: The Case of the Whitehead Torpedo,” *Mariner’s Mirror* 88, no. 4 (November 2002): 447–55; Alan Cowpe, “The Royal Navy and the Whitehead Torpedo,” in *Technical Change and British Naval Policy, 1860–1939*, ed. Bryan Ranft (London: Hodder and Stoughton, 1977), 23–36.

The Story So Far

The modern torpedo was invented by a British engineer named Robert Whitehead.⁴⁹ Born near Manchester, Whitehead moved to France in the 1840s to find work as a marine engineer. In 1847, he moved to Milan, then part of the Austrian Empire, but the revolutions of 1848 drove him to the Adriatic coast, where he eventually settled in Fiume (now Rijeka, Croatia), a major base for the Austrian Navy, for which he began building engines. In 1864, a retired Austrian naval officer named Giovanni de Luppis brought him plans for a primitive wooden torpedo (called *Der Küstenbrandner*, “the coastal fireship”). The design proved totally unworkable, but Whitehead was sufficiently intrigued with the idea of a torpedo to start from scratch. He produced a new prototype by 1866, powered by a unique two-cylinder engine of his own design. The torpedo could make roughly 6 knots for 200 yards, but its depth-keeping was erratic. In December 1866, Whitehead tried the torpedo officially for the Austrian Navy, and the British Admiralty knew of it within a month. Whitehead had a breakthrough on the depth-keeping problem while running the torpedo again for the Austrian Navy in October 1868. He came up with “The Secret,” a combination of a hydrostatic valve to control the depth and a pendulum to control the trim. The Austrian Navy was delighted with the resulting improvements, but it could not afford to purchase the exclusive rights to Whitehead’s torpedo.

Its inability left the way open for Britain. Whitehead had invited British officers to witness trials in October 1868, but it was not until August 1869 that the Admiralty appointed an official commission to report on the invention. In the meantime, then-Commander John Fisher (a future First Sea Lord), who was visiting the Prussian Navy to

⁴⁹ The following account draws on Gray, *The Devil’s Device*, 14–59, 77–89.

observe mining experiments, befriended one of the Austrian naval officers who had observed the December 1866 trials. Fisher submitted his own report on the Whitehead torpedo two weeks after the official British commission submitted its report. Duly impressed, the Admiralty decided to invite Whitehead to hold official trials in Britain. Overseen by a commission that included then-Lieutenant A. K. Wilson (another future First Sea Lord), the trials were held in October 1870 with a 14-inch and a 16-inch (diameter) torpedo. They were successful, and the Admiralty signed a non-exclusive contract to buy torpedoes from Whitehead's Fiume factory in April 1871. In 1872, the Royal Laboratory (subsequently the Royal Gunpowder Factory) at Woolwich, which was owned by the War Office rather than the Admiralty, began building Whitehead torpedoes for the Royal Navy under license from Whitehead. In 1890, Whitehead established a second factory at Weymouth, on the south coast of England, to build torpedoes for the Royal Navy. His factory at Fiume continued to take orders from navies all over the world.

The United States was an exception. Instead of buying torpedoes from Whitehead, the U.S. Navy attempted to develop a domestic counterpart. Its best hope was a torpedo known as the Howell, invented by an American naval officer named J.A. Howell, which the Navy began to test in 1870. In contrast to the Whitehead torpedo, which relied on compressed air, the Howell torpedo relied on the energy stored in a flywheel for propulsion. Aside from its propulsive effect, the flywheel also exerted a gyroscopic effect on the torpedo, improving its accuracy in the horizontal plane.

While it experimented with the Howell torpedo, the U.S. Navy flirted periodically with the Whitehead Company. An American delegation visited Fiume to observe the Whitehead torpedo in 1869, but the U.S. Navy was unwilling to pay Whitehead's asking

price.⁵⁰ American officers visited again in 1871, 1873, and 1874 without buying.⁵¹ Then Whitehead's American agent offered to sell the torpedo in 1877.⁵² The U.S. Navy negotiated directly with Whitehead in 1882 and 1883, but still declined to purchase.⁵³ Not until 1891 did it begin buying Whitehead torpedoes.

By that point, Robert Whitehead and his British customers had made several significant improvements to his design.⁵⁴ In 1875, he replaced his original two-cylinder engine with a three-cylinder version designed by the British engineering firm of Peter Brotherhood. The original single screw gave way to contra-rotating propellers, and Whitehead introduced a steering engine to amplify the effect of the depth mechanism on the horizontal rudders. After the Royal Navy discontinued production of 16-inch torpedoes in 1877, the 14-inch design remained the only model until 1889, when the Royal Navy ordered its first 18-inch torpedoes. By the mid-1890s, Whitehead torpedoes could make in the upper-20 knots for roughly 800 yards. The application of the gyroscope to torpedoes in 1895, when the present work begins, began their transformation into accurate, high-speed, long-range weapons.

The platforms for launching torpedoes were also changing during this period. Contrary to popular belief, the submarine had limited utility as a torpedo platform before World War I. Pre-war submarines were not true submarines but submersibles, spending

⁵⁰ The records relating to this delegation can be found in RG45/E45 (M89/R230) and RG74/E201/Subject 14/B16, NARA.

⁵¹ See Marvin to Simpson, 18 March 1871, RG74/E201/Item 15/B12; Kirkland to Jeffers, 8 December 1873, and Braine to Case, 29 September 1874, RG74/E201/Subject 14/B16, NARA.

⁵² Lines to House, 10 January 1877, RG74/E19/B175/V21, NARA.

⁵³ See John Whitehead to Sicard, 13 April 1882 (and related letters), RG74/E19/B177/V25; McLean to John Whitehead, 14 March 1883 (and related letters), RG74/E201/Item 27/B27 (see also RG74/E19/B178/V26), NARA.

⁵⁴ This paragraph is based on Bethell, "The Development of the Torpedo," 7.

most of their time on the surface of the water and submerging only to attack a target. Most submarines lacked sufficient surface speed to accompany battle fleets (i.e., they were not “fleet-keeping” submarines), which moved in the low-20 knots by 1914. The American navy did not lay down its first fleet-keeping submarines (the L class) until 1914, and the British did not complete their first fleet-keeping submarines (the K class) until 1916. When the war began, the fastest German U-boats (the U-27 class) had a surface speed of only 16 knots. Instead of serving with the battlefleet, the pre-war mission of most submarines was coast defense. They expected to fire their torpedoes at point-blank range (hundreds rather than thousands of yards), and therefore they did not need the faster or longer-range torpedoes developed for other platforms.

Other classes of vessels were much more likely than submarines to fire torpedoes in a battlefleet action. Torpedo boats, which many navies began to build in the 1870s, were the first vessels designed to use torpedoes as their primary weapons system. A short-lived type of vessel known as the torpedo catcher (or the torpedo gunboat) was developed in the 1880s to defend fleets against torpedo boats, but it soon emerged that the catchers lacked the speed to catch their prey.⁵⁵ Torpedo-boat destroyers (destroyers, for short) inherited the mission of the catchers in the early 1890s, but they also showed promise as torpedo boats—indeed, their greater size, durability, and sea-keeping ability made them more effective torpedo boats than torpedo boats themselves had been. Destroyers’ potential to perform both as destroyers (defending their own fleet against attack by enemy torpedo boats) and as torpedo boats (attacking the enemy fleet) complicated their armament: defense required guns while attack required torpedoes. When carrying

⁵⁵ See David Lyon, *The First Destroyers* (London: Mercury Books, 2005; first edn. 1996), 13–14.

torpedoes, destroyers launched them from above-water, not submerged, tubes. Destroyers, with submarines, were referred to as “flotilla craft” or “flotilla vessels,” not as “ships,” a term which designated large fleet vessels.

Destroyers’ dual potential also complicated the development of appropriate tactics for them. If they were defensive vessels, then they needed to stay with their fleet. If they were offensive vessels, however, then they might need to leave their fleet to attack the enemy fleet. Alternatively, as torpedo ranges lengthened, they might be able to stay with their fleet and launch attacks even at that distance. Destroyers’ ability to perform multiple missions made them desirable, but it also made their deployment uncertain.

Contrary to the modern tendency to associate capital ships with big guns, they, like destroyers, also carried torpedoes.⁵⁶ Capital ships initially launched torpedoes from above-water tubes, but they also carried submerged tubes by the turn of the century. Tacticians took the torpedo armament of capital ships very seriously. The danger was not that a single capital ship would target and hit single enemy capital ships, but that a line of capital ships could fire a spread of torpedoes at a line of enemy capital ships and sink a proportion of them.

Unlike submarines, destroyers and capital ships expected to fire their torpedoes at relatively long ranges. Ideally, they might even be able to fire torpedoes beyond the range of enemy guns, able to wound without being wounded. As the range of torpedoes lengthened, their speed became more important, for reasons related to torpedo targeting. To aim torpedoes, the target’s course and speed had to be estimated (the range did not, so

⁵⁶ Although its exact meaning varied over time, the phrase “capital ships” generally referred to battleships, armored cruisers, and battlecruisers, which could all join the line of battle.

long as the torpedoes ran at a uniform speed). The effect of errors in estimating target course and speed increased with the range at a given torpedo speed (that is, with the time of the torpedo's run); conversely, increasing a torpedo's speed for a given range (and therefore decreasing the time of its run) increased the tolerance for error in estimating target course and speed. For instance, if the target speed was misestimated by one knot, a 20-knot torpedo would miss the point aimed at by 300 feet, while a 40-knot torpedo would miss by only 150 feet.⁵⁷ In this scenario, if the target was the center of a 400-foot long capital ship, the 20-knot torpedo would miss, while the 40-knot torpedo would hit.

The physical range of torpedoes was not necessarily the same as their "effective" range. Effective range can be understood in at least two ways, and tacticians were not always precise in defining what they meant by the term. First, effective range could be defined as the maximum range at which torpedoes had a reasonable probability of hitting their target. Although this probability could be quantified in various ways and depended on many variables, an effective range defined in this way was almost certain to be less than the maximum physical range of the torpedo. Second, effective range could be defined at the maximum range at which torpedoes could affect battle ranges and tactics. Because fleets were large and unwieldy, and command-and-control methods were relatively primitive, commanders needed to add a buffer zone beyond the maximum physical range of the torpedo to prevent ships from blundering into torpedo range. Effective range defined in this way was almost certain to be greater than the maximum physical range of the torpedo.

⁵⁷ *Torpedo Manual for Her Majesty's Fleet, in Three Volumes*, vol. III (1909), 325.

The Argument

In supplying the first academic monograph on torpedo development, I seek to write naval history from the inside out rather than from the outside in (from the perspective of policy-makers rather than strategic theorists); from the bottom up rather than the top down (from the perspective of decision-makers rather than their higher-ranking supervisors); and, of course, from beneath the surface rather than on the surface (from the perspective of torpedoes rather than battleships). Using Sumida's work on British fire control as a model, I take a seemingly arcane piece of technology (the torpedo), show that its technical details mattered to naval officials, and relate them to large issues that interest historians.

Beginning with the introduction of the gyroscope in the mid-1890s, the growing accuracy, speed, and range of torpedoes posed serious challenges to conventional naval tactics, command-and-control methods, and gunnery practices. Traditional naval tactics called for capital ships sailing in close order and following visual signals from their leader to defeat their counterparts with heavy guns fired at point-blank range. Ships sailing (or steaming) in close order and engaging at short ranges were extremely vulnerable to torpedo fire, however. To deal with the torpedo threat, navies experimented with new formations, such as moving ships farther apart in the line of battle or even breaking the line of battle into independent divisions, but the new formations posed serious command-and-control problems. Navies also experimented with longer battle ranges to stay out of torpedo range, but the greater distances made it more difficult to achieve accurate gunfire. To cope with this challenge, navies sought to improve both their guns and their gunnery fire control. A race for range between guns and torpedoes

developed that was arguably more important than the better-known race between guns and armor, because it raised the possibility that the entire system of tactics built around capital ships primarily armed with big guns would give way to one built around smaller vessels primarily armed with torpedoes.

The implications of torpedo development were equally profound at the strategic as at the tactical level. Traditional naval strategy, as defined in previous centuries by the Royal Navy, called for close blockade of the enemy's coast to stifle his trade combined with decisive battle to destroy his fleet and achieve full command of the sea. Torpedoes threatened both aspects of this system. Expensive capital ships were so vulnerable to torpedo attack by cheaper vessels in battle that fleet actions could seem too risky. Ships engaged in close blockade were too vulnerable to torpedo attack by surface torpedo vessels under cover of darkness or by submarines at any time. One option was to move the blockade farther away from the enemy's coast, but distant blockade was more difficult to enforce. By threatening to deprive navies of battle and blockade, torpedo development forced nations to look for fundamentally new ways of applying naval power.

Thus torpedoes played a major role in the intense naval competition preceding World War I. Navies everywhere poured enormous resources into increasing and conserving their relative power. In a classic example of a "challenge-and-response" dynamic, no sooner did a navy get one (expensive) piece of technology to function than another navy invented a new (expensive) piece of technology which rendered the former technology obsolete—and with it the massive peacetime investment needed to produce

the technology on an adequate scale.⁵⁸

The depreciation of peacetime investment was particularly problematic for the naval-industrial complex, as distinct from the military-industrial complex. Until recently, naval warfare was far more technologically sophisticated than land warfare and required correspondingly greater peacetime investment. “You can go round the corner and get more guns, more rifles, more horses, more men who can ride and shoot,” as Admiral Sir John Fisher once said, “but you can’t go round the corner and get more Destroyers and more Cruizers [sic] and more Battleships.”⁵⁹ Lord Kitchener, Britain’s War Secretary for the first two years of World War I, confirmed Fisher’s claim: equipping the British army “was not much more difficult than buying a straw hat at Harrods.”⁶⁰ With so many resources sunk into the naval-industrial complex, representing such a high opportunity cost, the stakes were higher in the event of failure.

The Second Industrial Revolution exacerbated this dynamic, and torpedoes epitomized the process. Although steamships are the more familiar symbol of the Second Industrial Revolution at sea, torpedoes are a better symbol: like steamships, torpedoes were metal, ran on engines, and were eventually powered by fossil fuels; but torpedoes could be mass-produced because they were relatively inexpensive and small compared to ships. Warships might be built five to a class; torpedoes might be built five hundred to a mark. Even as the miniaturization of torpedoes enabled them to be produced in bulk, however, it posed serious design and production challenges. Given the many small,

⁵⁸ See Geoffrey Parker, “Introduction: The Western Way of War,” in *The Cambridge History of Warfare*, ed. Geoffrey Parker (Cambridge: Cambridge University Press, 2005), 6–10.

⁵⁹ Fisher to Thursfield, 6 November 1900, THU 1/1/1, NMM.

⁶⁰ Quoted in Jon Sumida, “Forging the Trident: British Naval Industrial Logistics, 1914–1918,” in *Feeding Mars: Logistics in Western Warfare from the Middle Ages to the Present*, ed. John Lynn (Boulder: Westview Press, 1993), 217.

precisely machined, and tightly fitted pieces of metal that composed torpedoes, sending a prototype into mass production without putting it through a rigorous research and development (R&D) process could easily create manufacturing, quality control, and assembly nightmares. The small size and cheap per-unit cost of torpedoes did not spare them from the need for an expensive development and production process: in fact, miniaturization and mass production made it all the more necessary.

Adjusting to new industrial realities changed the nature of innovation. Devising with a good idea for a weapon (basic science) was now the easy part; making it work (applied science) was the hard part. The former might flourish without a robust R&D infrastructure, but the latter could not: the infrastructure was vital to creating and testing prototypes, which in turn were a vital prerequisite for successful mass production. Without R&D resources, to borrow Robert Merton's famous language, discoveries in basic science might be "multiples" (discovered more than once by different parties), whereas innovations in applied science were doomed to "singleton" status" (successfully developed by only one party).⁶¹ In this key sector of naval-industrial R&D infrastructure, Britain was far stronger than the United States, despite the traditional depiction of a declining Britain and a rising United States during this period. As a result, Britain was able to perfect existing technology and thoroughly test new technology, while the United States had to take technological gambles.⁶² Precisely this pattern occurred with torpedo technology.

⁶¹ Robert Merton, "Singletons and Multiples in Scientific Discovery: A Chapter in the Sociology of Science," *Proceedings of the American Philosophical Society* 105, no. 5 (October 1961): 470–86.

⁶² By contrast, in *American and British Technology in the Nineteenth Century: The Search for Labour-Saving Inventions* (Cambridge: Cambridge University Press, 1962), H. J. Habakkuk identified labor supply, not R&D resources, as the independent variable in explaining differences in the rate of technological change between the United States and Britain.

The effort to create an R&D infrastructure capable of developing successful torpedoes profoundly changed the relationship between state and society in the United States and Britain. The historian William McNeill associated this change with the emergence of “command technology”: technology so sophisticated and expensive that the public and private sectors lacked the resources to develop it alone.⁶³ The present work draws out two implications of McNeill’s thesis. First, “command technology” put a premium on the development of a kind of technology—which I will call “servant technology”—that could generate information needed to improve “command technology.” Second, the collaboration between the public and private sectors required to develop “command technology” raised fundamental and complex questions about the nature of property in relation to invention.⁶⁴ When more than one party helped to invent a piece of technology, how could ownership of the intellectual property rights be established?

Liberal political philosophy offered a mixed answer. On the one hand, its commitment to private property as the fundamental civil liberty against state tyranny suggested that the private sector should own the property rights. On the other hand, its conviction that labor authors property suggested that the public sector deserved some ownership if it had aided the private sector in the process of invention. The existing procurement process was not equipped to deal with these issues: conventional contract and patent law, legislation, methods of cost accounting, risk assessment, and pricing were based on a procurement paradigm in which the public sector bought finished goods from

⁶³ William McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000* (Chicago: University of Chicago Press, 1982), 278–79.

⁶⁴ This is a major theme of Sumida’s *In Defence of Naval Supremacy*.

the private sector as ordinary commercial products, not on the new collaborative procurement process. In perhaps the most striking clash of the old and the new, the American government tried to apply the medieval doctrine of “eminent domain” (which originally applied to land) to intellectual property rights associated with torpedo technology. The underlying story was a familiar one: the state was attempting to suppress civil liberties (namely, property rights) in the name of national security.

Sources, Methodology, and Organization

To substantiate my interpretation, I draw on unused or under-utilized sources. On the American side, I rely primarily on the records of the Bureau of Ordnance, the Naval Torpedo Station, and the Naval War College (including its tactical papers), as well as the records of two legal cases that went all the way to the Supreme Court. The Bureau and War College records are remarkably well-organized and complete, but it is difficult to judge the completeness of the Torpedo Station records due to their disorganization and lack of the original registers. Unfortunately, the Bliss Company, which built the majority of American torpedoes, did not preserve its archives. On the British side, my core source is the annual reports of the torpedo school (HMS *Vernon*), supplemented by legal records and the files of the Admiralty Secretariat and the Royal Commission on Awards to Inventors, as well as the corporate archives of Vickers and Armstrong Whitworth. I turned to the latter, themselves incomplete, in an effort to supplement the Admiralty files, which are very incomplete. The holes are due mostly to normal archival “weeding,” but it is likely that some targeted weeding of records embarrassing to the Admiralty also

occurred.⁶⁵

The comparative approach is crucial to this work. When I began, the asymmetrical use of improvised explosive devices (IEDs) against conventionally powerful American forces in Iraq was on my mind, and I expected to find that torpedoes provided an analogue, as the weapons of the navally weak. To test this hypothesis, I needed to study torpedo development in a relatively weak naval power as compared to a hegemonic naval power. I chose the United States and Great Britain because they represented such powers, respectively, and because they offered ample and accessible archival material. I used international-relations theory about the balance of power as a guide for framing questions, not as an *a priori* explanatory model. The evidence that I found, which I present in the body chapters and analyze comparatively in the Conclusion, contradicted my initial hypothesis: torpedoes were not the natural weapons of the weak. Moreover, the search for comparative evidence sensitized me to asymmetries in my primary-source bases.

Organizing a manuscript is never easy, but comparative work presents special challenges. The desire to create parallel chapters runs the risk of imposing artificial chronological and thematic symmetry. Fortunately, torpedo development in Great Britain and the United States displayed enough symmetry to enable a reasonably organic structure to the manuscript, though I have neither attempted nor achieved perfect parallelism. The manuscript is divided into three parts: Part I compares the American and British experiences from 1895 through 1902; Part II compares their experiences from

⁶⁵ See Norman Friedman, *Naval Firepower: Battleship Guns and Gunnery in the Dreadnought Era* (Annapolis: Naval Institute Press, 2008), 297n21.

1903 through 1908; and Part III compares them from 1909 until the outbreak of World War I in 1914. Each Part contains a pair of chapters, one on the United States and one on Great Britain. Within each pair, the former precedes the latter, because, for reasons alluded to above and discussed at greater length in the Conclusion, the Americans adopted new torpedo technology more quickly than the British. Appendix A supplies an overview of torpedo technology; some readers may wish to read it before the body chapters. Appendices B and C explain my citations, which have some idiosyncrasies incidental to the archives I used. Appendices D and E provide lists of American and British torpedo marks, contracts, numbers, and prices.

This work is very much a beginning, not an end. While telling an accurate and coherent narrative, it is meant to raise new questions and to direct attention to underutilized sources, and its methodology matters more than its findings. Although I hope that readers will agree with my answers and interpretations, I am more interested in persuading them of the need to ask similar questions and use similar sources. More happened beneath the surface than on it.

Chapter 1: American Torpedo Development, 1895–1902

“The torpedo has become so excessively complicated, that any effort to simplify it must commend itself to all Naval men.”
– Bradley Fiske (Inspector of Ordnance at the Bliss Company), 1901¹

Introduction

By the mid-1890s, the U.S. Navy had two main types of torpedo in its arsenal: the Howell and Whitehead torpedoes. Because of limitations on their horizontal accuracy and propulsion systems, both models had effective ranges of less than 1,000 yards. By 1902, the situation was transformed. Production of the Howell torpedo was discontinued, while the Whitehead torpedo surged ahead on the strength of four major technological breakthroughs: the gyroscope, the nickel-steel air flask, the superheater, and the turbine engine. Because these technological changes greatly increased the range and accuracy of torpedoes, they had major implications for naval tactics and architecture. They also required new pricing and contracting arrangements. The technology was so new (and in some cases imported) that neither side could know in advance what performance to demand or guarantee. The challenge of developing the superheater and the turbine engine, in particular, began to draw the American government and private industry into a fundamentally new kind of relationship. Instead of buying finished products, the government started to invest directly in the experimental development of new technology.

¹ Fiske to O’Neil, 11 October 1901, BuOrd 9558/01, RG74/E25/B480, NARA.

In time, this investment would raise extremely difficult questions about property rights, but neither party to the arrangement perceived these questions before 1902. On the contrary, the period from the mid-1890s to 1902 closed on a note of optimism, with the government and its private suppliers believing that they had invented the makings for a uniquely American torpedo, in a proud bid for national independence.

The Arsenal

After two decades of on-and-off experimentation, the Navy finally purchased thirty Howell torpedoes from the Hotchkiss Ordnance Company of Providence, Rhode Island, which owned the rights, in January 1889, paying \$2,200 each for 30 torpedoes, which were designated as Mark I Howell torpedoes.² The specifications required the torpedo to have a range of 400 yards and a speed of 22.5 knots.³ The Navy ordered another round of 20 Howell torpedoes in August 1894.⁴ These 20 torpedoes were so slightly modified from the specifications governing the 1889 order that they were also known as Mark I Howell torpedoes, giving the Navy 50 Howell torpedoes in total by 1896.⁵

The other main type of torpedo in the American arsenal was the Whitehead torpedo. In 1890 and 1891, after several abortive attempts to purchase the Whitehead, the

² Contract between Hotchkiss Ordnance Company and Secretary of the Navy, 4 January 1889, B3-225, NTS.

³ "Specifications for the Manufacture of Howell Automobile Torpedoes and Launching Apparatus, 1888 [sic]," 3 January 1889, *ibid*.

⁴ *Idem*.

⁵ I could not find a copy of the August 1894 contract. I also could not find a clean copy of the 1894 specifications, but there is a draft copy listing the correspondence which slightly modified the 1889 specifications as an enclosure to Sampson [CoO] to Oliver [IoO, Hotchkiss Ordnance Co.], 18 October 1894, BuOrd 6593/94-LS22/606 with 4728/94, RG74/E25/B203, NARA.

Navy arranged to have an American company, the E. W. Bliss Company of Brooklyn, New York, buy the manufacturing rights from the Whitehead Company. The Navy purchased its first Whitehead torpedoes from the Bliss Company in May 1891, paying \$2,000 each for 100 torpedoes, including a £50 (~\$250) royalty per torpedo to be paid by the Bliss Company to the Whitehead Company.⁶ According to the specifications, the torpedoes had to make a speed of 28 knots for 800 yards.⁷ Three years later to the day, in May 1894, the Navy bought a second batch of Whitehead torpedoes, which became known as the U.S. Navy Mark II 3.55-meter Whitehead torpedo.⁸ This time it paid \$2,425 each for 50 torpedoes, which were required to make 26.5 knots for 800 yards.⁹ Combined, the 1891 and 1894 orders gave the Navy 150 Whitehead torpedoes in service by 1896.¹⁰

From the beginning to the middle of the 1890s, the 200 torpedoes in the Navy's arsenal changed little. The Howell torpedoes all had a diameter of 14.2 inches and a length ranging from 9.6 feet to 12 feet; the Whitehead torpedoes all had a diameter of 45 centimeters (roughly 18 inches) and a length of 3.55 meters (roughly 12 feet).¹¹ None of them was required to go more than 800 yards, and their effective range was limited to 500 yards.¹² Their dimensions and capabilities seemed unlikely to change in the near future.

⁶ Contract between E. W. Bliss Company and Secretary of the Navy, 19 May 1891, B7-137, NTS. These torpedoes were designated as the U.S.N. Mark I 3.55-meter Whitehead torpedo.

⁷ "Specifications for the Manufacture of Whitehead Automobile Torpedoes," 23 January 1891, *ibid.*

⁸ Contract between E. W. Bliss Company and Secretary of the Navy, 19 May 1894, B12-136, NTS.

⁹ "Specifications for the Manufacture of Whitehead Automobile Torpedoes, U.S.N., Mark II," 18 April 1894, *ibid.*

¹⁰ For delivery dates of the 150 Whitehead torpedoes ordered in 1891 and 1894, see O'Neil [CoO] to Herbert & Micou [Bliss Co. attorneys], 18 July 1900, BuOrd 7384/00-LS135/114-7 with 6164/00, RG74/E25/B424, NARA.

¹¹ The dimensions of the torpedoes are given in their specifications, cited above. The Navy referred to the Howell torpedo in inches and feet, presumably because it was an American invention, and to the Whitehead torpedo in centimeters and meters, presumably because it was a European invention.

¹² On effective range, see Torpedo Board [Hutchins, Smith, and Capehart] to Converse, 23 October 1895, B15-142, NTS. The Board used the term "effective range" rather loosely, as the range beyond which "hits

In the mid-1890s, however, the Bureau of Ordnance, which had the torpedo portfolio within the Navy Department, began to question whether the United States should continue to manufacture both the Howell and the Whitehead torpedoes, or settle on one.¹³ Early in 1896, the chief of the Bureau, W. T. Sampson, turned the question over to the Torpedo Board, a group of officers at the Naval Torpedo Station headed by the commander of the Torpedo Station, George Converse.¹⁴ In reply, the Board offered its qualified approval for manufacturing both kinds of torpedo. The Whitehead, it said, was a mature weapon, whose only drawbacks were inaccuracy in the horizontal plane and the danger of its air flask exploding: thus the Navy should regard the Whitehead as its standard torpedo. The Howell, by contrast, was not a mature weapon, and it had “serious objectionable features,” primarily the amount of time required to prepare it for launch and the use of steam and exhaust pipes to spin up its flywheel. On the plus side, however, the Howell was accurate in the horizontal plane, and this feature alone was sufficient to warrant its continued manufacture and development, though on a limited basis.¹⁵

The Board also recommended improvements in the performance of the Howell and Whitehead torpedoes which required larger sizes. The Hotchkiss Ordnance Company, which owned the Howell torpedo, had recently developed an experimental torpedo with an 18-inch diameter, and the Board recommended that the Bureau manufacture it alone, for use aboard large ships, dispensing with the older 14.2-inch model. The Board also

can be made” but “the odds are against it.” A more rigorous definition would have included a quantification of the acceptable “odds.” As discussed in the Introduction, probability of hitting was not the only way to define “effective range”: it could instead be defined as the range within which torpedoes influenced battle tactics.

¹³ Sampson to Converse, 1 February 1897, B15-142, NTS.

¹⁴ Sampson to Converse, 20 January 1896, BuOrd 627/96-LS33/346 with 790/96, RG74/E25/B249, NARA.

¹⁵ Torpedo Board [Converse, Dombaugh, and Smith] to Sampson, 23 January 1896, BuOrd 790/96, RG74/E25/B249, NARA [copy in B15-142, NTS].

renewed its recommendation, first made in September 1895, that the Bureau begin developing a 5-meter long, as opposed to 3.55-meter, Whitehead torpedo, for use aboard ships.¹⁶

The Howell Torpedo

The Bureau acted quickly on the Board's recommendations. In early February 1896, Sampson began negotiating with the Hotchkiss Ordnance Company for an 18-inch Howell torpedo.¹⁷ A board appointed to witness trials of the 18-inch Howell torpedo submitted a preliminary report in December.¹⁸ While the horizontal deviation of the torpedo passed the requirements, it met the limits of vertical deviation only two-thirds of the time; its speed was a full 3.5 knots below the speed called for in the specifications; and it often took more than three minutes longer than allowed by the specifications to spin up the motor that turned the flywheel. In a second round of tests focused on the motor, it performed better, spinning up to the required revolutions within the time limit of one minute, but it took too much steam pressure to do so. When a third round of tests was conducted to determine whether it could spin up fast enough with the lower, required

¹⁶ Torpedo Board [Converse, Smith, and Fletcher] to Sampson, 20 September 1895, BuOrd 6327/95 with 5906/95, RG74/E25/B234, NARA [copy in B12-136, NTS].

¹⁷ For the negotiations, see Sampson to Hotchkiss Ordnance Co., 3 February 1896, BuOrd 790/96-LS34/160, RG74/E25/B249, NARA; Ordway [Hotchkiss Ordnance Co. agent] to Sampson, 24 February 1896, BuOrd 1701/96; Very [Hotchkiss Ordnance Co. agent] to Sampson, 16 May 1896, BuOrd 3917/96; Ordway to Sampson, 9 July 1896, BuOrd 5185/96; Sampson to Converse, 22 October 1896, BuOrd 5185/96, all with 790/96, RG74/E25/B249, NARA. Converse to Fletcher, Smith, and Ziegemeier, [NTS officers] 29 October 1896, enclosure to BuOrd 11/97 with 9454/96, RG74/E25/B274, NARA [copy in B14-143, NTS].

¹⁸ Fletcher, Smith, and Ziegemeier to Converse, 1 December 1896, enclosure to BuOrd 11/97 with 9454/96; Converse to Sampson, 5 December 1896, BuOrd 9071/96 (NTS 2423/96) with 9454/96, both in RG74/E25/B274, NARA.

amount of pressure, it failed to do so.¹⁹

Perhaps discouraged by the 18-inch torpedo's dismal speed performance in the first round of tests, Sampson asked the American Ordnance Company (which had taken over the rights to the Howell torpedo from the Hotchkiss Ordnance Company) to submit a bid for a lot of thirty-five 14.2-inch torpedoes under the old 1889 specifications.²⁰

Specifications were drawn up, and on 19 January 1897, Sampson recommended to the Secretary of the Navy that the Department purchase 35 of the 14.2-inch torpedoes.²¹

Sampson even sent the contract to the printers.

That was as far as it got. A week later, the Secretary of the Navy, Hilary Herbert, had a conversation with Sampson in which he expressed doubts as to the value of the Howell torpedo. "Evidently," Sampson speculated, "he had been listening to the opinions of some people who were averse to the use of the Howell torpedo."²² Sampson urged him to appoint a board to report on the subject, which the Secretary promptly did. It became known as the Miller Board, after its president, Merrill Miller, with the commander of the Torpedo Station, Converse, and the Chief Intelligence Officer serving as the other two members. The mandate of the board was essentially the same as that given to the Torpedo Board by Sampson in January 1896, when the Board had recommended the continued development of both the Whitehead and the Howell torpedoes.

¹⁹ Wood [IoO, American Ordnance Co.] to Converse, 2 January 1897, enclosure to BuOrd 497/97; Converse to Sampson, 12 January 1897, BuOrd 497/97 (NTS 146/97); Wood to Sampson, 18 January 1897, BuOrd 613/97, all with 9454/96, *ibid.* Steam pressure mattered because it had to be supplied by the boiler of the vessel carrying the Howell torpedo, and boiler capabilities were limited; see Sampson to Hotchkiss Ordnance Co., 13 March 1895, BuOrd 8005/95-LS24/253 with 8133/93, RG74/E25/B184, NARA.

²⁰ For the negotiations, see Sampson to American Ordnance Co., 15 December 1896, BuOrd 9371/96-LS47/190 with 9454/96; Sampson to Herbert [SecNav], 19 January 1897, BuOrd 9454/96-LS88/479; Ordway to Sampson, 19 December 1896, BuOrd 9454/96, RG74/E25/B274, NARA.

²¹ Converse to Sampson, 13 January 1897, BuOrd 513/97 (NTS 157/97) with 9454/96; Sampson to Herbert, 19 January 1897, BuOrd 9454/96-LS88/479, *ibid.*

²² Sampson to Converse, 1 February 1897, B15-142, NTS.

The Miller Board reached a different conclusion, delivering its report on 4 February 1897.²³ The members compared the two torpedoes across various categories in their present stage of development, including weight of explosives (equally satisfactory), vertical accuracy (Whitehead superior), horizontal accuracy (Howell superior), time of preparation (Whitehead superior), durability (Whitehead superior), speed (Whitehead superior), mechanical simplicity (equal), and danger (equal, arising from the Whitehead's air flask and the Howell's steam pipes). The Board noted that the applicability of the Howell was restricted due to the time required to spin up the flywheel and prepare it for launch, and that it could not be adapted for submerged discharge. As presently developed, therefore, the Whitehead was superior to the Howell. Looking to future development, the Board focused on the issue of propulsion, arguing that no matter how perfected, the Howell's reliance on the stored energy of the flywheel would limit it far more than the Whitehead's reliance on compressed air. In conclusion, the Board noted that if a new device, the Obry gyroscope, proved successful, one of the chief disadvantages of the Whitehead—its lack of accuracy in the horizontal plane—relative to the Howell would disappear, and the Whitehead's superiority would become even more marked. Based on the Board's recommendations, Herbert ordered Sampson to prepare an order discontinuing the manufacture of Howell torpedoes.²⁴

²³ Miller, Converse, and Wainwright to Herbert, 4 February 1897, BuOrd 1639/97 with 1022/97, RG74/E25/B282, NARA [copy in B17-156, NTS].

²⁴ Undated endorsement by Herbert on Miller Board report, BuOrd 1639/97 with 1022/97, RG74/E25/B282, NARA. This order was a terrible blow to the American Ordnance Company, especially because it had made preparations to manufacture the 35 torpedoes which Sampson had led it to believe would be ordered; see the correspondence from January 1899 with BuOrd 9454/96, RG74/E25/B274, NARA. Herbert drove a final nail in the Howell torpedo's coffin when, as the new attorney (along with former Navy Department chief Clerk Benjamin Micou) for the Bliss Co., he heard that the new Secretary of the Navy, John Long, might reconsider the cancellation of the Howell contract, and wrote to Long to urge against it; see Herbert to Long, 16 April 1897, BuOrd 2933/97 with 1022/97, RG74/E25/B282, NARA.

Historians have been both vague and inaccurate in explaining the demise of the Howell torpedo, especially by implying that this outcome was inevitable. Edwyn Gray, author of the only book devoted to the subject of torpedo development, argued that the Howell began its fall from favor in 1892, when the “speed and range” of Whitehead torpedoes “completely outclassed all rival designs.”²⁵ This explanation is teleological, however, and does not take sufficient account of contemporary tactical conditions. The Howell torpedo would have been used either by large ships at close range or by small ships taking large ships by surprise at close range. Given the fact that the range would be short—1,000 yards at most and probably half that—the Miller Board had little reason to consider the Howell’s slower speed a major flaw. The most important weakness of the Howell torpedo as compared to the Whitehead was not speed or range but the time required to prepare it for action. Given that the Navy expected to use the Howell at close range, speed and range were relatively unimportant; given that it also expected to use the Howell on short notice, the time required for preparation was much more important. The primary culprit for this weakness was not the usual suspect, the flywheel, but rather the motor used to spin up the flywheel. The latter, not the former, was what doomed the Howell torpedo.

The Whitehead Torpedo and the Obry Gyroscope

Meanwhile, the Whitehead was running into its own problems. In February 1896, at the same time the Torpedo Board recommended the continued manufacture of both the

²⁵ Gray, *The Devil’s Device: The Story of Robert Whitehead, Inventor of the Torpedo* (Annapolis: Naval Institute Press, 1991; first edn. 1975), 122.

Howell and Whitehead torpedoes, it also recommended the development of a new, longer (5-meter) Whitehead torpedo. Within weeks of receiving the report, Sampson negotiated a preliminary deal for 100 long Whitehead torpedoes.²⁶ In June 1896, however, a hitch arose over the speed requirement for the new torpedoes. The Torpedo Board had recommended that the minimum be set at 28.5 knots for 800 yards, but the Bliss Company protested that its information from the Whitehead Company said the minimum should be a half-knot lower.²⁷ In August, Sampson proposed an unorthodox compromise: the speed requirement should be set at either the highest obtained by comparable torpedoes abroad, or at the average speed of the first five long torpedoes built by the Bliss Company.²⁸ The Company accepted the offer and it was embodied in the specifications.²⁹ The Bureau ordered 100 long torpedoes on 21 October 1896; these became known as the 5-meter Mark I torpedoes. As the negotiations for the long torpedoes wound down, the Bureau fielded a request from the Bliss Company to order 50 short torpedoes as well.³⁰ The Bureau obliged on 22 October 1896, and it ordered another 9 short torpedoes on 30 March 1897, in order to spend an outstanding appropriation.³¹ These 59 torpedoes

²⁶ Sampson to Bliss Co., 6 February 1896, BuOrd 790/96-LS34/262; Leavitt to Sampson, 12 February 1896, BuOrd 1377/96; Sampson to Leavitt, 14 February 1896, BuOrd 1377/96-LS34/251; Leavitt to Sampson, 18 February 1896, BuOrd 1561/96; Sampson to Bliss Co., 13 March 1896, BuOrd 1561/96-LS36/82, all with 790/96, RG74/E25/B249, NARA.

²⁷ Sampson to Converse, 18 June 1896, BuOrd 4568/96-LS39/583 with 790/96, *ibid*.

²⁸ Sampson to Bliss Company, 29 August 1896, BuOrd 4812/96-LS42/513 with 790/96, *ibid*.

²⁹ "Specifications for the Manufacture of Whitehead Automobile Torpedoes, U. S. N., Mark III," 26 September 1896, RG45/E502 (Envelope, "Mines and torpedoes, reports, correspondence & miscellaneous data relative to, 1871-1899"), NARA. Although the specifications refer to Mark III, this torpedo became known as the Mark I 5-meter torpedo, so as to distinguish it from the Mark III 3.55-meter torpedo, which was ordered almost simultaneously.

³⁰ Bliss to Sampson, 14 September 1896, BuOrd 6864/96, RG74/E25/B266, NARA.

³¹ The stock of short torpedoes at the Torpedo Station was running low, and it did not have enough to outfit torpedo boats; see Converse to Leavitt, 20 March 1897, B15-142, NTS. See also Sampson to Bliss Co., 24 March 1897, BuOrd 2261/97-LS51/346; Bliss Co. to Sampson, 26 March 1897, BuOrd 2371/96 with 2261/97; Sampson to SecNav, 29 March 1897, BuOrd 2261/97-LS51/460; Behrend [Acting CoO] to Bliss Co., 30 March 1897, BuOrd 2371/97-LS516-17, all with BuOrd 2261/87, RG74/E25/B286, NARA.

became known as the 3.55-meter Mark III torpedoes.

Production of the 59 Mark III 3.55-meter torpedoes and the 100 Mark I 5-meter torpedoes intersected with a significant new piece of torpedo technology: the Obry gyroscope. Just over a month before the Bureau ordered the Mark III and Mark I torpedoes, the Whitehead Company sent a circular to the American naval attaché in Berlin, announcing that it had acquired the rights to the Obry gyroscope, which allowed accurate shooting up to 2,000 meters.³² About a week after receiving the letter, the Navy Department ordered a board, which became known as the Fiume Commission, to visit the Whitehead factory at Fiume and report on the gyroscope.³³ Bureau officials alerted the Bliss Company of these developments and notified it that the Department might wish to put the gyroscopes in the torpedoes about to be ordered.³⁴ The Company promptly replied that it had written to the Whitehead Company for information, and its chief Engineer, F. M. Leavitt, unofficially opined that “[i]f the device pans out as well as the reports seem to show it would appear that it ought to be put in all the torpedoes in the service.”³⁵ Roughly two weeks after the Department had received the Whitehead Company’s offer, the Bliss Company could report that it had secured the rights to manufacture the Obry gyroscope in

³² Whitehead Co. (Weymouth) to Vreeland, 11 September 1896, BuOrd 5424/96 with 6864/96, RG74/E25/B266, NARA.

According to Edwyn Gray’s account, which is plausible but lacks adequate documentation, the Whitehead Company had been tracking gyroscope development with the idea of applying gyroscopes to torpedoes since the early 1890s at the latest; see Gray, *The Devil’s Device*, 145, 152–55. Given that Obry was an Austrian naval engineer, and that Whitehead had connections with the Austrian Navy, the Austrian connection was almost certainly vital to Whitehead’s procurement of the rights to the Obry gyroscope, but this surmise has not been documented. See Lawrence Sondhaus, *The Naval Policy of Austria-Hungary, 1867–1918: Navalism, Industrial Development, and the Politics of Dualism* (West Lafayette: Purdue University Press, 1994), 48, 72n42

³³ The date of the order, 8 October 1896, is given in the Commission’s report of 10 December 1896. Letters then took roughly three weeks to cross the Atlantic, so the Department ordered the Commission about one week after receiving the letter.

³⁴ Sampson to Bliss Co., 12 October 1896, BuOrd 7296/96-LS44/226 with 6864/96, RG74/E25/B266, NARA; Converse to Leavitt, 16 October 1896, B14-143, NTS.

³⁵ Leavitt to Converse, 19 October 1896, B15-142, NTS.

the United States, although negotiations over the exact terms continued.³⁶ Buoyed by his correspondence with Leavitt, and without waiting for the report of the Fiume Commission, the commander of the Torpedo Station (Converse) recommended that the Navy immediately procure two sample Obry gyroscopes for experimental purposes.³⁷

The Commission reported enthusiastically on 10 December 1896 that the Obry offered “marked advantages” to torpedoes, increasing their effective range by as much as 50%, and repeated Converse’s recommendation that two sample gyroscopes be ordered immediately. A month later, the Torpedo Board endorsed the Fiume Commission’s recommendations.³⁸ The Commission also enclosed a letter from the Whitehead Company under date of 9 December 1896 offering three different purchasing arrangements: the Navy could buy the gyroscopes directly from the Whitehead Company at £50 (~\$250) each, including royalty; it could buy the rights and manufacture them through the Bliss Company for a royalty of £30 (~\$150) each; or, instead of paying a royalty per gyroscope, it could pay one lump sum for all time of £15,000 (~\$75,000).³⁹ The Department chose the second option, and it ordered three sample gyroscopes.⁴⁰

Both the Bliss Company and the Navy found dealing with the Whitehead Company to be frustrating. The Navy had been under the impression that if the sample gyroscopes were ordered quickly—as they were, in January 1897—the Whitehead

³⁶ Leavitt to Converse, 19 October 1896, B15-142, NTS; Converse to Sampson, 21 October 1896, BuOrd 7877/96 (NTS 2011/96) with 790/96, RG74/E25/B249, NARA.

³⁷ Converse to Sampson, 27 October 1896, BuOrd 8044/96 (NTS 2054/96) with 790/96, *ibid.*

³⁸ Fiume Commission [Cowles, Rodgers, and Vreeland] to SecNav, 10 December 1896, B18-152, NTS. The Torpedo Board endorsed the Fiume Commission’s recommendations a month later; see Converse to Sampson, 8 January 1897, BuOrd 271/97 (NTS 80/97) with 6864/96, RG74/E25/B266, NARA.

³⁹ Whitehead Co. (Fiume) to President, Fiume Commission, 9 December 1896, enclosure to Fiume Commission report of 10 December 1896, B18-152, NTS.

⁴⁰ It later transferred the order for the gyroscopes to the Bliss Company’s name; see Sampson to Bliss Co., 24 May 1897, BuOrd 3581/97-LS54/228 with 6864/96, RG74/E25/B266, NARA.

Company could deliver them within ninety days. Ninety days came and went, and from March to May 1897, the correspondence between the Bureau and the Bliss Company was peppered with queries by the former as to when the sample gyroscopes would arrive and when the negotiations over the precise terms of manufacture would be concluded, and assurances by the latter that it was doing everything it could to hurry the Whitehead Company.⁴¹ Converse speculated that the delay “would indicate that either Mr. Whitehead is unusually slow in perfecting the device or else,” more sinisterly, “he is not in haste to send the apparatus to this country.”⁴² A sample finally arrived in mid-July.⁴³ After familiarizing itself with the gyroscope, the Bliss Company put it in a torpedo, and trials began in early August 1897.

In the meantime, a different question had to be settled about the 100 long torpedoes ordered in October 1896: their speed. Because these were the first 5-meter torpedoes manufactured in the United States, the specifications had stated only that the speed requirement would be set at the average speed of the first five long torpedoes, or at the best speed obtained abroad for comparable torpedoes. In December 1896, the Bliss Company asked the Bureau for a decision, offering to accept 26.5 knots, which the Bureau’s Inspector of Ordnance at the Company considered reasonable.⁴⁴ Sampson referred the question to the Torpedo Board and asked the Office of Naval Intelligence to

⁴¹ Converse to Leavitt, 20 March, B15-142, NTS; Leavitt to Converse, 22 March, *ibid*; Converse to Leavitt, 23 March, *ibid*. Behrend to Bliss Co., 12 May, BuOrd 7590/96-LS53/497-8; Leavitt to Sampson, 14 May, BuOrd 3554/97; Bliss Co. to Sampson, 15 May 1897, BuOrd 3581/97, all with 6864/96, RG74/E25/B266, NARA.

⁴² Converse to Leavitt, 23 March 1897, B15-142, NTS.

⁴³ Bliss Co. to Sampson, 14 July 1897, BuOrd 5007/97 with 6864/96, RG74/E25/B266, NARA; Rittenhouse [IoO, Bliss Co.] to Converse, 24 July 1897, B18-152, NTS.

⁴⁴ Bliss to Sampson, 23 December 1896, BuOrd 9591/96 with 9590/96, RG74/E25/B275, NARA; Rittenhouse to Sampson, 24 December 1896, B15-142, NTS.

collect information on what was required of 5-meter torpedoes abroad.⁴⁵ That information confused the situation further, since foreign navies used several types of 5-meter torpedoes, differing from each other in air flask capacity, weight of charge, shape of head, and other respects.⁴⁶ As for the other way of determining the speed requirement, averaging the first five 5-meter torpedoes, the Bliss Company was not ready for speed trials until mid-April 1897, due to delays in the procurement of forgings for the torpedo air flasks.⁴⁷ Once these trials were concluded, the Torpedo Speed Board—not to be confused with the regular Torpedo Board—delivered its report.⁴⁸ Based on information from abroad and from the trials, the Speed Board recommended that the speed requirement be set at 28 knots for 800 yards, and the Bureau agreed.⁴⁹ The prolonged uncertainty over performance requirements under-scored the difficulty of developing complex technology based on imported designs and involving multiple sub-contractors.

Just as the speed question was closed, the question of how the Obry gyroscope should affect the specifications and requirements for the 159 long and short torpedoes under contract opened. On 21 June 1897, E. W. Bliss, president of the eponymously named company, wrote to the Department to explain his company's quandary.⁵⁰ It could not conduct regular acceptance tests for the torpedoes under contract while experimenting

⁴⁵ Sampson to Converse, 28 December 1896, BuOrd 9454/96, RG74/E25/B274, NARA; Wainwright to Converse, 29 January 1897, B15-142, NTS; Cowles [Naval Attaché London] to Long [SecNav], 20 March 1897, BuOrd 2204/97 with 9590/96, RG74/E25/B275, NARA.

⁴⁶ Rittenhouse to Sampson, 13 April 1897, BuOrd 2847/97; also Converse to Sampson, 9 April 1897, BuOrd 2748/97 (NTS 1088/97), both with 9590/96, *ibid*.

⁴⁷ Leavitt to Converse, 22 March 1897, B15-142, NTS; Bliss Co. to Sampson, 3 April 1897, BuOrd 2590/97 with 9590/96, RG74/E25/B275, NARA.

⁴⁸ Rittenhouse and Fletcher to Long, 7 May 1897, B15-142, NTS. They delivered a second, very similar report on 13 May 1897, BuOrd 3558/97 with 9590/96, RG74/E25/B275, NARA.

⁴⁹ Sampson to Bliss Co., 18 May 1897, BuOrd 3558/97-LS64/46 with 9590/97, *ibid*. The Speed Board amended its report a month later; see Rittenhouse and Fletcher to Long, 17 June 1897, BuOrd 4440/97; O'Neil to Rittenhouse, 23 June 1897, BuOrd 4440/97, both with 9590/97, *ibid*.

⁵⁰ Bliss to Long, 21 June 1897, BuOrd 4485/97 with 6864/96, RG74/E25/B266, NARA.

with the Obyr gyroscope, and it would hurt the company financially to delay delivery of these torpedoes. Therefore, Bliss asked the Department temporarily to waive the usual trials for torpedoes accepted without the Obyr, of which there would probably be about forty, and if the Department later decided to install the Obyr in them, the Company would conduct the acceptance tests with the gear installed. The Bureau of Ordnance was sympathetic and recommended that the Department grant the request, promising to advise it on the desirability of installing the Obyr as soon as tests were finished. The Department agreed.⁵¹

In anticipation of favorable results with the Obyr, the Bureau began negotiating with the Bliss Company in early August 1897 over the terms on which it would install the gyroscope in the torpedoes under contract, letting the Company choose whether to manufacture the gyroscopes itself or purchase them from the Whitehead Company.⁵² The Company replied that if the Bureau placed the order promptly, it could be ready to present the gyroscopic torpedoes in early October and to test 50 before cold weather ended the testing season.⁵³ After itemizing the costs, the Company said that the price of manufacture and installation would average \$546 per torpedo on the whole order of 159 torpedoes.⁵⁴ It predicted that the price would drop to \$380 per torpedo on future orders because it could construct the torpedoes to receive the gyroscope from the beginning and would not have to retro-fit them. Attempting to preempt complaints over the price, the Company favorably (but misleadingly) compared its quote to that given by the Whitehead

⁵¹ Endorsements by O'Neil, 12 July 1897, and Long, 14 July 1897, both on BuOrd 4485/97 with 6864/94, *ibid.*

⁵² Behrend to Bliss Co., 10 August 1897, BuOrd 5424/97-LS58/248-9 with 6864/96, *ibid.*

⁵³ Bliss Co. to O'Neil, 12 August 1897, BuOrd 5861/97 with 6864/96, *ibid.*

⁵⁴ The Company itemized the costs in such a way as to include its preliminary expenses of \$5,000—for jigs, etc.—in its price for installing the gyroscopes in the 40 long torpedoes that had already been accepted.

Company in December 1896.⁵⁵ In any case, the Company's political argument was stronger than its financial argument: the Company was "under the impression that articles furnished to the Navy Department under the various appropriations must be of domestic manufacture."⁵⁶

With this offer on the table, the Torpedo Board submitted its preliminary and final official reports on the Obry gyroscope, having seen it run in both a long and a short torpedo. Its verdict was enthusiastic: the Obry was an "excellent practical apparatus," whose capacity to correct for deflection was "such as to improve the performance of the torpedoes one hundred per cent," and the Navy should adopt it.⁵⁷ The specifications should reduce the permissible horizontal deviation at 800 yards from 24 yards to 8 yards, and they should require 27.5 knots for the long torpedo and 26 knots for the short torpedo. The Bureau commended the Torpedo Board's report to the Department, sweetening the bitter pill of an estimated \$85,860 bill to install the gyroscopes in the torpedoes under contract with the promise that the cost would decrease for future installations, and

⁵⁵ The Bliss Company argued that where the Whitehead quote of £50 (~\$250) per gyroscope covered only the gyroscope, the Bliss quote of \$490 included the gyroscope (\$205, including parts and labor), associated apparatus like rudders (\$30), the royalty (\$145), and installation (\$110). Accordingly, the Company concluded that "[w]hat Whitehead furnishes for 50 pounds is the Gyroscope only ... so that in reality he charges about \$250.00 as against our \$205.00 for he controls the patents and pays no royalty." Technically, this statement was correct: Whitehead did indeed control the patents, so he did not have to pay Obry a royalty on each gyroscope he manufactured. Financially, however, the Company's statement was misleading: while Whitehead's price of \$250 did *not* include a royalty from him to Obry, it *did* include a royalty from Bliss to him—specifically, the \$145 royalty as itemized by the Bliss Company. Therefore, the correct financial comparison was not between Whitehead's \$250 (no royalty to Obry) and Bliss's \$205 (no royalty to Whitehead) as the Company had it, but between Whitehead's \$250 (including royalty from Bliss) and Bliss's \$350 (\$205 for gyroscope plus \$145 for royalty to Whitehead). Based on that comparison, the Bureau could have gotten the gyroscopes considerably cheaper from the Whitehead Company than from the Bliss Company.

⁵⁶ Bliss Co. to O'Neil, 12 August 1897, BuOrd 5861/97 with 6864/96, RG74/E25/B266, NARA.

⁵⁷ Torpedo Board [McLean, Rittenhouse, Fletcher, and Poundstone] to O'Neil, 28 August and 21 September 1897, BuOrd 6459/97 (NTS 2671/97) and 6962/97 (NTS 2958/97), respectively, both with 6864/96, *ibid.*

recommending that a board be appointed to determine the exact cost.⁵⁸ The Department approved the installation and appointed a compensation board.⁵⁹ The Bureau's estimate turned out to be high, and the compensation board fixed compensation at \$78,780.64, or \$8,033.36 less than the \$86,814 initially quoted by the Company; the average price per torpedo came to \$485.48 as against \$546, a difference of \$60.52.⁶⁰ The Bureau apprised the Bliss Company of the new specifications as to speed and deviation, including the stipulation, which would become a source of contention, that the torpedo pass its speed and deviation tests on three consecutive runs without readjustment of the gyroscope.⁶¹

Everything seemed to be going smoothly, but the calm was not to last. In the spring of 1898, at almost the same time as the Spanish-American War began, the new commander of the Torpedo Station (T. C. McLean, who had recently succeeded Converse) found that when the short torpedoes with gyroscopes were fired from moving boats, they entered the water at a high angle, causing the tail to swing and the torpedo to roll, which in turn caused the gyroscope to malfunction and take on a new directional axis.⁶² This discovery set off a long and torturous search for a way to secure a flat dive of the short torpedoes, so as to prevent the roll that deranged the gyroscope. It also led to the first real controversy between the Bliss Company and the Bureau of Ordnance.

⁵⁸ O'Neil to SecNav, 23 September 1897, BuOrd 6962/97-LS60/371-72 with 6864/96, *ibid.* The Bureau shaved \$6 off the average price per torpedo (\$546) quoted by the Bliss Company to arrive at this number. At \$546 per torpedo instead of \$540 per torpedo, the total cost would have come to \$86,814 instead of \$85,860, a difference of \$954.

⁵⁹ Theodore Roosevelt to O'Neil, 24 September 1897, BuOrd 7061/97; Long to Swift, 2 October 1897, BuOrd 7351/97, both with 6864/96, *ibid.*

⁶⁰ O'Neil to JAG, 12 February 1898, BuOrd 1316/97; O'Neil to Bliss Co., 23 February 1898, BuOrd 1316/98-LS68/555-56, both with 6864/96, *ibid.* I did not find a copy of the report itself, but its date (which must have been early February) and contents can be inferred from the letters cited.

Had the Bureau ordered the gyroscopes from Whitehead at \$250 each, plus apparati (\$30 each) and installation (\$110 each) from Bliss, the average cost per torpedo would have been \$390.

⁶¹ O'Neil to Bliss Co, 27 September 1897, BuOrd 7061/97-LS60/498-500 with 6864/96, *ibid.*

⁶² McLean to O'Neil, 23 May 1898, BuOrd 7044/98, RG74/E25/B335, NARA.

The first solution proposed, by McLean, was to add a second guide stud near the end of the torpedo, just before the tail, so that the launching tube would grip the torpedo for longer and the after part of the torpedo would not rise during discharge and cause the torpedo to enter the water at an angle.⁶³ When informed of the idea, the new Inspector of Ordnance at the Bliss Company, W. J. Sears, promptly objected that the addition of the second guide stud would unduly strain the tail.⁶⁴ Experiments with the extra guide stud led to the troubling discovery that the tails of the short torpedoes were too weak after being cut away for the rudders by which the gyroscope corrected the torpedo's course.⁶⁵ McLean also suggested that parts of the gyroscope needed to be stiffer and more durable.⁶⁶ Sears disagreed, suggesting it was "rather too late" to change the parts in the gyroscopes under contract, and he proposed a different explanation for the poor performance of the Obry: the impulse spring used to impart rotation to the gyroscope was too stiff, so that when released it knocked the gyroscope off its gimbals and reset its directional axis.⁶⁷ The Torpedo Station agreed that the spring was flawed, as did the Bureau, but argued that fixing it would not solve the problem—a flat dive remained essential.⁶⁸ The Bureau authorized experiments on both fronts, but believing that the tails were too weak to permit the use of a second guide stud, it proposed a different method for securing a flat dive: lengthening the spoon that projected beyond the mouth of the

⁶³ The second guide stud was also referred to as the aft guide stud or the second "T."

⁶⁴ O'Neil to Sears, 2 June 1898, BuOrd 7404/98 with 4979/98, RG74/E25/B328, NARA; Sears to O'Neil, 3 June 1898, BuOrd 7621/98 with 6864/96, RG74/E25/B266, NARA.

⁶⁵ O'Neil to McLean, 8 June 1898, BuOrd 7832/98-LS81/230; McLean to O'Neil, 15 June 1898, BuOrd 8420/98 (NTS 2679/98), both with 7044/98, RG74/E25/B335, NARA.

⁶⁶ McLean to O'Neil, 4 June 1898, BuOrd 7806/98 (NTS 2518/98) with 7044/98, *ibid*; Chambers to McLean, 4 June 1898, enclosure to same.

⁶⁷ Sears to O'Neil, 12 June 1898, BuOrd 8218/98 with 4979/98, RG74/E25/B328, NARA; Sears to O'Neil, 15 June 1898, BuOrd 8364/98 with 2214/98, RG74/E25/B319, NARA.

⁶⁸ McLean to O'Neil, 17 June 1898, BuOrd 8484/98 (NTS 2728/98) with 4979/98, RG74/E25/B328, NARA and 2 July 1898, BuOrd 9324/98 (NTS 2959/98) with 7044/98, RG74/E25/B335, NARA.

discharge tube.⁶⁹

The technical and abstruse—one might even say “boring”—debate over studs, springs, tails, and spoons obscured a deeper argument between the Torpedo Station and the Bliss Company over who was to blame for the Obry gyroscope’s poor performance. The Station’s search for a flat dive, which focused its attention on the weak tails of the short torpedoes, implied the existence of fundamental construction flaws, while Sears focused on a part of the torpedo—the impulse spring—that could easily be replaced without disturbing the overall construction.⁷⁰

Aside from the construction question, Torpedo Station officers also began to notice that gyroscopic torpedoes were not running as well in Newport as they had during their acceptance trials in Sag Harbor. While Sears professed himself “at a loss” to understand the discrepancy, Washington Chambers, who was leading Station efforts to improve the gyroscope, suspected “that the Obry is used ... to pass a torpedo with curved trajectory”—in other words, that the Company was using the Obry to cloak defects in the torpedo, instead of using it to correct for inaccuracy from causes external to the torpedo.⁷¹ Sears, believing that Chambers was questioning his honor along with the Company’s, fired back: “I regret that such a ‘suspicion’ exists, and in justice to my assistants, the E.W. Bliss Co. and myself would respectfully state that no such curves have been observed by any of us.”⁷² Chambers also questioned the quality of the Company’s workmanship, finding that the tails were too weak even before they were cut away to make room for the

⁶⁹ O’Neil to McLean, 14 June 1898, BuOrd 8218/98 with 4979/98, RG74/E25/B328, NARA; O’Neil to McLean, 18 June 1898, BuOrd 8420/98-LS82/285–6 with 7044/98, RG74/E25/B335, NARA.

⁷⁰ O’Neil to McLean, 14 June 1898, BuOrd 8218/98 with 4979/98, RG74/E25/B328, NARA.

⁷¹ Sears to O’Neil, 12 June 1898, BuOrd 8218/98 with 4979/98, *ibid*; Chambers to McLean, 30 August 1898, enclosure to Sears to O’Neil, BuOrd 11446/98 with 7044/98, RG74/E25/B335, NARA.

⁷² Sears to O’Neil, 21 September 1898, BuOrd 11446/98 with 7044/98, *ibid*.

Obry rudders.⁷³

The suspicion spread up the chain of command at the Station, to the Bureau, and beyond the gyroscope. After the Bureau made emergency purchases of torpedoes directly from foreign companies in response to the outbreak of the Spanish-American War, the new chief of the Bureau, Charles O'Neil, acidly informed the Bliss Company that the foreign torpedoes "exhibit many new and valuable features, none of which had ever been brought to the notice of the Bureau."⁷⁴ In asking the chief Intelligence Officer to obtain information directly from the Whitehead Company, O'Neil warned, "it may be necessary to intimate, in the most diplomatic manner possible, that (for unaccountable reasons) the Bureau has failed utterly in its endeavor to secure information, from or through the E. W. Bliss Co., concerning the progress being constantly made in the field of torpedo development."⁷⁵ An assistant inspector of ordnance at the Bliss Company, Homer C. Poundstone, felt the need to put out "private 'feelers'" to various naval attachés so as to have "a positive check on E.W.B.Co."⁷⁶ McLean found it "remarkable that the Bliss Company did not avail itself of business connections and keep informed as to the 'state of

⁷³ Chambers to McLean, n.d. but in reply to BuOrd letter of 18 June 1898, B5-145 and 21-171, NTS.

⁷⁴ O'Neil to Bliss Co., 28 November 1898, BuOrd 1900/98-LS94/242-44 with 7455/97, RG74/E25/B302, NARA. The Bureau purchased 12 14-inch x 4.62-meter Schwartzkopff torpedoes, B/57 model, in March 1898 (see O'Neil to Clover [CIO], 26 March 1898, BuOrd 3127/98-LS72/29, RG74/E25/B323, NARA); 10 long torpedoes, British Admiralty type, from the Whitehead Company in March (see Clover to O'Neil, 23 March 1898, BuOrd 3023/98 with 2214/98, RG74/E25/B319, NARA); and either 4 (see O'Neil to McLean, 18 June 1898, BuOrd 8364/98 with 2214/98, *ibid*), 6 (see Whitehead Company record sheet, 30 April 1898, B21-171, NTS), or 8 (see "List of all Automobile Torpedoes at Naval Torpedo Station and In Service, showing Condition and Whereabouts on October 10th, 1898," B21-171, NTS) torpedoes which the Brazilian government had ordered from the Whitehead Company in April or May. The first became known as the "Admiralty" torpedoes, Mark IA 5-meter and the second as the "Brazilian" torpedoes, Mark IB 5-meter. The Navy also recovered 16 Schwartzkopff torpedoes of the same B/57 model from Spanish ships.

⁷⁵ O'Neil to CoNav for ONI, 30 November 1898, BuOrd 1900/98 with 7455/97, RG74/E25/B302, NARA.

⁷⁶ Poundstone to McLean, 4 December 1898, Ms. Coll. 280/B1/F3, NHC. Emphasis in original.

the Art' in manufacture of torpedoes and gear.”⁷⁷

Although this friction boded ill for the future, it was secondary to fixing the gyroscopic torpedoes for the time being. This could not be done in time to get them into service during the Spanish-American War. Having promised in March 1898 to get the new gyroscopic torpedoes to the torpedo-boat flotilla assembled at Key West as quickly as possible, O’Neil had to reverse himself when it became clear that they were giving “more or less uncertain” results in practice, and he further ordered the Torpedo Station not to return 20 short torpedoes to the Bliss Company to be fitted with gyroscopes.⁷⁸ As it turned out, the questions of adding a second guide stud and the proper spoon length for securing a flat dive were not settled until March 1900, and the tails were not adequately strengthened until May 1901.⁷⁹ Experiments by the Bliss Company with a lighter impulse spring dragged on into September 1898, when its efforts were rendered superfluous by gyroscope development at the Torpedo Station.⁸⁰

Modified Gyroscopes

Washington Chambers, who was in charge of experimental work at the Torpedo Station, headed the gyroscope effort.⁸¹ He began by replacing the pivot bearings with ball

⁷⁷ McLean to Poundstone, 8 December 1898, *ibid.*

⁷⁸ O’Neil to CINC North Atlantic Squadron, 19 March 1898, BuOrd 2787/98-LS71/116, RG74/E25/B322, NARA; O’Neil to McLean, 18 June 1898, BuOrd 8364/98 with 2214/98, RG74/E25/B319, NARA.

⁷⁹ On the guide stud and spoon, see B23-174, NTS and RG74/E25/B302, NARA. The tail experiments occurred in three phases, from June to December 1898; from October 1899 to March 1900; and from January to May 1901. The relevant papers can be found with BuOrd 7044/98, RG74/E25/B335, NARA.

⁸⁰ Dieffenbach [IoO, Bliss Co.] to O’Neil, 16 August; O’Neil to Sears, 17 August; Chambers to McLean, 30 August; endorsement by McLean, 14 September; endorsement by O’Neil, 16 September; endorsement by Sears, 21 September 1898, all with BuOrd 11446/98 with 7044/98, RG74/E25/B335, NARA.

⁸¹ For more on Chambers, see Mason to O’Neil, 29 August 1899, Torpedo Station’s Annual Report for FY1898/99, NTS B21-171; and Stephen Stein, *From Torpedoes to Aviation: Washington Irving Chambers*

bearings and the spring with an air impulse.⁸² The ball bearings did not work well, reducing rather than increasing the duration of the gyroscope's rotation; Chambers reported an "unavoidable rattle," indicating that the bearings could not be fitted tightly enough and/or that they were not perfectly spherical due to defects in manufacture.⁸³ Chambers also abandoned the air-impulse idea fairly quickly when he found that it did not act quickly enough on the gyroscope.⁸⁴ Later iterations used a clock-spring motor in combination with different arrangements of the bearings and valve group.⁸⁵ A key objective of all the variations was to enable the gyroscope to steer the torpedo through an angle of 140° from its initial line of fire, the tactical significance of which is discussed below. The Bureau immediately seized on the possibility of this so-called angle fire, but McLean cautioned that the gyroscope needed to prove its ability to keep the torpedo on its initial line of fire before the more difficult question of angle fire was taken up.⁸⁶ Chambers' modified gyroscope was not ready to be tried in the water until February 1900.⁸⁷ Although the tactical radius was too large, meaning that it took too long for the gyroscope to turn the torpedo through an angle from its initial line of fire, the gyroscope

and Technological Innovation in the New Navy, 1876–1913 (Tuscaloosa: University of Alabama Press, 2007).

⁸² Chambers to McLean, 5 July 1898, B21-171, NTS.

⁸³ Chambers to McLean, 16 May 1899, *ibid.*

⁸⁴ McLean to O'Neil, 15 December 1898, BuOrd 15274/98 (NTS 4710/98) with 7455/97, RG74/E25/B302, NARA.

⁸⁵ Chambers to McLean, 18 February 1899, B21-171, NTS. Chambers' later reports date this one as 15 instead of 18 February, but the date on it is 18 February.

⁸⁶ O'Neil to McLean, 24 February 1899, BuOrd 2034/99-LS99/528; McLean to O'Neil, 25 August 1899, BuOrd 8530/99, both with 2034/99, RG74/E25/B372, NARA.

⁸⁷ For interim progress reports, interspersed with requests from the Bureau for updates, see Chambers to McLean, 16 May 1899; Holman and Chambers to McLean, 25 July 1899 (B18-152, NTS). Fenton to McLean, 18 August 1899; Chambers to McLean, 25 August 1899; McLean to O'Neil, 25 August 1899; Fenton to McLean, 29 August 1899; Fenton to Mason, 13 October 1899 (B21-171, NTS). Brown to Mason, 17 October 1899; Rees to O'Neil, 19 October 1899; O'Neil to Mason, 20 October 1899; Chambers to Mason, 10 November 1899; Chambers to Mason, 12 November 1899; Mason to O'Neil, 17 November 1899; Brown to Mason, 22 January 1900 (NTS B26-202); Mason to O'Neil, 24 January 1900 (B26-202, NTS).

performed well.⁸⁸

There the matter seems to have rested for several months, possibly because the Bureau and the Station were distracted by the development of a new 5-meter torpedo (see below), until Chambers wrote in October 1900 to propose a new modified gyroscope. Having caught wind of the Bureau's on-and-off interest in an air-driven gyroscope used in foreign torpedoes procured during the Spanish-American War, Chambers proposed a new model whose distinctive features were its return to air impulse in place of the spring motor, its use of the inner ring of the gyroscope as a turbine, and its return to ball bearings.⁸⁹ He wrote again a few weeks later to renounce his idea of using the inner ring as a turbine, on the grounds that it would prove too delicate in service, and instead to have the air act on a control shaft linked to the gyroscope's axis.⁹⁰ O'Neil ordered both models to be tried.⁹¹ This was done in June 1901, and the models failed to work, foundering on the same problem that had caused Chambers to abandon the idea of an air-driven gyroscope three years earlier, namely, that the air took too long to act on the gyroscope.⁹²

By that time there was a new competitor on the scene, a gyroscope designed by J. Moore, quartermaster machinist in charge of the Torpedo Station's machine shop. Moore's

⁸⁸ Mason to O'Neil, 7 February; Brown to Mason, 26 February; Mason to O'Neil, 1 March; O'Neil to Mason, 3 March; Mason to O'Neil, 6 March 1900, all with BuOrd 2034/99, RG74/E25/B372, NARA and in B26-202, NTS.

⁸⁹ Chambers to O'Neil, 9 October 1900, BuOrd 10407/00, RG74/E25/B437, NARA. The foreign gyroscope was the Kaselowsky gyroscope used in Schwartzkopff torpedoes. Kaselowsky was the manager of the Schwartzkopff factory in Berlin; see Clover [CIO] to O'Neil, 21 June 1898, BuOrd 8629/98 with 5841/97, RG74/E25/B297, NARA.

⁹⁰ Chambers to O'Neil, 29 October 1900, BuOrd 11111/00 with 10407/00, RG74/E25/B437, NARA.

⁹¹ O'Neil to Mason, 12 and 31 October, BuOrd 10407/00-LS141/259 and 11111/00-LS142/602 with 10407/00, respectively, *ibid.*

⁹² Miller to Mason, 12 June 1901, enclosure to Mason to O'Neil, 18 June 1901, BuOrd 5959/01 (NTS 2582/01) with 10407/00; Mason to O'Neil, 18 June 1901, *ibid.*

design had two features that distinguished it from Chambers'. First, the air that spun the gyroscope/turbine wheel came from inside the wheel (as in a Hero turbine), rather than from outside the wheel (as in a Pelton turbine).

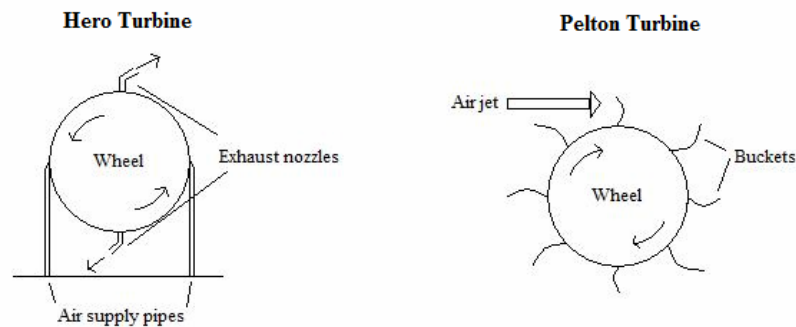


Figure 1.1: Hero and Pelton turbines.

Second, the valve group that admitted air from the flask to a temporary storage box before moving onto the turbine was positive (meaning that certain conditions of pressure had to be met before each valve would open) rather than automatic (meaning that once the first valve opened the sequence could not be stopped).⁹³

L. H. Chandler, an officer at the Station and commander of the torpedo-boat flotilla, conducted the tests on the Moore gyroscope and afterwards submitted a long report reviewing the past and future of gyroscope development.⁹⁴ He identified six different gyroscope models that had been tried and six requirements that they needed to

⁹³ Mason to O'Neil, 18 June 1901, BuOrd 5959/01 (NTS 2582/01) with 10407/00, *ibid*; Chandler to Mason, 30 September 1901, enclosure to Mason to O'Neil, 2 October 1901, BuOrd 9235/01 with 10407/00, *ibid*. The Moore gyroscope became known as the Mark II gyroscope, so as to distinguish it from the service gyroscope, which became known as the Mark I (Chandler to O'Neil, 1 October 1901, BuOrd 9239/01 with 10407/00, *ibid*).

⁹⁴ Chandler to Mason, 30 September 1901, enclosure to Mason to O'Neil, 2 October 1901, BuOrd 9235/01 (NTS 2366/01) with 10407/00, *ibid*.

meet. The service Obry, though “vastly better than nothing,” failed to meet all six requirements, and he dismissed two others because they were spring-driven rather than air-driven, leaving Chambers’ two recent air-driven models and Moore’s. He found that the two distinctive features of the Moore gyroscope gave it a decisive edge over Chambers’ designs: having air come from the interior of the turbine wheel made it less likely that the air would disturb the position of the wheel, and the positive-action valve group would produce more consistent results, since it would require the same conditions to be met at each valve rather than at the first one alone. He also thought that the Moore gyroscope would prove more durable in service and require less frequent readjustments, and he was confident that it was capable of angle fire. He enthusiastically endorsed it, and N. E. Mason, the new commander of the Torpedo Station, “unqualifiedly” recommended its adoption.⁹⁵

Their optimism proved premature. Bad weather and the absence of a testing boat delayed the resumption of tests until spring 1902, whereupon it was discovered that the Moore gyroscope could not secure angle fire due to the weakness of its steering engine.⁹⁶ Once the engine was strengthened, the torpedo made 33 of 36 successful runs, and Mason declared it “a practical success.”⁹⁷ One more round of tests with larger steering rudders decreased the tactical radius, and the officer in charge pronounced the gear “out of the experimental state” and declared that “direct ahead fire from broadside tubes is no longer a hope of the future but an accomplished fact.”⁹⁸ O’Neil decided that it would cost too

⁹⁵ Mason to O’Neil, 2 October 1901, BuOrd 9235/01 with 10407/00, *ibid.*

⁹⁶ Mason to O’Neil, 21 April 1902, BuOrd 3296/02; Williams to Mason, 18 April 1902, enclosure to Mason to O’Neil, 21 April 1902, BuOrd 3296/02, both with 10407/00, *ibid.*

⁹⁷ Mason to O’Neil, 21 April 1902, 21 April 1902, BuOrd 3296/02 with 10407/00, *ibid.*

⁹⁸ Williams to Mason, 1 June 1902, BuOrd 4449/02 with 10407/00, *ibid.*

much to install the gyroscope in older torpedoes, but he planned to put it in all new torpedoes.⁹⁹

Designing a New 5-Meter Torpedo: Dealing with the Whitehead Company and Developing the Nickel-Steel Air Flask

During the five years required to develop the Torpedo Station's gyroscope, the rest of the torpedo was not ignored. Two parts received particular attention: the engine and the air flask. In October 1897, needing to replenish the Bureau's stock of 5-meter torpedoes, O'Neil decided that the time had come to overhaul their design in search of higher speed.¹⁰⁰ His decision set off a burst of negotiations and information-gathering. The Bureau ordered 25 long torpedoes from the Bliss Company in December 1897, but the outbreak of the Spanish-American War in March 1898 abruptly ended the search for improvements, and the new order was built under the old October 1896 specifications with only slight modifications.¹⁰¹ (To meet war demands, the Bureau also placed an emergency order for 50 short torpedoes under the 1896 specifications in April 1898.)¹⁰²

When the war ended, O'Neil resumed his efforts to come up with a new 5-meter torpedo. After flirting with the idea of buying a sample torpedo from the Whitehead

⁹⁹ Endorsement by O'Neil, 3 May 1902 on Mason to O'Neil, 21 April 1902, BuOrd 3296/02 with 10407/00, *ibid.*

¹⁰⁰ O'Neil to SecNav, 6 October 1897, BuOrd 7397/97-LS61/278 with 7455/97, NARA RG74/E25/B302; O'Neil to Bliss Co., 8 October 1897, BuOrd 7455/97-LS61/370, *ibid.*

¹⁰¹ "Specifications for the Manufacture of Whitehead Automobile Torpedoes, U. S. N., 5m x 45cm, Mk I," 1 December 1897, RG45/E502 (Envelope "Mines and torpedoes, reports, correspondence & miscellaneous data relative to, 1871-1899"), NARA. The main differences between these specifications and the 1896 specifications was that they included the speed and gyroscope requirements which had been added to the 1896 specifications by correspondence. See also Bliss Co. to O'Neil, 3 January 1899, BuOrd 74/99 with 7455/97, RG74/E25/B302, NARA.

¹⁰² O'Neil to Bliss Co., 29 March; Bliss Co. to O'Neil, 30 March; O'Neil to Bliss Co., 31 March; O'Neil to SecNav, 31 March; Herbert & Micou to O'Neil, 31 March; SecNav to O'Neil, 5 April 1898; all with BuOrd 3462/98, RG74/E25/B324, NARA.

Company embodying several new features, O’Neil turned back to the Bliss Company.¹⁰³ O’Neil hoped that the Company might be able to replace the reciprocating engine of the Whitehead torpedo with a turbine engine: he had written to Charles Parsons, British inventor of the turbine engine for ships, and the American Curtis Turbine Company, to ask whether their turbines might be adaptable to torpedoes.¹⁰⁴ When informed by the Curtis Company that it had been working with the Bliss Company, apparently without O’Neil’s knowledge, to adapt a turbine for use in torpedoes, O’Neil seems to have left the matter in the Bliss Company’s hands.¹⁰⁵ It is important to note that the Bureau and the Bliss Company seem to have arrived independently at the idea of the turbine engine around the same time—a decade later, the two sides would hotly dispute this issue in court. In July 1899, the Bliss Company’s experimental turbine torpedo was accidentally wrecked, and the Company glumly advised the Bureau that it should buy torpedoes directly from Whitehead.¹⁰⁶ Undeterred, the Bureau said it would stick with the Bliss Company, because it believed that the Whitehead Company’s torpedo needed improvement.¹⁰⁷ In particular, the Bureau had high hopes for two experimental nickel-steel flasks.¹⁰⁸

The Bureau had several reasons for its interest in nickel-steel air flasks. One was the desire to increase the speed and range of torpedoes by raising the flask pressure from

¹⁰³ O’Neil to CoNav for CIO, 16 December 1898, BuOrd 1900/98 with 7455/97; O’Neil to Bliss Co., 5 June 1899, BuOrd 5625/99-LS107/16–17 with 7455/97, RG74/E25/B302, NARA.

¹⁰⁴ O’Neil to Parsons, 28 January, BuOrd 867/98-LS67/515; O’Neil to Curtis Co., 29 January 1898, BuOrd 867/98-LS67/516, both with 7455/97, RG74/E25/B302, NARA.

¹⁰⁵ Curtis Co. to O’Neil, 31 January 1898, BuOrd 1013/98 with 7455/97, *ibid.*

¹⁰⁶ Bliss Co. to O’Neil, 19 July 1899, BuOrd 7353/99, RG74/E25/B389, NARA.

¹⁰⁷ Fenton to Bliss Co., 31 July 1899, BuOrd 7353/99-LS110/239, *ibid.*

¹⁰⁸ O’Neil to Inspector of Ordnance, Midvale Steel Company, 29 April 1899, BuOrd 3666/99-LS104/222; O’Neil to Inspector of Ordnance, Bethlehem Iron Company, 29 April 1899, BuOrd 3666/99-LS104/203–4, both with 7455/97, RG74/E25/B302, NARA. Holman and Chambers to McLean, 25 July 1899, sections A-B, B18-152, NTS.

1,350 psi to 1,500 psi. O’Neil had begun to explore this idea in 1897 when he contemplated the design of a new 5-meter torpedo, dropped due to the press of business during the Spanish-American War, and picked back up once the war was over.¹⁰⁹ O’Neil also feared what would happen if torpedo air flasks were struck by shell fragments in battle and exploded. To find out, he ordered the Torpedo Station to conduct ballistic tests on charged air flasks.¹¹⁰ He particularly wanted to know whether the flask would explode, indicating that the metal was relatively hard and brittle, or tear, indicating that it was relatively soft and elastic. After some delay, the Torpedo Station carried the tests out in June 1898, firing a 6-pdr shell into a flask charged to 1,350 psi.¹¹¹ The flask “burst like a big shell,” the commander of the Torpedo Station privately reported to O’Neil:

In fact its behavior was “Unfit for publication.” May be [sic] the steel of the flask was too hard. It would have made havoc aboard ship. I saw it all very distinctly and could not but wish that I had been the only witness, as the results were not encouraging, in view of what might happen aboard ship. Of course an exploding shell, or the exploding of one’s own ammunition by an enemy’s shot could be just as dangerous, but reports of the test may be harmful at this time [i.e., in the middle of a war]. I have put personal on the envelope so that you will be first to see the report.¹¹²

This was an alarming result.

Fixing the problem was not easy, because air-flask metal needed to embody two sets of competing properties. One set was high strength and low weight, but these were difficult to reconcile. With simple steel—in ship armor as in air flasks—strength and

¹⁰⁹ Torpedo Board to O’Neil, 21 September 1897, BuOrd 7053/97; O’Neil to Rittenhouse, 30 September 1897, BuOrd 7053/97-LS61/63, both with 3407/97, RG74/E25/B290, NARA.

¹¹⁰ O’Neil to Commandant Newport Naval Station, 10 December 1897, BuOrd 9256/97-LS65/274, RG74/E25/B307, NARA.

¹¹¹ O’Neil to McLean, 12 February 1898, BuOrd 9256/97-LS68/272; O’Neil to McLean, 23 May 1898, BuOrd 9256/97-LS79/343, *ibid.*

¹¹² McLean to O’Neil, 6 June 1898, BuOrd 8500/98 with 9256/98, RG74/E25/B436 [misfiled, should be in B307], NARA.

weight increased proportionally: to increase the strength, more metal had to be added, making the object heavier, less buoyant, and slower (unless power increased disproportionately to weight). The other set of properties was hardness, meaning ability to resist stress without deformation, which would slow the torpedo down; and elasticity, meaning ability to resist stress without breakage, which increased safety. The June 1898 test revealed that the metal used in American air flasks was relatively weak and inelastic: when stressed beyond a certain point, which was not as high as the Americans would have liked, the metal did not go through a warning period of deformation, but simply shattered into dangerous fragments.

O'Neil believed that nickel steel could kill four birds with one stone: it could find a happy medium between strength and weight, and between hardness and elasticity. In November 1898, he told McLean that the specifications for air flasks required too high an elastic limit and too little elongation.¹¹³ He believed a nickel-steel flask would allow a lower elastic limit and higher elongation while still increasing the overall strength of the flask—meaning that he could have a stronger flask that was also safer.

In September 1899, the Bureau asked the Bliss Company to bid on new 5-meter torpedoes with the latest improvements in air flasks.¹¹⁴ The Company replied that it would manufacture 30 at \$4,200 each, or 50 or more at \$3,800 each.¹¹⁵ The Bureau

¹¹³ O'Neil to McLean, 28 November 1898, BuOrd 8023/97-LS? with 7455/97, RG74/E25/B302, NARA. The elastic limit referred to the amount of stress that metal could stand before it began to deform elastically (as opposed to plastically—elastic deformation was reversible, plastic deformation was permanent). The lower the elastic limit, the less stress it took to deform the metal elastically. The elongation percentage measured how much a metal “stretched” when pulled; a 25% elongation for a 2-inch specimen meant that the specimen began at 2 inches and, after being stretched, ended at 2.5 inches. The higher the percentage, the “stretchier” the metal was.

¹¹⁴ O'Neil to Bliss Co., 6 September 1899, BuOrd 5625/99 with 7455/97, *ibid.*

¹¹⁵ Bliss Co. to O'Neil, 25 September 1899, BuOrd 9361/99 with 7455/97, *ibid.*

balked at the higher price, observing that it was a \$900 increase over the 5-meter torpedoes ordered in December 1897.¹¹⁶ The Company countered that it had to rebuild its labor force and plant, among other things, and stuck to its price.¹¹⁷ O'Neil relented, agreeing to order 30 torpedoes at \$4,200 each with a speed of 28.5 knots when launched from an over-water tube without its fittings for submerged discharge (which added weight and slowed the torpedo down).¹¹⁸ These 30 torpedoes became known as Mark II 5-meter torpedoes.

The Superheater

As the ink was drying on the contract, the Bliss Company approached the Bureau with a new proposal. Its experimental turbine torpedo had been wrecked the previous summer, along with various improvements embodied in it, with one exception. "This one exception, however, is the most important one," declared the Company, "as its object is to increase materially the speed of the torpedo."¹¹⁹ It was the so-called superheater, which heated the remaining air in the air flask as the volume decreased, thus keeping up the pressure of the air acting on the engine. In contrast to later versions, this one was a dry inside superheater, and it was designed by Leavitt, the Company's chief engineer. The fuel (alcohol) for supporting combustion was stored in a reservoir outside the air flask, but combustion occurred inside the flask. The combustion chamber was covered by an inverted hood, which funneled the heated air into a pipe leading out of the air flask, through the reducer, and to the engine. The relative air pressures in the air flask and the

¹¹⁶ O'Neil to Bliss Co., 6 October 1899, BuOrd 9361/99 with 7455/97, *ibid.*

¹¹⁷ Bliss Co. to O'Neil, 9 October 1899, BuOrd 9816/99 with 7455/97, *ibid.*

¹¹⁸ O'Neil to Bliss Co., 12 October 1899, BuOrd 9816/99 with 7455/97, *ibid.*

¹¹⁹ Bliss Co. to Herbert & Micou, 7 February 1900, BuOrd 1538/00, RG74/E25/B410, NARA.

fuel reservoir regulated the rate of the fuel feed into the combustion chamber.

The Bliss Company offered the Bureau a novel testing and purchasing arrangement for the superheater. If the Bureau would let the Company put the superheater in one of the new Mark II 5-meter torpedoes and it failed to increase the speed by a knot, the Company would take the superheater out and deliver the torpedo like the others of its Mark. If the superheater increased the speed by a knot but for some reason the Bureau did not want it, the Company would take it out for a charge of roughly \$600. If the superheater increased the speed and the Bureau decided to adopt it in the experimental torpedo, the Bureau would pay \$500 for each half-knot increase over the contract speed of 28.5 knots. If the Bureau decided to have it installed in all of the Mark II 5-meter torpedoes under contract, the Company would do so for a reasonable charge.¹²⁰

Although O'Neil declined to commit the Bureau to any decision about the whole order of 30 Mark II torpedoes, he agreed to the Company's other terms regarding the use of a Mark II torpedo for experiments, including payment of \$500 for every half-knot over the contract speed.¹²¹ A conversation with Leavitt led to a slight modification, dropping the reference to the torpedo's contract speed and replacing it with the condition that the torpedo make at least one knot over what it would have made without the superheater.¹²² O'Neil ordered the Company to proceed with experiments, and to manufacture the other 29 Mark II torpedoes in such a way that they could be fitted with the superheater if the Bureau so chose.

The experimental torpedo was ready for tests in late July, which were overseen by

¹²⁰ Bliss Co. to Herbert & Micou, 7 February 1900, BuOrd 1538/00, *ibid.*

¹²¹ O'Neil to Bliss Co., 9 February 1900, BuOrd 1538/00-LS122/480-81, *ibid.*

¹²² O'Neil to Bliss Co., 24 February 1900, BuOrd 1538/00-LS123/542-43, *ibid.*

Bradley Fiske, the new Inspector of Ordnance at the Bliss Company. At 1,500 yards, the torpedo averaged 23.56 knots without the superheater and made 27.9 knots with it, an 18% increase.¹²³ When tested with the heater at 800 yards, the engine broke, as it was unable to stand the increased horsepower caused by the superheater. In Fiske's opinion, "the superheating device is an improvement of far reaching importance," whose accomplishments would be limited only by the strength of the engine. He did not think there was time to put it in all the Mark II torpedoes, but he recommended that work continue with the experimental torpedo. The Bureau accepted both of his suggestions.¹²⁴ Once the engine of the experimental torpedo was repaired, it was run again at 800 yards, where it averaged 29.57 knots without the superheater and 31.6 knots with it, an increase of 14.5%.¹²⁵ Despite the complications added by the superheater to "an apparatus already excessively complicated," Fiske recommended that it be adopted in future contracts.¹²⁶

With Fiske's recommendation in hand, the Bureau asked the Bliss Company to quote prices for various arrangements by which the superheater could be purchased.¹²⁷ The Company replied that it would charge \$150,000 for the exclusive or non-exclusive American right to the device, \$500 for each torpedo fitted with the device, or \$4,700 for each torpedo ordered in lots of twenty.¹²⁸ The Bureau decided to withhold its decision pending experiments with the heated Mark II torpedo at the Torpedo Station.¹²⁹

¹²³ Fiske to O'Neil, 1 August 1900, BuOrd 8113/00 with 1538/00, *ibid.*

¹²⁴ Endorsement by O'Neil, 6 August 1900 on Fiske to O'Neil, 1 August 1900, BuOrd 8113/00 with 1538/00, *ibid.*

¹²⁵ Fiske to O'Neil, 10 September 1900, BuOrd 9404/01, RG74/E25/B434, NARA.

¹²⁶ Fiske to O'Neil, 1 December 1900, BuOrd 12387/00 with 9404/00, RG74/E25/B479 [misfiled, should be in B434], NARA.

¹²⁷ O'Neil to Bliss Co., 5 December 1900, BuOrd 12387/00-LS146/39-40 with 9404/00, *ibid.*

¹²⁸ Bliss Co. to O'Neil, 10 December 1900, BuOrd 12715/00 with 9404/00, *ibid.*

¹²⁹ O'Neil to Bliss Co., 13 December 1900, BuOrd 12715/00 with 9404/00, *ibid.*

There the torpedo sat nearly untested for six months, due to bad weather and a personnel shortage—the latter an indication of the poverty of the Navy’s research and development resources. The Torpedo Station was able to make only two runs before June. N. E. Mason, who had succeeded McLean as commander of the Station in October 1899, while refraining from final judgment, reported that the initial impression was not favorable, due to the additional complication of the torpedo and the dirt caused by the burning alcohol of the superheater, which would get into the gyroscope’s valve group and interfere with its performance.¹³⁰ Full trials reversed this opinion. The heated torpedo averaged 35.6 knots at 800 yards, a 16% increase over the speed obtained in the September acceptance trials, and more than 7 knots over the contract speed.¹³¹ The Torpedo Board found that its fear of dirt interfering with the alcohol was unfounded, and it declared the superheater simple, easy to understand, and no less durable than any other part of the torpedo. It recommended that the Bureau adopt the device in future torpedoes, but it recommended against purchasing the exclusive American right, since it (presciently) expected that a simpler and more efficient heater could be designed.

Thus buoyed, the Bureau wrote to ask what the Bliss Company would charge to install the superheater in the remaining 29 Mark II torpedoes, and it was quoted a price of \$14,500.¹³² On advice from the Torpedo Station that the engines were not strong enough to take the superheater, the Bureau checked with the Bliss Company to make sure that the

¹³⁰ Mason to O’Neil, 18 April 1901, BuOrd 3970/01 with 9404/00, *ibid.*

¹³¹ Torpedo Board [Hodgson and Miller] to Mason, 10 June 1901 (Report #36), enclosure to Mason to O’Neil, 12 June 1901, BuOrd 5830/01 with 9404/00, *ibid.*

¹³² O’Neil to Fiske for Bliss Co., 13 September 1901, BuOrd 8686/01-LS167/208 with 9404/00; Bliss Co. to Fiske for O’Neil, 23 September 1901, BuOrd 8943/01 with 9404/00, *ibid.* This was an extra \$500 per torpedo, on top of the initial \$4,200 price, bringing the total cost to \$4,700 per torpedo.

price included stronger engines.¹³³ Assured that it did, the Bureau received the Torpedo Station's blessing to place the order.¹³⁴

The Turbine Engine

In September 1901, towards the end of the negotiations over the superheater, and influenced by the knowledge of the extra stress placed on the engine by the superheater, O'Neil dusted off an idea that had been floating around the Bureau for years: the use of a turbine engine. As previously discussed, O'Neil and the Bliss Company had independently arrived at the idea of using a turbine engine in early 1898, and the Company had built an experimental turbine torpedo, but it was wrecked in July 1899, and nothing could be salvaged from it except the superheater idea.¹³⁵ After this setback, the turbine concept languished for two years while the Bureau and the Company focused on developing the Mark II torpedo and the superheater.

O'Neil revived the turbine idea in a letter to Mason, the commander of the Torpedo Station, forwarding tentative specifications for a turbine torpedo and requesting his opinion.¹³⁶ Mason solicited advice from three of his subordinates, W. G. Miller, L. H. Chandler, and G.W. Williams (a future commander of the Torpedo Station). Anticipating subsequent developments, Miller and Chandler worried that the rotation of the turbine would cause the torpedo to roll and interfere with its accuracy, but Williams discounted

¹³³ Miller to Mason, 30 September; Chandler to Mason, 30 September 1901, enclosures to Mason to O'Neil, 1 October 1901, BuOrd 9404/00; O'Neil to Bliss Co., 3 October 1901, BuOrd 8943/01-LS168/396 with 9404/00, *ibid*.

¹³⁴ Bliss Co. to O'Neil, 7 October 1901, BuOrd 9374/01 with 9404/00; Mason to O'Neil, 19 November 1901, BuOrd 10950/01 with 9404/00, B30-168, NTS.

¹³⁵ Bliss Co. to O'Neil, 19 July 1899, BuOrd 7353/99, RG74/E25/B389, NARA.

¹³⁶ O'Neil to Mason, 11 September 1901, BuOrd 8621/01 with 9558/01, RG74/E25/B480, NARA.

the possibility.¹³⁷ Chandler added that he had conversed with Leavitt on the subject in the past, and Leavitt had doubted the worth of a turbine engine. “Of course this may be correct,” Chandler allowed, “and at the same time Mr. Leavitt may very readily have been influenced by outside or business motives which may have made him ready to condemn the turbine without sufficient grounds, as he has most certainly done the Oby gear.” Chandler advised a direct approach to Leavitt, expecting that he would “talk more freely” since he was no longer with the Bliss Company, and a robust effort to develop the turbine idea, since the benefits “would be well worth a considerable outlay of thought, money, work and time.”¹³⁸ Mason agreed, and he agreed with Williams that the turbine would not cause the torpedo to roll.¹³⁹

While the Torpedo Station considered the issue, Fiske, still the Inspector of Ordnance at the Bliss Company, began discussing the possibility of a turbine torpedo with Leavitt, the past and future chief engineer of the Bliss Company.¹⁴⁰ Fiske forwarded a letter from Leavitt to O’Neil, in which Leavitt recommended dynamometric tests with the turbine before putting it in a torpedo, at a cost probably not exceeding \$3,000.¹⁴¹ (Dynamometric tests referred to the practice of running the engine against resistance in a dynamometer to measure certain aspects of its performance, such as horsepower.) Fiske allowed that the price seemed high for a single experiment, but he justified it on the grounds that “[t]he torpedo has become so excessively complicated, that any effort to

¹³⁷ Miller to Mason, 14 September; Chandler to Mason, 16 September; Williams to Mason, 3 October 1901; all enclosures to Mason to O’Neil, 11 October 1901, BuOrd 9563/01 with 9558/01, *ibid*.

¹³⁸ Chandler to Mason, 16 September 1901, enclosure to Mason to O’Neil, 11 October 1901, BuOrd 9563/01 with 9558/01, *ibid*.

¹³⁹ Mason to O’Neil, 11 October 1901, BuOrd 9563/01 with 9558/01, *ibid*.

¹⁴⁰ Fiske to O’Neil, 11 October 1901, BuOrd 9558/01, *ibid*.

¹⁴¹ Leavitt to Fiske, 10 October 1901, enclosure to Fiske to O’Neil, 11 October 1901, BuOrd 9558/01, *ibid*.

simplify it must commend itself to all Naval men.”¹⁴² He requested permission to get a definite proposition from the Bliss Company, which O’Neil granted, requiring the Company to guarantee that the turbine would generate at least 90 horsepower when using superheated air, the same as the reciprocating engine.¹⁴³ The Company agreed to build a turbine and conduct dynamometric tests for \$3,000, and then to turn both the turbine and the data over to the Bureau.¹⁴⁴ O’Neil accepted the offer and ordered the Company to proceed immediately.¹⁴⁵ This was a landmark moment in the naval-industrial complex: the state was investing directly in experimental work instead of buying a finished product. Moreover, it was purchasing not only a physical commodity (the turbine), but also information (the data from the dynamometric tests).¹⁴⁶

The turbine had its dynamometric tests six months later, in April 1902. The naval officer reporting on the tests, G. C. Davison (a name to remember), noted that it gave mixed results.¹⁴⁷ By one measure of efficiency, it seemed inferior to the reciprocating engine, because it did less work for each pound of air. This definition of efficiency was partial, however, because the temperature and pressure of the air mattered—other things being equal, one pound of higher-pressure, hotter air does more work than one pound of lower-pressure, colder air. The turbine used air at a lower pressure, so that less work done per pound of air was to be expected, but it nevertheless developed a higher maximum horsepower, 108 to the reciprocating engine’s 82. It was also simpler and more durable, the latter a particularly appealing feature when heated air was used. Davison said the

¹⁴² Fiske to O’Neil, 11 October 1901, BuOrd 9558/01, *ibid.*

¹⁴³ O’Neil to Fiske, 14 October 1901, BuOrd 9558/01-LS168/175–76, *ibid.*

¹⁴⁴ Bliss Co. to O’Neil, 18 October 1901, BuOrd 9791/01 with 9558/01, *ibid.*

¹⁴⁵ O’Neil to Bliss Co., 19 October 1901, BuOrd 9593/01-LS169/449 with 9558/01, *ibid.*

¹⁴⁶ The implications of these decisions are discussed more fully in Chapter 3.

¹⁴⁷ Davison [BuOrd officer] to O’Neil, 26 April 1902, BuOrd 3677/02 with 9558/01, *ibid.*

Company planned to conduct a second round of tests using higher air pressure in the hopes of increasing the turbine's work per pound of air.¹⁴⁸

Leavitt, who was overseeing the dynamometric tests even though he was no longer with the Company, submitted his own report when the second round of tests was complete.¹⁴⁹ He made three main points. First, although the turbine did less work per pound of air, it used air at a lower pressure than did the reciprocating engine. Second, Leavitt argued that the best metric of value was not work done per pound of air, but rather the total energy delivered by the engine to the propeller shaft. The implication of this point was that the turbine could increase the range of torpedoes: because it could potentially do the same amount of work as the reciprocating engine at a lower pressure, it would be able to utilize air in the flask after it had dropped below the pressure at which the reciprocating engine could use it. Third, the turbine could withstand higher heat, which, being directly proportional to pressure, meant that it could withstand higher pressures as well. In other words, the turbine could work across a greater range of pressures than could the reciprocating engine: it could start at a higher initial pressure than could the reciprocating engine, and it could keep working at a lower final pressure than the reciprocating engine. Accordingly, Leavitt calculated that the turbine was almost 20% better than the reciprocating engine. He predicted that the turbine could generate 100 horsepower without needing repair, which would give speeds of 36 knots at 900 yards, 34 knots at 1,000 yards, 32 knots at 1,200 yards, and 29 knots at 1,500 yards. E. R. Pollock, the new Inspector of Ordnance at the Company, agreed with Leavitt, concluding

¹⁴⁸ I am grateful to Terry Lindell for calling my attention to the importance of temperature and pressure in measuring work, and hence efficiency.

¹⁴⁹ Leavitt to Bliss Co., 19 May 1902, B31-161, NTS.

that “[f]or durability and reliability the turbine has been proven to be the superior of the Whitehead engine.”¹⁵⁰

Satisfied that the Bliss Company had held up its end of the bargain, and probably eager to have his own people get their hands on it, O’Neil ordered the turbine, by then in a Mark II 5-meter torpedo, shipped to the Torpedo Station for further experiments.¹⁵¹ Like the experimental heated torpedo, it languished there for several months due to a lack of officers to conduct tests, during which time events overtook it.¹⁵² The Bliss Company, encouraged by the performance of the turbine in dynamometric tests, during which it had been jury-rigged to a Mark II torpedo, began designing a new torpedo especially for the turbine. Among other features, the new torpedo required larger exhaust than the reciprocating engine, a new steering engine, a new valve group, and a new location for the diving gear.¹⁵³ As it turned out, the torpedo would also include the superheater and a new gyroscope of Leavitt’s design.¹⁵⁴ In November 1902, however, just as tests of the new torpedo were getting underway, a freak accident occurred, causing major damage to the torpedo (and to the arm of a foreman, which had to be amputated), which delayed tests for another year, and another chapter.

Tactics and Naval Architecture

All of this activity—the choice of the Whitehead over the Howell, the

¹⁵⁰ Pollock to O’Neil, 24 May 1902, *ibid.*

¹⁵¹ Chase [Acting CoO] to Pollock, 12 June 1902, BuOrd 4704/02-LS184/531 with 9558/01, RG74/E25/B480, NARA.

¹⁵² Fletcher to O’Neil, 8 September 1902, BuOrd 7682/02 (NTS 1612/02) with 9558/01, *ibid.*

¹⁵³ Pollock to Hill (BuOrd officer), 11 June 1902, B31-161, NTS.

¹⁵⁴ Chambers, Sears, and Hill [board that tested the torpedo] to O’Neil, 19 November 1903, BuOrd 13021/03 with 9558/01, RG74/E25/B480, NARA.

introduction of new marks of torpedoes, the changes to the gyroscope, and the development of nickel-steel air flask, superheater, and turbine engine—occurred in an atmosphere of great confusion over how the fruits of the activity would actually be used.

Between 1895 and 1902, naval tactics began to change dramatically, largely as a result of the gunnery revolution led by Britain's Percy Scott. Improvements in gunnery lengthened the range at which tacticians expected future battles to be fought, and they created both new challenges and new opportunities in maneuvering and signaling. The United States was slow to adapt to the changes, in large part because it lacked provision for the formal consideration of tactical problems. The Naval War College took its first steps toward filling the void in the early 1890s, when it introduced a new feature into the curriculum: a "problem" to be solved during the summer.¹⁵⁵ Until 1901, however, the problems focused on solving strategic questions of interest to the United States, and tactics were discussed only insofar as they bore on the strategic issue at hand. The discussion of tactics in 1899, for instance, was restricted to "A discussion of the tactical value of the harbors of the North Atlantic, with respect to the position of our battleship fleet."¹⁵⁶

In 1901, however, the College began to focus on tactics, specifically fleet battle tactics, as a subject in its own right. The solutions to the problems began to feature sections on battle tactics, and the new lecturer in tactics, Lieutenant Commander J. B. Murdock (who had served at the Torpedo Station in the late 1880s) re-oriented the lectures to focus on battle tactics. By way of justifying the new emphasis, Murdock told

¹⁵⁵ See Ronald Spector, *Professors of War: The Naval War College and the Development of the Naval Profession* (Newport: Naval War College Press, 1977), 71–73.

¹⁵⁶ Solution to the Problem of 1899, Section C, RG12, NHC.

his students “that we have to-day no battle tactics.”¹⁵⁷ Murdock spent most of his time and energy introducing his students to a recent phenomenon called line-of-bearing tactics, which were designed to facilitate both gunnery and maneuvering, and preaching the importance of target practice. He barely mentioned torpedoes. In 1901 and 1902, while crediting the Whitehead torpedo with some moral influence and for turning thought away from ramming and *mêlée*, which many officers thought desirable for decades following the battle of Lissa in 1866, and towards longer fighting ranges, he thought its contributions ended there.¹⁵⁸ In 1902, quoting a British officer named H. J. May, he pointed out, but only in passing, that a retreating fleet had a major advantage over a pursuing fleet in torpedo fire.¹⁵⁹ This was the extent of his attention to the effect of torpedoes on tactics.

The study of tactics received another institutional boost in 1900 with the establishment of the General Board, which collaborated with the War College to promote the subject.¹⁶⁰ The General Board, headed by Admiral George Dewey, the victor of Manila Bay, was a purely advisory body which opined on subjects ranging from naval construction to strategy. Together, the General Board and the War College designed fleet maneuvers in 1901 and the problems to be solved by the summer “conference” of War College students in 1901 and 1902. The 1901 maneuvers included attacks by torpedo boats on the battle fleet, but their main purpose was to test and improve the

¹⁵⁷ Murdock, “Battle Tactics,” lecture delivered 20 June 1901, RG14/B2, NHC.

¹⁵⁸ Murdock, “Naval Tactics (4),” lecture delivered summer 1902, *ibid.*

¹⁵⁹ Murdock, “Naval Tactics (5),” lecture delivered summer 1902, *ibid.* The logic behind this point was that the pursuing fleet was moving towards the retreating fleet, thereby lengthening the effective range of the latter’s torpedoes, while the retreating fleet was moving away from the pursuing fleet, thereby reducing the effective range of the latter’s torpedoes.

¹⁶⁰ Crowninshield [temporary president, General Board] to SecNav, 25 November 1901, RG80/E285/B1/V1/P390–93, NARA.

maneuverability of the battle fleet.¹⁶¹ Likewise, the solutions to the tactical problems presented at the 1901 and 1902 War College conferences focused overwhelmingly on concentrating gun-fire, maneuvering so as to achieve it, and the command-and-control problems created by maneuvering.¹⁶² In a paper for the 1902 conference, however, Murdock made two new points about torpedoes. First, he argued that the existence of torpedoes would tend to keep fleets from closing within 2,000 yards. Second, despite this pressure to keep the range long, he argued that whether by accident or by the desire of the fleet with inferior gunnery, battles were likely to include actions within 2,000 yards, where the torpedo could make an essential contribution to victory or defeat. “The War College therefore is of the opinion,” he announced, “that it is a great error to design our battleships without torpedo tubes.”¹⁶³ This was a concrete measure of the torpedo’s impact on naval architecture (not to mention the close relationship between tactics and naval architecture), but its importance should not be over-stated. Fundamentally, the War College continued to think of gunnery as the controlling element in naval tactics, with torpedoes playing a supporting role.

The Bureau of Ordnance and the Torpedo Station, meanwhile, were laying the groundwork for torpedoes to play a primary and independent role. The key figure in this effort was Charles O’Neil, the chief of the Bureau from spring 1897 to spring 1903, during which time he was also president of the Board on Construction. Established in 1889, the Board on Construction brought together the chiefs of the bureaux involved in

¹⁶¹ Dewey [president, General Board] to commander, North Atlantic Squadron, 22 March 1901, RG80/E285/B1/V1/P181–83, NARA.

¹⁶² Solution to Problem of 1901, Appendix B: Tactics; and Solution to Problem of 1902, “Note” and Murdock’s paper, both RG12, NHC.

¹⁶³ Solution to Problem of 1902, “Note” and Murdock’s paper, both *ibid.*

naval construction (Construction and Repair, Steam Engineering, Equipment, and Ordnance), along with the Chief Intelligence Officer, to advise the Secretary of the Navy on the subject. Shortly after relieving W. T. Sampson as chief, O'Neil began a campaign to acquire an under-water torpedo tube for use in battleships. During Sampson's tenure, this prospect had been unlikely, since Sampson had "no faith in under-water discharge" and a pet scheme for an armored over-water tube, which he repeatedly referred to the Torpedo Board for report despite its denunciations of the idea and endorsements of under-water discharge.¹⁶⁴ A few months after taking over, O'Neil moved aggressively to buy the rights and a sample submerged tube from Armstrong, Whitworth & Company.¹⁶⁵

In an apparent irony, O'Neil became the leading opponent of placing submerged tubes on battleships. The irony was not real, however, as O'Neil's reversal had nothing to do with abandoning his goal, but rather with the failure of another of his tactical initiatives on which the utility of submerged fire depended: the search for angle fire. Angle fire, sometimes called curved fire, referred to the practice of setting the gyroscope so as to make a torpedo curve through a certain angle from its initial line of fire. While opening up some tactical possibilities for over-water torpedo fire, like firing a torpedo from a broadside tube direct ahead in line with the keel, angle fire was most significant for submerged tubes. Unlike over-water tubes, which could be pivoted through a considerable degree of horizontal train, submerged tubes were fixed. Without angle fire,

¹⁶⁴ For quote, see Sampson to Converse, 1 February 1897, B15-142, NTS. For Sampson on tubes, see Sampson to Converse, 31 August 1895, BuOrd 5822/95 with 5906/95, RG74/E25/B234, NARA; Torpedo Board [Converse, Fletcher, and Smith] to Sampson, 20 September 1895, BuOrd 6327/95 with 5906/95, *ibid*; Sampson to Converse, 24 March 1897, BuOrd 1435/97, B15-142, NTS; Converse to Sampson, 5 April 1897, NTS 1040/97, *ibid*; Poundstone to Converse, 10 April 1897, *ibid*; Sampson to Converse, 25 May 1897, BuOrd 3602/97 with 619/97, RG74/E25/B280, NARA; Converse, Fletcher, Rittenhouse, and Poundstone to Sampson, 1 June 1897, BuOrd 4101/97 (NTS 1642/97) with 619/97, B15-142, NTS.

¹⁶⁵ These negotiations are contained in the bundle of letters with BuOrd 5841/97, RG74/E25/B297, NARA.

to fire a torpedo from a submerged tube, the whole ship had to be turned to the appropriate bearing. With angle fire, the gyroscope merely had to be set to curve the torpedo through the appropriate angle, thereby making it independent of the firing ship's bearing, the train of the tube, and its initial line of fire.

Chambers, who led the Torpedo Station's efforts to improve the Obry gyroscope, was quick to pick up on this tactical significance, and his modifications to the original Obry gyroscope featured two key improvements: first, he rearranged the position setting, position holder, and steering valve so that the torpedo could be caused to curve at any angle up to 140° on either side of the initial line of fire; and second, he redesigned the adjusting rod so that it could be turned from outside the torpedo tube, thereby increasing the ease and speed of adjusting the gyroscope for the proper angle in action.¹⁶⁶ O'Neil pounced on the idea, ordering the Torpedo Station to hurry tests of Chambers' gyroscope in part so that the Bureau could make a decision about its capability for angle fire.¹⁶⁷ As previously discussed, however, Chambers' modified gyroscope proved unsatisfactory, and the Navy did not develop a gyroscope suitable for angle fire until the improved version of Moore's Mark II gyroscope in April 1902. In September, O'Neil ordered an innovative series of experiments with angle fire.¹⁶⁸

O'Neil also championed the pursuit of higher speeds and longer ranges in torpedoes by means of the superheater and turbine. Responding to Mason's initially negative assessment of the superheater, O'Neil explained why he thought the superheater added value to torpedoes: first, by increasing the efficiency of the available compressed

¹⁶⁶ Chandler to Mason, 30 September 1901, enclosure to BuOrd 9235/01 (NTS 2366/01) with 10407/00, RG74/E25/B437, NARA.

¹⁶⁷ O'Neil to McLean, 24 February 1901, BuOrd 2034/99-LS99/528, RG74/E25/B372, NARA.

¹⁶⁸ O'Neil to Fletcher, 10 September 1902, BuOrd 7734/02, B32-164, NTS.

air, it increased the range; and second, by increasing the speed, it decreased the duration of the run and permitted greater errors in aiming the torpedo.¹⁶⁹ The Bureau was already investigating how greater speed affected the probability of hitting the target, and O’Neil ordered the Torpedo Station to help. For the time, this was an innovative approach—the War College was thinking about the probabilities of hitting with gunfire, but it had not thought to apply the same calculations to torpedoes. O’Neil also asked Mason to consider how much the superheater could be used to increase the range at lower speeds, concluding with the startling information that the Bureau was thinking of requiring the distance gear in all future torpedoes to be set for at least 3,000 yards with the superheater and 2,000 without it—both significant increases over the 800 yards called for in the most recent specifications.

None of these developments matured quickly enough, however, to save the submerged tubes of the five *Virginia*-class battleships from O’Neil when the question came before his Board on Construction in 1902. At that time, the most modern torpedoes in the Navy’s arsenal were still the Mark II 5-meter torpedoes ordered in February 1900, which lacked superheaters, turbines, and Moore’s gyroscope. In opposing the installation of submerged tubes in battleships, O’Neil and the majority pointed to the limited range of torpedoes (800 yards at maximum speed) and the fact that the tubes were fixed, which made the probability of effective use “very remote” and reduced their efficiency “to a minimum.”¹⁷⁰ Given these limitations, the size and intricacy of submerged-tube installations, and the dangers arising therefrom, the majority recommended against

¹⁶⁹ O’Neil to Mason, 7 June 1901, BuOrd 3970/01, B30-168, NTS.

¹⁷⁰ Board on Construction [majority] to Long, 20 January 1902, RG80/E180/V6/P191, NARA. For a similar analysis, see Board of Construction [majority] to Long, 27 December 1902, RG80/E180/V7/PP55–60, NARA.

installing them on battleships. The dissenting member of the Board, R. B. Bradford, pointed vaguely to foreign practice and tried to cast the dispute in terms of the hoary line-versus-experts controversy, saying that tactical experts should decide the question, but O’Neil—who, incidentally, was a line officer as well as an ordnance expert—in fact had a good grasp of the tactical possibilities and limitations of the Navy’s torpedoes at the time.¹⁷¹

Battleships aside, three other classes of ships that would later play a significant role in torpedo tactics were almost entirely ignored during this period: the torpedo boat, the torpedo-boat destroyer (or destroyer, for short), and the submarine. The War College was exclusively concerned with maneuvering and concentrating the gun-fire of battleships in the battle-line, and was not yet thinking in terms of fleets containing several classes of vessels. Neither the Bureau nor the Torpedo Station did much more. They seem to have given almost no thought to destroyers. Congress had forced submarines on an unwilling Bureau, and though the Torpedo Station was friendlier, submarine commanders spent their energy on training their crews to operate the ship and not on maneuvering with the fleet.¹⁷² Aside from a series of experiments at the Torpedo Station in 1895 to discover how close torpedo boats could get to battleships before being detected, and the General Board’s order to have torpedo boats participate in fleet maneuvers in 1901, torpedo boats were ignored.¹⁷³ Indeed, they were ignominiously used as picket-boats and mail-ships

¹⁷¹ Bradford [minority] to Long, 12 February 1902, RG80/E180/V6/P218, NARA.

¹⁷² See Nicholas Lambert, “The Influence of the Submarine Upon Naval Strategy, 1898–1914” (Ph.D. Diss., Oxford University, 1992), 70–75; Mason to O’Neil, 1 October 1900, BuOrd 8943/01, B30/168, NTS.

¹⁷³ See the bundle of letters from October 1895 in B15-142, NTS.

during the Spanish-American War.¹⁷⁴

Conclusion

Even though advances in torpedo technology did not immediately make themselves felt in naval architecture and tactics, the future looked bright for American torpedo development by the end of 1902. True, the Navy had not incorporated any of the three major improvements—the Moore gyroscope, the superheater, and the turbine—into torpedoes on a large scale, preferring to build from scratch rather than retro-fit older models, but it seemed to have worked out their defects. Pending large-scale incorporation of these improvements, the concept of torpedo tactics remained in its infancy, but officers at the Bureau and the Torpedo grasped the potential of the subject. The relationship between the Department and the Bliss Company had survived its first squabbles, over the quality of the gyroscopes supplied by the latter, and grown stronger, thanks to Leavitt's design of a turbine engine and superheater. For better or worse, the Navy was now more dependent on the Bliss Company than ever before. An officer at the Bureau of Ordnance proudly declared, "A torpedo containing the Curtis turbine, the Leavitt superheater, and the new adjustable gyroscopic steering gear would be essentially an American torpedo and could not properly be called a Whitehead."¹⁷⁵ As the next decade would reveal, however, an essentially American torpedo was not necessarily a good torpedo.

¹⁷⁴ B. H. McCalla, "Lessons of the Late War," lecture delivered 1 June 1899 at the Naval War College, pp. 21–24, RG15/B1, NHC.

¹⁷⁵ Davison to O'Neil, 26 April 1902, BuOrd 3677/02 with 9558/01, RG74/E25/B480, NARA [copy in B31-161, NTS].

Chapter 2: British Torpedo Development, 1895–1902

“There would be naturally some reluctance on our part to be forced to some changes after what we have accomplished, but it is clear that we must hurry now so as not to allow foreigners too much start.”
– George Goschen (First Lord of the Admiralty), 1897¹

Introduction

By the mid-1890s, the Royal Navy had been building torpedoes for more than two decades. During that time, it fielded torpedoes designed by both a government agency and a private company—the Royal Gunpowder Factory (RGF), run by the War Office, and the Whitehead Company, respectively. In 1894, however, the Royal Navy decided to eliminate the Whitehead Company from the design market and retain its services for supply only. Because this decision unified torpedo patterns, it was known as the pattern-unification policy. Naturally, it alienated the Whitehead Company, while the loss of competition in design work led to lower-quality RGF torpedoes. The Whitehead Company did not suffer in silence. It exploited its control of a major advance in torpedo technology—the gyroscope, which greatly improved torpedo accuracy—as leverage to re-enter the torpedo design market. The Admiralty could not afford to ignore this invention, which had serious implications for both battle tactics and Britain’s naval hegemony. After internal disagreements were resolved, the Admiralty embraced the

¹ Minute by Goschen, 17 January 1897, Adm G7032/96, ADM 116/519, TNA.

gyroscope (breaking Treasury regulations in the process) and overturned the pattern-unification policy. By 1902, the Admiralty also improved other parts of the torpedo, especially the engine, thanks to its superior research-and-development resources. With a well-developed reciprocating engine in hand, the Royal Navy felt no need to adopt a turbine engine, and it rejected the American Bliss Company's superheater, which it had good reason to doubt had been tested adequately.

The Pattern-Unification Policy

The Royal Navy had adopted the Whitehead torpedo in 1870. The main works of the Whitehead Company were in Fiume, but in 1890, with Admiralty encouragement, the Company established a second factory in Weymouth, on the south coast of England.² Another source of supply was the RGF, part of the Woolwich Arsenal complex run by the War Office. By the mid-1890s, the Royal Navy had two models each for three different classes of torpedoes under manufacture: RGF and Whitehead models of a long 18-inch torpedo; RGF and Whitehead models of a short 18-inch torpedo; and RGF (Mark IX) and Whitehead models of a 14-inch torpedo.³ Of these, the first five were being produced in quantity, while the last—the 14-inch Whitehead model—was in an early stage of development. Problems with the 14-inch Whitehead model touched off a crisis which bedeviled the Admiralty's torpedo policy for years to come.

As of September 1894, the Fiume Whitehead Company was under contract to

² For a concise overview of the establishment of the Weymouth works, see "Précis of patterns relative to the trials of New Torpedoes Manufactured by Whitehead and Co.," attachment to minute by May [ADT], 28 September 1894, Adm G5476/94, ADM 116/412, TNA.

³ I use the term "Whitehead" here to indicate that these torpedoes were produced by the Whitehead Company. In terms of design rather than production, the RGF torpedoes were essentially Whiteheads as well.

deliver two 14-inch torpedoes of its own design for trial, with the prospect of a larger order.⁴ That month, it sent one of the two torpedoes to England for assessment, in which the torpedo performed very poorly.⁵ The Assistant Director of Torpedoes, William H. May—the holder of the torpedo portfolio at the Admiralty—took the torpedo’s poor performance as an opportunity to offer sweeping recommendations about Britain’s future torpedo production policy.⁶ He urged that the Navy stop manufacturing different models for each class of torpedo, and instead manufacture only one model per class. Since the 14-inch Fiume models submitted for trial had proven unsatisfactory, May suggested that the Navy adopt the RGF Mark IX model for the 14-inch class, stop encouraging the Fiume Whitehead Company to produce its own design, and instead ask the Company to bid on building torpedoes to the 14-inch RGF Mark IX design. Admiralty officials accepted May’s recommendation about the 14-inch class, and asked the Torpedo Design Committee, consisting of experts from *Vernon*, the British torpedo school, and the RGF, to report on which 18-inch pattern it preferred.⁷

In reply, the majority of the Committee went beyond their immediate terms of reference to oppose the pattern-unification policy. The Committee was chaired by B. W. Walker—later to play a important role at the Admiralty—who was the captain of *Vernon*. While expressing a preliminary preference for the RGF pattern on the grounds that it was simpler and stronger, the Committee worried about the RGF pattern’s greater sensitivity

⁴ The location of the Company is identified here as Fiume to distinguish it from the branch in Weymouth, on the south coast of England. Unless the Company is identified as the Fiume branch, the Weymouth branch is meant.

⁵ Torpedo Design Committee [Walker, Jackson, Ingles, Haddy] to Salmon [CINC Portsmouth], 6 September 1894, enclosure to Salmon to SecAdm, 14 September 1894, Adm G5476/1894, ADM 116/412, TNA.

⁶ May [ADT] minute, 28 September 1894, Adm G5476/94, ADM 116/412, TNA.

⁷ See minutes by DNO, Controller, and First Naval Lord on Adm G5476/94, ADM 116/412, TNA.

to deflection and erratic depth-keeping. Accordingly, the Committee thought it “most desirable that the matter be postponed till we shall have had the experience of Mr. Whitehead’s manufacture of the 14-inch [RGF] Mark IX. torpedo,” reminding the Admiralty of “the enormous advantages to the Service gained in development of torpedo design, through association and competition with Mr. Whitehead in the past.”⁸ By ending competition, the pattern-unification policy might stifle advances in torpedo design.

May, the policy’s champion, brushed off the Committee’s concerns, however, and instead recommended the immediate adoption of the 18-inch RGF pattern. He pointed out the “great advantage” of having the 18-inch and 14-inch RGF patterns that were “similar in all details of mechanism.”⁹ Perhaps to remove a potential source of opposition to his recommendation, he further recommended that the Torpedo Design Committee be dissolved. His recommendations were approved, and the unification of patterns was complete. The Admiralty had already asked the Whitehead Company to tender to build 14-inch RGF Mark IX torpedoes; now it inquired whether the Company would be willing to build 18-inch RGF torpedoes as well.¹⁰

This change in the relationship between the Admiralty and the Company did not go smoothly. There ensued a prolonged back-and-forth over the nature of Admiralty assistance to the Company—whether, and when, it would supply drawings, a sample torpedo, and jigs and gauges—followed by a delay in the Admiralty actually getting the

⁸ Walker to Salmon [CINC Portsmouth], 1 January 1895, Adm G46/95, ADM 116/403, TNA [copy in PQ/95/2183/37-38].

⁹ Minute by May, 8 January 1895, Adm G46/95, ADM 116/403, TNA [copy in PQ/95/2183/39—but note that the author of this minute is misidentified as the DNO, Kane.]

¹⁰ SecAdm to Whitehead Co. (Weymouth), 19 October 1894, Adm G5478/7434/94, ADM 116/412, TNA [copy in PQ/94/2124/274]; SecAdm to Whitehead Co. (Weymouth), 30 January 1895, Adm G46/805/95, ADM 116/403, TNA [copy in PQ/95/2183/41].

promised assistance to the Company.¹¹ As it dragged on, both parties to the negotiations cut corners in their haste to build the torpedoes. Pressured by the Admiralty, the Whitehead Company reluctantly agreed to tender for 150 x 14-inch and 60 x 18-inch torpedoes despite misgivings over the vague inspection guidelines, and without having seen a sample torpedo, complete working drawings, or the specification that it would be required to build to.¹² The Admiralty, meanwhile, agreed to place a provisional order before the specification was complete in order to allow the Company to begin operations immediately.¹³ These short-cuts planted the seeds of future disputes.

No sooner had the Admiralty placed the preliminary orders with the Whitehead Company than problems with the patterns began cropping up. Early in February 1895, the Director General of Ordnance Factories reported that the 18-inch torpedoes showed negative buoyancy, meaning that they would sink at the ends of their runs.¹⁴ Walker, still the captain of *Vernon*, was furious, arguing that the RGF designers had miscalculated the relevant weights.¹⁵ Inquiries by the Director of Naval Ordnance, Henry Kane, to the Director General revealed not only that the buoyancy was a problem, but also that the

¹¹ SecAdm to Whitehead Co. (Weymouth), 21 November 1894, Adm G6413/8380/94; Whitehead Co. (Weymouth) to SecAdm, 27 November 1894, Adm G7009/94; Whitehead Co. (Weymouth) to SecAdm, 8 December 1894, Adm G7245/94; DNO to Whitehead Co. (Weymouth), 28 December 1894; Whitehead Co. (Weymouth) to SecAdm, 20 December 1894, Adm G7581/94; Whitehead Co. (Weymouth) to SecAdm, 28 February 1895, Adm G1157/95; Whitehead Co. (Weymouth) to SecAdm, ~6 March 1895, Adm G1312/95, ADM 116/412, TNA.

¹² Whitehead Co. (Weymouth) to SecAdm, 2 July 1895, Adm G3583/95; Whitehead Co. (Weymouth) to SecAdm, 29 October 1894, Adm G6413/94, ADM 116/412, TNA. For its unhappiness, see Whitehead Co. (Weymouth) to SecAdm, 9 January 1895, Adm G226/95, ADM 116/412, TNA.

¹³ For the preliminary order of 14-inch torpedoes, see minutes on Whitehead Co. (Weymouth) to SecAdm, 9 January 1895, Adm G226/95, ADM 116/412, TNA. For the preliminary order of 18-inch torpedoes, see minutes on Whitehead Co. (Weymouth) to SecAdm, 5 February 1895, Adm G737/95, ADM 116/412, TNA.

¹⁴ DGOF [Anderson] to DNO [Kane], 9 February 1895, NO3407/95, ADM 116/403, TNA [copy in PQ/95/2217/97].

¹⁵ Walker to DNO [Kane], 21 February 1895, NO3407/95, ADM 116/403, TNA [copy in PQ/95/2217/97].

meta-centric height was low.¹⁶ Even before he received this information, Walker took it upon himself to write a scorching letter to the Admiralty.¹⁷ He observed that the unsatisfactory buoyancy and meta-centric height arose despite “every care being taken” to reduce the weight, and despite the reduction of manufacturing limits to the minimum. The latter did not reflect well on the suitability of the pattern for a universal type, and it boded especially ill for the pattern’s prospects with private trade, which did not share the RGF’s capacity for “extreme accuracy” of manufacture and therefore could not fairly be expected to build to the same minimal margins for error. More bad news soon arrived from Walker: the 14-inch torpedoes had the same problems as the 18-inch ones—likely due to the same “similarity in all details of mechanism” that May had touted as an advantage.¹⁸

Armed with the information from Walker, May’s successor as Assistant Director of Torpedoes—M. A. Bourke—launched a flank attack on his predecessor’s pattern-unification policy. Initial tanking tests with the 14-inch RGF Mark IX torpedo went so poorly that “great errors” must have been made in the design or manufacture of the pattern.¹⁹ The Controller, John (“Jackie”) Fisher, piled on. Fisher, who had long been fighting the War Office over the control of naval ordnance and was doubtless delighted to be able to criticize it, demanded “some further action ... to avoid so serious a blunder in

¹⁶ Bourke [for DNO] to DGOF, 23 February 1895, NO3407/95, ADM 116/403, TNA [copy in PQ/95/2217/98]; DGOF to DNO, 4 March 1895, NO3407/95, ADM 116/403, TNA [copy in PQ/95/2217/98]. In torpedoes as in ships, low meta-centric height meant that the object was more liable to roll.

¹⁷ Walker to CINC Portsmouth [Salmon], 7 March 1895, Adm G1497/95, ADM 116/403, TNA [copy in PQ/95/2249/150].

¹⁸ Walker to CINC Portsmouth [Salmon], 29 March 1895, enclosure to minute by ADT [Bourke], 3 May 1895, Adm G1497/95, ADM 116/403, TNA.

¹⁹ Minute by ADT [Bourke], 3 May 1895, Adm G1497/95, ADM 116/403, TNA.

the future.”²⁰ The Senior Naval Lord, Sir Frederick Richards, ominously asked who had designed and built the torpedoes.²¹ Upon being told, he responded, “This is a very serious matter and cannot be allowed to rest. It requires full investigation and report as to where the fault lies.”²²

Bourke, the Assistant Director of Torpedoes, was ordered to carry out the investigation. Given his job title, Bourke was an understandable choice—but he was not an independent one. Based at the center, his perspective inclined him to blame the periphery. This he promptly proceeded to do. The first time that “anything was known”—an artful use of the passive voice—at the Admiralty of possible problems was when the RGF deigned to inform it.²³ Bourke’s audience unanimously agreed that mistakes had been made, that a conference with the War Office was in order, and that appointing an Admiralty inspector at the RGF was a capital idea. The outgoing First Lord, Spencer, captured the mood perfectly. “It seems essential to show where the responsibility for the mistake rests, and to take effectual steps to prevent the recurrence of such a bad blunder,” he wrote. Pausing only to start a new, more cheerful paragraph, he continued, “Under present circumstances we must leave the conclusion of the inquiry in the hands of our successors.”²⁴

While the Whitehead Company worked on the flawed RGF patterns, it received another blow. In 1890, the Admiralty had decided to use the Whitehead Company as its sole private torpedo supplier, cutting a Leeds-based company called Greenwood & Batley

²⁰ Minute by Controller [Fisher], 3 May 1895, Adm G1497/95, ADM 116/403, TNA.

²¹ Minute by Richards, 6 May 1895, Adm G1497/95, ADM 116/403, TNA.

²² Second minute by Richards, 6 May 1895, Adm G1497/95, ADM 116/403, TNA.

²³ Minute by Bourke, 15 June 1895, Adm G3258/95, ADM 116/403, TNA [PQ/96/2360/120-124].

²⁴ Minute by Spencer, 29 June 1895, Adm G3258/95, ADM 116/403, TNA [copy in PQ/96/2360/120-124].

out of the supply market—much as it would later cut the Whitehead Company out of the design market. In January 1896, however, the Admiralty began to worry that one private supplier was not sufficient.²⁵ “[I]t appears most desirable,” the Director of Naval Ordnance wrote, “that there should be a second [private] firm in competition with Whitehead.”²⁶ After the Whitehead Company’s reply to an Admiralty inquiry failed to quell doubts about its production capability, the Admiralty invited Greenwood & Batley to re-enter the market, ending the Whitehead Company’s monopoly on private supply.²⁷

Nevertheless, the Whitehead Company still retained an important role in the supply base, and with it some leverage over the Admiralty. When asked to tender for 220 torpedoes, the Company showed signs of its mounting frustration.²⁸ It insisted that it would have to raise the price per torpedo by £30, on the grounds that last year’s prices had been artificially low because the Company had not seen the specifications when it made its tender—one of the short-cuts that the Admiralty had pressured it to take—and therefore did not appreciate the accuracy of the work required. It shifted the blame for delays onto the Admiralty’s failure to provide drawings and specifications in a timely manner. And it complained of having to incorporate “glaring errors in design” in the RGF-pattern torpedoes. This last charge was a shot across the bow: going beyond the confines of the existing contract, the Company was officially notifying the Admiralty of its dissatisfaction with the pattern-unification policy.

²⁵ See sinute by Walker, 29 January 1896, Kane, 31 January 1896, and FinSec, 6 February 1896, Adm G543/96, ADM 116/519, TNA.

²⁶ Minute by Kane, 31 January 1896, Adm G543/96, ADM 116/519, TNA.

²⁷ See Walker [ADT] to Whitehead Co. (Weymouth), 10 February 1896, Adm G934/96; Whitehead Co. (Weymouth) to Walker, 12 February 1896, Adm G934/96; Minute by Walker, 17 February 1896, Adm G543/96, PQ/96/2406/231–32.

²⁸ See SecAdm to Whitehead Co. (Weymouth), 4 June 1896, Adm G2704/3452/96; Whitehead Co. (Weymouth) to SecAdm, 15 June 1896, Adm G3552/96, ADM 116/519, TNA.

Admiralty officials responded forcefully. Walker, the Assistant Director of Torpedoes, who two years earlier had opposed the pattern-unification policy and sharply criticized the RGF designs, now called the policy “a great economy and public utility,” and professed ignorance as to what “glaring errors in design” the Company might have in mind, as the RGF reported no problems with the torpedoes.²⁹ The RGF was hardly a disinterested source for information on its own torpedoes, however, and a “glaring error in design” was already apparent: the weakness of the 14-inch RGF Mark IX afterbody, which would lead to the development of a new design a year later.³⁰ Advised by the Director of Naval Ordnance that the “glaring errors” were “comparative trifles,” George Goschen, the First Lord, ascribed the Company’s complaints to sour grapes.³¹ For the time being, the Admiralty’s reply to the Company smoothed over the dispute, and it accepted Whitehead’s tender.³² This truce would not last.

As the Gyroscope Turns

Weeks after accepting the Whitehead Company’s tender for 220 torpedoes, the Admiralty received its first official report, courtesy of its naval attaché in Vienna, of an invention that would roil its dealings with the Company: the Obry gyroscope.³³ The Whitehead Company’s control of this device gave it new leverage in its relationship with the Admiralty and helped it to over-turn the pattern-unification policy. For the Admiralty, the device was a mixed blessing: it promised to solve difficult tactical problems, but it

²⁹ Minute by Walker, 30 June 1896, Adm G3552/96, ADM 116/519, TNA.

³⁰ See ART96/19, ART97/23.

³¹ Minute by Goschen, 10 July 1896, Adm G3552/96, ADM 116/519, TNA.

³² SecAdm to Whitehead Co. (Weymouth), 18 July 1896, Adm G3552/4360/96, ADM 116/519, TNA.

³³ Lewis Wintz [Naval Attaché] to Sir E. J. Monson [Ambassador], 23 July 1896, Adm G5560/96, ADM 116/519, TNA. The Foreign Office forwarded the report to the Admiralty on 28 July.

also weakened the Admiralty's negotiating position with the Whitehead Company and threatened its naval hegemony. Negotiations over the gyroscope also produced an interesting debate about technological secrecy.

Several weeks after the Vienna attaché's report, the Whitehead Company's official announcement of its acquisition of the gyroscope rights and of the gyroscope's capabilities arrived at the Admiralty.³⁴ The circular described three possible agreements for the gyroscope: purchase of the right to manufacture for a lump sum; purchase of the right to manufacture with a royalty payment of £25 on each gyroscope; or purchase of the gyroscopes directed from the Company for £50 each. In forwarding the announcement, the Weymouth branch of the Company mentioned that it expected to have a gyroscopic torpedo in England within a month, and that it would be happy to try it before Navy representatives.³⁵ Walker, the Assistant Director of Torpedoes, pounced on the opportunity, in view of the "great importance" of the invention, and the Admiralty decided to ask the Company to ask for specifics as to the date when the sample gyroscopic torpedo would be tried, along with the financial terms that the Company would demand for its use.³⁶ The Company replied that, in lieu of royalties, it would demand a lump sum of £20,000 for the right to manufacture and use the gyroscope, and for the right to any future improvements it made to the gyroscope.³⁷ Admiralty officials agreed that the price seemed excessive, and that they needed to see trials before it could

³⁴ Undated circular letter, Adm G5127/96, ADM 116/519, TNA.

³⁵ Whitehead Co. (Weymouth) to SecAdm, 7 September 1896, Adm G5127/96, ADM 116/519, TNA.

³⁶ Minute by Walker, 7 September 1896, Adm G5127/96; SecAdm to Whitehead Co. (Weymouth), 8 October 1896, Adm G5127/96, ADM 116/519, TNA.

³⁷ Whitehead Co. (Weymouth) to SecAdm, 24 October 1896, Adm G5995/96, ADM 116/519, TNA.

be considered.³⁸

On the same day, 7 September, that the Weymouth branch wrote to inform the Admiralty about the gyroscope, it sent a long letter describing its frustrations with the 14-inch RGF Mark IX torpedo.³⁹ It singled out the reducing valve for special criticism, complaining that it allowed air pressure in the engine room to rise dangerously high and failed to prevent the engine from hanging on dead points. Extending an olive branch in a mailed fist, the Company asked the Admiralty to send experts to determine whether it was doing something wrong with the torpedoes, while warning the Admiralty that it could not meet the specification unless it was permitted to change several valves. In a minute on the Company's letter, Walker, the Assistant Director of Torpedoes, down-played the Company's critique of the reducer.⁴⁰ Citing "experiments conducted at Woolwich," he conceded that the reducer allowed engine pressures to rise to dangerous levels when the engine hung on a dead point, but said that a Company representative told him that dead points were easy to avoid. In fact, the "experiments at Woolwich" had originated in response to the explosion of several engines in RGF torpedoes in June 1896. In response, competitive tests were held between Whitehead and RGF reducers, which vindicated the Whitehead design.⁴¹ Walker was not telling the whole truth.

The coincidence of the Company's frustrations with the 14-inch RGF Mark IX torpedo and its announcement of the gyroscope meant that there were simultaneously two very different dynamics in the Admiralty's relationship with the Company in the closing months of 1896. In the battle over the Mark IX torpedo, the Admiralty held the upper

³⁸ Minutes on Adm G5995/96, ADM 116/519, TNA.

³⁹ Whitehead Co. (Weymouth) to SecAdm, 7 September 1896, Adm G5246/96, PQ/96/2424/278-80.

⁴⁰ Minute by Walker, 1 October 1896, Adm G5246/96, PQ/96/2424/280.

⁴¹ The following account is drawn from ART96/21-27.

hand, thanks to its possession of a contract signed by the Company. When it came to the gyroscope, however, the Company held the upper hand, thanks to its possession of the rights.

The Admiralty had two powerful reasons to want the gyroscope. One was its desire to keep abreast of foreign technological developments, which is discussed below. The other was a recent crisis in discharging torpedoes from above-water stern tubes. In August 1895, a cruiser on the China Station reported that one of her torpedoes had been damaged in practice from an above-water stern tube due to the tube becoming partially submerged when the ship was moving at high speed.⁴² In June 1896, to investigate the problem, the Admiralty ordered the Mediterranean Fleet and Channel Squadron to report on practice from stern tubes and on the tactical value of the tubes.⁴³ Their reports generally agreed that the stern tube was tactically valuable but that accurate shots could not be made from it when the ship was under helm, i.e., turning.⁴⁴ The captain of *Vernon* (Durnford), the Assistant Director of Torpedoes (Walker), and the Director of Naval Ordnance (Kane) immediately perceived the gyroscope's potential to solve the latter problem: the gyroscope would hold the torpedo steady on its initial line of fire, regardless of the motion imparted to the torpedo by the ship's turn.⁴⁵

Thus the stern-tube problem was on the Admiralty's mind when its second official report on the gyroscope arrived. This report, by the commanding officer of H.M.S.

⁴² ART96/36–37.

⁴³ SecAdm to Med and Channel, 16 July 1896, Adm G3695/95; minute by Fisher, 24 June 1896, Adm G3695/4425/96, both in PQ/97/2487/71–72 [copies in ART96/Appendix K].

⁴⁴ On the former, see Durnford to CINC Portsmouth, 27 October 1896; on the latter, see Durnford to CINC Portsmouth, 21 November 1896, Adm G5708/96, both in ART96/Appendix K.

⁴⁵ Durnford to CINC Portsmouth, 21 November 1896, ART96/Appendix K; minutes by Walker, 1 December 1896, and Kane, 2 December 1896, Adm G5708/96, PQ/97/2487/72–73 [copy in SC146/F106, BF].

Vulcan, C. G. Robinson, was longer and more substantial than the naval attaché's July account.⁴⁶ (*Vulcan* was the Navy's dedicated torpedo vessel in the Mediterranean.) While allowing that the gyroscope was still "experimental," Robinson praised the "marvelous" results achieved by it, and "strongly" urged the Navy to acquire gyroscopic torpedoes from the Whitehead Company for trial. "The great advantage of the apparatus," he continued, "is that it enables one to fire at the object irrespective of the speed or movement of the ship firing, the speed of the ship fired at, being the only calculation necessary." The officer who forwarded Robinson's report, Charles Drury, observed that the prospect of obtaining accurate practice "from the large numbers of above-water and stern tubes we have in the service which are now unreliable, is a very important matter," adding that "no less than six" foreign nations had ordered gyroscopic torpedoes.⁴⁷

Robinson's report was passed to *Vernon* for comment.⁴⁸ Durnford responded with a mix of enthusiasm about what the gyroscope meant for torpedo technology and worry as to what it meant for British naval supremacy. The device, he wrote, "promises to be the most important discovery that has been made in improving the value of the Whitehead torpedo since its introduction." It would ease certain considerations in naval architecture and correct any horizontal deviation by the torpedo regardless of how it was discharged, "stern tube included." It would greatly increase the effective range of torpedoes firing at anchored fleets—a persistent British fear being night-time French torpedo-boat attacks on the Mediterranean Fleet in harbor—though firing at ships underway would still take place

⁴⁶ Robinson to Senior Officer Poros [Drury], 23 November 1896, enclosure to CINC Med [Hopkins] to SecAdm, 7 December 1896, Adm G7032/96, ADM 116/519, TNA.

⁴⁷ Minute by Drury, 24 November 1896, on Adm G7032/96, ADM 116/519, TNA. Drury did not name the six nations.

⁴⁸ ADT [Walker] to Captain of *Vernon* [Durnford], 14 December 1896, Adm G7032/96, ADM 116/519, TNA.

at closer ranges. Aside from specific tactical uses, he continued, “This new invention will probably benefit weaker nations more than ourselves as by constant practice and superior training we have been able to get more out of the torpedo than others.” Given that the invention had come and that foreign nations were taking it up, however, “I think it is most essential that we should try it at once, and carefully utilise its value, so that we may be able at least to place ourselves in as favorable a position as our neighbours.”⁴⁹

Although Britain stood to lose more from the invention than anyone else, it might be able to turn the gyroscope to its advantage.

Probably the same day that Durnford’s mixed message of fear and cheer landed on the desk of the Assistant Director of Torpedoes, so did a very different letter from the Whitehead Company. The Company refused to bid on a new round of torpedoes, giving vent to more than two years of accumulated frustrations. “[A]s no suggestions of ours are ever taken into consideration,” the Company declared, “we feel we do not possess that amount of confidence and support essential to any firm who has to turn out satisfactory work for the Government.” Again the Whitehead Company criticized the RGF design, pointing to lack of buoyancy, weak engines liable to explosion, and a faulty reducer, among other things. It was “no credit to us to be known as the makers of” RGF torpedoes. To try to remedy the design flaws, the specifications required “such narrow limits and extraordinary exactness ... that the cost and time required for manufacture is enormous.” The Company would not build any more torpedoes to RGF patterns; “we would rather close our works at Weymouth than again accept an order under the conditions of the

⁴⁹ Durnford to ADT, 17 December 1896, Adm G7032/96, ADM 116/519, TNA [copy in ART96/Appendix I].

present one.”⁵⁰

This ultimatum created space for a fresh pair of eyes to re-examine the 1894 pattern-unification policy. Possibly alone among the leading members of Britain’s torpedo establishment, Durnford, the captain of *Vernon*, was not a hold-over from the pattern-unification decision. Stating frankly that the 14-inch RGF Mark IX torpedo had not lived up to expectations, he attacked the pattern-unification policy. “I am very strongly of the opinion that Whitehead & Co. will never make satisfactorily the Woolwich 14” torpedo,” he declared. “It is against their interest and,” even more to the point, “I believe it to be also against ours. I think we should utilise the unique experience of Mr Whitehead, (to whom much of the development is due) by encouraging the Firm to give us a Torpedo of their own design.”⁵¹

Remarkably, considering that Durnford was making exactly the same case that he himself had made in Durnford’s position, Walker, the Assistant Director of Torpedoes, now ranged himself on the opposite side of the argument.⁵² Walker said that the Company “had steadily taken every opportunity to depreciate the Woolwich type, which, although not perfect, is considerably in advance of any torpedo” of either the Company’s or the RGF’s design. The pattern-unification policy had been settled on after “exhaustive” trials which, at the time they were conducted, Walker had criticized as insufficient. He wanted to write the Company off and rely exclusively on the RGF for the 14-inch Mark IX torpedoes. The Director of Naval Ordnance took up Walker’s torch and assured Fisher,

⁵⁰ Whitehead Co. (Weymouth) to SecAdm, 15 December 1896, Adm G7098/96, ADM 116/519, TNA [copy in PQ/97/2516].

⁵¹ Durnford to Walker [for DNO], 2 January 1897, Adm G7098/96, ADM 116/519, TNA [copy in PQ/97/2516].

⁵² Minute by Walker, 8 January 1897, Adm G7098/96, ADM 116/519, TNA.

the Controller, that the RGF had a large enough supply capacity to meet the Navy's demands.⁵³ To this assurance, Fisher tersely responded: "See my minute on G588-97 herewith."⁵⁴

G588-97 was a letter from the Weymouth branch of the Whitehead Company describing the sample gyroscopic torpedo which it had received from the Fiume branch and offered to run for the Admiralty.⁵⁵ Now the Company added a new twist: it was offering the gyroscope and the torpedo as a package deal. Having suffered powerlessly for two years under Admiralty conditions which it considered intolerable, the Company was exploiting the invention of the gyroscope to turn the tables. The gyroscope was the leverage it needed to seek re-entry into the torpedo design market from which the pattern-unification policy had shut it out. The fact that Fisher linked his minutes on the earlier ultimatum over the 14-inch RGF Mark IX torpedo and on this letter was a measure of how well the Company succeeded.

Then again, given Fisher's distrust of the War Office, he probably did not need any encouragement from the Whitehead Company to doubt the RGF pattern. He welcomed competitive trials between it and the new Whitehead pattern, dryly observing that "it will be most satisfactory to ascertain definitively that the Woolwich pattern is so superior as stated to the Whitehead pattern." Fisher also dismissed concerns that helping the Company to carry out trials of the sample gyroscopic torpedoes would leak sensitive information about Britain's own naval technology: "There is no real secrecy on these matters wherever the trials are made." "Obviously Mr. Whitehead deserves altogether

⁵³ Minutes by Fisher, 12 January, and Kane, 23 January 1897, Adm G7098/96, ADM 116/519, TNA.

⁵⁴ Minute by Fisher, 6 February 1897, Adm G7098/96, ADM 116/519, TNA.

⁵⁵ Whitehead Co. (Weymouth) to SecAdm, 30 January 1897, Adm G588/97, ADM 116/519, TNA.

special treatment,” Fisher concluded. “[H]e is not merely the inventor of the torpedo that bears his name, but has kept the lead in improvements up to the present moment.”⁵⁶

Others, especially the Senior Naval Lord (a position that would be re-named First Sea Lord in 1904), Richards, were less kindly disposed towards the inventor. “[I]t is not too much to say,” wrote Richards of Whitehead,

that no man ever did his Country a worse service. The millions which his invention has taxed his Country with up to the present would have built a large fleet.... But granted that he has made himself an indispensable nuisance, what the Admiralty has to guard against, is the position of being a useful tool in his hands, for purposes of advertisement to Foreign Powers.⁵⁷

Accordingly, Richards did not want to loan any of Britain’s most recent, fastest destroyers to the Company to conduct the trials. In view of foreign movement on the gyroscope, however, he was unwilling to ignore the invention entirely, and he recommended that the Admiralty purchase one or two gyroscopic torpedoes so that it could conduct its own trials. Even so, Richards concluded gloomily that purchasing the gyroscope “will unfortunately leave the Admiralty no nearer finality than is the beginning—there is always something in reserve.”

The First Lord, Goschen, shared Richards’ concerns. “We as the stronger nation, and who have [spent?] so much to perfect existing systems, are clearly sufferers from such a new invention,” Goschen wrote. “There would be naturally some reluctance on our part to be forced to some changes after what we have accomplished, but it is clear that we must hurry now so as not to allow foreigners too much start, if the invention as

⁵⁶ Minute by Fisher, 6 February 1897, Adm G588/97, ADM 116/519, TNA.

⁵⁷ Minutes by Richards, 10 and 11 February 1897, Adm G588/97, ADM 116/519, TNA.

appears probable, turns out to be an excellent one in trial.”⁵⁸ The fact that senior Admiralty officials weighed in on the international ramifications of a piece of torpedo technology reflects the remarkably consultative nature of Admiralty decision-making.

The minutes by these officials also illuminate the Admiralty’s attitude towards protecting the secrecy of sensitive technology. Fisher’s statement that “there is no real secrecy on these matters” is striking for its apparent unconcern about security, but the Navy had two safeguards in case secrecy was breached. One, already alluded to, was the “extreme accuracy” of RGF manufacture, which other suppliers could not match. Thus, even if other nations copied the RGF design, their torpedoes would be mechanically inferior. Second, given that all the accuracy in the world could not make up for a poor design, the more fundamental safeguard was the “constant practice and superior training” which allowed the British “to get more out of the torpedo than others.”⁵⁹ This practice and training, in turn, required resources that only Britain possessed, as Richards and Goschen recognized. These resources included both financial power and the best torpedo infrastructure (research and development, production, testing) that money could buy. Richards and Goschen realized, however, that any change in torpedo technology threatened to waste the resources sunk into the infrastructure. Foreign interest in the gyroscope reduced the likelihood that Britain could avoid spending money on it and that money spent would prove unnecessary. Admiralty officials focused on foreign development because it affected their assessment of the risks associated with investing in new technology.

⁵⁸ Minute by Goschen, 17 January 1897, Adm G7032/96, ADM 116/519, TNA. Goschen’s handwriting was extremely poor. I am confident, but not certain, that the word in brackets was “spent.”

⁵⁹ Durnford to ADT, 17 December 1896, Adm G7032/96, ADM 116/519, TNA [copy in ART96/Appendix I].

While Admiralty officials agreed in principle to investigate the gyroscope in early 1897, they were far from nailing down all the details. Walker, the Assistant Director of Torpedoes, minuted that the gyroscope seemed valuable enough to warrant a £25 royalty on each, and that any royalties paid per torpedo would go towards redeeming the £20,000 lump sum for the right to manufacture any number of gyroscopes, which had been quoted by the Company in October 1896, if the Admiralty decided to take up the large-scale manufacture of gyroscopes in the future.⁶⁰ Richards, the Senior Naval Lord, said that payment of the lump sum was out of the question without trials.⁶¹ Negotiations over the shape of the trials were complicated and took up a month. The Company wanted to draw the Admiralty into its trials as much as possible. The Admiralty wanted to limit its participation, fearing that the Company was using it to advertise the Company's wares to foreign powers. Instead, the Admiralty wanted to buy sample gyroscopic torpedoes for trials of its own.⁶²

After a month of discussion, the two parties agreed to limited trials of the gyroscope under the Company's direction in March 1897.⁶³ Durnford, the captain of *Vernon*, thought well enough of the gyroscope to recommend urgently that Britain explore the device further, but he felt that the tests were not sufficient to prove that the gyroscope could withstand the demanding conditions of service use, and therefore he was

⁶⁰ Minute by Walker, 2 February 1897, Adm G588/97, ADM 116/519, TNA [copy in PQ/97/2516/150].

⁶¹ Minute by Richards, 11 February 1897, Adm G588/97, ADM 116/519, TNA.

⁶² Whitehead Co. (Weymouth) to SecAdm, 24 February 1897, Adm G1061/97; minutes on Adm G588/97, ADM 116/519, TNA.

⁶³ Whitehead Co. (Weymouth) to SecAdm, 24 February 1897, Adm G1061/97, and minutes thereon; SecAdm to Whitehead Co. (Weymouth), 11 March 1897, Adm G1061/1700/97; Whitehead Co. (Weymouth) to SecAdm, 12 March 1897, Adm G1419/97, and minutes thereon; SecAdm to Whitehead Co. (Weymouth), 19 March 1897, Adm G1419/1865/97; Whitehead Co. (Weymouth) to SecAdm, 20 March 1897, Adm G1788/97 and minutes thereon, all ADM 116/519, TNA.

not prepared to recommend its general adoption.⁶⁴ Although Walker, upon receiving Durnford's report, took a notably more skeptical tone, he agreed that further trials were desirable, and his recommendations were approved.⁶⁵ The Admiralty ordered four gyroscopes from the Company at £50 each—£25 for the gyroscope plus £25 for the royalty—to be fitted to four RGF-pattern torpedoes, two 14-inch and two 18-inch.⁶⁶ The Company agreed, though it added £25 per gyroscope for fitting it to the torpedo, bringing the total cost of the order to £300 (4 x £75).⁶⁷

Walker Unmasked and the Pattern-Unification Policy Overturned

Vernon did not try the four gyroscopic torpedoes until December 1897. In the interim, the Whitehead Company developed a new 14-inch torpedo in addition to its Obry gyroscope. The Assistant Director of Torpedoes, Walker, did his best to undermine the Whitehead Company at the Admiralty, going so far as to mislead his superior officers. The discovery of Walker's deceit in early 1898 cleared the way for the adoption of the Obry gyroscope and the reversal of the pattern-unification policy.

Walker attempted to delay the adoption of the Obry gyroscope, despite his colleagues' growing interest in it. In October 1897, the Admiralty ordered four gyroscopic torpedoes from the Fiume branch of the Whitehead Company for a vessel in the Mediterranean Fleet, on the same terms that the Weymouth branch had recently been ordered to fit four torpedoes with gyroscopes. The vessel reported favorably on the

⁶⁴ Durnford to CINC Portsmouth [Salmon], 26 March 1897, Adm G1866/97, ADM 116/519, TNA [copy in ART 1897/98–99].

⁶⁵ Minutes on Adm G1866/97, ADM 116/519, TNA.

⁶⁶ SecAdm to Whitehead Co. (Weymouth), 1 May 1897, Adm G1788/2670/97, ADM 116/519, TNA.

⁶⁷ Whitehead Co. (Weymouth) to SecAdm, 22 May 1897, Adm G2954/97 and minutes thereon; SecAdm to Whitehead Co. (Weymouth), 29 June 1897, Adm G2954/2854/97, ADM 116/519, TNA.

gyroscopic torpedoes in November.⁶⁸ Probably just a few days before the report arrived at the Admiralty, however, Walker disparaged the utility of the Whitehead gyroscope—citing “thoroughly reliable” sources who had told him that the Italians were planning to give up on the gyroscope. He exploited the RGF’s development of a rival gyroscope to argue that decision on the Obry gyroscope should be postponed until the RGF model had been tried. His recommendation was approved.⁶⁹ Accordingly, *Vernon’s* highly favorable report of December 1897 on the Whitehead gyroscope, which recommended the immediate purchase of 18 gyroscopes for limited issue to seagoing vessels, produced no action at the Admiralty.⁷⁰

While competition between the Whitehead and RGF gyroscopes brewed, so too did competition between their new 14-inch torpedo patterns. In mid-1897, seeking greater simplicity, strength, buoyancy, and speed, the Admiralty authorized the RGF to develop a new 14-inch design (which would evolve into the Mark X).⁷¹ Meanwhile, the 14-inch Whitehead design rejected by the Admiralty in 1894 had evolved to include a gyroscope and a much stronger engine, capable of withstanding 2,020 psi (by contrast, the Mark IX

⁶⁸ Bourke [for DNO], 28 September 1897, Adm G5143/97, and minutes thereon; SecAdm to Whitehead Co. (Fiume), 4 October 1897, Adm G5143/5803/97; SecAdm to Whitehead Co. (Fiume), 22 October 1897, Adm G5424/97; Robinson to CINC Med, 20 November 1897, Adm G6333/97 and minutes thereon, ADM 116/519, TNA.

⁶⁹ The RGF design had actually been developed two or three years earlier, but officials took interest in it only after the development of the Whitehead gyroscope; see ART97/30. See also PQ/98/2627 and minute by Walker, 5 May 1898, Adm G2023/98, ADM 116/519, TNA. On the approval of his recommendation, see minutes on Adm G5953/97, ADM 116/519, TNA. The decision was affirmed on Adm G6333/97, *ibid.* See also Durnford to DNO [Jeffrey], 10 December 1897; DNO to Durnford, 11 January 1898, both Adm G6333/97, ADM 116/519, TNA.

⁷⁰ Durnford to CINC Portsmouth, 28 December 1897, Adm G58/98, ADM 116/519, TNA [copy in ART97/100–102].

⁷¹ Minute by Walker, 15 July 1897, Adm G3818/97, ADM 116/519, TNA [copy in PQ/97/2550/217–18].

engine could withstand only 1,000 psi).⁷² The latter strongly appealed to Durnford, the captain of *Vernon*, who was dissatisfied with the engines in the RGF Mark IX torpedo. He visited Weymouth to see the new Whitehead design and reported very favorably on it, singling out the engine strength, which “alone forms a very important improvement” over the Mark IX engines, and the reducer for special mention.⁷³ On his own initiative, calculating that trials with the experimental RGF Mark X would take some time, he immediately ordered two of the Company’s new torpedoes to *Vernon* for testing.⁷⁴

Durnford’s favorable report piqued the interest of the new Director of Naval Ordnance, Edmund Jeffrey, who asked whether money was available to purchase the sample torpedoes.⁷⁵ Then Jeffrey went on leave. His subordinate, Walker, falsely claiming to be writing “for DNO” to the new Controller, A. K. Wilson, argued that the Whitehead pattern should not be tried unless it showed some “very obvious advantages ... which could not be obtained” by RGF torpedoes.⁷⁶ Of course, the Whitehead pattern *did* have a very obvious advantage—double the engine strength—and the support of both the Director of Naval Ordnance and the Captain of *Vernon*. Nevertheless, Wilson approved Walker’s minute, and the Company was informed that the Admiralty was not interested in adopting its new design.⁷⁷

Three months later, in February 1898, Walker dug himself a deeper hole. Alerting his colleagues that the supply situation for 18-inch torpedoes was unsatisfactory, he

⁷² Whitehead Co. (Weymouth) to SecAdm, 24 February 1897, G1061/97; Whitehead Co. (Weymouth) to SecAdm, 2 September 1897, Adm G4695/97, ADM 116/519, TNA.

⁷³ Durnford to DNO [Jeffrey], 8 September 1897, Adm G4695/97, ADM 116/519, TNA.

⁷⁴ Durnford to DNO [Jeffrey], 6 September 1897, Adm G4708/97, ADM 116/519, TNA.

⁷⁵ Minute by Jeffrey, 9 September 1897, Adm G4695/97, ADM 116/519, TNA.

⁷⁶ Minute by Walker, 12 November 1897, Adm G4965/97, ADM 116/519, TNA.

⁷⁷ Minute by Wilson, 18 November 1897, Adm G4695/97; SecAdm to Whitehead Co. (Weymouth), 27 November 1897, Adm G4695/6914/97, both ADM 116/519, TNA.

blamed the Whitehead Company, complaining that it missed a deadline for completing delivery under a contract.⁷⁸ Whether due to incompetence or deceit, Walker had his dates wrong: the original delivery date had indeed been December 1897, but the Company, with Walker's approval, had secured an extension to March 1898.⁷⁹ Jeffrey, the Director of Naval Ordnance, asked if this was the contract referred to "in G7098-96 and subsequent correspondence."⁸⁰ Jeffrey's question was dangerous: on G7098-96, in January 1897, Walker had implied that the RGF had the supply capacity to meet the Navy's needs without the Whitehead Company—meaning that his announcement in March 1898 of the precarious supply situation undermined his credibility.⁸¹ Walker misunderstood the import of Jeffrey's question, however, and confirmed that Jeffrey had the correct correspondence.⁸² Jeffrey replied that the deficiencies were not satisfactory, and that he was preparing "a submission" on the whole question of the supply of Whitehead torpedoes.⁸³

This "submission" did not bode well for Walker, but he was oblivious, adding another nail to his coffin. In March 1898, John Whitehead, the son of the inventor, informed the Admiralty that he would have to close the Weymouth branch of the Whitehead Company unless the Admiralty ordered more torpedoes from Weymouth, or allowed Weymouth to charge higher prices per torpedo, than it had done.⁸⁴ As one of the

⁷⁸ Minutes by Walker, 8 and 12 February 1898,

⁷⁹ Whitehead Co. (Weymouth) to SecAdm, 1 June 1897, Adm G3052/97; Minute by Walker, 3 June 1897, Adm G3052/97; SecAdm to Whitehead Co. (Weymouth), 23 June 1897, Adm G3052/3727/97, ADM 116/519, TNA.

⁸⁰ Minute by Jeffrey, 12 February 1897, Adm G647/97, ADM 116/519, TNA.

⁸¹ Minute by Walker, 8 January 1897, Adm G7098/96, ADM 116/519, TNA.

⁸² Minute by Walker, 12 February 1897, Adm G647/97, ADM 116/519, TNA.

⁸³ Minute by Jeffrey, 14 February 1897, Adm G647/97, ADM 116/519, TNA.

⁸⁴ Whitehead to SecAdm, 1 March 1898, Adm G1107/98, ADM 116/519, TNA.

main causes of Weymouth's lack of profit, Whitehead cited the high cost of labor and material. To this bombshell, Walker reacted with unconcern. He suggested that Whitehead was being disingenuous by failing to mention that the reason labor and material cost so much was because the Company had located its factory so far from centers of labor and material, and he recommended that only 100 torpedoes be ordered from the Company, rather than the 200 Whitehead said were needed to keep it solvent.⁸⁵ In fact, Walker was himself being disingenuous. The Admiralty—including, unfortunately for Walker, then-Assistant Director of Torpedoes Jeffrey—had supported the factory's location in Weymouth because it offered a perennial salt-water range for running torpedoes and proximity to *Vernon* in Portsmouth.⁸⁶ In effect, Walker was blaming the Whitehead Company for the Admiralty's decision.

In a private submission to the Controller, Jeffrey set himself the task of undoing the damage that Walker's mis-representations, and the pattern-unification policy, had done. In 1894, Jeffrey began, the Admiralty had decided—"contrary to the recommendations of the Torpedo Design Committee, of which the present A.D.T. (Sir B. Walker) was president"—to adopt the pattern-unification policy. This decision had led to "great difficulties, especially as regards the 14" torpedo." The Admiralty had made the decision in the belief that the 14-inch RGF Mark IX torpedo was a "thoroughly satisfactory" weapon, but in fact "Mark IX has never been satisfactory." The question of reversing the decision had been brought up several times, and in March 1897, the

⁸⁵ Minute by Walker, not dated but between 1 March [date of the Company's letter] and 28 March [date of the next minute] 1898, Adm G1107/98, ADM 116/519, TNA.

⁸⁶ "Précis concerning Messrs. Whitehead establishing works in England, and result with regard to orders to them and Greenwood & Batley," enclosure to minute by Jeffrey, 28 March 1898, Adm G1107/98, ADM 116/519, TNA [copy in PQ/99/2736/323-28]. The relevant minute in the "Précis" was G6482/90.

Admiralty had told the Whitehead Company that it would try samples of the Company's latest 14-inch pattern. In early September 1897, the Company had informed the Admiralty that its design was ready for trial, Jeffrey had asked if money was available, "and I went on leave immediately thereafter." On 9 November, the Assistant Director of Torpedoes had minuted "for DNO" recommending that the Company's offer be refused, a recommendation which Wilson had approved. "By the marking it would appear," Jeffrey continued, "that this paper went to you without any formers [i.e., earlier papers], and it is to be regretted that your attention was called to the Board's decision of 1894, but not to that of G.1061/97, which practically canceled the former." Having demolished the credibility of his mutinous subordinate, Jeffrey tipped his own hand: "My own opinion is strongly in accordance with that of [the] Capt. of 'Vernon' and of [the] late Controller [Durnford and Fisher, both opponents of the pattern-unification policy]." He could see no reason why the Admiralty should treat torpedoes any differently from guns, for example, in which the Admiralty preserved "quite a free hand, with the result that we have made great progress.

If we had tied ourselves to the Ordnance Factories, as regards all questions of design, we should undoubtedly now be in a very different position to what we are. When there is no competition, there is every inducement in a government factory to avoid trouble, by adhering to established patterns.

Since the Admiralty had given itself over to the RGF for torpedoes, its supply situation was "not very good, and I consider that competition and probably larger orders to trade, is the only way out of it." As a first step, it would be "very desirable" to try the new 14-inch RGF pattern against Whitehead's new 14-inch pattern.⁸⁷ Wilson approved Jeffrey's

⁸⁷ Jeffrey to Controller [Wilson], 19 March 1898, Adm G1457/98, ADM 116/519, TNA.

recommendations.⁸⁸

To his other colleagues, Jeffrey circulated a sanitized version of his minute to Wilson, leaving out the parts about Walker's misconduct, but including enough information to let them draw their own conclusions.⁸⁹ He submitted that it would be "very desirable" to keep the Weymouth branch open, though he was willing to leave the question of exact orders to it undecided for the present. Richards, the Senior Naval Lord and an experienced administrator, was not: "My experience here is that once a question is started on a paper course, time becomes no object."⁹⁰ The Navy could not afford to let the Weymouth branch close, "and there is no use beating about the bush": better to settle at once on best terms that could be obtained. The First Lord, Goschen, "quite agree[d]" with Richards' argument that the Admiralty needed the branch to stay open, but he wanted to await the outcome of trials with the new 14-inch Whitehead torpedo at *Vernon* before settling the exact terms.⁹¹ In the meantime, however, he wanted to write to the Company "in a tone to prevent their asking a hasty decision, and with full recognition of the importance which the Admiralty attach to their keeping open their works."

At the same time as Jeffrey overcame Walker's obstructionism on the 14-inch Whitehead torpedo, the logjam over the Whitehead gyroscope also broke. In March 1898, Walker had to inform his colleagues that the RGF gyroscope exhibited defects during preliminary trials and would require modifications before a final report could be rendered; in the interim, he endorsed *Vernon's* earlier suggestion to purchase 18 Whitehead

⁸⁸ Minute by Wilson, 19 March 1898, Adm G1457/98, ADM 116/519, TNA.

⁸⁹ Minute by Jeffrey, 28 March 1898, Adm G1107/98, PQ/99/2736/321-22.

⁹⁰ Minute by Richards, 1 April 1898, Adm G1107/98, PQ/99/2736/321-22.

⁹¹ Minute by Goschen, 25 April 1898, Adm G1107/98, PQ/99/2736/321-22.

gyroscopes for further trials. His recommendation was approved.⁹²

The Whitehead Company gained further momentum in July 1898, when its long-delayed 14-inch design was finally tried. According to *Vernon's* effusive report, the Whitehead design (which would become known as the 14-inch Weymouth Mark I) was faster, longer-range, and stronger than the RGF Mark IX, and the Royal Navy should order 100 forthwith.⁹³ Jeffrey, the Director of Naval Ordnance, seized the opportunity to drive the final nail into the coffin of the pattern-unification policy. Circulating his minute to a list from which the Assistant Director of Torpedoes was strikingly absent, Jeffrey declared that the pattern-unification policy “has now received full trial; and the result has been great difficulties and delays, the present deficient supply of torpedoes being in great measure owing to our being confined to one type.” The distortion of the design base had distorted the supply base, resulting in the absence of a reliable 14-inch pattern. Jeffrey “strongly” submitted to reverse the pattern-unification policy and to order some of the new 14-inch Whitehead-designed torpedoes.⁹⁴ His recommendation was approved, and the pattern-unification policy ended.⁹⁵

Further victories were in store for the Whitehead Company. In August 1898, competitive trials between the RGF gyroscope and the Whitehead gyroscope showed the latter to be decidedly superior, and *Vernon* recommended its introduction on a larger

⁹² Minutes on Adm G1474/98, ADM 116/519, TNA.

⁹³ Durnford to CINC Portsmouth [Culme Seymour], 22 July 1898, Adm G4171/98, ADM 116/519, TNA [copy in ART98/20–21]. Durnford sent a preliminary version of this report to Jeffrey, to which Jeffrey referred in his minute of 15 July 1898, Adm G3915/98, PQ/99/2736/329–31; I could not find the preliminary version, but judging from Jeffrey's reference to it, it was substantially the same as Durnford's formal report of 22 July 1898 herein cited.

⁹⁴ Minute by Jeffrey, 15 July 1898, Adm G3915/98, PQ/99/2736/329–31.

⁹⁵ Minutes on Adm G3915/98, July 1898, PQ/99/2736/329–31.

scale.⁹⁶ In October, the first seagoing ship to get gyroscopic torpedoes—the Channel Squadron’s *Majestic*, captained by Prince Louis of Battenberg—delivered a fulsome report. The practice made by the torpedoes was “so highly satisfactory,” Battenberg wrote, “that I consider all torpedoes should be fitted with [gyroscopes] without delay.”⁹⁷ *Vernon* was impressed, stating that the Whitehead gyroscope had “fully maintained” its reputation, shown its superiority to the RGF pattern, and could now confidently be recommended for general adoption.⁹⁸ The new Assistant Director of Torpedoes, Charles Egerton, agreed. Although Egerton believed that the gyroscope could and would be improved, “the policy of waiting until the instrument has arrived at a more perfect stage of its development, would leave us behind other nations and is not recommended.”⁹⁹ The First Lord, Goschen, concurred: “It is often unwise to lose too much time in aiming at perfection.”¹⁰⁰ Accordingly, the Admiralty ordered the Company to fit all 150 torpedoes under contract to take the gyroscope, and it ordered 75 gyroscopes.¹⁰¹ A month later, Jeffrey recommended that the Navy order 300 additional gyroscopes, which was also done.¹⁰²

Although the decisions to order 375 gyroscopes in late 1898 were a quantum leap forward over the last order, which had been 18 gyroscopes for limited issue to seagoing ships in March 1898, it was still comparatively ad hoc. In August 1899, Jeffrey, still the

⁹⁶ Durnford to CINC Portsmouth, 27 August 1898, Adm G4871/98, ADM 116/519, TNA [copy in ART98/47–48].

⁹⁷ Battenberg to Officer Commanding Channel Squadron [Stephenson], 1 October 1898, Adm G5598/98, ADM 116/519, TNA.

⁹⁸ Durnford to DNO, 5 October 1898, Adm G5598/98, ADM 116/519, TNA.

⁹⁹ Minute by Egerton, 11 October 1898, Adm G4871/98, ADM 116/519, TNA.

¹⁰⁰ Minute by Goschen, 21 October 1898, Adm G4871/98, ADM 116/519, TNA.

¹⁰¹ SecAdm to Whitehead Co. (Weymouth), 25 October 1898, Adm G4871/6243/98, ADM 116/519, TNA.

¹⁰² I do not have the original records for this order; it is referred to in “Précis of correspondence in regard to Whitehead Gyroscopes,” enclosure to minute by Jeffrey [DNO], 31 August 1899, Adm G5661/99, ADM 116/579, TNA.

Director of Naval Ordnance, decided that the time had come to put gyroscope policy on sound long-term footing, and he went back to the archives to review the evolution of the policy.¹⁰³ He discovered a financial and legal mess, at the heart of which was a question of royalties which the Admiralty had never fully answered.

When the Admiralty first began to consider purchasing gyroscopes from the Whitehead Company, in early 1897, it had received several price quotes from the Company. It had the Company's initial offer from September-October 1896 for £50 per gyroscope if supplied by the Company, £25 royalty per gyroscope if manufactured by the government or its agents, or £20,000 as a lump sum for the right to manufacture any number of gyroscopes.¹⁰⁴ In February 1897, the Company added that it would charge £25 per fitting of the gyroscope to a torpedo.¹⁰⁵ The same month, Walker, then the Assistant Director of Torpedoes, suggested that payment of royalties per gyroscope would go towards the redemption of the lump sum if the Admiralty ever decided to purchase the right to make as many gyroscopes as it wanted; this suggestion made its way into the Admiralty's deliberations without scrutiny.¹⁰⁶

In March 1897, upon receiving a report on the preliminary trials conducted at Weymouth under the direction of the Company with its sample gyroscopic torpedo from Fiume, the Admiralty debated whether to order four gyroscopes to be fitted to torpedoes for *Vernon* to test further (see pages 98–99 above). The Accountant General pointed out that, because the £25 royalty appeared to be 100% of the £25 cost of manufacture,

¹⁰³ Minute by Jeffrey [DNO], 31 August 1899, Adm G5661/99, ADM 116/579, TNA.

¹⁰⁴ Undated circular letter from September 1896, Adm G5127/96; Whitehead Co. (Weymouth) to SecAdm, 24 October 1896, Adm G5995/96, ADM 116/519, TNA.

¹⁰⁵ Whitehead Co. (Weymouth) to SecAdm, 24 February 1897, Adm G1061/97, ADM 116/519, TNA.

¹⁰⁶ Minute by Walker, 2 February 1897, Adm G588/97, ADM 116/519, TNA [copy in PQ/97/2516/150].

Treasury regulations would require the Admiralty to obtain Treasury sanction before the Admiralty could guarantee payment for the four torpedoes.¹⁰⁷ When the Admiralty wrote to the Company on 1 May 1897 to inquire as to its terms for fitting four gyroscopes, the Admiralty said it expected the cost for each torpedo to come to £75—£25 for the gyroscope, £25 for the royalty, and £25 for the fitting—and it described the issue with the Treasury regulations, explaining that it would not recommend payment of the royalty to the Treasury without further proof that the royalty was justified by the value of the device.¹⁰⁸ The implication was that the Company would have to provide a few gyroscopes to the Admiralty free of royalty for trial, after which the question of royalties could be taken back up.

On 14 May 1897, the Company replied to say that it could not supply gyroscopes under those conditions at present, but that it was taking steps to patent the gyroscope so that it could supply the gyroscopes without an agreement on royalties.¹⁰⁹ The implicit logic of the Company's position was that it could not supply un-patented technology to the Admiralty without a royalty agreement of some sort, because the lack of such an agreement might be taken to imply that the technology was unprotected: if the Admiralty decided to pirate the technology, the Company would have no recourse without a royalty agreement to point to as proof that the technology was protected. On 22 May 1897, the Company wrote again to the Admiralty to say that it had taken out the patents and could therefore supply the four gyroscopes for trial and any more that the Admiralty might wish

¹⁰⁷ Minute by Awdry on draft letter, 9 April 1897, Adm G1788/97, ADM 116/519, TNA.

¹⁰⁸ SecAdm to Whitehead Co. (Weymouth), 1 May 1897, Adm G1788/2670/97, ADM 116/519, TNA. The draft letters show that the final copy sent was very carefully worded.

¹⁰⁹ Whitehead Co. (Weymouth) to SecAdm, 14 May 1897, Adm G2649/97, ADM 116/519, TNA.

to order, while leaving the settlement of a royalty agreement to a later date.¹¹⁰ It quoted prices of £50 per gyroscope—*without* itemizing the royalty—plus £25 for fitting each gyroscope to torpedoes.

According to Jeffrey, the Director of Naval Ordnance, the lack of itemization was important: “No Treasury sanction appears ... to have been asked for or to have been necessary for a case in which the patented article is purchased direct from the patentee and royalty is included in the price.”¹¹¹ Jeffrey’s reasoning seems to have been that holders of a patent could not pay royalties on that patent to themselves. If so, however, his use of the term “royalty,” which suggested that it had a discrete existence of its own within the price, was confusing. Even more problematic was the fact that, under the artfully named category of payments “over and above the actual price named for manufacturing and fitting” (a royalty by any other name sounding sweeter to Treasury ears), Jeffrey included £200 for the two 1897 orders of four gyroscopic torpedoes, or £25 for each gyroscope, which was, of course, the royalty amount. Here he counted the £25 as a royalty because he wanted it to go towards redeeming the lump sum of £20,000 to be paid to the Whitehead Company. Thus, while the Admiralty’s interest vis-à-vis the Treasury was to combine the royalty with the price, its interest vis-à-vis the Company to separate the royalty from the price. Jeffrey was trying to have it both ways: to argue that there had been no royalty so as to free the Admiralty from the obligation to seek Treasury sanction for the contracts; and to argue that there had been a royalty so as to count it towards redemption of the lump sum.

¹¹⁰ Whitehead Co. (Weymouth) to SecAdm, 22 May 1897, Adm G2954/97, ADM 116/519, TNA.

¹¹¹ “Précis of correspondence in regard to Whitehead Gyroscopes,” enclosure to minute by Jeffrey [DNO], 31 August 1899, Adm G5661/99, ADM 116/579, TNA.

Jeffrey was interested in the lump-sum possibility because he projected sufficiently high gyroscope needs that it would be more economical to buy wholesale than retail. Jeffrey calculated that the Navy would need roughly 2,500 gyroscopes over the next five years; if it had to pay a royalty of £25 per gyroscope, the total would be £62,500. But Jeffrey believed that the Treasury would not agree to any royalty higher than 15% of the cost of manufacture, which was £25, such that the royalty would be £3.15.00, and the cost for 2,500 torpedoes would come to £9,375—but the royalties would continue for future orders, not end there.¹¹² In either case, Jeffrey hoped, based on Walker's suggestion of February 1897, that the Whitehead Company would agree to count the royalties already paid (amounting to £10,025) towards the lump sum of £20,000, plus 5% interest for the time that the Company had not had the lump sum, which would add some £3,500. The Financial Secretary recommended that instead of explaining to the Company the real reason for the Admiralty's openness to a lump payment—that it expected to need a lot of gyroscopes—the Admiralty simply say that it was finally in a position to accept the Company's offer of a £20,000 lump payment, to include the £10,025 already paid.¹¹³ His approach was embodied in the letter that the Admiralty sent to the Company.¹¹⁴

Unsurprisingly, considering that the Admiralty was trying to reap the rewards of risks borne by the Company, the latter was not open to this idea.¹¹⁵ The Company also pointed out that the Admiralty would have owed interest. The Company acknowledged, however, that the royalties already paid should allow it to modify its original offer, and it

¹¹² There were 20 shillings to the pound, so £3.15.00, in decimal terms, was £3.75, not £3.15.

¹¹³ Minute by Financial Secretary, 7 September 1899, Adm G5661/99, ADM 116/579, TNA.

¹¹⁴ SecAdm to Whitehead Co. (Weymouth), 21 October 1899, Adm G5661/6686/99, ADM 116/579, TNA.

¹¹⁵ Whitehead Co. (Weymouth) to SecAdm, 27 October 1899, Adm G7085/99, ADM 116/579, TNA.

counter-proposed. The Company would permit the £10,025 already paid to count towards defraying the £20,000 and accept the balance of £9,975, instead of requiring the Admiralty to start from scratch. In return for its agreement to accept the money already paid as partial defrayment, the Admiralty would agree to give the Company a monopoly on its gyroscope supply for three years at a cost of £30 per gyroscope, the one exception to the monopoly being that the RGF would be permitted to manufacture a small number per year, say 20, so as to be in a position to supply the Admiralty when its monopoly agreement with the Company ended.

Jeffrey—after graciously reminding his colleagues that he had told them that the Company would demand interest—argued that the monopoly proposal would benefit the Admiralty, based on its future needs, and would benefit it even more if defined in terms of numbers instead of time.¹¹⁶ Pointing out that the Company probably thought the Admiralty's needs were lower than they actually were based on past trends, he suggested fixing the monopoly at 1,000 gyroscopes instead of at three years. His colleagues agreed, and the Financial Secretary added that the Admiralty might press for the right to have 50 instead of 20 gyroscopes made by the RGF each year.¹¹⁷ The Admiralty wrote to the Company accordingly.¹¹⁸

The Company accepted the Admiralty's proposed terms in their entirety.¹¹⁹ The Admiralty belatedly wrote to the Treasury for authorization, including this careful account of the negotiations: “[T]he exact proportion of the £50 [price] which was to be

¹¹⁶ Minute by Jeffrey, 2 November 1899, Adm G7085/99, ADM 116/579, TNA.

¹¹⁷ Minutes on Adm G7085/99, ADM 116/579, TNA.

¹¹⁸ SecAdm to Whitehead Co. (Weymouth), 27 November 1899, Adm G7085/7672/97, ADM 116/579, TNA.

¹¹⁹ Whitehead Co. (Weymouth) to SecAdm, 3 January 1900, Adm G7912/99, ADM 116/579, TNA.

charged as royalty was not definitely agreed to; but from correspondence it was assumed that about £25 was to be paid for that purpose.”¹²⁰ The under-staffed Treasury authorized the necessary expenditures, and the Admiralty had a long-term gyroscope policy.¹²¹

Events confirmed the wisdom of the Admiralty’s decision to switch from royalty payments to a lump sum, and to define the monopoly in terms of numbers rather than time. In Fiscal Year [FY] 1900/01, the Admiralty ordered 800 gyroscopes from the Company and only 50 from the RGF, as per the terms of the monopoly agreement.¹²² In FY 1901/02, it ordered 550 gyroscopes from the Company, taking it well over the 1,000 monopoly, and it was therefore free to order 450 gyroscopes from the RGF.¹²³ In effect, the monopoly agreement had bound the Navy for only one financial year, instead of the three originally sought by the Company.

Beginning with the Admiralty’s order of 75 gyroscopes in October 1898, improvements were repeatedly introduced. The first was a switch from pivot bearings to ball bearings, which reduced friction and therefore increased the gyroscope’s spin time.¹²⁴ The second was the reduction in strength of the spring that started the gyroscope so as to prevent the force of its release from breaking other parts of the gyroscope.¹²⁵ The third was the replacement of the automatic clutch for holding the gyroscope in the cocked position with a more reliable mechanical (manual) clutch.¹²⁶ The fourth was the

¹²⁰ SecAdm to Treasury, 21 December 1899, Adm G7912/8247/99, ADM 116/579, TNA.

¹²¹ Treasury to SecAdm, 3 January 1900, Adm G81/00, ADM 116/579, TNA. On the Treasury’s staffing problems, see Jon Sumida, *In Defence of Naval Supremacy: Finance, Technology and British Naval Policy, 1889–1914* (Boston: Unwin Hyman, 1989), 25.

¹²² ART00/39.

¹²³ ART01/39.

¹²⁴ ART98/37. The increase was from 5 minutes to 35 minutes.

¹²⁵ ART00/40.

¹²⁶ ART00/38.

introduction of more effective screws for holding the cups of the ball bearings in place.¹²⁷ Finally, a valve in the gyroscope was changed to prevent oil and rust particles from fouling the gyroscope.¹²⁸ Although these changes resulted from mundane trial-and-error experiment, not from sophisticated design work, they combined to produce a much more effective gyroscope.

Engine, Flask, and Superheater Developments—Or Not

After years of wandering through the wilderness of the pattern-unification policy and kicking the gyroscope can down the road, the Navy's torpedo policy was, at least for the time being, on sound footing. Moreover, the mis-steps had not entirely been in vain. The debacle with the reducer and engine of the 14-inch RGF Mark IX torpedo had concentrated attention on those two parts. Thus, while other nations were putting their hopes in the turbine engine, Britain was primed to improve the reciprocal engine.

Vernon had begun experimenting with new reducers in 1896. Authorization to develop new designs of 14-inch and 18-inch RGF torpedoes in July 1897 and May 1898, respectively, provided further motive and opportunity to develop new engines as well.¹²⁹ The basic idea was to manipulate the air pressure acting on the engines, and the size of the parts acted on, to find the best combination.¹³⁰ Various engines were designed, differing from each other in the diameter of the cylinders, the length of the pistons' stroke, the valves, and the cylinders' exhaust. The Navy also tried a four-cylinder engine in two

¹²⁷ ART01/39.

¹²⁸ ART01/39, ART02/29.

¹²⁹ See, respectively, Adm G3818/97, ADM 116/519, TNA; Adm G2006/98, mentioned in PQ/99/2741/345.

¹³⁰ Detail on the new designs and the experiments can be found in ART96/22–30; ART97/23–25; ART98/19–20, 32–33, 36–37, 50–54; ART99/19–23; ART00/34, 49–53; ART01/36–37, 40–41; ART02/26–28.

experimental torpedoes in lieu of the usual three-cylinder engine in 1900. Although the four-cylinder engine increased the speed, it decreased the uniformity of the speed and the stability of the torpedo. These decreases probably stemmed from the crunch involved in squeezing four cylinders into the same space where there had been three: the diameter of the pistons got smaller, so they were liable to jam, and room for the counter-weights needed to balance the four cylinders was inadequate.¹³¹ Due to these problems, the Navy temporarily shelved the idea of a four-cylinder engine.¹³² A new 14-inch engine was settled on in 1897, and a new 14-inch torpedo—the RGF Mark X—in 1898; while a new 18-inch engine was settled on in 1899, and a new 18-inch torpedo—the RGF Mark V—in 1901.

The development of these new engine and torpedo designs also improved understanding of the Navy's existing designs. A series of experiments carried out in 1898 to determine the best speed and range settings for the new 18-inch torpedoes uncovered "some capabilities of our present torpedo which are not generally known," namely, that varying the setting of the reducer could dramatically increase the speed of the torpedo, by roughly 5 knots over 300 yards and 1 knot over 600 yards.¹³³ The experiments also showed that the reducer, the source of so much trouble over the past four years, might not even have been necessary: varying the settings of a different valve, the stop valve, revealed that the stop valve could be made to act as a reducer, a revelation that must have been relieving and galling in equal measure.¹³⁴ Another set of experiments produced a

¹³¹ Peter Bethell, "The Development of the Torpedo," Parts 1–7, *Engineering* 159–61 (25 May 1945 to 15 Mar 1946), 14.

¹³² ART00/34.

¹³³ ART98/51.

¹³⁴ ART98/51-53.

comparable revelation, which was that “in previous engine designs the size of the valve,” an important factor in engine performance, “has been a matter of guess work.”¹³⁵

“Guess work” was perhaps too strong a term, as a good deal of calculation and planning was undoubtedly involved in engine design, but it did point to a larger truth, which was the empirical nature of much design work. Mathematical calculations could carry the design process far, but only so far, and at some point—a point undoubtedly far earlier than what it would be in an age of computer modeling—the only way to figure out the best settings was to try many different ones. However frustrating for the designers, empiricism actually played to one of Britain’s great comparative advantages, which was the extent of its research and development infrastructure. No other nation had the combination of money, range facilities, expertise, material, and personnel to undertake experiments of such scope and intensity. Trial-and-error design work could not be done, or could not be done as well, without such resources.

In 1902, a new development rendered the painstaking experiments of the past six years with reducers and engines partly irrelevant: the use of nickel steel for air flasks. This allowed a quantum increase in the weight and pressure of air carried for a given volume—roughly a 20-33% increase in the weight of air (a smaller increase in 18-inch torpedoes than in 14-inch torpedoes), and a 25% increase in the pressure.¹³⁶ In theory, these increases were desirable, since they allowed greater speeds and ranges. The problem was that existing engines had been designed to work at a given pressure, and they had been settled on only recently after a prolonged development process. Thus the

¹³⁵ SRGF to Captain *Vernon*, 2 November 1899, NO6185, copy in ART99/22–23.

¹³⁶ ART02/26. Expressed in absolute terms instead of percentages, the increases in weight and pressure for 14-inch torpedoes were from 34.75 to 46.25 lbs., and from 1,350 to 1,700 psi; and for 18-inch torpedoes, from 77.55 to 94.5 lbs., and from 1,400 to 1,700 psi.

prospect of changing them, problematic under the best of circumstances, was particularly unappealing. Accordingly, at a conference between representatives of the RGF and *Vernon* in June 1902, it was decided to put off the design of new 14-inch and 18-inch engines that would be needed to get the most out of the new air flasks, and to settle for modest, rather than optimal, improvements in speed and range for the time being.¹³⁷

While calculating that the gyroscope and nickel steel flasks were quantum leaps forward over any existing technology and demanded adoption, the Admiralty reached a different conclusion about the turbine engine. The RGF first carried out experiments with turbine propulsion of torpedoes in 1897, using a Parsons turbine.¹³⁸ They were a failure. In 1901, the Assistant Superintendent of the RGF, C. R. Acklom, decided to try again, using a different form of turbine.¹³⁹ At first the turbine's efficiency was well under half that of the latest reciprocating engine, but Acklom managed to get it up to well over half, though still less. Then a screw came loose while he was testing it and the turbine was practically destroyed. Acklom had spent £200 already and asked for £150 more to continue his efforts. The Director of Naval Ordnance turned him down, giving a clear indication of how much value—or lack thereof—the Admiralty attached to the development of a turbine engine.¹⁴⁰

The Admiralty also decided not to adopt another new piece of torpedo technology: the superheater. In June 1901, F. M. Leavitt's patent for the superheater was sent to *Vernon*, but the device was judged too dangerous, due to the risk of premature ignition

¹³⁷ ART02/26–27.

¹³⁸ These experiments are alluded to in ART97/41 and ASRGF [Acklom] to CSOF [Bainbridge], 1 July 1901, NO11668/01, PQ/01/2842/143–44.

¹³⁹ ASRGF [Acklom] to CSOF, 1 July 1901, NO11668/01, PQ/01/2842/143–44.

¹⁴⁰ Egerton [for DNO] to CSOF, 6 August 1901, NO11668/01, PQ/01/2842/143–44.

and consequent bursting of the air flask, to warrant trial.¹⁴¹ Whether in response to the news of the Leavitt superheater, or on his own initiative, the intrepid RGF Assistant Superintendent Acklom began to work on his own design of a superheater.¹⁴²

A year later, the E. W. Bliss Company approached the Admiralty about the superheater, stating that the U.S. Navy had made “exhaustive” tests of the device and found that it increased the speed of the torpedo by 16% over 800 yards, while creating “no complications of any kind.”¹⁴³ The new Captain of *Vernon*, Charles Egerton, was intrigued, judging a 16% increase in speed “certainly sufficient” to warrant trial—if it could be shown that the danger of premature ignition of the alcohol that heated the air had been overcome. Acklom was more openly skeptical: the Company said the tests had been “exhaustive,” yet the Navy report it cited “only rests on 22 runs!”¹⁴⁴ Egerton and Acklom agreed that the first order of business should be to get fuller details from the Company, and the Admiralty wrote to the Bliss Company accordingly.¹⁴⁵

In its reply, the Company attempted to allay the Admiralty’s fears over premature ignition of the superheater and offered to equip a sample torpedo with the device.¹⁴⁶ *Vernon* was satisfied with the Company’s explanation and suggested sending a torpedo to Paris, whence the Company’s representatives were writing, if the cost was not prohibitive.¹⁴⁷ The Director of Naval Ordnance preferred to have the Company send

¹⁴¹ I do not have records on this episode, but it is alluded to in a minute by Captain of *Vernon* [Egerton], 25 July 1902, Adm G7197/02, Docket “Application of Heat to Compressed Air for Torpedoes. Consideration of Commercial Offer,” ADM 1/7657, TNA. Leavitt’s patent was GBP 10,126/1900.

¹⁴² Alluded to in Acklom [signature difficult to discern] to DNO, 5 August 1902, Adm G7197/02, ADM 1/7657, TNA.

¹⁴³ Bliss Co. (Paris) to SecAdm, 12 July 1902, Adm G7197/02, *ibid.* Emphasis in the original.

¹⁴⁴ Acklom to DNO, 5 August 1902, Adm G7197/02, *ibid.*

¹⁴⁵ Controller to Bliss Co. Paris, 13 August 1902, Adm G7197/9036/02, *ibid.*

¹⁴⁶ Bliss Co. (Paris) to SecAdm, 16 September 1902, Adm G9487/02, *ibid.*

¹⁴⁷ Charlton [for Egerton] to DNO, 23 September 1902, Adm G9487/02, *ibid.*

workmen to fit the superheater to a sample torpedo in England, and the Admiralty wrote to ask the Company if it would be willing.¹⁴⁸ The Company replied that it would be happy to do so, after the Admiralty bought the patent rights to the superheater, or the Admiralty could send workmen to it.¹⁴⁹ Though aghast that the Company apparently expected the Navy to buy the patent rights without conducting trials, a “very unreasonable” attitude, Acklom thought the Navy should try “this ingenious device.”¹⁵⁰ Egerton agreed that trials were desirable, and that purchase of the patent rights was impossible without trials.¹⁵¹ The Admiralty informed the Company accordingly, and asked what the Company would charge for two superheaters and drawings.¹⁵²

The Company counter-proposed terms very similar to those it had worked out with the U.S. Navy: it would equip a torpedo with a superheater at no charge, provided that the Admiralty agreed to try the torpedo in the presence of a Company representative in England, and to pay the Company a certain amount for each half-knot of speed gained. The Company would also, “of course,” need to come to some arrangement with the Admiralty as to how many superheaters the Admiralty would purchase if the Company’s claims for it were borne out, suggesting that the number be spread over five years so that the payment per year would be comparatively low.¹⁵³ In a role reversal, Egerton now played skeptic to Acklom’s enthusiast. Egerton said that a Whitehead Company representative had informed him that the superheater was too dangerous; Acklom said

¹⁴⁸ Minute by Jackson [for DNO], 11 November 1902, Adm G9487/02; Controller to Bliss Co. (Paris), 19 November 1902, Adm G9487/13319/02, *ibid.*

¹⁴⁹ Bliss Co. (Paris) to SecAdm, 22 November 1902, Adm G12350/02, *ibid.*

¹⁵⁰ Acklom to DNO, 26 November 1902, Adm G12350/02, *ibid.*

¹⁵¹ Egerton to DNO, 17 December 1902, Adm G12350/02, *ibid.*

¹⁵² SecAdm to Bliss Co. (Paris), 8 January 1903, Adm G12350/397/02, *ibid.*

¹⁵³ Bliss Co. (Paris) to SecAdm, 9 February 1903, Adm G1820/03, and 10 February 1903, Adm G1890/03, *ibid.*

that a Whitehead Company representative had spoken favorably of the device. Egerton suggested that the proposal be declined; Acklom was willing to have an experimental torpedo fitted with the device and to personally superintend experiments with it.

Apparently Acklom changed his mind, however, because the Assistant Director of Naval Ordnance, H. B. Jackson, said that in conversation, both *Vernon* and the RGF agreed that the device was “too complicated and dangerous ... even if a considerable gain in speed could be guaranteed at a moderate cost,” and he recommended that the Company’s offer be declined, with thanks, and with an expression of the Admiralty’s willingness to consider any simplified version of the device in the future.¹⁵⁴ The Company replied that the superheater was already very simple, but to no avail: as far as the Admiralty was concerned, the matter was closed.¹⁵⁵

Tactics and Naval Architecture

Tactics and naval architecture in the Royal Navy were intimately related to each other and to torpedo development. Of the two subjects, tactics is the harder to track, because it was the more decentralized. At the Admiralty, although ship design involved many different entities, the process was coordinated by the Director of Naval Construction, of whom there were only two over a quarter century—William White, from 1885 to 1902, and Philip Watts, from 1902 to 1912. Aside from the stability in leadership, the process of ship design had a certain rhythm, largely governed by the fiscal calendar and the preparation of estimates for submission to Parliament.

¹⁵⁴ Minute by Jackson, 4 March 1903, Adm G1890/03; SecAdm to Bliss Co. (Paris), 13 March 1903, Adm G1890/3696/03, *ibid*.

¹⁵⁵ Bliss Co. (Paris) to SecAdm, 17 March 1903, Adm G3622/03; minute by Jackson, 24 March 1903, Adm G3622/03, *ibid*.

There was no such stability in leadership or rhythm to tactical development. The lack of a nerve center for tactical thought has sometimes been taken for a lack of tactical thought; so too has the absence of agreed-upon solutions been taken for a failure to recognize problems. These views are mistaken. While it is true that the Royal Navy had nothing like modern centers for the generation, dissemination, and correction of doctrine, tactical thought still occurred, and intensely so, chiefly in three fora: during the discussion of naval architecture at the Admiralty, in courses at the Royal Naval College in Greenwich, and at the initiative of station fleet commanders.

Each forum presents a distinct historiographical challenge, however.¹⁵⁶ Tactical thought at the Admiralty is the easiest to track, since Admiralty minutes were comparatively plentiful and well preserved, but operationally it was the least important. Tactical thought in the Royal Naval College is more difficult to track, since the records were not as well preserved and the discussion of tactical questions was more ad hoc. Tactical thought in the third forum, the regional fleet commands, is the most difficult to track, unfortunately so, since it was operationally the most important. The Admiralty could reach whatever tactical agreement it wanted when it designed ships, but its agreements were in no way binding on the officers who would command the fleets it built. Battle tactics were almost entirely the prerogative of the fleet commanders, with the Admiralty confining itself to administrative, logistical, financial, and strategic direction in wartime (although the nature of these functions changed somewhat when Fisher became First Sea Lord in 1904). As a rule, operationally significant tactical records were generated and remained—or were lost—at the regional level, rarely making their way to

¹⁵⁶ I am grateful to Nicholas Lambert for discussing the historiographical issues with me.

central record offices for preservation. Fortunately, there were a few important exceptions to this rule of lost tactical treasures, one of which was the tactical records generated during Fisher's tenure as Commander-in-Chief of the Mediterranean Fleet from 1899 to 1902.

The invention of the gyroscope portended a revolution in naval tactics. On top of improving stern fire, which has already been alluded to, the gyroscope held out the possibility of attacking ships with torpedoes outside gun range. In his report on the first four gyroscopic torpedoes tried at *Vernon* in late 1897, Durnford observed that "one of the first advantages would be a great increase of range ... [which] would mean Boats could often afford to discharge their torpedoes at a range, practically safe from the gun-fire of the ships they are attacking."¹⁵⁷ The tactical importance of this prospect can scarcely be over-stated. It meant that the torpedo, not the gun, might be the primary weapon in a naval battle, and that a centuries-old system of tactics and naval architecture geared towards bringing the largest broadside concentration of fire on the enemy fleet might be rendered irrelevant.

Although the importance of this prospect was obvious, determining the exact increases in range was less clear. In late 1899, H. J. May, captain of a modern battleship in the Channel Squadron when he wrote, and the future leader of the War Course at the Royal Naval College, estimated that the gyroscope had increased the effective range of torpedoes to 2,400 yards, which he seems to have defined as the range at which torpedoes

¹⁵⁷ Durnford to CINC Portsmouth [Culme Seymour], 28 December 1897, Adm G58/98, ADM 116/519, TNA [copy in ART97/100–102].

stood a one in three chance of hitting a two-mile long enemy line-of-battleships.¹⁵⁸ His estimate of range was three times higher than the Navy's torpedoes were designed to go, and 900 yards higher than the longest range at which *Vernon* conducted long-range experiments by 1902. Fisher, commanding the Mediterranean Fleet, rated the effective range even higher, defining "the torpedo zone" as 4,000 yards.¹⁵⁹ He did not actually believe that torpedoes could be aimed accurately for 4,000 yards, but considered the range at which they had a reasonable probability of striking the target to be considerably less.

Fisher and May had two reasons for defining the "torpedo zone" so generously. First, they feared that ships at the end of the battle line, or farthest from the control of the commanding admiral, might accidentally blunder into torpedo range. In combined exercises between the Channel Squadron and Mediterranean Fleet in 1901, May observed that, in its effort to obtain a superiority in gunfire, one side had unwittingly exposed the rear of its battle line to "almost certain destruction" by torpedoes for a full 45 minutes, without ever getting a chance to return torpedo fire.¹⁶⁰ Commenting on exercises a year later, Fisher observed that one side risked losing several ships to torpedo fire, despite getting a superiority in gunfire, "[b]ecause the initial error was committed of approaching inside 4,000 yards, and thus giving no margin for keeping outside the Torpedo Zone."¹⁶¹ Second, in addition to poor command-and-control making a buffer zone necessary, Fisher, and possibly May, feared that the enemy fleet might quickly close the range in order to

¹⁵⁸ May, 1 December 1899, copy in ART00/37–38.

¹⁵⁹ Fisher, "Extracts from Confidential Papers: Mediterranean Fleet, 1899–1902" (printed at Foreign Office 15 October 1902), p. 22, FISR 8/1, CAC.

¹⁶⁰ May to President of RNC Greenwich [Montgomery], 22 May 1902, ADM 1/7617, TNA.

¹⁶¹ Fisher, "Extracts from Confidential Papers: Mediterranean Fleet, 1899–1902" (printed at Foreign Office 15 October 1902), p. 22, FISR 8/1, CAC.

fire torpedoes, in which case the British fleet would need a buffer zone to give it time to turn away.¹⁶² The range of torpedoes could be said to be “effective” not merely insofar as they stood a reasonable chance of hitting the target, but also insofar as they exerted an effect on the battle range. As of 1902, their “effective” range in the latter sense was roughly twice as long as it was in the former. Hence Fisher was thinking of a *minimum* gunnery range that was double torpedo range.

These calculations made his attempts to carry out long-range firing at 6,000 yards in 1899 and 1900 understandable. The Admiralty picked up on his efforts and introduced 6,000-yard practice into the fleet at large in 1901, but as Jon Sumida has explained, British gunnery was far from effective at that range.¹⁶³ Although it is dangerous to generalize, given that important variations existed depending on the nature of the gun (a heavy gun trained and elevated by clumsy hydraulic machinery was much more difficult to aim than a lighter, quick-firing gun capable of being manipulated by hand), the weather (clear conditions with good visibility and a calm sea to minimize roll and yaw made it possible to fire more accurately at longer ranges), and the nature of the engagement (one in which the range between fleets varied at a constant or changing rate made accurate gunnery much more difficult than one in which the range was constant), it is safe to conclude, as Sumida did, that the large-scale adoption of the gyroscopic torpedo in 1898 began a period in which torpedoes out-ranged guns.

As torpedoes became more effective, the defenses of capital ships against small

¹⁶² Fisher, “Appendix A,” in “Extracts from Confidential Papers: Mediterranean Fleet, 1899–1902,” 118, FISR 8/1, CAC. See also Fisher to Selborne, 14 May 1904, enclosure 1, in Peter Kemp, ed., *Papers of Admiral Sir John Fisher*, vol. 1 (London: Navy Records Society, 1960), xxi, cited in Sumida, “The Quest for Reach: The Development of Long-Range Gunnery in the Royal Navy, 1901–1912,” in *Military Transformation in the Industrial Age*, ed. Stephen D. Chiabotti (Chicago: Imprint, 1996), 59.

¹⁶³ Sumida, “The Quest for Reach,” 50–51.

craft firing torpedoes became less effective. Experiments carried out early in 1902, on the assumption that small guns like 12-pounders (3-inch caliber) would be the first put out of action in a battle and that anti-torpedo craft responsibilities would devolve onto 4.7-inch and 6-inch guns, revealed that shrapnel fired from these guns could not stop small vessels (torpedo boats or destroyers) carrying torpedoes, and that shells had to be practically direct hits to stop them.¹⁶⁴ In effect, the experiments implied that the small- and medium-caliber guns of capital ships were useless against torpedo craft. In April 1902, acting on recommendations that had been made in January, a month before the experiments were reported, the Admiralty officially de-emphasized the importance of the anti-torpedo craft armament in capital ships.¹⁶⁵

To be sure, the inability of capital ships to defend themselves did not mean that they were defenseless against torpedo craft. In the early 1890s, the Navy began building a new class of vessel called the torpedo-boat destroyer, later shortened simply to “destroyer.” By the late 1890s, these vessels were expected to make 30 knots. Their high speed came at the expense of strength, however, and they were unable to keep the sea in anything but the calmest weather. In 1900, prompted by the complaints of British destroyer commanders and inspired by the example of slower but stronger German destroyers, the Admiralty began to contemplate the design of slower but more seaworthy destroyers.¹⁶⁶ In late 1901, the Admiralty decided that instead of requiring 30 knots, it would be content with 25.5 knots along with a stronger, more seaworthy vessel.¹⁶⁷

¹⁶⁴ Minute by DNO, 13 July 1901, PQ/02/2881/85; report by Ordnance Committee, 21 February 1902, PQ/02/2881/85.

¹⁶⁵ Minutes on G537/02, PQ/03/2904/7–8.

¹⁶⁶ See SC184/F8–8j and F14, BF.

¹⁶⁷ Minutes on S22945/01, SC184/F22, BF.

Not all parties were happy with the decision. In the Mediterranean, Fisher had a different diagnosis of the problem and a different cure. The problem was not that destroyers were too weak, but that they were being used for missions that should have been performed by other types of vessels. “Because we had an insufficiency of Cruisers,” Fisher complained, “Destroyers, instead of ‘laying to’ in bad weather, had to be forced against heavy seas to carry information that should have been taken by Cruisers!”¹⁶⁸ The misuse of destroyers was creating a mania for strength which they did not need; in fact, their frailty was “necessary and essential.... If we go making Destroyers stronger, they will be heavier, they will be slower and bigger, and will degenerate into vessels that won’t catch anything and won’t be able to run away!”¹⁶⁹ While it was true that destroyers in the Mediterranean, unlike those in the Channel, had to operate at sea far from bases for long periods, Fisher thought the answer was not prolonged sea-keeping ability, but “towing by day for economizing coal and giving the crew rest.”¹⁷⁰ Sufficiently fast destroyers could wreak havoc during battle. Reporting on exercises in 1900, Fisher described “[t]he destroyers all dashing about like mad in the middle of it all! and torpedoing everyone! It is certainly the best thing I have ever seen and the most realistic.”¹⁷¹ As Fisher’s reference to destroyers being “in the middle of it all” indicated, he did not contemplate destroyers joining the line of battle to fire their torpedoes while capital ships fired their guns; rather, the fear was that destroyers might be able to dash

¹⁶⁸ Fisher, “Brief Summary of Three Years’ Exercises,” in “Extracts from Confidential Papers: Mediterranean Fleet, 1899–1902” (printed at Foreign Office 15 October 1902), p. 51, FISR 8/1, CAC.

¹⁶⁹ Fisher, “Brief Summary of Three Years’ Exercises,” in “Extracts from Confidential Papers: Mediterranean Fleet, 1899–1902” (printed at Foreign Office 15 October 1902), p. 49, FISR 8/1, CAC.

¹⁷⁰ *Ibid.*, p. 51.

¹⁷¹ Fisher to Lady Fisher, 29 September 1900, in *Fear God and Dread Nought: The Correspondence of Admiralty of the Fleet Lord Fisher of Kilverstone*, Vol. 1, *The Making of an Admiral, 1854–1904*, ed. Arthur Marder (Cambridge: Harvard University Press, 1952), 160.

between opposing battle lines and fire their torpedoes before capital ships, distracted by dealing with enemy capital ships, or other destroyers could destroy them.

In advocating the use of torpedo-boat destroyers as torpedo boats, Fisher hit upon another controversial point. Throughout the 1890s, destroyers carried either a gun armament (when they were expected to be used as torpedo-boat destroyers), or a torpedo armament (when they were expected to be used as torpedo boats). In July 1901, an Admiralty official pointed out that the system undermined preparedness, and asked whether one alternative should be chosen over the other.¹⁷² The Admiralty decided to choose the gun armament, but disagreement by the commander of a major destroyer base touched off another round of debate.¹⁷³ The Assistant Director of Naval Ordnance, H. B. Jackson, argued that destroyers should retain both armaments so that they could operate offensively as torpedo boats and defensively against torpedo boats, while the Director of Naval Intelligence, Reginald Custance, argued that their gun armament should be favored, since their primary mission was to defend against torpedo boats.¹⁷⁴ The Controller, W. H. May, and Senior Naval Lord, Lord Walter Kerr, backed Custance, and the matter was decided in favor of the gun armament.¹⁷⁵ No sooner was the issue closed, however, than the commander of the Portsmouth instructional destroyer flotilla wrote to express his regret that destroyers would carry only the one torpedo tube associated with the gun armament, rather than the two tubes associated with the torpedo armament.¹⁷⁶ The

¹⁷² President of Mobilization Committee to CINC Devonport, 2 July 1901, G5489/01, PQ/03/2902/2-3.

¹⁷³ Minute by DNO, 10 July 1901, G5489/01, *ibid*; CINC Devonport to SecAdm, 27 March 1902, G3044/02, PQ/03/2902/3.

¹⁷⁴ CINC Devonport to SecAdm, 27 March 1902, G3044/02, PQ/03/2902/3; minutes by ADNO, 30 April, and Custance, 5 May 1902, G3044/02, PQ/03/2902/3-5.

¹⁷⁵ Minutes by May, 4 June, and Kerr, 5 June 1902, *ibid*.

¹⁷⁶ J. B. de Robeck to CINC Portsmouth, 14 August 1902, L11548/02, PQ/03/2910/16.

Commander in Chief of Portsmouth and the captain of *Vernon* backed him.¹⁷⁷ Not missing his chance, the recently over-ruled Jackson urged that the question be reopened, with added support from the Inspecting Captain of Destroyers, but May and Kerr refused to budge.¹⁷⁸ It was with good reason that Kerr observed, “The use of Destroyers in company with battle ships is a vexed question”—as was nearly every tactical question from 1895 to 1902.¹⁷⁹

Conclusion

With some exceptions, the Royal Navy’s torpedo policy from the mid-1890s through 1902 was generally cautious and thoughtful. The exceptions were the decision to institute the pattern-unification policy over the objections of the expert Torpedo Design Committee (including then-captain of *Vernon* B. W. Walker) and Walker’s subsequent misconduct at the Admiralty, which delayed reversal of the pattern-unification policy and adoption of the gyroscope. Nevertheless, the Admiralty thoroughly tested the gyroscope before committing, and its decisions to reject the turbine engine and superheater were perfectly rational given that its superior research-and-development resources allowed it to improve existing technology and test new technology more than any other navy. The consultative nature of Admiralty decision-making was noteworthy: on the gyroscope question, everyone from the captain of *Vernon* to the First Lord weighed in, touching on

¹⁷⁷ CINC Portsmouth to SecAdm, 22 August, and Captain of *Vernon* to DNO, 14 September 1902, L11548/02, PQ/03/2910/16–17.

¹⁷⁸ Minutes by Jackson, 19 September; May, 17 October; ICD, 7 November; Kerr, 10 November 1902, L11548/02, PQ/03/2910/17–21.

¹⁷⁹ Minute by Kerr, 17 November 1900, Docket, “Study of Naval Tactics. Supply of Captain King-Hall’s Naval War Game to the Fleet,” sub-docket, “Naval Tactics (in reply to Admiralty Letter M165 of 14 Apr 1900),” ADM 1/7461B, TNA.

issues ranging from tactics to national power. Although the Royal Navy adopted new technology more slowly than the U.S. Navy or not at all, its behavior was not due to an irrationally conservative institutional culture, but rather to a rational analysis of material resources. Because it was the naval hegemon, the Royal Navy had more to lose from technological change than any other navy—but its superior resources also made it more likely to exploit change than any other navy.

Chapter 3: American Torpedo Development, 1903–1908

“[H]uman foresight is fallible, and many great and unforeseeable expenses may, and no doubt will be encountered.”
– Bliss Company, 1905¹

Introduction

In 1902, an American officer proudly declared that a prospective torpedo containing a turbine engine and superheater “would be essentially an American torpedo and could not properly be called a Whitehead.”² By 1908, however, hope had turned to disappointment. Under pressure from the Navy at large, the Bureau of Ordnance committed to a torpedo—the Bliss-Leavitt—containing a radically new turbine engine, but neither the Bureau nor the Bliss Company was prepared for this commitment. Both failed to realize that the technology was experimental rather than perfected, and therefore both struggled to apply price theory, risk assessment, and cost-accounting methods appropriate for mature technology to immature technology. Only after recognizing that the Bliss-Leavitt torpedo was experimental, not perfected, did the Bureau and the Company realize that their relationship had fundamentally changed: they would have to collaborate to fix the torpedo, and this collaboration would raise extremely difficult

¹ Bliss Co. to Mason, 27 October 1905, BuOrd 17761/60, RG74/E25/B842, NARA.

² Davison to O’Neil, 26 April 1902, BuOrd 3677/02 with 9558/01, RG74/E25/B480, NARA [Copy in B31-161, NTS]. Davison, whose name will appear again, had been the Bureau’s representative at the 1902 tests of the turbine engine.

questions about property rights. Grasping the legal and philosophical implications of these issues only partially, the Bureau tried but failed to adapt contracts and patents to this new type of technology and to a correspondingly new relationship between the government and private industry. While this largely intellectual misadventure laid the foundation for future disputes, a simultaneous failure to fix the physical flaws of Bliss-Leavitt torpedoes caused a supply crisis to erupt in the fall of 1906. As a result, the Bureau established its own torpedo factory and turned back to Whitehead torpedoes. The purchase of Whitehead torpedoes, though intended as a temporary expedient, confirmed that American torpedo development, from its glittering promise in 1903, had fallen behind its foreign counterparts by 1908.

Gyroscoping out the Competition: The Moore, Modified Obry, and Leavitt

Gyroscopes, 1903–1904

In May 1902, the Chief of the Bureau of Ordnance, Charles O’Neil, had announced his intention to put the Moore gyroscope in new torpedoes.³ He ordered the Torpedo Station to build 12 and opened negotiations with the Bliss Company to construct 60.⁴ Everything seemed to be going smoothly—but then Washington Chambers, back at the Torpedo Station after service in the Philippines, disrupted proceedings. On 9 May

³ Endorsement by O’Neil, 3 May 1902, on Mason to O’Neil, 21 April 1902, BuOrd 3296/02 with 10407/00, RG74/E25/B437, NARA.

⁴ See O’Neil to CNTS, 22 September 1902, BuOrd 6041/02; O’Neil to CNTS, 31 January 1903, BuOrd 6041/02-LS200/535; Fletcher to O’Neil, 4 February 1903, BuOrd 1494/03 (NTS 386); O’Neil to Fletcher, 6 February 1903, BuOrd 1494/03-LS201/238; O’Neil to Bliss Co., 6 February 1903, BuOrd 1494/03; Fletcher to O’Neil, 9 February 1903, BuOrd 1669/03 (NTS 492); O’Neil to Fletcher, 12 February 1903, BuOrd 1718/03-LS201/491; O’Neil to Bliss Co., 26 February 1903, BuOrd 1494/03-LS202/483-4; Bliss Co. to O’Neil, 27 February 1903, BuOrd 2453/03; Bliss Co. to O’Neil, 26 March 1903, BuOrd 3679/03; O’Neil to Fletcher, 2 April 1903, BuOrd 1718/03-LS206/141 all with 6041/02, RG74/E25/B511, NARA.

1903, he announced that the Moore gyroscope was not sufficiently reliable to be manufactured by private industry.⁵ Noting that much of Moore's design depended on his own experimental work, but disclaiming any sense of "rivalry," Chambers explained that he had examined Moore's design closely and found "serious defects." The main flaw, according to Chambers, was that one of the air valves leaked. The new commander of the Torpedo Station, Frank Fletcher, did not share Chambers' concern over the air leak, but he worried that the Moore gyroscope had not received rigorous testing and noted that the Obry gyroscope had performed well in service.⁶

O'Neil listened. On 20 June, he ordered the Torpedo Station to conduct careful experiments with the Moore gyroscope and formally solicited the opinions of five torpedo experts—Fletcher, Chambers, L. H. Chandler, G. W. Williams, and G. C. Davison—on its performance.⁷ Chandler, Williams, and Davison all enthusiastically preferred Moore's gyroscope to the service Obry, agreeing that it was mechanically more reliable and, thanks to its capability for angle fire, tactically superior.⁸ Strikingly, these three officers thought angle fire was more significant for above-water fire from torpedo boats than for submerged fire from capital ships. The idea was that a torpedo boat could simultaneously fire three torpedoes (one from the bow tube, one each from the two broadside tubes) to run parallel to each other, thereby covering a larger zone upon reaching the target than a single torpedo could, and increasing the probability of hitting.

⁵ Chambers to Fletcher, 9 May 1903, BuOrd 5918/03 (NTS 1679) with 6041/02, RG74/E25/B511, NARA.

⁶ Fletcher to O'Neil, 14 May 1903, BuOrd 5918/03 (NTS 1679) with 6041/02, RG74/E25/B511, NARA.

⁷ O'Neil to Fletcher, 20 June 1903, BuOrd 3679/03-LS213/129 with 6041/02, RG74/E25/B511, NARA. See his letters of the same date to Fletcher, Chambers, Davison, Williams, and Chandler, all BuOrd 3679/03, *ibid.*

⁸ Chandler to O'Neil, 5 July 1903, BuOrd 8059/03 (NTS 2734/386); Davison to O'Neil, 22 June 1903, BuOrd 7561/03 (NTS 2734/386); Williams to O'Neil, 17 July 1903, BuOrd 8937/03, all with 6041/02, RG74/E25/B511, NARA.

This plan for a three-torpedo salvo is illustrated in Figure 3.1 below.

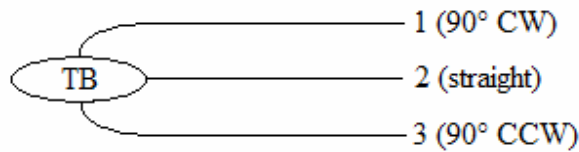


Figure 3.1: A three-torpedo salvo from a torpedo boat, using angle fire.

Chambers, by contrast, affirmed that in originating the notion of angle fire, he “had uppermost in mind the desirability for so doing from fixed submerged tubes.”⁹ He criticized the air impulse arrangement in Moore’s gyroscope and offered his own alternative.

Fletcher’s reply to O’Neil’s solicitation was the most comprehensive. Having combed the Torpedo Station’s records on the Moore gyroscope, he found that the “complete record,” such as it was, consisted of three reports covering 91 runs.¹⁰ The three reports furnished insufficient data for determining the accuracy and reliability of the device, Fletcher felt, and thus he concluded that the capability for angle fire had been behind its adoption. Fletcher was not enthusiastic about angle fire. He dismissed Chandler’s idea of using angle fire from torpedo boats, and he was “inclined to place a rather low estimate” on the utility of angle fire from the fixed submerged tubes of capital ships.

The Moore gyroscope was running into trouble. Though slowed by a lack of labor and plant—continuing evidence of the Navy’s weakness in research and development resources—the experiments that O’Neil had ordered with the Moore gyroscope

⁹ Chambers to O’Neil, 8 July 1903, BuOrd 8251/03 (NTS 2426) with 6041/02, RG74/E25/B511, NARA.

¹⁰ Fletcher to O’Neil, 25 July 1903, BuOrd 8946/03 (NTS 2698) with 6041/02, RG74/E25/B511, NARA.

confirmed some of Chambers' criticisms.¹¹ Fletcher also began to improve the service Obry.¹² Of the several changes suggested, the most important was a change from pivot bearings to ball bearings for the axle bearings and the side bearings to reduce friction and hence to increase the spin time.¹³ With these two sets of bearings changed, by January 1904, the Obry gyroscope was able to spin for 42 minutes, instead of the 13 minutes it managed with pivot bearings.¹⁴

While the experiments with the Moore gyroscope proceeded, and Fletcher plotted to improve the service Obry, yet another competitor arrived on the scene: a gyroscope designed by F. M. Leavitt of the Bliss Company. Like the Moore gyroscope, Leavitt's used air impulse, but unlike Moore's (and like Chambers' two late 1900 designs), instead of having the air come from inside the gyroscope wheel (as in a Hero turbine), Leavitt's had air come from outside the wheel and act on buckets attached to the wheel (as in a Pelton turbine).¹⁵ Leavitt's design also had two entirely new features. First, he used a connection to the main engine shaft, rather than an air-operated steering engine, to amplify the power of the gyroscope to operate the vertical rudders. (Thanks to its use of direct mechanical power, Leavitt's steering engine became known as the "mechanical steering engine.") Second, he used an electric circuit, rather than an air valve, to control

¹¹ Sargent to Fletcher, 1 August 1903, enclosure to BuOrd 14468/03 (NTS 4592) with 6041/02, RG74/E25/B511, NARA; Fletcher to O'Neil, 10 September 1903, BuOrd 10850/03 (NTS 3225), RG74/E25/B566, NARA.

¹² Although the earliest record I found relating to improvements to the service Obry was a letter from Moore to Fletcher, it is improbable that Moore would have taken the initiative to improve a rival gyroscope. Moreover, judging from other letters (e.g., Fletcher to Leavitt, 18 January 1903, NTS B42-347), Fletcher was clearly enthusiastic about improving the service Obry, adding further weight to the supposition that the initiative was his.

¹³ Moore to Fletcher, 26 October 1903, B36-135, NTS.

¹⁴ Fletcher to Leavitt, 18 January 1903, B42-347, NTS.

¹⁵ See Figure 1.1 for an illustration.

the transmission of power from the gyroscope to the rudders.¹⁶ All three sets of bearings were old-fashioned pivot, rather than ball, bearings. A board of three naval officers, led by the ubiquitous Chambers, tested and reported on Leavitt's gyroscope, among other things, in November 1903.¹⁷ The Board liked Leavitt's use of mechanical power and thought that a minor change would make the gyroscope capable of angle fire. It recommended further trials.

A week after the Chambers Board delivered its report on the Leavitt gyroscope, Fletcher delivered a major report on the Moore gyroscope, based on new experiments. At Fletcher's urging, the Torpedo Station tested the tactical diameters of torpedoes under various helm angles, and the "transfer" of the torpedo from its initial line of fire to its final course, which is illustrated and explained in Figure 3.2 below.

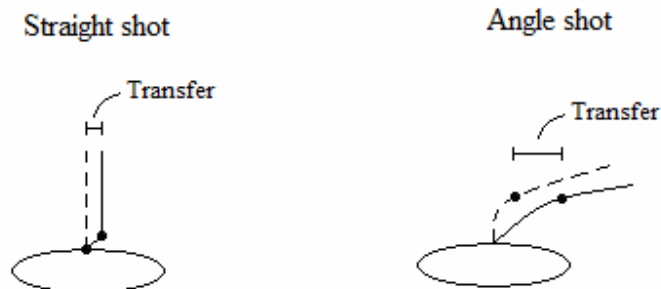


Figure 3.2: Torpedo transfer.

In both figures, the dots indicate the point at which the torpedo steadies onto its final course. In a straight shot, the gyroscope steadies the torpedo on its final course as soon as it overcomes the initial deflection, minimizing the transfer from the intended final course to the actual final course. In an angle shot, as in a straight shot, the gyroscope still takes control after a short initial deflection, but the effect of that deflection is multiplied as a result of the turn, with the result that, with the same initial deflection, the transfer is larger in an angle shot than a

¹⁶ Chambers, Sears, and Hill to O'Neil, 19 November 1903, pp. 15–17, BuOrd 13021/03 with 9558/01, RG74/E25/B480, NARA.

¹⁷ Chambers, Sears, and Hill to O'Neil, 19 November 1903, BuOrd 13021/03 with 9558/01, RG74/E25/B480, NARA.

straight shot. Similarly, with the same initial deflection, the transfer is larger in a larger angle shot than in a smaller angle shot.

The results confirmed Fletcher's fears: the tactical diameters varied for individual torpedoes of the same mark (and for the same helm angle to right and left), and the transfer varied with the initial deflection and the helm angle.¹⁸ The former was the less problematic, since, in theory, the tactical diameters for each helm angle to the left and right could be determined for each torpedo—although in practice, doing so would have been a nuisance—and then factored into the targeting problem as a known variable. Accounting for variation due to initial deflection before the gyroscope took over was impossible, however, since the initial deflection varied unpredictably from shot to shot, depending on the impulse charge and on the course and speed of the firing ship. In theory, advanced mathematics could account for all the variables, but in the heat of action, the acquisition and calculation of the necessary information was impossible. Fletcher pointed the way to the future by noting that the problem of initial deflection could be overcome by permitting the gyroscope “to immediately assume control.” In the meantime, however, there were additional variables that had to be known and accounted for with angle fire, including the longer time and distance of travel in an angle than in a straight run (which, in aiming the torpedo, could be accounted for as a lower speed). Fletcher also pointed out that knowledge of the target range was necessary for angle fire. On top of the complexity of calculations necessary to make angle fire effective, Fletcher doubted its tactical utility

¹⁸ For these fears, see Fletcher to O'Neil, 8 Jul 1903, BuOrd 8221/03 (NTS 2172) with 6041/02, RG74/E25/B511, NARA.

from torpedo boats and capital ships.¹⁹

O'Neil had already made up his mind, however. In a meeting with representatives of the Bliss Company on 28 October 1903, he unveiled his intention to hold competitive trials of the Leavitt and Moore gyroscopes in two new turbine torpedoes to be built by the Bliss Company (discussed below).²⁰ While these two torpedoes were being built, O'Neil ordered Fletcher to continue developing the Moore gyroscope.²¹ It seemed to be re-gathering momentum.

Personnel changes disrupted this momentum. In March 1904, G. A. Converse replaced O'Neil as Chief of the Bureau of Ordnance. Five months later, in August 1904, N. E. Mason replaced Converse (who took over the Bureau of Navigation after the death of its Chief).²² Although Mason liked the idea of angle fire, he was not wedded to the Moore gyroscope but instead approached gyroscopes as a diner would a buffet, mixing-and-matching the features he thought best. He ordered the Torpedo Station to try incorporating several aspects of Leavitt's gyroscope into Moore's air-impulse design. In case those efforts failed, he also ordered the Torpedo Station to begin converting the service spring-impulse Obry to a strengthened, ball-bearing model.²³ Several weeks later, Fletcher submitted three designs of the Moore gyroscope conforming to Mason's

¹⁹ Fletcher to O'Neil, 25 November 1903, BuOrd 14468/03 (NTS 4592) with 6041/02, RG74/E25/B511, NARA.

²⁰ This meeting is described in Porter to O'Neil, 29 October 1903, BuOrd 12865/03, RG74/E25/B664 [misfiled, should be in B566], NARA.

²¹ O'Neil to Fletcher, 19 December 1903, BuOrd 14468/03-LS227/402-3 with 6041/02, RG74/E25/B511, NARA.

²² See Christopher Havern, Sr., "A Gunnery Revolution Manqué: William S. Sims and the Adoption of Continuous-Aim in the United States Navy, 1898-1910" (Master's thesis, University of Maryland, 1995), 99n76.

²³ Fletcher to Converse, 13 June 1904, BuOrd 6858/04 (NTS 2363) with 9890/03, RG74/E25/B565, NARA.

specifications.²⁴

Development of the Moore gyroscope stalled there for three years. In September 1904, the Leavitt gyroscope beat the Moore gyroscope in competitive trials.²⁵ Also hurting the Moore design was Mason's desire to develop a spring-driven alternative to the Moore and Leavitt gyroscopes. Mason probably had several motives. First, the modified (spring-impulse) Obry with ball bearings was giving very good results. In competitive trials at the Torpedo Station, apparently carried out at Fletcher's initiative, it spun for 36 minutes, while the Moore gyroscope spun for half that time.²⁶ The spring-impulse, ball-bearing Obry gyroscopes became known as the Mark I, Mod[ification]. 1 gyroscopes, while the original pivot-bearing gyroscopes became known as the Mark I.²⁷ Second, a spring impulse in conjunction with mechanical control of the rudders would avoid the possibility of clogged air valves causing a circular run.²⁸ Third, observers began to notice that Leavitt gyroscope had a relatively short spin time—so short that the new commander

²⁴ Fletcher to Mason, 20 September 1904, BuOrd 11010/04 (NTS 4110) with 9890/03, RG74/E25/B565, NARA.

²⁵ Chambers, Sears, Bristol, and Gise to SecNav, 27 September 1904, BuOrd 11932/04 (Dept 17755-3) with 12865/03, RG74/E25/B664 [misfiled, should be in B575], NARA. Chambers and Sears had been members of the board that reported on the Bliss-Leavitt turbine torpedo in November 1903; Bristol and Gise had not.

²⁶ Williams to Fletcher, 19 September 1904, enclosure to Fletcher to Mason, 22 September 1904, BuOrd 11137/04 (NTS 4161), RG74/E25/B651, NARA. See also Fletcher to Mason, 4 October 1904, BuOrd 11590/04 (NTS 3399) with 9890/03, RG74/E25/B565, NARA.

²⁷ For the anguished taxonomical debate and its triumphant resolution, see Mason to Gleaves, 31 January 1905, BuOrd 16647; Gleaves to Mason, 6 February 1905; Gleaves to Mason, 23 May 1905, and endorsement by Mason, 25 May 1905, BuOrd 16647/5, all B45-131, NTS. Confusingly, since the nomenclature of the Leavitt gyroscope was consistent with the nomenclature of its torpedo, the nomenclature of the Mark I Mod. 1 gyroscope had nothing to do with that of the Mark I Mod. 1 5-meter Whitehead torpedo—that is to say, the Mark I Mod. 1 torpedo was so called because of changes to its exercise head and air flask which distinguished it from the Mark I, not because it carried the Mark I Mod. 1 gyroscope. See “General Description Whitehead 5m x 45cm Mark I Torpedo (including Modifications of the 5 m. x 45 cm., Mark I, to be found in the 5m. x 45 cm. Mark I, Mod. 1 Torpedo and Modifications of the 5m. x 45c/m., Mark I, to be found in the 5m. x 45 c/m. Mark II Torpedo)” (c. 1904), p. 38, B45-131, NTS.

²⁸ Chambers, Sears, Bristol, and Gise to SecNav, 27 September 1904, para. 19G, BuOrd 11932/04 (Dept 17755-3) with 12865/03, RG74/E25/B664 [misfiled, should be in B575], NARA.

of the Torpedo Station, Albert Gleaves, asked if the data contained a typo.²⁹ Fourth, with the Leavitt gyroscope, too much time elapsed between the instant that the torpedo started and the instant that the gyroscope took over, during which time (as Fletcher had emphasized in November 1903) the torpedo would be unpredictably deflected off its intended course. Fifth, Gleaves realized that controlling the distance run by Bliss-Leavitt torpedoes would interfere with the functioning of Leavitt's gyroscope.³⁰ Finally, Mason wanted to stimulate development of the air-impulse Leavitt gyroscope by providing spring-impulse competition.³¹ It was an early indication of Mason's concern with the Bliss Company's monopoly on torpedo manufacture.

Under Pressure: A Premature Commitment to an Immature Weapon

While the gyroscope tangle developed, a revolutionary torpedo entered naval service. The initiative behind the new torpedo was not entirely the Bureau's: it acted under sharp pressure from the rest of the Navy, which vented its frustration over the Navy's torpedo situation at the 1903 Naval War College conference. The hypothetical enemy before the officers gathered that summer was Germany, which presented special challenges from a torpedo perspective.³² In war games played to study the problem of fighting the German fleet, the American fleet lost all but once due to inferior speed and

²⁹ Clark [Bliss IoO] to Mason, 28 November 1904, B39-223, NTS; and Gleaves to Mason, 5 December 1904, BuOrd 14497/04 (NTS 5541) with 12865/03, RG74/E25/B664 [misfiled, should be in B575], NARA.

³⁰ Gleaves to Mason, 14 February 1905, BuOrd 16686/3 (NTS 734), RG74/E25/B769, NARA. Since Bliss-Leavitt torpedoes lacked distance gear, the only way to control the distance was to vary the pressure in the air flask or to vary the setting of the reducer. Since the Leavitt gyroscope, in turn, relied for impulse on air directly from the flask and reducer—lacking, say, its own dedicated reducing valve—the impulse would vary with the distance adjustments of the flask and reducer. Due to variations in the impulse, both the time that the gyroscope took to spin up and the time that it kept spinning would vary.

³¹ Mason to Gleaves, 2 March 1905, BuOrd 16686/3-LS275/151-2, RG74/E25/B769, NARA.

³² See Supplementary Tactics, Question 2, p. 43, Problem of 1903, RG12, NHC.

lack of torpedoes on its capital ships.³³ “A number of tactical games carefully played to develop the value of torpedoes shows that they turn the scale of battle in their favor in a most decided manner,” a special sub-committee appointed to study the issue reported, and “[n]o weight of guns and armor can precisely compensate for even the smallest torpedo armament.”³⁴ To solve the problem, the War College concluded that American capital ships must carry (submerged) torpedo tubes and long-range torpedoes.³⁵ Adding high-level backing, the General Board endorsed the War College’s conclusions in a letter to the Secretary of the Navy.³⁶

Pressure to improve the Navy’s torpedo armament was not only top-down but bottom-up. At the same 1903 conference of the War College, the torpedo officer of the Bureau of Ordnance, F. K. Hill, lambasted the absence of submerged torpedo tubes on capital ships. While the short range of “our torpedoes as they now stand” might have justified the decision to keep submerged tubes off capital ships, Hill allowed, the justification “certainly does not apply to the most modern torpedoes developed.”³⁷ Coming from the officer within the Bureau with responsibility for torpedo development, this was a scathing indictment of American efforts.

The obvious target of these criticisms from Hill, the War College, and the General Board was O’Neil, the chief of the Bureau of Ordnance and president of the Board on

³³ Tactical Committee, “Tactics: Report of a Special Committee,” 18 September 1903, Problem of 1903, *ibid.*

³⁴ See especially Supplementary Tactics, Question 4, pp. 45–46, Problem of 1903, *ibid.*

³⁵ Supplementary Tactics, Question 4, pp. 45–46; “Tactics: Report of a Special Committee, Appendix B: Torpedoes,” pp. 6–7, Problem of 1903, *ibid.*

³⁶ Dewey [President, General Board] to SecNav, GB [General Board] 420, 26 September 1903, NARA RG80/E285/B1/V2/P368–69.

³⁷ F. K. Hill, “Submerged Torpedo Tubes and Tactics of the Torpedo,” lecture delivered at NWC in August 1903, RG8/B112/F1, NHC. Emphasis in the original.

Construction. In the former capacity, O'Neil was responsible for torpedo development; in the latter capacity, he was responsible for the decision not to place submerged torpedo tubes on capital ships. Thus he bore the brunt of these widespread complaints about the state of American torpedoes on capital ships. It is noteworthy that the fleet was demanding better torpedoes from the shore experts, like O'Neil, rather than parochial shore experts pushing the latest disruptive technology on a conservative fleet.³⁸ Future development problems would have amply justified more caution from O'Neil.

Under pressure from within his own Bureau and from powerful bodies outside it, O'Neil hastily committed to a radically new technology. In September 1903, the Bliss Company informed the Bureau that it had repaired the experimental turbine torpedo wrecked the previous summer and was ready to submit it for trials.³⁹ O'Neil soon met with Company representatives in Washington to discuss the details of a new torpedo contract. With a tentative agreement in place, O'Neil sent the Bliss Company a draft contract and specifications on 2 November 1903. "As soon as the Bliss Company agree to the within [i.e., enclosed] contract and specifications," he said, "the Bureau will give the order."⁴⁰ Given the timing, this was a remarkable statement. Although the contract for the torpedoes was not actually signed until January 1904, two months after the trial turbine torpedo was tested, O'Neil was prepared to make the contract two weeks *before* the report arrived.

The report, which arrived in late November 1903, was favorable but expressed

³⁸ For an alternative explanation, see William McBride, *Technological Change and the United States Navy, 1865-1945* (Baltimore: Johns Hopkins University Press, 2000), 55.

³⁹ Bliss Co. to O'Neil, 15 September 1903, BuOrd 10986/03 with 9558/01, RG74/E25/B480, NARA.

⁴⁰ Bliss Co. to O'Neil, 29 October 1903, BuOrd 12865/03, RG74/E25/B664 [misfiled, should be in B575], NARA; O'Neil to Bliss Co., 2 November 1903, BuOrd 12865/03, *ibid.* A similar letter followed on 5 November 1903, *ibid.*

significant reservations. It praised the simplicity, reliability, strength, and durability of the turbine engine, which suited it better than reciprocating engines to run at the higher speeds and longer ranges enabled by the superheater. The report also pointed out, however, that the turbine engine had certain disadvantages compared to the reciprocating engine: turbine torpedoes could have not have multiple speed/range settings, because turbines ran most efficiently at the one speed for which they were designed; and the rotational velocity of the turbine could create unbalanced torque.⁴¹ In time, these disadvantages turned out to be significant.

O'Neil focused on the advantages, however, using the report as an endorsement of his policy, and ignoring its qualifications. In December 1903 and January 1904, he formalized the Navy's commitment to the Bliss-Leavitt torpedo by signing contracts for 52 torpedoes.⁴² O'Neil failed to solicit the opinion of the commander of the Torpedo Station. He also failed to ask the Navy Department for advice on the form of the contract, which lacked two clauses that would later become standard: one which imposed penalties for delays in delivery, and another which protected the Navy's rights to devices of its own invention.⁴³ Experience with the first Bliss-Leavitt torpedoes taught the Bureau that the technology was experimental, not perfected, and that these two clauses were necessary in a contract for experimental technology. O'Neil's premature commitment to an immature

⁴¹ Chambers, Sears, and Hill [Chambers Board] to O'Neil, 19 November 1903, BuOrd 13021/03 with 9558/01, RG74/E25/B480, NARA.

⁴² See "Contract for Fifty Bliss-Leavitt Torpedoes, U.S.N., 5m. x 45cm., Mark III, Fitted for Overwater Discharge," 11 January 1904, enclosure to Chambers, Sears, Bristol, and Gise to SecNav, 27 September 1904, BuOrd 11932/04 (Dept 17755-3) with 12865/03, RG74/E25/B664 [misfiled, should be in B575], NARA.

⁴³ The first clause made its debut (as Clause 7) in the March 1905 Contract for 18-inch BL Mark IV torpedoes, and the latter (as Clause 19) in the November 1905 Contract for 21-inch BL Mark I torpedoes. See "Contract for the Manufacture of Torpedoes, U.S. Navy, Fifty (50) Torpedoes, 5m x 45c/m Mark IV," B50-158, NTS, and "Contract for the Manufacture of 300 Torpedoes for the U.S. Navy, Bliss-Leavitt 5-meter, 21-inch, Mark I," B45-151, NTS, respectively.

weapon laid the foundation for later struggles.

The Trouble Starts: “A Reasonable Share of Patriotism” and the Exclusivity Debate

It soon became evident that the Navy had failed to think through the implications of its commitment to the Bliss-Leavitt torpedo. Having replaced O’Neil as chief of the Bureau in March 1904, G. A. Converse fielded a novel proposition in April 1904 from the Bliss Company to sell the exclusive international rights to the Bliss-Leavitt torpedo. The Company had been approached, it informed the Bureau, by “[a] number of interests, having large dealings with foreign governments, and there is little doubt that we could quickly make connections which would lead to very large business.”⁴⁴ Although its business interests pointed abroad, the Company wanted “to defer to the wishes of our own Government.” Therefore, it asked the Bureau to decide whether it wanted the exclusive rights or to free the Company to pursue foreign sales. The Company enlisted its law firm, Herbert & Micou, to help make its case. “Herbert” was Hilary Herbert, former Democratic chairman of the House Committee on Naval Affairs and Secretary of the Navy. “Micou” was Benjamin Micou, former chief clerk of the Navy Department. On 23 April 1904, on behalf of the Bliss Company, the firm formally offered to sell the exclusive rights for \$1.5 million.⁴⁵

Converse thought this too high a price. In a meeting with Herbert on 25 April, he used the £50 (~\$250) royalty that the Bliss Company paid to Whitehead on each torpedo, apparently assuming that the Bliss Company would charge the Navy a similar royalty on

⁴⁴ Bliss Co. to Converse, 21 April 1904, BuOrd 4647/04 with 12865/03, NARA RG74/E25/B575.

⁴⁵ Herbert & Micou to Converse, 23 April 1904, BuOrd 4681/04 with 12865/03, *ibid.*

each Bliss-Leavitt torpedo, to calculate that the Navy would need to order 6,000 torpedoes at that royalty to make the exclusive rights of \$1.5 million economical ($\$1.5 \text{ million} \div \$250 = 6,000$).⁴⁶ Since he did not think that the Navy would need 6,000 torpedoes, he concluded that it would be uneconomical for the Navy to pay the asking price of \$1.5 million.

Herbert was aghast at Converse's rationale. "My dear Mr. Secretary," he wrote in a personal letter to his successor as Secretary of the Navy, "the price of the royalty of an inferior torpedo that can be manufactured by any government that will pay the price, cannot be taken as a factor in estimating the value of the exclusive right to manufacture a torpedo so immensely superior as ours is to the Whitehead." When it was considered that a single \$5,000 torpedo could put a \$6,000,000 battleship out of action; that the Bliss-Leavitt torpedo was superior to the Whitehead; and that the performance of the Bliss-Leavitt torpedo was guaranteed by contract, the exclusive right to manufacture was "certainly" worth more than \$1.5 million. In a marvelous turn of phrase which illustrated the clash between market and nation, Herbert assured the Secretary that the officers of the Bliss Company had "a reasonable share of patriotism," and therefore would prefer to sell the exclusive rights to the United States.⁴⁷

While Herbert wrote as one politician to another, the Bliss Company took a more business-like tone, focusing on the key issue at stake: the exclusivity of the rights. Undermining the basis of Converse's logic, the Company observed that it was not asking the government to pay any royalties. "The question, therefore, to be decided by our

⁴⁶ For a report of the meeting, see Herbert to SecNav, 26 April 1904, BuOrd 4681/04 with 12865/03, *ibid.*

⁴⁷ Herbert to SecNav, 26 April 1904, BuOrd 4681/04 with 12865/03, *ibid.*

Government is not one of royalties,” the Company wrote, “but whether or not it is advisable to prevent any foreign Nation from possessing this weapon by obtaining control of it”—and in so doing, to deprive the Company of foreign sales.⁴⁸

The Company’s criticisms of Converse’s logic were justified. It was indeed inapt, but not necessarily inept, given the novelty of the proposition he was offered. Converse conflated two purchasing arrangements which, despite certain similarities, were distinct. He was thinking of a one-time lump-sum royalty payment on a large lot of items in lieu of royalty payments on each item. Given that the Company undoubtedly built hypothetical lost royalties into the price for the exclusive rights in much the same way that they were built into a lump-sum royalty, Converse was not entirely off base to be thinking in the latter terms. The factor he missed, as the Company pointed out, was foreign sales. Although it was natural for a company in a global marketplace to think in such terms, it would have been unnatural for a naval officer to do so, since the Navy had rarely, if ever, been offered an item of domestic design and manufacture that foreign buyers were interested in, let alone exclusive rights to such an item. The Bliss Company’s offer was a new phenomenon, and it is not surprising that Converse fell back on an old way of thinking about the naval-industrial relationship.

Realizing that he was ill-equipped to handle this new phenomenon, Converse decided to seek advice. In May, a board appointed at his request delivered its report on the Bliss Company’s offer.⁴⁹ After a brief overview of foreign torpedo performance, the

⁴⁸ Bliss Co. to Herbert & Micou, 27 April 1904, enclosure to Herbert & Micou to Converse, 28 April 1904, BuOrd 4681/04 with 12865/03, *ibid.*

⁴⁹ For Converse’s request, see Converse to Fletcher, 29 April 1904, BuOrd 4681/04-LS239/382-3 with 12865/03, NARA RG74/E25/B664 (misfiled, should be B575); for the Board’s report, see Fletcher, Chambers, and Sears to SecNav, 19 May 1904, BuOrd 7218/04 with 12865/03, NARA RG74/E25/B575.

Board declared (incorrectly) that the Bliss Company had “perfected” a torpedo superior to foreign torpedoes. The military value of the torpedo, in the Board’s view, depended on the secrecy of not only its mechanical details, but “just as important or even more important” the results attained by it. The importance of secrecy was due to a “challenge-and-response” dynamic then prevailing among the world’s navies (see the Introduction). “The development of war material has reached such a stage in all first class Naval Powers and the competition to obtain the best weapons is so close,” the Board explained, “that no sooner is it known that one nation has developed a weapon of a given power, than results are soon duplicated by similar weapons in other Navies.” Since the publication of results incentivized competition, it was important not only to keep technological means secret, but also (less obviously) to keep technological results secret.⁵⁰

Because the military value of exclusive rights depended on the ability to preserve secrecy, and because secrecy was likely to be breached, the Board considered the military value of exclusive rights to be temporary. More permanent, and by implication more valuable, was a robust domestic supply system. Pointing to the great armaments firms of Vickers and Armstrong in Britain, and of Krupp in Germany, the Board wished “to emphasize the value to any Government of having within its borders well equipped commercial factories capable of producing war material.” This point is an important reminder, given the extensive literature on the relative decline of Britain and relative rise

⁵⁰ This understanding was evidently widely shared. In 1908, the British informed the Americans, through the naval attaché, that their best results were 1,000 yards at 34 knots and 2000 yards at 26.5 knots (see CIO to Mason, 11 February 1908, BuOrd 16664/104 (ONI 8700), NARA RG74/E25/B766). In fact, the best British results were more like 4,000 yards at 35 knots with the RGF Mark VI* torpedoes they were then converting to heated torpedoes in large numbers, while the experimental heated Mark VII torpedoes they ordered in 1907 were capable of 3,000 yards at 41 knots or 6,000 yards at 29 knots. In other words, the British deliberately under-reported the results they were getting so as to avoid incentivizing competition.

of the United States in the decades before World War I, that in certain important respects, the United States still lagged decidedly behind Britain. Although the board managed to avoid giving a direct “yes” or “no” to the question of whether the Navy should buy the exclusive rights at the asking price, the strong implication of its report was to answer in the negative.⁵¹ Acting on the logic of the Board’s report, Converse informed the Bliss Company in May that the Navy would not purchase the exclusive rights.⁵²

Though abortive, these negotiations were significant. They revealed the clash of perspectives between a navy thinking in terms of national security and a business thinking in terms of international profit. They showed that what was commercially valuable for the Bliss Company was not necessarily militarily valuable for the Navy, and they underscored the difficulty of pricing a commodity when its value was debated. These problems would only become more acute when the Navy discovered that the technology at issue was not perfected but experimental.

The “Sheer” Problem, Command Technology, Servant Technology, and the Commodification of Information

The experimental nature of the Bliss-Leavitt torpedo began to dawn on the Bureau in the early spring of 1905, with the arrival of reports on the performance of the first Bliss-Leavitt torpedoes ordered by O’Neil in late 1903 and early 1904. It soon became clear that the torpedoes had two serious problems: poor depth control in the vertical plane

⁵¹ For Converse’s request, see Converse to Fletcher, 29 April 1904, BuOrd 4681/04-LS239/382-3 with 12865/03, NARA RG74/E25/B664 (misfiled, should be B575); for the Board’s report, see Fletcher, Chambers, and Sears to SecNav, 19 May 1904, BuOrd 7218/04 with 12865/03, NARA RG74/E25/B575.

⁵² Converse to Bliss Co., 28 May 1904, BuOrd 4647/04-LS242/288-90 with 12865/03, NARA RG74/E25/B575.

and poor accuracy in the horizontal plane. The latter was known as “sheer,” referring to the torpedoes’ tendency to “sheer” off from their intended course before taking up a final course parallel but distant from their intended course. Clearly, the Bureau was not dealing with a perfected technology.

In the fall of 1905, naval officers advanced two different hypotheses to explain the sheer problem. One, championed by the assistant inspector of ordnance at the Bliss Company, G. C. Davison, attributed the fundamental cause of the problem to partial cavitation (i.e., the formation of an air cavity) at the tail of the torpedo caused by the streamlines of water past the torpedo as it moved through the water at high speeds, causing the propellers to work in fluids of different densities (water and air).⁵³ Since the problem was most serious when the torpedo was on or near the surface, where the water had relatively little assistance from hydro-static pressure to fill the space vacated by the torpedo as it moved, Davison focused on proper depth-taking and depth-keeping as the key to solving the problem.

The other hypothesis was championed by a naval constructor working at the Washington Navy Yard named D. W. Taylor. He argued that the fundamental cause of the problem was not cavitation as the torpedo moved through the water, but initial roll as the torpedo moved through the air upon discharge from above water. The cause of this initial roll, both he and Davison agreed, was the unbalanced torque generated by the turbine engine. Thus, where Davison focused on depth-taking and depth-keeping as the solution,

⁵³ Davison to Clark, 15 August 1905, enclosed in BuOrd 18172/7, RG74/E25/B873; Davison to Clark, 24 August 1905, enclosed in BuOrd 16928/33, RG74/E25/B790, NARA; Davison to Clark, 16 October 1905, BuOrd 16928/48, *ibid*; and Davison to Clark, 18 September 1905, BuOrd 16928/42, B45-131, NTS.

Taylor focused on balancing the turbine so that its net torque was zero.⁵⁴

Davison's and Taylor's efforts to solve the "sheer" problem marked a watershed in the relationship between the American state and society with respect to armaments procurement. In tasking naval officers to solve the "sheer" problem, the state was investing directly in the development of experimental products by the private sector—in today's parlance, the state was collaborating with private industry on research and development (R&D). This collaboration departed from the traditional procurement process, in which the government either purchased finished products from the private sector or developed its own products from start to finish. Perhaps the most insightful student of this fundamental change in the procurement process was William McNeill, who coined the term "command technology" to describe weapons developed in this collaboration between state and society.⁵⁵ In essence, McNeill saw this collaboration, driven by the growing sophistication and expense of naval armaments in the late nineteenth and early twentieth centuries, as marking the birth of the modern military-industrial complex.

McNeill's student Jon Sumida refined the argument by pointing out that the involvement of multiple parties in the process of invention where previously there had been just one complicated the task of establishing who had invented what, and when.⁵⁶ In particular, where the labor of invention was shared between state and society, how should ownership of the resulting property be divided? That this question had legal

⁵⁴ Taylor to Mason, 23 October 1905, BuOrd 17761/55, RG74/E25/B842, NARA.

⁵⁵ William H. McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000* (Chicago: University of Chicago Press, 1982), 278-279.

⁵⁶ Property rights are a major theme of Sumida's *In Defence of Naval Supremacy: Finance, Technology, and British Naval Policy, 1889-1914* (Boston: Unwin Hyman, 1989).

ramifications is obvious; perhaps less obvious were its political-philosophical ramifications. It was a fundamental tenet of liberal political philosophy, given canonical form in John Locke's *Second Treatise of Civil Government*, that the right to create property by labor, and the right to dispose of property by contract, were natural rights, preceding the formation of government.⁵⁷ Command technology required the participation of government labor, however, throwing the precedence of property before government into confusion. The intellectual stakes of command technology were very high indeed.

Command technology was so important and so complex that it spawned a new class of technology which, to extend McNeill's metaphor, might be called "servant technology": that is, technology dedicated to generating information that could be used to improve command technology. The Bureau of Ordnance acquired two servant technologies in its effort to solve the sheer problem. One was a dynamometer, which measured various aspects of engine performance in a tank of water, so that valuable resources did not have to be spent in running torpedoes on a range.⁵⁸ Another was an improved rolling register, which measured the torpedo's angle of inclination from the vertical as it moved through the water.⁵⁹ Both the dynamometer and rolling register exponentially increased the Bureau's power to generate information and, by implication, to perform independent quality control on products sold by the Bliss Company.

Given its power to affect market relationships, the information generated by

⁵⁷ See especially Chapter 5 ("On Property") of Locke's *Second Treatise of Civil Government* (1690).

⁵⁸ See Mason to Gleaves, 14 September 1905, BuOrd 18533-LS302/204, RG74/E25/B893, NARA; Gleaves to Mason, reporting arrival of dynamometer tank, 21 February 1906, BuOrd 18533/4 (NTS 840), *ibid*; and Gleaves to Mason, 7 March 1906, transmitting the information, BuOrd 17761/97 (NTS 1071), RG74/E25/B842, NARA.

⁵⁹ See Mason to Gleaves, 18 October 1905, BuOrd 17761/41, B45-131, NTS.

servant technology was a commodity unto itself. Indeed, it amounted to a new type of property. To be sure, intellectual property like patents and trade secrets had been around for centuries, but such property could easily be reduced into material, or non-intellectual, property—a patent for an engine could be turned into an engine, a trade secret for a metallurgical formula could be turned into metal. In contrast, commodified information could not readily be reduced into material form: data derived from servant technology could be used to improve command technology, but it could not be transformed into command technology. In fact, because commodities can be traded in markets as though they possess value in and of themselves, their value is at least partly independent of their convertibility to material form. Thus, the acquisition of information-generating servant technology amounted to a stronger position in the information-commodity market, giving servant technology some value independent of its contributions to command technology.

Separately and together, these trends—the emergence of command technology, the growing premium on servant technology, and the commodification of information—challenged traditional understandings of value, property, and ownership. In so doing, they implied changes in price theory and contract law, which the Bureau of Ordnance, without seeking expert counsel, was attempting to cope with in a major new torpedo contract.

Pricing and Purchasing Experimental Command Technology

Needing torpedoes to outfit new construction in October 1905, the Bureau of Ordnance—now headed by N. E. Mason—began negotiating a large new torpedo contract

with the Bliss Company.⁶⁰ These negotiations explicitly addressed some, but not all, of the problems with experimental command technology.

The emergence of the “sheer” problem in spring 1905 had taught the Bureau that it was dealing with experimental technology and that it would therefore have to contribute to the process of improving the imperfect mechanisms. Realizing that some special contractual provision was necessary to protect its property rights in this collaborative process, it sought to introduce a new clause, numbered 19, which prohibited the Bliss Company from exhibiting or selling technology invented by the Bureau without the Bureau’s approval. Unfortunately for its own interests, the Bureau drafted Clause 19 in such a way that it could be at best a partial success. To claim protection for a “device or design” invented by itself under Clause 19, the Bureau had to “state to the [Bliss Company] in writing, at the time when the said device or design is itself conveyed to the [Bliss Company] by written communication from the [Bureau], that the [Bureau] considers that the said device or design is embraced within the provisions of this clause.”⁶¹ This notification procedure required the Bureau to present the Bliss Company with a finished design, but given the nature of command technology, the government could not finish a design without help from the private sector. While recognizing that contracts had to change to deal with command technology, the Bureau was setting itself up for failure with the notification procedure.

The Bliss Company was more concerned that the Bureau was setting the Company up for failure by reserving the right to apply Clause 19 unilaterally. To prevent

⁶⁰ See Bliss Co. to Mason, 20 October 1905, BuOrd 17761/53, RG74/E25/B842, NARA.

⁶¹ See “Contract for the Manufacture of 300 Torpedoes for the U.S. Navy, Bliss-Leavitt 5-meter, 21-inch, Mark I,” 22 November 1905, B45-131, NTS.

unilateral application, the Bliss Company asked that the clause be modified so as to cover only those improvements which the Bureau *and the Company* agreed to in writing.⁶² The Bureau countered that the Company's suggestion would give the Company the power "to absolutely nullify the entire clause," assured it that the requirement for written notification "amply" protected its interests, and rejected its request.⁶³ As a subsequent lawsuit would show, the protection was in fact not at all "ample."

Appropriate contractual language was not the only novelty needed to deal with experimental technology: so too was appropriate price theory. In an echo of the debate over exclusive rights in 1904, the Bureau complained that the price of the proposed new torpedoes was too high, and the Company retorted that the Bureau was using an inappropriate metric of evaluation.⁶⁴ "If the material to be furnished under the proposed contract were of such ordinary commercial character as to involve no other than the common risks incidental to a manufacturing business, and such as to enable costs, risks, and profits, to be accurately calculated," the Company explained, "then we quite agree with the Bureau's contention that our price is unreasonably high."

As a matter of fact, [however,] the contract calls for a weapon having a performance far beyond anything yet offered to the United States or any other navy in the world. It is true, from data already at hand, we are firmly convinced that we can attain the high standard demanded, or naturally we would not enter into the agreement. But it is also true that no such weapon has ever yet been actually built.... [H]uman foresight is fallible, and many great and unforeseeable expenses may, and no doubt will be encountered and we feel that it is no more than reasonable and just that we should have a fair margin for unforeseen reverses, as the burden of responsibility of them falls on us and the Bureau assumes none. We cannot but feel that the price we have asked does not more than fairly cover

⁶² Bliss Co. to Mason, 27 October 1905, BuOrd 17761/59, RG74/E25/B842, NARA.

⁶³ Mason to Bliss Co., 28 Oct 1905, BuOrd 17761/59-LS309/131-32, *ibid*.

⁶⁴ The Bureau made this complaint in a letter which no longer survives, dated 25 October 1905, file reference BuOrd 17761/47; its contents can be inferred from the Company's reply.

such contingencies.⁶⁵

The Company was willing to lower the price, however, if the risks were redistributed: if the Bureau would remove a penalty clause for delays, then the Company would lower its price by \$100 per torpedo. Mason felt that so small a reduction in price did not justify dropping the penalty clause and resigned himself to paying the higher price.⁶⁶ The contract was signed in November 1905.⁶⁷ The time-table for deliveries called for 50 torpedoes in 1906, 125 in 1907, and 125 in 1908.

Though the signatures suggested consensus, the contract left large questions on both sides unresolved. The Bureau would soon have cause to regret its botched drafting of the notification procedure, and the Bliss Company would realize that it should have set its price even higher. While both parties obviously understood that fundamental changes in the procurement process and pricing criteria were underway, their comprehension of these changes was only partial.

Balancing the Turbine, Acquiring a Patent, and Compromising the Contract

As the contract negotiations wound up and wound down in the fall of 1905, the Torpedo Station began trying to solve the “sheer” problem. Although the experiments along the lines of Davison’s theory failed (and therefore will not be discussed further), the work of balancing the turbine went very successfully. From the start, the Bureau intended to cover the balanced turbine with Clause 19 and ordered the Torpedo Station not to reveal any information about it to the Bliss Company—but the Bureau’s execution

⁶⁵ Bliss Co. to Mason, 27 October 1905, BuOrd 17761/60, RG74/E25/B842, NARA.

⁶⁶ Mason to Bliss Co., 28 October 1905, BuOrd 17761/60-LS309/133, *ibid.*

⁶⁷ See “Contract for the Manufacture of 300 Torpedoes for the U.S. Navy, Bliss-Leavitt 5-meter, 21-inch, Mark I,” B45-131, NTS.

of this intention was another matter.⁶⁸

In November 1905, following a preliminary experiment suggested by Taylor to determine the unbalanced turbine's moment of inertia, the Torpedo Station outlined a method for balancing the turbine.⁶⁹ As it was, the turbine, though referred to as a one-wheel turbine, actually consisted of two wheels connected by an intermediate segment which changed the flow of air such that both wheels revolved in the same direction. The Station suggested doing away with the intermediate segment and connecting the two wheels in such a way that they would rotate in opposite directions, meaning that the torque of one would balance the torque of the other. The Station built an experimental balanced turbine on these lines and tested it in the dynamometer tank in May 1906.⁷⁰ These tests showed that the principle of the design was practicable, and suggested that it would eliminate the "sheer" problem.

Mason, the chief of the Bureau, immediately appreciated the significance of the prospect of placing balanced turbines in the Bliss-Leavitt torpedoes. Although the Bureau's past contributions to torpedo design had been minor, he told the Secretary of the Navy, the balanced turbine would make torpedoes with unbalanced turbines "markedly inferior."⁷¹ If the Bliss Company got control of the balanced turbine, Mason feared—presciently, as it turned out—that the Company would try to sell it to foreign governments, and he was determined to avoid such an outcome. Since part of the labor of balancing the turbine had been done by Davison, and part by the government as a whole,

⁶⁸ Mason to Gleaves, 7 November 1905, BuOrd 17761, *ibid.*

⁶⁹ Mason to Gleaves, 10 November 1905, BuOrd 17761/55-LS311/346-8, RG74/E25/B842, NARA; Gleaves to Mason, 12 January 1906, BuOrd 17761/93 (NTS 177/34), *ibid.*

⁷⁰ Gleaves to Mason, 28 July 1906, BuOrd 17761/109 (NTS 3366), *ibid.*

⁷¹ Mason to SecNav, 15 September 1906, BuOrd 17761, B52-157, NTS.

Mason asked the Secretary who owned the property. If Clause 19 represented the Bureau's awareness that command technology complicated the establishment of ownership *between* the public and private sectors, Mason's question to the Secretary showed his awareness that command technology also complicated the establishment of ownership *within* the public sector. It is also noteworthy that Mason was writing to the Secretary: this was the first time that the Bureau had invited substantive department-level involvement into the development of the Bliss-Leavitt torpedo.

Replying to Mason's question regarding the export of technology to foreign governments, the only possible legal means that the Secretary could think of to prevent it was Section 5335 of the Revised Statutes.⁷² Section 5335 embodied a law passed by Congress in 1799 to restrict the conduct of international relations to professional diplomats, after a private citizen named George Logan visited France in 1798 and met with Talleyrand in an unofficial effort to improve relations between the two countries; hence the law was informally known as the Logan Statute.⁷³ It read in part:

Every citizen of the United States ... who, without the permission or authority of the Government, directly or indirectly, commences or carries on any verbal or written correspondence or intercourse with any foreign government or of any officer or agent thereof with an intent to influence the measures or conduct of any foreign government or of any officer or agent thereof in relation to any disputes or controversies with the United States, or to defeat the measures of the Government of the United States ... shall be punished by a fine of not more than \$5,000, and by an imprisonment during a term not less than six months, nor more than three years.

The Secretary doubted whether Section 5335 could be made to penalize the communication of technological plans to foreign powers and said that a test case would

⁷² Newberry to Mason, 21 September 1906, BuOrd 17761/119 (Dept 649-4), B52-157, NTS.

⁷³ John Bassett Moore, *A Digest of International Law*, vol. 4 (Washington: Government Printing Office, 1906), 448-50.

be necessary to answer the question with certainty.

In reply to Mason's question as to whether Davison or the government owned the rights to the balanced turbine, the Secretary requested more information about Davison, who responded by outlining the respective roles of the government and himself in balancing the turbine.⁷⁴ He had submitted a sketch drawing of the device, the government had converted his sketch drawing into a detailed drawing, the government had constructed the turbine according to its detailed drawing based on his sketch drawing, and the government had tested the device.⁷⁵ "In the strict sense of 'development,'" Davison concluded, "no assistance [by the government] was furnished." In the work of "demonstration," by contrast, the government did provide assistance and incur expense. Thus, in the sense of development as "the embodiment of the idea into a concrete object," as opposed to the "strict" sense, the government had provided some assistance. These linguistic acrobatics underscored the difficulty of translating property rights into law when the lines between different parties to and different stages of the invention crossed so frequently.

To secure the rights to the balanced turbine, the Secretary suggested that Davison could take out a patent and assign it to the government.⁷⁶ Davison agreed to do so, "contrary to the advice of friends and legal advisers," who told him that he could make substantial royalties by retaining control of the patent.⁷⁷ Davison applied for the patent in October 1906, and it was issued, as No. 858,266, in June 1907. Its issuance was "very gratifying," Davison acknowledged, "as the claims were unusually broad, so that the

⁷⁴ Acting SecNav to Mason, 21 September 1906, BuOrd 17761/119 (Dept 649-4), B52-157, NTS.

⁷⁵ Davison to Mason, 2 October 1906, endorsement on BuOrd 17761/119 (Dept 649-4), *ibid.*

⁷⁶ Acting SecNav to Mason, 21 September 1906, BuOrd 17761/119 (Dept 649-4), *ibid.*

⁷⁷ Davison to Mason, 22 October 1906, B50-158, NTS.

device should be absolutely protected in spite of any attempts to get around it.”⁷⁸

Like Clause 19, however, Davison’s patent was a pyrrhic victory, reflecting in equal parts the Bureau’s awareness of a problem and its failure to arrive at a solution. In publishing the balanced turbine by patenting it, the Bureau compromised any future claims to the secrecy of the balanced turbine under Clause 19. Where the Bureau had meant to strengthen its contract rights by acquiring patent rights, it had weakened them.

The Bureau was also maladroitly executing the poorly conceived Clause 19 notification procedure. This mess began, innocently enough, when the Bliss Company asked the Bureau to reduce the performance requirements for certain torpedoes under contract.⁷⁹ That was on 17 October—the exact dates are important, because they were at the heart of a later lawsuit. In his reply of 22 October, Mason informed the Company that the torpedoes could meet their contract requirements “by the installation of an improved propelling mechanism” which increased the range and speed and eliminated sheer—this was, of course, a vague reference to the balanced turbine.⁸⁰ On 30 October, a group of Bureau representatives (the Torpedo Board) met at the Bliss Company to witness tests of new torpedoes, where the balanced turbine “was brought up in a general way to give the Bliss Company the idea involved, but without details.”⁸¹ On 29 December, the commander of the Torpedo Station, Albert Gleaves, reported that the Company “has recently actively been experimenting with a balanced turbine,” and that these experiments had begun after the 30 October meeting of the Torpedo Board.⁸²

⁷⁸ Davison to Mason, 8 December 1906, *ibid.*

⁷⁹ Bliss Co. to Mason, 17 October 1906, BuOrd 17761/128, RG74/E25/B843, NARA.

⁸⁰ Mason to Bliss Co., 22 October 1906, BuOrd 17761/128-LS358/374-5, *ibid.*

⁸¹ Gleaves to Mason, 29 December 1906, B50-158, NTS.

⁸² Gleaves to Mason, 29 December 1906, *ibid.*

At this point, more than two months after Mason had first vaguely tipped the Bureau's hand about the balanced turbine, someone finally realized that the Bureau should have held its cards closer to its chest. "If the Bliss Company succeeds by its own unaided efforts in developing a balanced turbine," Gleaves observed, "it will be in a position to entirely free itself from the obligations of Clause 19."⁸³ Since the Company had not yet passed "beyond the experimental stage" in developing the device, Gleaves recommended notifying the Company that Clause 19 covered the device, to which end the Torpedo Station could immediately supply a "sketch" which, by the terms of Clause 19, was necessary to establish a claim.

Coming this late, Gleaves' advice might as well have never come at all: the damage had already been done. For an improvement to be protected under Clause 19, the Bureau had to state "in writing, at the same time when the said device or design is itself conveyed" to the Bliss Company, that it considered the "said device or design is embraced within the provisions of this clause."⁸⁴ The Bureau had described the device to the Bliss Company *without* stating that it was covered under Clause 19, and *without* supplying the device or design thereof. The Bureau did not notify the Bliss Company in writing that it intended for Clause 19 to cover the balanced turbine until 9 November 1906, and it did not provide a drawing until 9 January 1907.⁸⁵ Thus the Bureau had created a window of anywhere from 18 to 79 days between revealing the existence of the balanced turbine and triggering Clause 19 protection. It could scarcely have done

⁸³ Gleaves to Mason, 29 December 1906, *ibid*.

⁸⁴ Clause 19, "Contract for the Manufacture of 300 Torpedoes for the U.S. Navy, Bliss-Leavitt 5-meter, 21-inch, Mark I," B45-131, NTS.

⁸⁵ Mason to Bliss Co., 9 November 1906, BuOrd 17761/128-LS361/231-32, RG74/E25/B843, NARA; endorsement by Mason, 9 January 1907, BuOrd 20361/3, RG74/E25/B1003, NARA.

otherwise, given the underlying inapplicability of the clause to command technology.

The Supply Crisis and the Search for New Production

The emergence of the “sheer” problem, the realization that the Bliss-Leavitt torpedo was far from perfected, the argument over Clause 19 and price, the legal messes associated with the patent and the botched application of Clause 19—all were injuries, arising from the Bureau’s failure adequately to consider important legal questions before committing to the Bliss-Leavitt torpedo. Now it was time to add insult: a supply crisis so serious that vessels were forced to sail for foreign stations without torpedoes, leading to the admission that the American bid for independence from the foreign Whitehead torpedo had failed.

The Bureau and the Bliss Company could not fix the mechanical problems with the Bliss-Leavitt torpedo quickly enough for the Company to be able to mass-produce a reliable torpedo. Even as the Torpedo Station worked to balance the turbine in 1905 and 1906, the Bliss Company was requesting delivery due-dates to be extended, but even with the extensions, Bliss-Leavitt torpedoes were failing to meet their performance requirements as to range and speed.⁸⁶ The situation came to a head in September 1906, when the commander of the Torpedo Station, Gleaves, submitted a long analysis of the torpedo situation to Mason after witnessing Bliss-Leavitt torpedoes perform poorly on a visit to the Company’s Sag Harbor testing facility.

⁸⁶ See Gleaves to Mason, 7 April 1906, BuOrd 16928/65, and 11 April 1906, BuOrd 16928/67, RG74/E25/B790, NARA; Bliss Co. to Mason, 12 June 1906, BuOrd 15157/36, RG74/E25/B680, NARA; Bliss IoO to Mason, 23 July 1906, BuOrd 17761/108, RG74/E25/B842, NARA; Bliss Co. to Mason, 25 July 1906, and endorsements thereon, BuOrd 15157/37, RG74/E25/B680, NARA; Bliss IoO to Mason, 30 July 1906, BuOrd 16928/86, RG74/E25/B790, NARA.

Over the past two years, Gleaves stated, various Bliss-Leavitt torpedoes had made 1,872 runs, which should have been enough to correct all the faults, but instead old flaws persisted and new ones emerged. The effort to fix them had created a backlog, as a result of which an armored cruiser division had just been forced to sail for its foreign station with torpedo tubes installed and her ordnance outfit complete—except for torpedoes. Though the Bliss-Leavitt torpedo would “undoubtedly” be perfected, in Gleaves’ opinion, it was impossible to say how long the process would take, given the Bliss Company’s history of failing to meet its optimistic promises. In the meantime, he argued that the Navy should purchase Whitehead torpedoes abroad as an expedient. “There can be but little doubt that this action,” Gleaves added, “would have a decided moral effect upon the E. W. Bliss Co., and would tend to hasten the complete development of their torpedo.”⁸⁷

Mason agreed, and he was actually prepared to go further. On 17 October, he addressed a long memorandum to the Secretary of the Navy. The Bureau had granted various extensions on torpedo contracts, Mason explained, some at the request of the Bliss Company, and some to allow the Company to install improvements ordered by the Bureau. “While specific reasons for extensions have been urged in almost all cases,” Mason continued,

the contractors have laid great stress upon the fact that this is a new device and that delay and minor failures were therefore to be expected. This plea was submitted however after the delays and failures had occurred. Before the contract was awarded the company’s communications were replete with promises of quick deliveries and wonderful performances. This plea had great weight with the Bureau, but recent events have forced the Bureau to the belief that it has been used in cases where the delay and failure were not limited to those to be expected in the process of evolution, but were more due to the reluctance of the company to discard auxiliary devices of proved inefficiency at an expense to itself and to

⁸⁷ Gleaves to Mason, 15 September 1906, BuOrd 17761/116 (NTS 3963), RG74/E25/B843, NARA.

inferior workmanship than to any other causes, the company hoping to pass the tests required by good luck and tinkering, or in case of failure to have the tests modified to fit the capabilities of the torpedoes.

The Bureau has resisted the efforts of the contractors to force the acceptance of inferior weapons, but in all its dealings with this company concerning torpedoes the Bureau has been handicapped by the knowledge that, due to the monopoly held by the company, the Bureau would have to accept the terms offered or get no torpedoes. The Bureau has become convinced that a belief in the helplessness of the Government has influenced the E. W. Bliss Company in its prices, deliveries and workmanship.⁸⁸

While the Bureau had long realized that “absolute dependence” on the Bliss Company was “a situation of serious disadvantage,” only in the recent past had the Bureau felt that it could do its part to provide “the obvious remedy” for the situation: setting up its own factory. Thanks to its invention of the balanced turbine, the Bureau could acquire the rights to manufacture Bliss-Leavitt torpedoes in its own factory at an acceptable price. “That there may be a question of patent right to be decided, the Bureau admits,” Mason added—and indeed there would be.

Establishing a new factory would take time, however, and the Navy required immediate relief. Since that relief could not be obtained in the United States, the Bureau saw “no recourse save to purchase [torpedoes] abroad.” Mason was reluctant to make the suggestion, but given that “the only beneficiaries of the opposite course would be a monopoly, who besides not being able to supply the Government’s needs have in the past unhesitatingly taken advantage of the Government that protects it”—a description obviously made with a congressional audience in mind—he thought the radical step justified. Therefore, Mason asked the Secretary to seek special appropriations for a

⁸⁸ Mason to SecNav, 17 October 1906, BuOrd 19800-LS358/135-42, RG74/E25/B958, NARA.

torpedo factory and for purchasing torpedoes abroad, and the Secretary did so.⁸⁹

In February 1907, as the Bureau prepared to go abroad for supply, the Bliss Company dropped two bombshells: it had “under course of construction, and nearly completed, a balanced turbine,” and it was experimenting with “a heating device for heating the air outside the flask.”⁹⁰ The first of these has been discussed sufficiently that its potential implications are clear. The second, the so-called outside superheater, was the next generation of heater technology. In 1905, the British firm Armstrong Whitworth & Company and the Bliss Company had signed an agreement (discussed more fully below) in which the Bliss Company promised not to block applications for American superheater patents by the Armstrong Company, and in return the Armstrong Company promised the Bliss Company the American rights to any improvements it made on Leavitt’s original superheater.⁹¹ In the Bliss Company’s experiments, the outside superheater developed 50% more energy than its latest inside superheater. The reason for this superiority had to do with the location of the combustion chamber. When air was heated before passing through the reducer (as it was inside the flask), it lost heat as its pressure was lowered by the reducer, and reached the engine considerably cooler than it had been; but when the air was heated after passing through the reducer, this drop in pressure and temperature was avoided, and the air reached the engine at nearly the same temperature to which combustion had heated it. In his reply to the Company, Mason said only that he was “delighted” to hear about the promising results with the new superheater, and he did not

⁸⁹ See endorsement by Mason, 9 March 1907, BuOrd 16928/96 (NTS 2/62), RG74/E25/B790, NARA.

⁹⁰ Leavitt to Mason, 15 February 1907, BuOrd 17761/212, RG74/E25/B843, NARA.

⁹¹ A copy of the agreement was not found, but some of it is quoted in *E. W. Bliss Company v. United States*, No. 32838 (53 Ct. Cl. 47, 1917).

mention the balanced turbine at all.⁹²

While the Bureau dealt with the fall-out of its premature commitment to the Bliss-Leavitt torpedo by swallowing its pride and purchasing Whitehead torpedoes, the Bliss Company suffered the consequences of its errors regarding price theory in relation to experimental technology. In May 1907, the Company accepted that the torpedoes which it had offered to the Bureau with such fanfare in 1903 could not make their promised performance requirements, and asked that the requirements be reduced.⁹³ The Bureau was willing to do as requested, but at a cost. “[A] price that was fixed at an exorbitant [sic] figure in order to provide for extraordinary expense in the development of an extraordinary weapon,” the Torpedo Station felt, “should not be paid when the extraordinary qualities are not required.”⁹⁴ The Bureau had no intention of paying for an experimental weapon what it had been willing to pay for a perfected weapon.

The Company, however, had no intention of settling for a loss when it had poured so many resources into improving an experimental weapon. “In justice and equity,” the Company replied, “the conditions under which [the contract] was entered into should be taken into consideration.” Contracts for commercial articles

are based on the known performance of previous similar construction. For the performance of the torpedo there was no previous adequate data. The contracts were entered into by us in good faith and based upon what we fairly thought could be accomplished, but it was quite well understood by the Navy Department, as well as ourselves, that the performance required by the contracts was not based on results previously attained; but on certain improvements which at the time it seemed reasonable to suppose could be made.

⁹² Mason to Bliss Co., 26 February 1907, BuOrd 17761/212-LS375/390, RG74/E25/B843, NARA.

⁹³ Bliss Co. to Mason, 16 May 1907, BuOrd 17761/233, *ibid*.

⁹⁴ Torpedo Board [Gleaves, Williams, Davison, and McCormick] to Mason, 23 May 1907, BuOrd 18172/18, RG74/E25/B873, NARA; Mason to Bliss Co., 25 May 1907, BuOrd 17761/233, LS387/543-44, RG74/E25/B843, NARA.

Any board of naval officers looking over the facts would have to conclude that the Company had “energetically and honestly grappled with a vast number of unforeseen [sic] problems ... and that these unexpected difficulties have been caused by unavoidable delays.”⁹⁵

The Bureau was unmoved. Mason reviewed the dispute over the price of the torpedoes that had occurred in October 1905, discussed previously, when, to justify a price that the Bureau considered excessive, the Company had observed that the torpedoes were not conventional commercial articles, that their promised performance exceeded anything that had actually been achieved before, and that unforeseen difficulties were likely to arise—exactly the arguments that the Company was repeating in 1907.⁹⁶ “It is no more than reasonable and just,” Mason directly quoted the Company’s letter of 27 October 1905, adding his own emphasis, “that we should have a fair margin for such reverses, as the burden of responsibility for them falls on us and the Bureau assumes none.” Having stated that its price allowed profit and covered risk adequately, and having explicitly assumed the responsibility for failure, the Company could not very well ask the Bureau to accept inferior torpedoes at the same price. By failing to anticipate the higher safety margins necessary for pricing experimental rather than perfected technology, the Company had backed itself into a corner.

As the Bureau’s disputes with the Bliss Company over price unfolded from May to July 1907, its efforts to secure another source of supply came to fruition. With the approach of 1 July, the beginning of the 1908 fiscal year, when new appropriations

⁹⁵ Bliss Co. to Mason, 25 June 1907, BuOrd 17761/250, *ibid.*

⁹⁶ Mason to Bliss Co., 8 July 1907, BuOrd 17761/250-LS393/546–50, *ibid.*

became available, Mason pressured the Secretary for authorization to purchase torpedoes from the Whitehead Company.⁹⁷ After some back-and-forth over what appropriations Bureau could use for the purpose and how many torpedoes it could order, the Department authorized Mason to buy 50 torpedoes from the Whitehead Company.⁹⁸ Final negotiations were carried out by Bureau representatives in Europe, and the contract was signed on 3 July, two days after the money became available.⁹⁹ The torpedoes would become known as the Whitehead 18-inch Mark V torpedoes; they were the first Whitehead torpedoes purchased by the Bureau in seven years.

Things would get worse for the Bliss Company before they got better. Not only was the Bureau now buying directly from Whitehead, but it was also giving consideration to building Whitehead torpedoes, instead of Bliss-Leavitt torpedoes, in the new government torpedo factory. “Experience with the Bliss-Leavitt torpedo points unmistakably to its abandonment,” explained Gleaves in his annual report for 1906/7,

and the return to the standard Whitehead torpedo, the accepted type of all other countries. The Torpedo Station fully appreciates the difficulties of such a radical step, but it feels that with the absolute knowledge of what obtains abroad on this subject, and the disheartening and discouraging efforts to perfect the Bliss-Leavitt, that it would be neglecting a paramount duty to withhold the recommendation that the Bliss-Leavitt torpedo be replaced by the latest ... Whitehead torpedo, until the manufactures of the torpedo succeed in obtaining a reliable weapon capable of fulfilling with certainty the Bureau’s requirements.¹⁰⁰

The negotiations with the Whitehead Company began in earnest in October 1907, when its agent in Washington, H. C. Sheridan, was empowered to deal directly with the

⁹⁷ Mason to SecNav, 29 May 1907, BuOrd 19800/1-LS388/208–9, and 5 June 1907, BuOrd 19800-LS389/125-26, RG74/E25/B958, NARA.

⁹⁸ SecNav to Mason, 17 June 1907, BuOrd 19800/50 (Dept 7166); Mason to SecNav, 18 June 1907, BuOrd 19800/50-LS391/67; JAG to Mason, 19 June 1907, BuOrd 19800/51 (Dept 7166-2), RG74/E25/B958, NARA. Note the Judge Advocate General’s involvement.

⁹⁹ Gleaves and Davison to SecNav, 10 August 1907, para. 4, RG8/B111/F2, NHC.

¹⁰⁰ Gleaves to Mason, 17 August 1907, Torpedo Station’s Annual Report for FY1906/7, B55-209, NTS.

Bureau.¹⁰¹ He offered the Bureau the right to manufacture Whitehead torpedoes at a royalty of £100 (~\$500) each, provided that the first lot consisted of at least 100 torpedoes, and the next two lots of at least 50 each, plus the patterns, jigs, gauges, drawings for an additional £2,418.16.11 (~\$12,090).¹⁰²

These propositions, Gleaves told Mason, brought the torpedo question “to its most critical stage”: the Bureau had to decide whether it would continue to develop the Bliss-Leavitt torpedo exclusively, or to take up the manufacture of the Whitehead torpedo.¹⁰³ “It is a natural desire to have an American invention of this kind in the lead,” Gleaves allowed, “but as we have only to do with the best, if the American invention is not the best, then it becomes necessary to look elsewhere for what the Government requires.” After four years, from the “promise and expectation of being the most efficient torpedo in the world,” the Bliss-Leavitt torpedo had developed a reputation “so shady that, so far as known, no other nation—except possibly France—will touch it.” By contrast, over the past four years, the Whitehead torpedo had steadily improved. As a solution, Gleaves proposed that the Bliss Company be allowed as free a hand as possible to develop its torpedo, while the Torpedo Factory undertook the manufacture of 100 Whitehead torpedoes. Upon securing an acceptable offer from the Whitehead Company to build Whitehead torpedoes in the Bureau’s factory, Mason immediately made the purchase.¹⁰⁴

Still more business was in store for the Whitehead Company. In late 1907, the

¹⁰¹ See Sheridan to Mason, 17 October 1907, BuOrd 21017/5, and Whitehead IoO to Mason, 29 October 1907, BuOrd 21017/12, RG74/E25/B1043, NARA.

¹⁰² Sheridan to Mason, 25 October 1907, BuOrd 21017/6, and Sheridan to Mason, 28 October 1907, BuOrd 21017/8, *ibid.*

¹⁰³ Gleaves to Mason, 29 October 1907, BuOrd 21017/9, *ibid.*

¹⁰⁴ Sheridan to Mason, 3 January 1908, BuOrd 21017/15; Mason to Sheridan, 4 January 1908, BuOrd 21017/15-LS420/365, *ibid.*

Bureau began to consider the purchase of new torpedoes for new destroyers and submarines, effectively putting the Bliss-Leavitt and Whitehead torpedoes into direct competition.¹⁰⁵ In trials, a new Bliss-Leavitt torpedo made only 34.9 knots for 1,200 yards and 32.6 knots for 2,000 yards; by contrast, the Whitehead torpedoes recently purchased by the Bureau were guaranteed to make 27 knots for 4,000 yards.¹⁰⁶ Keeping its options open, the Bureau felt out the Whitehead Company on the possibility of ordering either 100 or 130 Whitehead torpedoes, and arranged a tentative agreement.¹⁰⁷ Gleaves was strongly for the Whitehead option, given the Bliss-Leavitt torpedo's record "of unbroken disappointments and unrealized promises," and a board of torpedo experts agreed with him.¹⁰⁸

Adding weight to the experts' recommendations was the stunningly good performance of the reciprocating engine in the new Whitehead torpedoes. After experiencing frequent troubles with the Whitehead torpedoes delivered in early 1908, the Torpedo Station traced its difficulties to using the wrong type of oil to lubricate the engine—an example of how a small, cheap change could transform the outcome of a contract costing thousands of dollars.¹⁰⁹ With the right lubrication, the reciprocating engine showed efficiency "considerably in excess" of any results obtained with the turbine, and it maintained that efficiency "for highly desirable variations of speed and

¹⁰⁵ Acting CoO to Bliss Co., 29 November 1907, BuOrd 20160/12-LS415/253, RG74/E25/B987, NARA.

¹⁰⁶ On the Bliss-Leavitt torpedo, see Bliss IoO to Mason, 31 January 1908, BuOrd 20065/8, RG74/E25/B979, NARA; on the Whiteheads, see Gleaves to Mason, 29 October 1907, BuOrd 21017/9, RG74/E25/B1043, NARA.

¹⁰⁷ Williams [BuOrd officer] to Mason, 23 March 1906, BuOrd 21723/1, with enclosed draft specifications and contract, NARA RG74/E25/B1086. The General Board recommended the purchase of 200 Whitehead torpedoes; see Dewey to SecNav, 4 January 1908, GB 420-2, RG80/E285/B2/V5/P182, NARA.

¹⁰⁸ Gleaves to Mason, 26 March 1908, BuOrd 21719/2, RG74/E25/B1086, NARA; Torpedo Board [Gleaves, Williams, Miller, and Babcock] to Mason, 1 April 1908, BuOrd 18172/26, RG74/E25/B873, NARA.

¹⁰⁹ See Gleaves to Mason, 1 February 1908, B62-199, NTS; Gleaves to Mason, 6 April 1908, *ibid.*

range, a performance of which the turbine is inherently incapable.”¹¹⁰ Moreover, there was “evidently no cause for apprehension on the subject of excessive and detrimental engine temperatures caused by this type of superheater.” These statements demolished the foundation of the turbine’s supposed superiority: its ability to withstand heated air.

With any doubts about the Whitehead engine apparently erased, Mason informed the Secretary that he wanted to purchase 130 Whitehead torpedoes, and the contract was signed in July 1908.¹¹¹ The original requirements called for 40 knots for 1,000 yards and 30 knots for 4,000 yards; in November 1908, as the result of range running, they were changed to 41 knots for 1,000 yards and 29 knots for 4,000 yards.¹¹² The specifications for a putatively more powerful Bliss-Leavitt torpedo, by contrast, called for 26 knots for 3,500 yards—a lower speed for a shorter distance.¹¹³ How the mighty had fallen, indeed.

The supply crisis was the most concrete consequence of the Navy’s commitment to the Bliss-Leavitt torpedo, while its return to the Whitehead torpedo marked the failure of its bid for independence. Yankee ingenuity and industry could not produce reliable weapons in sufficient quantities to arm its vessels, and as a result, America slid back into colonial torpedo status.

The Bliss-Armstrong Contract and the Origins of the Superheater Royalty Dispute

Colonial status brought with it international legal complications. The Whitehead

¹¹⁰ Gleaves to Mason, 6 April 1908, *ibid.*

¹¹¹ Mason to SecNav, 16 May 1908, and endorsements thereon, BuOrd 21723/4 (Dept 24970-3), RG74/E25/B1086, NARA; Mason to Sheridan, 16 June 1908, BuOrd 21723/4-LS448/218, *ibid.*; “Contract for Torpedoes,” enclosed in Mason to Wells, 17 October 1908, BuOrd 21723/29-LS463/347, *ibid.*

¹¹² Whitehead Co. Weymouth to Wells, 13 November 1908, and Wells to Mason, 13 November 1908, BuOrd 21723/44; Mason to Wells, 23 November 1908, BuOrd 21723/44, RG74/E25/B1087, NARA.

¹¹³ Paras. 18 and 94B, “Specifications for the Manufacture of Bliss-Leavitt Automobile Torpedoes, U.S.N., 5m x 21”, Mark II,” B60-209, NTS.

torpedoes purchased by the Bureau in 1907 and 1908 contained superheaters potentially infringing the Bliss Company's rights under a 1905 contract with the Armstrong Company, mentioned previously. Like so many other torpedo contracts, the Bliss-Armstrong contract had not caught up to market realities, in particular the fluidity of international mergers and acquisitions, which raised difficult legal questions.

In April 1905, the Bliss Company had signed an agreement with the Armstrong Company relating to the control of superheater patents.¹¹⁴ Clause 2 of this agreement granted the Bliss Company

the sole and exclusive license and authority to use and exercise the said inventions [superheaters] under the said letters patent [American patents that the Armstrong Company wished to apply for] for the whole period of the term to be granted by the said letters patent and any extension of the said term in the manufacture of apparatus for heating compressed air for the purpose of propelling Bliss-Leavitt torpedoes wherever sold by the Bliss Co., and Whitehead torpedoes sold only to the United States Government.

In Clause 9, the Armstrong Company agreed that it would not

at any time during the continuance of this license use or exercise the said invention or grant any license to any other person or persons whomsoever to use or exercise the same for the purpose of propelling Bliss-Leavitt torpedoes or Whitehead torpedoes so far as such Whitehead torpedoes may be intended for sale to the United States Government.

In Clause 11, the Armstrong Company agreed that

in case the said letters patent shall be infringed, the Armstrong Co. shall at their own cost, take all necessary proceedings for effectually protecting and defending the same.

In return, the Bliss Company agreed that it would not "either directly or indirectly oppose or in any way hinder the granting" of American patents for superheaters to the Armstrong

¹¹⁴ A copy of the agreement was not found. The following quotations from and descriptions of the agreement are taken from *E. W. Bliss Company v. United States*, No. 32838 (53 Ct. Cl. 47, 1917).

Company, and that it would pay a royalty of \$25 on each torpedo fitted with superheaters covered by Armstrong's patents.

Several factors complicated this seemingly straightforward agreement. First, the exclusivity of the agreement—and hence whether it was an assignment or a license agreement—was open to question, which affected the Bliss Company's standing to sue for infringement of the patents covered by the agreement.¹¹⁵ Second, Clause 11 of the agreement suggested that the Armstrong Company, not the Bliss Company, had the necessary standing to sue for infringement of the patents covered by the agreement. Third, all contracts signed by the Bureau for torpedoes contained a clause obligating the contractor to hold the government harmless from any claims of patent infringement.¹¹⁶ This clause implied that if third parties believed their patent rights to be infringed, the target of their claim could only be the contractor, not the government. Finally, in 1906, the Armstrong Company (with Vickers) became a partial owner of the Whitehead Company. While Clause 9 of its agreement with the Bliss Company prohibited the Armstrong Company from *licensing* the Whitehead Company, as another firm, to use Armstrong superheaters, the clause did not contemplate the circumstance of the Armstrong Company owning the Whitehead Company.¹¹⁷

The advent of the torpedo supply crisis and the prospect of establishing a

¹¹⁵ This question of the exclusivity of the license and legal standing—not any other of the complicating factors discussed here—was the issue upon which the court's decision in *E. W. Bliss Company v. United States*, No. 32838 (53 Ct. Cl. 47, 1917) turned; see its opinion of 3 December 1917.

¹¹⁶ See, e.g., "Contract for Torpedoes," 7 July 1908, Clause 9, enclosure to BuOrd 21723/29, RG74/E25/B1086, NARA.

¹¹⁷ Based on the Bliss Company's petition, the Court of Claims mistakenly stated the exact opposite: "It does not appear that Armstrong & Co. had any interest in Whitehead & Co. or in torpedoes made by that Company" (*E. W. Bliss Co. v. United States* (53 Ct. Cl. 47, 1917)). Whether and how a correct appreciation of this fact might have changed the Court's opinion is unclear.

government factory prompted a flurry of communications regarding royalty rights. In October 1906, the Bureau asked the Bliss Company what royalties it would charge on Bliss-Leavitt torpedoes built by the government.¹¹⁸ In December 1906, the Company replied that it would charge \$750 per torpedo.¹¹⁹ In June 1907, considering how to spend the new appropriations that would become available in July, and evidently with some idea as to the Bliss Company's rights to the Armstrong superheater, Mason asked the Bliss Company for permission to purchase a limited number of Whitehead torpedoes containing the Armstrong superheater.¹²⁰ At a meeting on 17 June 1907, the Bliss Company agreed to let the Bureau purchase no more than 100 Whitehead torpedoes containing the Armstrong superheater, the amount of the royalty for the superheater to be settled later and agreed on by both the Company and the Bureau. This agreement cleared the way for the Bureau's July 1907 purchase of 50 Whitehead torpedoes.

Negotiations then began to cover any subsequent purchase of Whitehead torpedoes by the Bureau. In October 1907, Vickers, on behalf of the Whitehead Company, offered the Bureau the right to build at least 100 Whitehead torpedoes, except for superheaters and gyroscopes, at the Torpedo Factory.¹²¹ In November 1907, Vickers clarified its October proposal by stating that while the Bliss Company owned the rights to the "first" Armstrong superheater patent, Vickers would be prepared to grant the rights to all improvements made by the Whitehead Company on the original patent.¹²² Obviously,

¹¹⁸ Mason to Bliss Co., 18 October 1906, BuOrd 20160-LS358/107-8, RG74/E25/B987, NARA.

¹¹⁹ Lane [Bliss Co. President] to Mason, 1 December 1906, BuOrd 20160/6, *ibid.*

¹²⁰ The original record of Mason's request was not found; this account is taken from the Bliss Company's petition of 29 May 1914 in *E. W. Bliss Co. v. United States* (53 Ct. Cl. 47, 1917), p. 6, a copy of which can be found as BuOrd 28200/12 in RG74/E25/BBB316, NARA.

¹²¹ Sheridan to Mason, 25 October 1907, BuOrd 21017/6, RG74/E25/B1043, NARA.

¹²² Sheridan to Mason, 4 November 1907, BuOrd 21017/11, RG74/E25/B1043, NARA.

Vickers' standing to make that offer was complicated by the 1905 contract between Bliss and Armstrong and by the 1906 Vickers-Armstrong purchase of Whitehead. On 9 November 1907, the Bureau, referring to the Bliss Company's letter of 1 December 1906 (but not to the alleged June 1907 agreement—a significant omission, from a later legal perspective), notified the Company that it wished to settle the royalty question, and asked the Company to state what royalty it would charge for Bliss-Leavitt torpedoes made by the government, what royalty it would charge for superheaters or gyroscopes made and installed by the government in Whitehead or other torpedoes, and what price (as opposed to royalty) it would charge for superheaters or gyroscopes made by the Bliss Company and installed by the government in Whitehead or other torpedoes.¹²³ On 25 November 1907, the Company replied that it would charge a royalty of \$750 for torpedoes made by the government, a royalty of \$500 for superheaters made and installed by the government in Whitehead or other torpedoes, and a price of \$650 (royalty of \$500 plus production cost of \$150) for superheaters made by the Bliss Company for installation in Whitehead or other torpedoes.¹²⁴

The Company's offer was discussed at a meeting of the Torpedo Board on 3 December 1907. The Board recommended that the Torpedo Factory build Bliss-Leavitt rather than Whitehead torpedoes, despite the high royalty charge, because the Whitehead offer required the Torpedo Factory to build more torpedoes than it could manage.¹²⁵ On 3 January 1908, however, Vickers offered to let the Torpedo Factory build a smaller number of Whitehead torpedoes, except for superheaters and gyroscopes, and the Bureau

¹²³ Mason to Bliss Co., 9 November 1907, BuOrd 20160-LS412/17-18, RG74/E25/B987, NARA.

¹²⁴ Page to Mason, 25 November 1907, BuOrd 20160/12, *ibid.*

¹²⁵ Torpedo Board [Gleaves, Chase, Williams, and McCormick] to Mason, 4 December 1907, BuOrd 18172/23, RG74/E25/B873, NARA.

pounced.¹²⁶ On 4 June 1908, the Bureau ordered 20 superheaters for the Whitehead torpedoes from the Bliss Company, thus avoiding any dispute with Bliss over royalty rights.¹²⁷ In July 1908, the Bureau ordered another 130 torpedoes from the Whitehead Company, plus the right to build, free of royalty charges, 75 Whitehead torpedoes at the Torpedo Factory except for gyroscopes and superheaters.¹²⁸ It was this July 1908 contract between the Bureau and the Whitehead Company that sparked the real controversy, but since it did not erupt until the very end of 1908, it will be covered in Chapter 5.

Tactical Limits on the New Technology, 1903–1906

Trying to develop a gyroscope and turbine torpedo capable of high speeds, long ranges, and angle fire was all well and good, but exploiting their tactical benefits was another matter. Using a turbine instead of a reciprocating engine made it difficult for torpedoes to have multiple range and speed settings, while using angle fire required a targeting system capable of accounting for variables not involved in straight fire. The Bureau of Ordnance and the Torpedo Station appreciated these complications only gradually.

The Mark IV Director

Like guns, torpedoes were of little use if they could not be aimed accurately—but

¹²⁶ Sheridan to Mason, 3 January 1908, BuOrd 21017/15, RG74/E25/B1043, NARA.

See Mason to Sheridan, 4 January 1908, BuOrd 21017/15-LS420/365, and endorsement by Mason to Gleaves, 9 January 1908, BuOrd 21017/17, *ibid.*

¹²⁷ The original record of this order was not found; this account is taken from the Bliss Company's petition of 29 May 1914 in *E. W. Bliss Co. v. United States* (53 Ct. Cl. 47, 1917), p. 7, a copy of which can be found as BuOrd 28200/12 in RG74/E25/BBB316, NARA.

¹²⁸ See "Contract for Torpedoes," 7 July 1908, Clauses 1 and 16, enclosure to BuOrd 21723/29, RG74/E25/B1086, NARA.

aiming torpedoes was easier than aiming guns, and so were the techniques and instruments used to do so. The main instrument used in torpedo fire control was the director. Using the course and speed of the enemy and the course and speed of the torpedo as input variables, the director worked on the principle of similar triangles, reproducing the large triangle formed among the location of own ship, current location of target, and projected location of target in smaller form on the director, as illustrated in Figure 3.3 below.

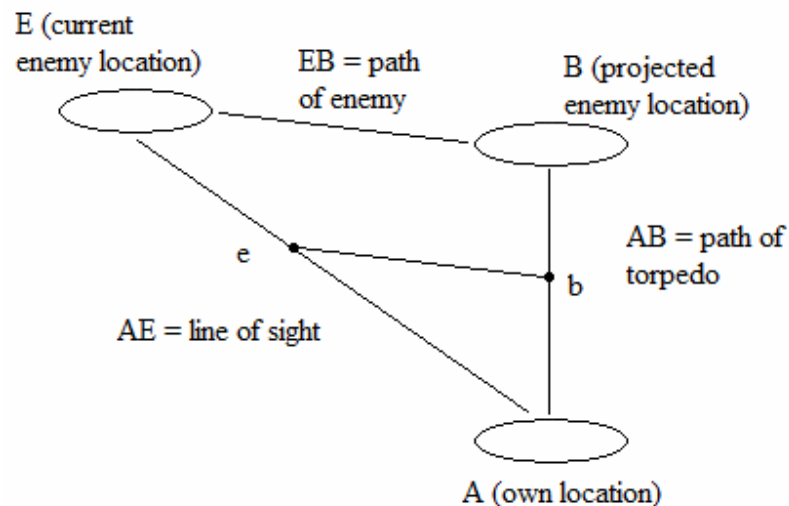


Figure 3.3: The torpedo triangle.
 Triangle AEB is similar to triangle Aeb. Triangle Aeb becomes the director.¹²⁹

In gun fire control, finding the range and correcting for roll, pitch, and yaw were serious challenges. In torpedo fire control, by contrast, the torpedo's balance mechanism and

¹²⁹ Adapted from *Torpedo Manual for Her Majesty's Fleet, in Three Volumes*, vol. 3, *Whitehead Torpedoes. Air Compressors. Net Defence and Obstructions* (London: Eyre & Spottiswoode for HMSO, 1909), plate facing p. 313, Jb 61, AL.

gyroscope corrected for the effects of roll, pitch, and yaw. Moreover, so long as the torpedo's speed was uniform, the range did not have to be known—but if the torpedo's speed varied, then the range had to be known, so that an average speed could be calculated. To make an analogy, the director was to torpedoes as sights were to guns—not as range-finders or range-generators were to guns.

In 1900, the Bureau of Ordnance and the Torpedo Station discussed the design of a new director but decided to wait until establishing whether or not angle fire would be adopted.¹³⁰ In June 1904, with the adoption of angle fire seemingly settled, the Bureau ordered the development of a director to work with angle fire.¹³¹ Fletcher, the commander of the Torpedo Station, submitted a design in October 1904, though he doubted whether it was sufficiently simple to work in battle.¹³² Mason, the chief of the Bureau, tentatively approved the design but did not place any orders for it to be manufactured, and he soon had second thoughts.¹³³ Although the principles of the design appeared to be “mathematically correct,” Mason informed Fletcher's successor, Albert Gleaves, it was so complicated “that the Bureau hesitates to order it placed aboard ship.” He asked the Station to reconsider the design with a view towards simplifying it. Gleaves agreed that

¹³⁰ O'Neil to Mason, 8 December 1899, B23-174, NTS. Torpedo Board to Mason, 15 May 1900, enclosed in Mason to O'Neil, 16 May 1900, BuOrd 5158/00; O'Neil to Mason, 18 May 1900, BuOrd 5158/00-LS130/326; Torpedo Board to Mason, 28 September 1900, enclosed in Mason to O'Neil, 4 October 1900, BuOrd 10220/00, with 7455/97, RG74/E25/B302, NARA. O'Neil to Mason, 11 October 1900, BuOrd 10220/00, B25/201, NTS. Torpedo Board to Mason, 6 December 1900, enclosed in Mason to O'Neil, 11 December 1900, BuOrd 12727/00; Mason to O'Neil, 13 December 1901, BuOrd 11686/01, and O'Neil's endorsement thereon, with 7455/97, RG74/E25/B302, NARA. See also Fletcher to O'Neil, 22 December 1902, B33-162, NTS.

¹³¹ Converse to Fletcher, 6 June 1904, BuOrd 5952; I did not see a copy of this letter, but its date and contents can be inferred from Fletcher to Mason, 18 October 1904, BuOrd 12283 (NTS 4640), RG74/E25/B659, NARA.

¹³² Fletcher to Mason, 18 October 1904, BuOrd 12283 (NTS 4640); Torpedo Board [Capehart, Williams, and Gherardi] to Fletcher, 18 October 1904, enclosed in BuOrd 12283 (NTS 4640), RG74/E25/B659, NARA.

¹³³ Mason to Fletcher, 11 July 1905, BuOrd 12283-LS294/98-9, RG74/E25/B659, NARA.

the design was overly complicated, and three officers were asked to submit alternatives.¹³⁴ Two of the three replies were deemed sufficiently promising that the authors, H. I. Cone and G. C. Davison, were asked to collaborate on a new design.¹³⁵ Based on 25 shots from a stationary ship against a target with a speed of 9 knots at a range which they did not state—easy conditions, in other words—Cone and Davison recommended the adoption of their design, and Mason approved.¹³⁶ The Cone/Davison design became the Mark IV director.

The Mark IV director could be used for straight or angle fire. When aiming a straight shot, three pieces were used, just the same as a regular director: a bar representing the course and speed of the target (the “enemy bar”); a bar representing the course and speed of the torpedo (the “torpedo bar”); and a sighting bar. When aiming an angle shot, a fourth piece was used, namely, a circle running underneath the three bars and graduated in degrees. The intersection of the torpedo bar with this circle indicated the angle at which the gyroscope should be set. This angle then had to be corrected to account for the target range by reference to a pre-calculated table which showed the proper corrections for given gyroscope angles and target ranges.

Exclusions from the design were as significant as the inclusions. One was a correction for parallax due to the distance of the director from the tube, which had to be

¹³⁴ Gleaves to Mason, 14 July 1905, BuOrd 12283/10 (NTS 3755); Torpedo Board [Gleaves, Clark, Chandler, Williams, Davison, and Cone] to Mason, 7 September 1905, BuOrd 12283/11; Mason to Clark, Davison, and Cone, 15 September 1905, BuOrd 12283/11, RG74/E25/B659, NARA. For the replies of all three officers, see Davison to Mason, 6 October 1905, BuOrd 12283/13; Cone to Mason, 20 October 1905, BuOrd 12283/14; Clark to Mason, 26 October 1905, BuOrd 12283/15, RG74/E25/B659, NARA.

¹³⁵ Torpedo Board [Gleaves, Clark, Chandler, Williams, Davison, and Cone] to Mason, 12 December 1905, BuOrd 12283/17, RG74/E25/B659, NARA.

¹³⁶ Cone and Davison to Gleaves, 26 May 1906, enclosed in BuOrd 12283/20, and Mason’s endorsement of 3 July 1906 thereon, RG74/E25/B659, NARA.

estimated, probably by reference to a table showing different parallax corrections for different target ranges.¹³⁷ Another was the use of a gyroscope, in conjunction with timers, to measure both the change of target bearing and the rate of change of target bearing for conversion into target course and speed. The idea of mechanizing and automating the generation of bearing estimates was common in gunnery fire control, where greater accuracy and the elimination of human error were more important, but its proposed application to torpedo fire control was remarkable. “At present the speed and course of target are guessed, and of course this is impracticable,” wrote the proponent of the idea, Lewis J. Clark, “so that the instrument for measuring angular change does seem a necessity.”¹³⁸ It is not clear that the significance of Clark’s suggestion was understood.¹³⁹ The most far-reaching proposal of all came from Davison, who, comparing directors to gun sights, argued that a supporting system distinct from the directors and their operators was needed to collect and calculate data needed for input into the director. He suggested that both plotting and automatic gyro-correction for the effects of yaw should form part of an integrated torpedo fire control system.¹⁴⁰ Both Clark and Davison sought to adapt the more sophisticated methods of gunnery fire control to torpedo fire control.

That level of sophistication was far off, however. In a tepid endorsement of the new director, Gleaves rejected the idea of adding a telescope to the sighting bar on the

¹³⁷ See “General Description of Torpedo Director, U.S. Navy, Mark IV,” October 1907, pp. 1–2, B59-169, NTS. Such a table is mentioned in Gleaves to Mason, 31 May 1906, BuOrd 12283/20, RG74/E25/B659, NARA. British directors included a piece called the “tangent bar,” which the American director lacked, for readjusting the sights to account for parallax.

¹³⁸ Clark to Mason, 26 October 1905, Para. 2, BuOrd 12283/15, RG74/E25/B659, NARA.

¹³⁹ See endorsement by Gleaves, 4 November 1905, BuOrd 12283/15, RG74/E25/B659, NARA.

¹⁴⁰ Davison to Mason, 6 October 1905, Para. 3 and section under “Course and Speed Finder,” BuOrd 12283/13, RG74/E25/B659, NARA. Mason referred Davison’s suggestion to the Fire Control Board then in session; see Mason to SecNav, 15 December 1905, BuOrd 12283/17-LS316/444, RG74/E25/B659, NARA.

grounds that sighting errors were “insignificant when compared with the other errors (course and speed of enemy; speed of torpedo; setting of gyro; tactical radius; etc.) which enter into the problem.”¹⁴¹ Although the Mark IV director was capable of dealing with angle fire in principle, it was error-ridden in reality.

The Turbine, the Reducer, and Uniform—but Single—Speed

To begin with, the subtle importance of the reducer must be understood. The reducer governed the pressure of air admitted to the engine, which in turn governed the speed of the torpedo. Without an effective reducer, the torpedo’s speed varied. For reasons explained above, uniform speed was crucial for targeting purposes, because it eliminated the need to know the target range. Once reducer improvements enabled torpedoes to run at uniform speeds, further improvements could enable torpedoes to run at different uniform speeds for different ranges.

In theory, the turbine engine militated against multi-speed torpedoes, because turbines ran most efficiently at the one speed for which they were designed, as experiments confirmed.¹⁴² Apparently theory differed from practice, however. In 1906, the commander of the Torpedo Station made the startling admission that the same turbine, gear ratio, and propellers were being used in torpedoes with different speeds.¹⁴³ If the gear ratio and propellers were the same, then the turbine itself was being run at different speeds. Different turbines for multi-speed torpedoes were not developed, probably due to lack of resources.

¹⁴¹ Endorsement by Gleaves, 5 July 1906, BuOrd 12283/20, RG74/E25/B659, NARA.

¹⁴² See Gleaves, “Torpedoes,” lecture delivered at the Naval War College on 23 July 1906, p. 42, B52-157, NTS.

¹⁴³ Gleaves to Mason, 6 October 1906, Para. 7, BuOrd 19377/12 (NTS 4255), RG74/E25/B938, NARA.

The fact that the Navy, for whatever reason, was running the same turbine at different speeds suggests that the main obstacle to multi-speed torpedoes was not the turbine but the reducer. Indeed, multiple sources attest to the Navy's attempt and failure to develop a dual-adjustment reducer.¹⁴⁴ "It is apparently impossible," the Bureau of Ordnance stated in formalizing the principle that each torpedo mark would have only one range and speed, "to get a controlling or reducing valve that can be accurately set for different speeds."¹⁴⁵ The possibility of multiple range adjustments was further limited by the abandonment of distance gear in the Bliss-Leavitt torpedoes, which meant that the only way to reduce the distance was to charge the air flask with less air, an impracticable method in action (although not in exercise).¹⁴⁶

In theory, two settings were desirable: a higher-speed, moderate-range setting for use from torpedo vessels, which would rely on surprise or the distraction of enemy capital ships to attack at relatively short ranges; and a lower-speed, long-range setting for use from capital ships, which would remain at long range from the enemy battle line. If the same torpedoes were not capable of dual adjustment, then different torpedoes had to be built for different classes of vessels. Moreover, the lack of a long-range setting on short-range torpedoes indirectly limited the tactical freedom of destroyers: either destroyers had to leave the ships which they were supposed to be defending from enemy

¹⁴⁴ For the unsuccessful attempts to develop a multi-speed reducer, see Fletcher to Bristol, 31 May 1904, B39-223, NTS; Fletcher to Hepburn, 8 July 1904, B42-347, NTS; P. Williams to Fletcher, 13 September 1904, and Fletcher to Mason, 22 September 1904, BuOrd 11140/04 (NTS 4143) with 9890/03, RG74/E25/B565, NARA; Gleaves to Mason, 17 January 1905, BuOrd 15157/5 (NTS 147), RG74/E25/B680, NARA; Mason to Gleaves, 20 July 1905, BuOrd 17761 [referenced in Torpedo Board to Mason, 5 September 1905, NTS B44-358]; Torpedo Board to Mason, 5 September 1905, B44-358, NTS; and Mason to Gleaves, 18 September 1905, BuOrd 17761/28, B45-131, NTS.

¹⁴⁵ Mason to Gleaves, 18 September 1905, BuOrd 17761/28, B45-131, NTS.

¹⁴⁶ See F. K. Hill, lecture to NWC, "Submerged Torpedo Tubes and Tactics of the Torpedo," August 1903, p. 12, RG8/B112/F1, NHC.

torpedo craft to fire torpedoes at enemy capital ships, or they had to stay near their capital ships to protect them but forgo the opportunity to sink enemy capital ships. Without the ability to fire torpedoes at long range, destroyers could not perform offensive and defensive missions simultaneously.

The 21-inch Bliss-Leavitt Mark II and Mark II Mod. 1 Torpedoes, 1907–1908

While the Bureau's and Bliss Company's experiences with the first three Bliss-Leavitt models—the 18-inch Mark III and IV, and the 21-inch Mark I—were little short of disastrous, the development of the 21-inch Mark II and Mark II Mod. 1 went more smoothly. The Mark II torpedoes accounted for 200, and the Mark II Mod. 1 accounted for 50, of the remaining torpedoes under the November 1905 contract, the first 50 having constituted Mark I.¹⁴⁷ When the Bliss Company had approached the Bureau in February 1907 to discuss the design of the Mark II, the Bureau effectively washed its hands of the matter, giving the Company full freedom—and full responsibility—to develop the design.¹⁴⁸ Of the changes between the Mark I and Mark II designs, two were especially noteworthy: the Mark II had the Company's own balanced turbine and the outside superheater developed by the Armstrong Company.¹⁴⁹

At first, the pattern of disappointment seemed to be repeating itself. Throughout 1907, the Mark II torpedoes performed poorly, exhibiting range, speed, and depth

¹⁴⁷ On the nomenclature, see Miller to Mason, 6 March 1908, BuOrd 20939/30, and Bristol to Mason, 23 November 1908, BuOrd 20939/82, RG74/E25/B1038, NARA.

¹⁴⁸ Leavitt to Mason, 17 December 1906, BuOrd 17761/172; Mason to Bliss Co., 1 February 1907, BuOrd 17761/172-LS372/286, RG74/E25/B843, NARA.

¹⁴⁹ McCormick to Mason, 12 July 1907, BuOrd 20939/2, RG74/E25/B1038, NARA.

problems.¹⁵⁰ Early in 1908, however, the Company's position began to improve. The Bureau had found, in running ten 21-inch Mark I torpedoes at Key West the previous spring, that they had heeling tendencies which caused sheer—despite the fact that they had balanced turbines. In a throwback to Davison's old theory, Gleaves believed that the problem was caused by streamlines along the torpedo and at the propellers.¹⁵¹ The Bliss Company discovered the real culprit: the exhaust from the torpedo got mixed up with the propellers (effectively causing partial cavitation), “an accident of design which no one could have suspected of influencing the performance of the torpedo.”¹⁵² This explanation of the heeling tendency would later loom large in court, but the Bureau did not appreciate its significance at the time. Mason gave the Company some breathing room, and a remarkable admission, when he extended the deadline for delivering the Mark II torpedoes, on the grounds that “sufficient time for the development of this torpedo was not allowed in the original contract.”¹⁵³

The extension was more or less unnecessary. By September 1908, the Bliss Company had completed and passed through shop tests the remaining 250 torpedoes under the November 1905 contract, within the original time-frame for final (though not initial) delivery, and the torpedoes were exceeding their contract requirements for range and speed.¹⁵⁴ At Leavitt's urging, the Bureau agreed to soften several requirements

¹⁵⁰ McCormick to Mason, 3 May 1907, BuOrd 17761/224, and 11 December 1907, BuOrd 17761/325, RG74/E25/B843, NARA.

¹⁵¹ Gleaves to Mason, 18 May 1907, Para. 8, BuOrd 19339/41, RG74/E25/B935, NARA.

¹⁵² Page to Mason, 17 January 1908, Para. 6, BuOrd 17761/342, *ibid*.

¹⁵³ Mason to Bliss Co., 19 February 1908, BuOrd 17761, enclosed in Miller to Mason, 6 November 1908, BuOrd 17761/386, RG74/E25/B844, NARA.

¹⁵⁴ Leavitt to Mason, 17 September 1908, and Miller's [Bliss IoO's] endorsement thereon, 21 September 1908, BuOrd 17761/378, *ibid*.

relating to buoyancy, depth-keeping, and tactical diameter.¹⁵⁵ In a more telling sign of progress on the 21-inch front, the Bureau agreed to let the Company bid on a new order of 21-inch torpedoes, even as it refused to let the Company bid on the less reliable 18-inch model.¹⁵⁶

The Strategy of the Weak?

What did not happen in history can be just as noteworthy as what did happen. Given the U.S. Navy's second-class status in the balance of naval power, and its need to defend a newly acquired Pacific empire after the Spanish-American War, one might expect that it gravitated to torpedoes and torpedo vessels as the inexpensive weapons of the weak. (A strategy built around them was known as "flotilla defense" in Britain, and it is discussed in the next chapter.) Instead, the U.S. Navy preferred to invest in big guns and capital ships, competing symmetrically rather than asymmetrically against the great naval powers. Its choice requires explanation.

In the Navy's eyes, the main argument against flotilla defense was budgetary. Torpedoes and torpedo craft cost less than big guns and battleships, and the Navy wanted reasons to justify a larger budget, not reasons to cut it.¹⁵⁷ True, the vast oceans surrounding the United States did not lend themselves to flotilla defense as readily as the narrow seas around Britain, but the harbors and waters of its newly acquired Pacific

¹⁵⁵ Leavitt to Mason, 17 September 1908, BuOrd 17761/378; Bristol to Mason, endorsement of 5 October 1908, BuOrd 17761/378; Mason to Bliss Co., 7 October 1908, BuOrd 17761/378-LS463/362, *ibid.*

¹⁵⁶ Page to Mason, 30 November 1908, BuOrd 17761/387; Mason to Page, 9 December 1908, BuOrd 17761/387-LS472/469; Page to Mason, 11 December 1908, BuOrd 17761/389; Mason to Page, 15 December 1908, BuOrd 17761/389-LS474/9, *ibid.*

¹⁵⁷ This account rests on Nicholas Lambert, "The Influence of the Submarine upon Naval Strategy, 1898–1914" (Ph.D. dissertation, University of Oxford, 1992), 89–102.

empire were another matter. Until 1907, the Navy refused to consider using flotilla defense to protect the Philippines, preferring instead to rely on its battlefleet to intimidate potential adversaries from attacking—“strategic deterrence” over “tactical deterrence,” in Nicholas Lambert’s felicitous phrase.¹⁵⁸ In the face of naval opposition, Congress supported flotilla defense because it was cheaper, and urged submarines on the resisting Navy. When combined with congressional pressure, a diplomatic crisis convinced the Navy to change course. The West Coast’s discrimination against Asian immigrants led to a war scare with Japan in late 1906 and converted the threat to the Philippines from abstraction to imminent reality. The Navy suddenly warmed to the idea of flotilla defense, proposing to move 60% of its submarine force into Asian waters. Its newfound interest stalled, however, once the threat had passed, and the Navy continued to rely on its battlefleet.

Conclusion

What had gone wrong with American torpedo development? In 1909, Gleaves’ successor as the commander of the Torpedo Station, Mark Bristol, offered one possible answer. In 1904, he recalled, it was believed that the Bliss-Leavitt torpedo

was to lead the world. It did then, and if it had not been for the short-sighted policy of the Bliss Company, that believed it had struck a ‘get rich quick’ scheme, which others could not beat, this torpedo or one on the same principles would still lead the world. . . . [B]y failing to improve the turbine, except in minor ways which our Government has virtually forced upon Mr. Leavitt, the Bliss-Leavitt torpedo today is inferior to the Whitehead except as to simplification of the mechanism due to the turbine.¹⁵⁹

¹⁵⁸ Lambert, “The Influence of the Submarine upon Naval Strategy,” 92.

¹⁵⁹ See Bristol, “Lecture on Torpedoes,” lecture delivered at NWC on 26 August 1909, pp. 10-11, B66-173, NTS [copy in RG8/B111/F3, NHC].

Bristol's explanation of what had gone wrong may have been true, but it was not the whole truth. Officers affiliated with the Bureau of Ordnance had their own reasons, regardless of the truth, to blame the Company, which made a convenient scapegoat for diverting attention from the Bureau's own mistakes.

Fundamentally, responsibility for the premature and over-optimistic commitment to the Bliss-Leavitt torpedo lay with the Bureau. True, those who would command the Navy's vessels in battle (today's military would call them "warfighters") pressured the Bureau by identifying what they believed, for tactical reasons, to be a serious weakness in the Navy's torpedo armament—but that was their job. It was the Bureau's job to resist that pressure if necessary, and when dealing with command technology, resistance was indeed necessary. In its absence, the Bureau failed to subject the Bliss-Leavitt torpedo to a sufficiently rigorous development process and sent a deeply flawed weapon into production.

Belatedly fixing undetected mechanical flaws—for instance, balancing the turbine—proved easier than overcoming undetected intellectual challenges. Experimental technology required different pricing and risk assessment from perfected technology. The Bliss Company understood that some difference was necessary, but it did not understand just how extreme the difference was, and it had to swallow a financial loss in consequence. Command technology demanded seismic shifts in the relationship between the public and private sectors, with far-reaching legal and political-philosophical adjustments to match, and the Bureau was only partly up to the challenge. Its insertion of Clause 19 into the contract reflected awareness that some change was necessary, but its

drafting of the notification procedure, its botching of the notification, and its application for a patent which potentially weakened its contract rights showed that it was unaware of all the necessary changes. The government would pay for the Bureau's mistakes with a rash of lawsuits on the eve of World War I, and with a navy that was scarcely equipped to enter the war, even if its commander-in-chief had wanted it to.

Chapter 4: British Torpedo Development, 1903–1908

“You must remember that the inventor may be lured away
from the Government service for his brains.”
– H. C. L. Holden (Superintendent of the RGF), 1905¹

Introduction

Of the three major new pieces of torpedo technology adopted by the U.S. Navy before 1902—the gyroscope, the superheater, and the turbine engine—the Royal Navy had adopted only the first. The increase in effective ranges enabled by the gyroscope presented new opportunities, but also new problems. Longer ranges made it more difficult for firing officers to estimate target course and speed, and they also increased the probability of misses. Moreover, the gyroscope itself could fail and cause a catastrophic circular run. To cope with these problems, the Royal Navy overhauled its torpedo practice regime, tried to increase its rate of torpedo fire, and experimented with gyroscope safety devices. While it worked to iron out the gyroscope’s kinks, it also developed another important piece of new technology: the superheater. Almost simultaneously, the Armstrong Company introduced a dry outside superheater, and a naval officer named S. U. Hardcastle began working on a wet superheater. The latter was a great success by 1908, but its development caused friction with the Armstrong Company and raised difficult

¹ Testimony of Colonel H. C. L. Holden [SRGF], 25 October 1905, Appendix VII, “Report of the Inter-Departmental Committee Appointed to Consider the Regulations as to the Taking out of Patents by Officers and Subordinates in Government Employment, with Appendices, 1905–06,” WO 32/5080, TNA.

questions about Hardcastle's property rights. At the same time, the Navy's torpedo supply base was undergoing major changes: the Armstrong Company and Vickers Company became co-owners of the Whitehead Company, and the relocation of the Navy's torpedo factory from Woolwich to Greenock began. The constantly improving performance characteristics of torpedoes continued to pose major tactical challenges, but they also enabled the Royal Navy to perform its traditional strategic missions in the face of budgetary declines, forming the basis of a revolutionary way of thinking about naval power.

The Gyroscope's Loose Ends: Longer Range, Rate of Fire, Uniform Speeds, and Gyro Failures

In 1902, the Admiralty had undertaken a thorough reformation of torpedo practice "to bring this instruction in peace time more on a level with what will be done in war."² The advent of the gyroscope had eliminated unpredictable deflection by the torpedo, making it more accurate, but it had also introduced a complicated piece of equipment into the torpedo, making it harder to care for, and it had lengthened effective torpedo ranges, making it more difficult to estimate the course and speed of the target. To deal with the former, the Admiralty issued a series of instructions on gyroscope care and began developing a safety gear in case the gyroscope failed, discussed below. To improve officers' ability to estimate target course and speed, the Admiralty instituted fleet torpedo

² Minute by ADNO, 16 July 1902, G5272/02, PQ/03/2914/33-35; see also his minute of 21 January 1903, G694/03, PQ/03/2914/36-37.

practice, in which vessels fired torpedoes with collision heads at each other.³ Fleet torpedo practice was not intended to mimic the conditions of actual battle. In 1905, the maximum range allowed for firing torpedoes in fleet practice was 1,800 yards—not the longest range which torpedoes could run, and too short to be a likely battle range.⁴

The Navy's first fleet torpedo practices, held in 1903 and 1904, immediately confirmed two ideas that had been circulating for at least a year. One was that the increase in torpedo ranges meant that a higher percentage of torpedoes would miss their targets due to errors in estimating target course and speed. To compensate for this higher miss rate, more torpedoes had to be fired.⁵ As H. J. May had pointed out in 1902, the lengthening of ranges put a premium on the rate of torpedo fire to make up for misses.⁶ In 1903, the Navy began experimenting with ways to increase the rate of fire from the submerged tubes of large ships. The sequence for loading a submerged tube was as follows:

- opening a drain valve to allow water to drain from the tube
- closing a sluice valve at the outer end to prevent water from entering the tube
- loading a torpedo into the tube from the inner end
- closing the rear door to prevent water from entering the ship
- opening the sluice valve to allow water to enter the tube
- running a protective bar out from the tube
- firing a torpedo along the protective bar by impulse pressure.

To reload the tube, the bar had to be pulled back in and the sluice valve closed. The purpose of the bar was to protect the rear of the torpedo from damage: if the torpedo was

³ Collision heads were collapsible heads that prevented the bodies of torpedoes from injury upon impact with a ship.

⁴ *Torpedo Manual*, vol. III., 1898, parts. I-II (with 1906 Addenda) (Admiralty, Gunnery Branch, 1 January 1906), 195–98, Jb 59, AL.

⁵ "Paper prepared by the Director of Naval Ordnance and Torpedoes for the Information of his Successor," 31 December 1903, 16.

⁶ May to President of RNC Greenwich [Montgomery], 1 August 1902, ADM 1/7617, TNA.

fired without the bar, it was feared that the current of water passing the ship would push against the front of the torpedo as it left the tube while its rear was still inside the tube, thereby straining and possibly damaging the torpedo. Having the bar go out *in front of* the torpedo instead of *with* the torpedo was a distinctive feature of the British system. In the Armstrong submerged tubes (discussed in Chapter 1), an inner tube ejected with the torpedo performed the same protective function as the bar.

The need to bring the guide bar back in before closing the sluice valve and placing a torpedo in the tube slowed the loading time, and in 1903, the fleet was asked to try closing the sluice valve with the guide bar still out, along with any other time-saving measures it could think of.⁷ Reports arrived in 1904.⁸ The new record-holder, the armored cruiser *Cressy*, beat the previous fleet-wide record of 2 minutes and 2 seconds with a reloading time of 50.75 seconds.⁹ In addition to the fleet's work, the Admiralty convened a conference in November 1904 to consider the whole question of submerged discharge. The conference made a number of recommendations to improve the loading time, some minor, like increasing the size of the drain valve, and others major, like using electricity rather than a hydro-pneumatic system to run the bar in and out and a handier "purchase" for moving torpedoes in the torpedo rooms.¹⁰ Even with the old tube, the introduction of a new purchase into *Vernon's* tender for submerged discharge, *Furious*, allowed her crew to make an average reloading time of 32.4 seconds.¹¹ Aside from improvements to the torpedo rooms, Portsmouth Dockyard submitted seven designs of new tubes, along with

⁷ ART03/vi, 46.

⁸ These are quoted in ART04/45–51.

⁹ An ironic achievement, since *Cressy* would be sunk, along with *Aboukir* and *Hogue*, by a single German U-boat on 22 September 1914.

¹⁰ ART04/Appendix H.

¹¹ ART05/38.

one from the Engineer-in-Chief's Department, and one from the torpedo school *Defiance*. A second conference reported on these designs in May 1905, recommending three— Designs B, G, and J—for further investigation.¹² In Design B, fitted to *Dreadnought*, the bar was worked by electricity instead of hydro-pneumatic power, the side and rear doors of the tube could be opened and closed simultaneously, the gear for operating the sluice valve was improved, and the size of the drain valve was increased.¹³ By 1907, it had emerged as the winner, and the Navy had a new submerged tube design.

The introduction of fleet torpedo practice also confirmed that the increase in range made knowledge of the torpedo's speed more important. Commenting on the Mediterranean Fleet's practice, Commander in Chief Admiral Sir Compton Domville noted, "the speed of a torpedo ... must be an absolutely known quantity" and would "remain a grave source of error" if unknown.¹⁴ When the speed varied over the range, the range had to be known in order to calculate the average speed. So long as ranges were short, say, within 1,000 yards, the effect of errors in estimating the average speed was small, but when the ranges lengthened, the effect of errors became large enough to make it likely that torpedoes would miss their targets.

In 1903, the Royal Navy resumed experiments with the reducer to determine if a new model would produce more uniform speeds. Indeed it did, halving the variation in the speed of an 18-inch torpedo, and it was approved for all torpedoes.¹⁵ The effort to achieve a more uniform speed gained momentum the following year from the re-establishment of the Torpedo Design Committee, which met for the first time in February

¹² Report of the conference, quoted in ART05/34–36.

¹³ "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," 1907, 37–38.

¹⁴ Domville to SecAdm, n.d. (but reporting on practice carried out 15 August 1904), quoted in ART04/62.

¹⁵ ART03/38–41.

1904.¹⁶ While the proximate cause for the reconstitution of the Committee was the need to design a new 18-inch torpedo, the Committee also affirmed the desirability of uniform speeds and suggested appropriate ones for each Mark of torpedo in service; the tactical rationale for the speeds it suggested is discussed below.¹⁷

In addition to faster submerged fire and uniform speeds, the gyroscope also put a premium on new safety measures. If the gyroscope failed for any reason, the vertical rudders actuated by the gyroscope would lock in position and steer the torpedo in a circle back towards the ship that had fired it, turning it into a source of danger to one's own fleet. While the Navy worked to eliminate the causes of gyroscope failure, it also attempted to develop safety gear for rendering the gyroscope harmless in case of failure.¹⁸ *Vernon* began experiments along these lines in 1903, when it tried a Royal Gunpowder Factory (RGF) device to sink the torpedo if the gyroscope steered it too far off course, and a Whitehead Company device to control the course of the torpedo by automatically moving the rudders from side to side at regular intervals.¹⁹ Although both devices worked well on some occasions, they caused the gyroscope to fail when it was working correctly on others, and were therefore rejected. In lieu of introducing safety gear into the gyroscope itself, *Vernon* experimented with different methods for increasing the turning circle of torpedoes, the idea being that the longer the torpedo took to turn back whence it came, the less likely it would be to strike one's own ships in the event of gyroscope

¹⁶ See PQ/04/3011/229–30. The Committee was established by G514/2226/04 of 6 February 1904.

¹⁷ Second Report of the TDC, n.d. but submitted 29 August 1904, ART04/134–36.

¹⁸ See "Paper prepared by the Director of Naval Ordnance and Torpedoes for the information of his Successor," 31 December 1903, 17; ART04/35; ART05/28; ART06/17; and minutes on G5864/06, PQ/06/3224/685–86.

¹⁹ ART03/45.

failure.²⁰ After several alternatives failed, *Vernon* settled on reducing the size of the vertical rudders as a temporary solution until a better one was found.

Finding one took several years. In 1904 and 1905, *Vernon* tried five safety gears, of which one emerged victorious: Gyroscope Safety Gear No. 15.²¹ Twelve were issued to the torpedo schools and seagoing ships for trial in 1906 and performed satisfactorily, but a simpler design, Gear No. 28, was adopted in 1908, only to develop its own flaws in 1909.²² The search for a gyroscope safety gear continued into 1912, when the adoption of air-driven gyroscopes made such gear much less urgent; this story is covered in Chapter 6.²³

New Designs: The Last Cold Torpedoes and the First Heated Torpedoes

At the close of 1902, the most modern torpedoes in the Navy's arsenal were the 14" RGF Mark X* and 18" RGF Mark V*, which embodied both the promise and the problems of the previous seven years of torpedo development. They had the latest gyroscopes, valve groups, engines, and nickel-steel air flasks (distinguishing them from the Mark X and Mark V), but they lacked engines designed to work with the higher flask pressures enabled by the use of nickel steel.

The 14-inch Mark XI torpedo, which began to be built in 1903, was the first to marry the nickel-steel flask with a new engine.²⁴ Depending on the reducer setting, with a working pressure of 1,700 psi (as opposed to the 1,350 psi of simple-steel-flask

²⁰ ART04/45–46.

²¹ ART04/38–40, ART05/28–29.

²² ART06/16; ART 07/16–17 ART08/11; ART 09/19.

²³ ART 10/48–49; ART 11/26–29; ART 12/18

²⁴ ART03/47.

torpedoes), the Mark XI could make around 29 knots for 600 yards and 24.5 knots for 1,500 yards. No sooner was this breakthrough achieved, however, than the 14-inch torpedo was abandoned altogether. There were probably several reasons for this step. First, from 1903 to 1905, longer ranges and higher speeds seemed to be the tactical future of torpedo development, a trend which the 18-inch torpedo, thanks to its larger air flask, was bound to exploit better than any 14-inch model. Second, although 14-inch torpedoes cost less per unit than 18-inch models, eliminating the type altogether would have offered obvious savings. Third, the class of ships that had carried the 14-inch torpedoes—surface torpedo boats—were no longer being built, because destroyers and submarines, which carried 18-inch models, could perform their mission more effectively. Finally, in 1903, the Fiume branch of the Whitehead Company offered the Admiralty a promising new 18-inch model.²⁵ In addition to its nickel-steel flask capable of being charged to 2,134 psi, the torpedo had a four-cylinder engine which used air more efficiently than the Navy's service three-cylinder engine. This Whitehead model passed into service the next year as the 18-inch Fiume III torpedo, capable of making uniform speeds of 32 knots for 1,000 yards and 20 knots for 3,000 yards.²⁶ Slightly improved versions of these torpedoes became known as the Fiume III* and III**.²⁷

While it ordered 100 of the new Whitehead Company torpedoes, the Navy was determined to have a home-grown version. In 1904, to oversee the development of a new 18-inch model, the Admiralty reconstituted the Torpedo Design Committee, which had

²⁵ ART03/53–54; “Paper prepared by the Director of Naval Ordnance and Torpedoes for the information of his Successor,” 31 December 1903, 16.

²⁶ ART04/41.

²⁷ ART05/19.

been dissolved in 1895.²⁸ The Admiralty also asked the Committee to consider the tactical scenarios in which torpedoes would be used, and it wanted the Committee to design a torpedo especially for use from submarines.²⁹

Before it turned to designing a new 18-inch torpedo, the Committee considered how to get more speed and range out of existing 18-inch torpedoes without dramatically changing the engines or air flasks.³⁰ One of the methods it pursued was heating the air. This was the first indication of British interest in torpedo heating since the Admiralty had rebuffed the Bliss Company's offer to sell its superheater in 1901. The Committee proceeded along lines very different from the Bliss superheater. One of its ideas was to introduce a long coil in contact with the surrounding ocean-water through which the air had to pass before it entered the engines, the idea being that the water would warm the air as it passed to the engines.³¹ The other was to introduce a superheater between the air flask and the engine, in which a substance called thermit would be ignited and heat the passing air. The coil added a half-knot of speed over 1,500 yards, while the thermit increased the amount of work done by the engine by roughly 10%.³² Since either heating method would have taken time to develop for use in torpedoes on a large scale, the Committee recommended charging air flasks to a higher pressure as the only way to get higher speeds quickly.

Accordingly, in 1904–1905, the Admiralty raised action pressures from 1,350-

²⁸ Minute by DNO, 12 January 1904, G514/04, PQ/04/3011/229–30.

²⁹ SecAdm to CINC Portsmouth, 6 February 1904, PQ/04/3011/230.

³⁰ First Report of the TDC (with 6 appendices), n.d. but submitted on 29 August 1904, ART04/121–33.

³¹ See Appendices E and F of the TDC's report.

³² I found no documentary trail for these two avenues of experimentation, despite the Committee's request to continue working on them. Some trail undoubtedly existed, if only consisting of an Admiralty order to discontinue experiments.

1,400 psi to 1,600 psi for torpedoes with simple-steel air flasks (14-inch RGF Marks IX-X and Weymouth I, and 18-inch Marks I*-V) and from 1,700 psi to 2,000 psi for those with nickel-steel air flasks (14-inch Marks X*-XI, 18-inch Mark V*).³³ These changes enabled the nickel-steel 14-inch Mark X* and XI to add two knots to their speeds at 1,000 yards; or, if the extra pressure was put towards range rather than speed, it enabled 18-inch torpedoes to make nearly the same speeds for 2,000 yards as they had for 1,500 yards.

Raising the action pressure of older torpedoes was essentially a stop-gap measure, however. The Admiralty also asked the Committee to consider two possibilities for an altogether new design: one with a stronger engine and higher flask pressure, but of the same dimensions; and the other with a greater overall length, due to a longer flask. After ensuring that a longer torpedo could be efficiently discharged from the Navy's torpedo tubes, the Committee informed the Admiralty that it preferred to design a longer torpedo so that the extra air could be used to increase the speed or the range.³⁴ Its proposed Mark VI torpedo would be a foot longer than the Mark V, work at 2,000 psi instead of 1,700 psi, and have the Navy's first four-cylinder torpedo engine. The Committee expected it to make 33 knots over 1,000 yards and 23.75 knots over 3,000 yards, as compared to 28.3 and 20 knots, respectively.

Two experimental torpedoes were built to the Committee's design and tested in 1905, along with six different four-cylinder engines.³⁵ The RGF, *Vernon*, and the Torpedo Design Committee all reported on the tests. The longer Mark VI torpedoes did not meet

³³ ART04/vii, 53; ART05/x, 30–31. Raising action pressures meant that more air would be pumped into the air flask.

³⁴ Third Report of the TDC, n.d. but late 1904 or early 1905, ART04/141–43.

³⁵ See ART05/21–26.

expectations regarding speed, though they were still faster than the Mark V* torpedo, making 23 knots for 3,000 yards and just over 20 knots for 4,000 yards. The Committee did not consider the moderately higher speed of the longer torpedo to be worth complicating the stowage and loading arrangements, especially since experiments with new superheaters had shown that they could achieve the same advantages without the disadvantages associated with increasing the length. The Admiralty therefore decided to build the Mark VI torpedo to the same length as previous models, correctly anticipating that it would be the Navy's last unheated 18-inch torpedo. Manufacture of the Mark VI began in 1905.

The Brotherhood, Armstrong, and Hardcastle Systems and the Changing Supply Base

At this time, there were three prospective sources of improvement in British torpedoes: two involving superheaters, and one involving an internal combustion engine (as opposed to the existing external combustion engine). The latter was being developed by the Brotherhood Company, which built the engines for Whitehead torpedoes. One superheater was being developed by the Armstrong Company, the great armaments firm, and the other by an officer in the Royal Navy named Sydney Undercliffe Hardcastle. Reconstructing the story of these three lines of development is extremely difficult. The extant documentary record is thin. Moreover, what little survives must be treated with extra care, because it was largely generated in the course of subsequent litigation, the likely effect of which was partisan distortion. On a development of this importance, huge volumes of paperwork must have passed through the Admiralty Secretariat—and yet

there is almost no trace of superheaters in ADM 1, the Admiralty Secretariat files at The National Archives. This striking absence could be due entirely to the normal archival “weeding” process; more likely, it is due both to normal weeding and to targeted weeding of papers that would have embarrassed the Admiralty if discovered during litigation.³⁶ The relevant corporate archives are also disappointing, though occasionally helpful.

Given these archival limitations, the origins of Armstrong’s work on superheaters are murky. The earliest known date for Armstrong’s involvement is November 1904, when it applied for its first superheater patent (GB 25,003/1904), but its work on superheaters must have begun some time before that. This patent, filed under the name of William Horace Sodeau, the Armstrong engineer who spear-headed the company’s torpedo work, was for an inside dry superheater, whose chief point of difference from the original Bliss-Leavitt superheater was the use of a second fuel tank to better control the rate of fuel feed. In February 1905, Sodeau applied for a second and much more novel patent (GB 3,495/1905), describing an outside (though still dry) superheater—but this patent was not accepted and published until February 1906, a noteworthy delay. In April 1905, Armstrong signed an agreement with the American Bliss Company in which the latter agreed not to contest Armstrong’s efforts to take out American superheater patents in return for the Armstrong Company giving Bliss the American rights for any improvements made to the superheater. This agreement gave the Armstrong Company access to the American market.

In September 1905, the Torpedo Design Committee tested an Armstrong

³⁶ The Admiralty appears to have carried out just such a targeted weeding of papers related to gunnery fire control for the period 1910 to 1914, when it infringed Arthur Pollen’s patents (see Norman Friedman, *Naval Firepower: Battleship Guns and Gunnery in the Dreadnought Era* (Annapolis: Naval Institute Press, 2008), 297n21.).

superheater in an 18-inch RGF Mark IV torpedo.³⁷ The device used on this occasion was an inside superheater, probably similar to the one covered by patent 25,003/1904, notwithstanding that Armstrong had applied to patent an outside superheater several months earlier.³⁸ Despite its relatively primitive design, the inside superheater added 6 knots in speed when the torpedo was set to run either 1,000 or 2,000 yards, and it nearly doubled the range for a given speed. “[N]o time should be lost in carrying out further experiments,” the Committee advised, since the device marked “a new era” in torpedo development and would “probably be shortly in the hands of all foreign Governments.” The government should undertake its own development at Woolwich, under the supervision of a specially designated officer to hurry the pace. The Admiralty should also reach an agreement with Armstrong “so that modifications and improvements found necessary may not be immediately made common property and that the benefits of early experiments with this apparatus may rest with our service.”³⁹ In this instance, the Committee’s realization that new legal instruments were needed to deal with command technology was very quick.

Whether and how the Admiralty acted on that realization is unclear, however, because the relevant records have disappeared. Their loss is most unfortunate, because this episode represented an important moment in the evolution of the military-industrial complex in Britain. The officer assigned to oversee development of the Armstrong

³⁷ These were probably the experiments promised in ART 1904/54 and mentioned in ART 1905/x, and they occurred more than a year before the better known experiments with the Armstrong heater in Japanese torpedoes.

³⁸ The fact that it was an inside superheater is not stated but can be inferred from the Committee’s reference to “the use of fuel in [as opposed to outside] air vessels” (Briggs to Jellicoe, 27 September 1905, T 173/257, TNA), and from the distinction it drew a week later between the Armstrong superheater and Hardcastle’s outside superheater (Briggs to Jellicoe, 5 October 1905, T 173/257, TNA).

³⁹ Briggs to Jellicoe, 27 September 1905, T 173/257, TNA.

superheater was Lieutenant T. J. Croker, then attached to *Vernon*. Croker had taken out a secret superheater patent himself in 1904, and in 1907 he would be re-assigned as Hardcastle's assistant. Clearly, the situation was ripe for the informal exchange of information between the public and private sectors; it would be very interesting to know whether it occurred and how the Admiralty dealt with it.

At almost exactly the same time that the Admiralty was testing the Armstrong superheater in Weymouth, Hardcastle, then stationed at Chatham, came up with his own idea for a superheater. While it is clear that the final version of the famed Hardcastle superheater did not spring fully formed from his mind in fall 1905, lack of archival materials make it very difficult to establish just when the various steps that led up to his final conception did occur. Certain facts are clear, however. In December 1904, then-Engineer Lieutenant Hardcastle was transferred to Chatham Dockyard to care for and maintain torpedoes.⁴⁰ Sometime during 1905, and not as part of his official duties, he began thinking about superheaters. In the fall of 1905, he gave a description of his idea—the exact contents of which came to be hotly disputed—for an outside superheater to the officer who supervised torpedo care and maintenance at Chatham and Portsmouth. This officer, Captain Gibbs, took Hardcastle's description to the Torpedo Design Committee, which considered it at a meeting on 4 October 1905. The Committee found Hardcastle's idea sufficiently promising to recommend that he be transferred to *Vernon* and given an assistant to develop the superheater further, and it also recommended that he take out a

⁴⁰ Transcript of proceedings in Hardcastle's RCAI claim [hereafter Hardcastle's RCAI claim], p. 5, T 173/649, TNA.

secret patent.⁴¹ The Director of Naval Ordnance (John Jellicoe) swiftly approved both recommendations. On 18 October, Hardcastle applied for a secret patent (GB 21,176/1905), and on 22 October, he arrived at *Vernon*.⁴² Thus only a few months passed between Hardcastle's first ideas and his transfer to *Vernon* to devote himself to the subject—hence the importance of the document that Gibbs carried with him to the meeting of the Torpedo Design Committee on 4 October 1905, and of Hardcastle's patent application, in establishing what Hardcastle knew and when he knew it.

Hardcastle was deliberately vague in both documents, and he had reason to be. "I was very careful not to put too much through the office" at Chatham dockyard to give to Gibbs, Hardcastle later testified. "There was a danger in putting too much through the office," and it was "very desirable" not to mention anything more than was necessary to obtain a secret patent.⁴³ Hardcastle was not alone in fearing that his ideas would be stolen if he committed them to paper. In 1906, an inter-departmental committee charged with investigating the status of inventors in government service reported that the requirement of passing an invention through a long channel of communication in order to obtain patent protection "is apt to arouse the suspicion of the inventor that the nature of his invention may be divulged before he has obtained protection."⁴⁴ Naval officers in charge of the Chatham, Devonport, and Portsmouth dockyards, backed by the captain of *Vernon*,

⁴¹ Briggs to Jellicoe, 5 October 1905, T 173/257, TNA.

⁴² Jellicoe to Briggs, 7 October 1905, T 173/257, TNA.

⁴³ Examination of Hardcastle by Moritz, 4 April 1927, Hardcastle's RCAI claim, p. 37; re-examination of Hardcastle by Moritz, 4 April 1927, Hardcastle's RCAI claim, p. 76, T 173/649, TNA.

⁴⁴ "Report of the Inter-Departmental Committee Appointed to Consider the Regulations as to the Taking out of Patents by Officers and Subordinates in Government Employment, with Appendices, 1905–06," 30 April 1906, p. 5, WO 32/5080, TNA.

agreed that the existing regulations discouraged inventors.⁴⁵ Hardcastle's reluctance to commit his ideas to paper at this stage, which later hampered his attempts to establish when he had conceived the various components of his invention, was by no means an irrational fear.

The procedure for seeking patent protection favored the government instead of the inventor, and the provision of secret patents was an especially powerful tool. Going back to the seventeenth-century Statute of Monopolies, the granting of patents in Britain was a matter of crown prerogative.⁴⁶ By implication, what the crown could give, the crown could interfere with.⁴⁷ Without this principle, any parties besides the inventor and Patent Office examiners might reasonably have been excluded from viewing the patent application between its deposit and acceptance ("sealing"); with it, government departments had the justification they needed to see applications during the review period. The government classified the first secret patent in 1855, under the Patent Law Amendment Act of 1852.⁴⁸ The somewhat murky provisions of the 1852 act regarding secret patents were put on more explicit footing with the Secret Patents Act of 1859, and retained in the Patents, Designs, and Trade Marks Acts of 1883.⁴⁹ By keeping a patent secret, the government could date its claim to prior discovery in the case of future

⁴⁵ Appendix VI ("Précis of remarks by Admiralty officials on the working of the existing regulations"), "Report of the Inter-Departmental Committee Appointed to Consider the Regulations as to the Taking out of Patents by Officers and Subordinates in Government Employment, with Appendices, 1905–06," 30 April 1906, WO 32/5080, TNA.

⁴⁶ T. H. O'Dell, *Inventions and Official Secrecy: A History of Secret Patents in the United Kingdom* (Oxford: Clarendon Press, 1994), 9–10.

⁴⁷ This principle was given statutory codification in the Patents, Designs, and Trade Marks Act of 1883 (46 & 47 Vict. c. 57), Section 27. See Jan Vojáček, *A Survey of the Principal National Patent Systems* (New York: Prentice-Hall, 1936), 102.

⁴⁸ O'Dell, *Inventions and Official Secrecy*, 4. The patent was for the "Application of Incendiary Materials to be used in Warfare."

⁴⁹ O'Dell, *Inventions and Official Secrecy*, 4–22; Vojáček, *A Survey of the Principal National Patent Systems*, 99–104.

litigation, without divulging the contents of its discovery. In effect, secret patents combined two incompatible forms of protection: trade secrets and patents. Trade secrets derive protection from non-publication (but sacrifice proof of prior discovery), while patents prove prior discovery (but sacrifice secrecy). Literally a contradiction in terms, secret patents allowed the government to have its cake and eat it too.⁵⁰

Roughly a month after Hardcastle arrived at *Vernon* to work on his superheater, the Torpedo Design Committee met to consider the third line of torpedo development in Britain: the new Brotherhood engine. Judging from the Committee's laconic description of "a torpedo engine in which carburetted air is exploded in the cylinders," Brotherhood's design was not for a superheater but for an internal combustion engine.⁵¹ The Committee recommended that Brotherhood should be approached "with a view to obtaining exclusive rights as the invention promises to be of considerable value," and that the officer already designated to work on the Armstrong superheater (Lt. Croker) take on the Brotherhood engine as well.⁵² Brotherhood had already applied for a patent to cover the internal combustion engine, but it had not yet been published.⁵³ The Admiralty reached an agreement with him to keep the patent secret and to pay royalties per engine linked to

⁵⁰ "Patent" comes from the Latin *patens*, meaning "open," so "secret patent" means "secret open thing"—which is nonsense.

⁵¹ Briggs to Jellicoe, 1 December 1905, T 173/257, TNA. Sodeau's and Hardcastle's superheaters were designed for external combustion engines: both the mixture of the fuel and air and combustion occurred in the combustion chamber, which was external to the torpedo engine. In Brotherhood's design, the fuel and air were mixed in the carburettor, but combustion ("explosion") did not occur until the mixture was inside the engine.

⁵² Briggs to Jellicoe, 1 December 1905, T 173/257, TNA.

⁵³ The number of the secret patent is unknown (I am trying to track it down), but it should not be confused with Brotherhood's public patent 6,789/1905, applied for in March 1905 and accepted in March 1906. This latter patent was for use with superheaters and external combustion engines, and it was primarily concerned with controlling the rate of the fuel feed into the (external) combustion chamber.

the increase in energy achieved by the superheater.⁵⁴

While Armstrong, Hardcastle, and Brotherhood worked on their inventions, a major change in the Navy's supply base occurred. In catastrophically short order, the top leadership of the Whitehead Company died: John Whitehead, Robert's son, in 1902; Count George Hoyos, Robert's Austrian son-in-law, in 1905; Robert himself in 1905; and E. P. Gallwey, the director of the Weymouth factory, in 1906. The Armstrong Company had been angling to enter the torpedo market for some time: the board of directors appointed a committee, chaired by Henry Whitehead (a relative of Robert), to deal with the question of buying the Whitehead Company in late 1905.⁵⁵ Alas, "the Whitehead interest is in so many hands, and what is worse most of them ladies," Henry reported, "that I see little chance of their coming to reasonable terms."⁵⁶ Admiralty involvement seems to have broken the logjam. Learning that the Whitehead Company was up for sale and fearing that it would fall into foreign hands, the Admiralty summoned Sir Trevor Dawson, an executive at Vickers, the armaments firm and Armstrong rival, late one evening in 1906, and asked him to buy it.⁵⁷ The Admiralty made a similar approach to

⁵⁴ "Paper prepared by the Director of Naval Ordnance and Torpedoes for the information of his Successor," 1907, 37.

⁵⁵ Board minutes of 16 November 1905 and 18 January 1906, Accession 130/1267 (Minute Book #2), T&W. On the family relationship between Henry ("Harry") and Robert, see Saxton Noble to Albert Vickers, 30 November 1910, Microfilm R306, VA.

⁵⁶ Henry Whitehead to Rendel, 25 January 1906, Accession 31/7269, MF 1076, T&W.

⁵⁷ This story comes from a poorly understood manuscript entitled "The Whitehead Torpedo Companies" in the Vickers Archive. The Archive actually contains two copies of this manuscript. One is to be found in Document 771, mis-dated as 20 February 1935 and mis-credited to V. F. G. Pritchett. The other copy is to be found in Document 57, Folder 47, giving the correct date of 21 February 1935 and the correct author as J. P. Davison, who was then the director of the Weymouth branch of the Whitehead Company. In 1935, Vickers was hauled in front of a Royal Commission on arms manufacturing, and the firm's central office asked Davison, among other subsidiary directors, to put together histories of their companies for use in preparing testimony. "The Whitehead Torpedo Companies" was Davison's reply. According to the manuscript, Dawson told the story of being summoned to the Admiralty at a company gathering in Weymouth on 24 February 1931. J. D. Scott, the historian of Vickers who was given privileged access to its papers, reported the story in *Vickers: A History* (London: Weidenfeld and Nicolson, 1962), 83–84, without

Armstrong.⁵⁸ Sometime between January and May 1906, Vickers and Armstrong reached an agreement to purchase control of the Whitehead Company.⁵⁹ Vickers and Armstrong each took 184 shares (or 368 total) of the 735 shares in the Whitehead Company, leaving 367 shares in the hands of the Whitehead family. The purchase price for 184 shares was roughly £200,000, or £1,087 per share.⁶⁰ The new owners registered the Weymouth branch as a separate company (“Whitehead Torpedo Works, Ltd.”) under English law on 1 January 1907.⁶¹

Armstrong’s purchase of the Whitehead Company paved the way for a long-running patent battle with the Admiralty. In February 1906, Sodeau’s patent 3,495/1905 was granted, and in April 1906, Hardcastle’s patent 21,176/1905 was granted. Since both patents were important in their own rights, and the Armstrong Company would later charge Hardcastle with infringing Sodeau’s patent, it is worthwhile to compare the two. Sodeau’s dry outside superheater was an improvement on Leavitt’s original patent for a dry inside superheater. In addition to moving combustion out of the air flask, Sodeau made the rate of feed of the fuel into the combustion chamber constant, and he made the rate of feed of air, on the one hand, and of fuel, on the other hand, into the combustion chamber maintain a constant ratio. For air and fuel to flow into the combustion chamber, the pressure within the combustion chamber needed to be lower than the pressure acting

explaining the provenance of the story. Gray subsequently repeated the story in *The Devil’s Device: The Story of Robert Whitehead, Inventor of the Torpedo* (Annapolis: Naval Institute Press, 1991; first edn. 1975), 176–78, having consulted (according to his statement of records consulted) the version of “The Whitehead Torpedo Companies” dated 20 February 1935, and without mentioning Scott’s work.

⁵⁸ Gray, *The Devil’s Device*, 176–78.

⁵⁹ The purchase was discussed at an Armstrong board meeting on 17 May 1906; see Accession 130/1267 (Minute Book #2), T&W.

⁶⁰ Armstrong board minute of 17 May 1906, Accession 130/1267 (Minute Book #2), T&W

⁶¹ The registration papers can be found in BT 31/17962/91493, TNA.

on the air and the fuel. Sodeau used a sprayer to atomize the fuel entering the combustion chamber, which required the pressure forcing the fuel through the sprayer to be “markedly higher” than the pressure within the combustion chamber.⁶² By contrast, Hardcastle used something known as the “swirler,” which projected the air into the combustion chamber in the shape of a spiral current and the fuel in the shape of a contra-rotating spiral current, such that the collision of the two oppositely “swirling” currents atomized the fuel. Whereas Sodeau needed a “marked” pressure differential to force the fuel through the sprayer, Hardcastle needed only the minimum differential required to “pull” the fuel into the combustion chamber. The references to a “sprayer” and to a “marked” pressure differential came to be at the heart of subsequent litigation between Armstrong and the Admiralty.

While the battle-lines for a future patent dispute were being drawn, the inventors continued to work on their inventions. According to Hardcastle’s log-book, he first used water with his superheater in December 1905, two months after his arrival at *Vernon*.⁶³ In January 1906, Hardcastle claimed, he showed his wet superheater to the captain of *Vernon*.⁶⁴ In July, Hardcastle submitted provisional specifications for his patent 16,929/1906. The provisional specifications, which contained several important differences from the complete specifications submitted in February 1907, covered Hardcastle’s efforts to adapt his superheater to work with paraffin oil (kerosene) as a fuel

⁶² GBP 3,495/1905, Claim 1 (Line 16).

⁶³ Examination of Hardcastle by Moritz, 4 April 1927, Transcript of proceedings in Hardcastle’s RCAI claim, p. 39, T 173/649, TNA.

⁶⁴ Hardcastle to Gamble, 29 September 1908, enclosed in Hardcastle to Robertson, 15 April 1926, T 173/257, TNA.

rather than alcohol.⁶⁵ In August, Hardcastle carried out trials of his superheater in an 18-inch RGF Mark IV torpedo. The purpose of these trials was to test the ability of the engine to withstand heated air, and the superheater used for them was the one described in Hardcastle's patent 21,176/1905—a dry superheater—which still added 3 knots to the Mark IV torpedo for 1,000 yards.⁶⁶ In October 1906, Hardcastle later claimed, the first range trials of a wet version of his superheater occurred, but they were not successful, due to the torpedo running into the shore.⁶⁷ Hardcastle believed that the culprit was the hanging-up of the engine's piston valves, and by December 1906, he had invented a double-beat valve to replace them. At the same time, Hardcastle submitted the first drawing of a wet superheater whose date both he and the Admiralty later accepted.⁶⁸ The captain of *Vernon* was sufficiently impressed to recommend Hardcastle's reassignment to the RGF, which had better facilities.⁶⁹ Hardcastle moved from *Vernon* to the RGF in January 1907, where he began to fit his wet superheater to an 18-inch Fiume III torpedo and to an 18-inch RGF Mark VI torpedo.⁷⁰

As Hardcastle moved from an outside dry superheater to a wet superheater, the Armstrong Company was moving from an inside to an outside dry superheater. In

⁶⁵ Hardcastle to Briggs, undated but c. 29 August 1906, enclosed in Briggs to DNO, 29 August 1906, T 173/257, TNA.

⁶⁶ See Briggs to DNO, 29 August 1906, T 173/257, TNA; Hardcastle's RCAI claim, pp. 69–71, T 173/649, TNA. In the papers before the RCAI, an undated report by Hardcastle was enclosed in the letter of 29 August 1906 from Briggs to DNO; both parties to the claim seem to have accepted that Hardcastle's report concerned these August trials.

⁶⁷ See Hardcastle to Gamble, 29 September 1908, enclosed in Hardcastle to Robertson, 15 April 1926, T 173/257, TNA; and re-examination of Hardcastle by Moritz, 4 April 1927, Hardcastle's RCAI claim, pp. 77–78, T 173/649, TNA.

⁶⁸ For the Admiralty's acceptance of the date, see Whitehead's cross-examination of Hardcastle, 4 April 1927, Hardcastle's RCAI claim, pp. 71–72, T 173/649, TNA.

⁶⁹ Hardcastle to Gamble, 29 September 1908, enclosed in Hardcastle to Robertson, 15 April 1926, T 173/257, TNA. This letter refers to a letter from Briggs to Jellicoe dated 17 December 1906, which may be refer to the letter of that date which also appears in T 173/257, TNA.

⁷⁰ Hardcastle to Gamble, 29 September 1908, enclosed in Hardcastle to Robertson, 15 April 1926, T 173/257, TNA.

December 1906, the Company invited Admiralty representatives to witness trials of its newest superheater in a torpedo being built for the Japanese navy. Whereas the Armstrong superheater used in an 18-inch RGF Mark IV torpedo in the September 1905 trials was an inside version, probably conforming to Armstrong's patent 25,003/1904, the superheater in the Japanese torpedo—an 18-inch Fiume III type, incidentally, no doubt reflecting Armstrong's recent purchase of the Whitehead Company—was an outside superheater, probably conforming to Armstrong's patent 3,495/1905. The outside superheater added 10 knots to the speed of the torpedo for 1,750 yards, as compared to a 6-knot increase for 2,000 yards for the inside superheater.⁷¹ Although the Armstrong Company had permitted the Admiralty to assign an officer (Lt. Croker) to oversee development of its original inside superheater, the Company kept the development of its outside superheater very secret.⁷² Accordingly, the captain of Vernon recommended that Croker be reassigned from working on Armstrong's inside superheater to assist Hardcastle at the RGF.⁷³ The Armstrong Company also dealt cautiously with its new partial subsidiary, the Whitehead Company, when the latter expressed a desire to become the sole owners of the Armstrong outside superheater.⁷⁴ After some discussion, the Armstrong Company decided not to sell the superheater outright but instead to charge royalties on it.⁷⁵

From the RGF, in February 1907, Hardcastle filed the complete specifications for his patent 16,929/1906. Unlike the provisional specifications, the complete version

⁷¹ ART06/24–25.

⁷² Briggs to Jellicoe, 17 December 1906, T 173/257, TNA.

⁷³ Briggs to Jellicoe, 17 December 1906, T 173/257, TNA.

⁷⁴ Armstrong board minute of 24 January 1907, Accession 130/1267 (Minute Book #2), T&W.

⁷⁵ Armstrong board minutes of 10 April and 3 July 1907, Accession 130/1267 (Minute Book #2), T&W.

described a wet superheater. His was actually the second patent for a wet superheater in Britain—two Austrians, Johann Gesztesy and Julius von Petravich, had left complete specifications for a wet superheater (patent 7,390/1906) in September 1906—but no litigation resulted. The complete specifications for Hardcastle’s patent 16,929/1906 described two possible constructions for pre-heating the fuel before it reached the combustion chamber. In the second construction, Hardcastle provided for the injection of water into the combustion chamber “[t]o prevent excessive temperatures”—not to add to the volume of the working fluid, a related but distinct purpose. Hardcastle did not explicitly claim his use of water as a novelty, though he may have intended to cover it with his claim to the constructions he described.

In June 1907, the Admiralty began planning competitive trials of the Armstrong, Hardcastle, and Brotherhood systems.⁷⁶ Hardcastle ran his wet superheater in an 18-inch Fiume III** torpedo in July and in an 18-inch RGF Mark VI* torpedo in October 1907. The other two systems were tried sometime during this period as well, Armstrong’s in two Fiume III** torpedoes (one converted and one purpose-built) and Brotherhood’s in a Mark VI* torpedo.⁷⁷ Hardcastle’s Fiume III** torpedo made 33 knots for 3,000 yards, and his Mark VI* torpedo made 35 knots for 3,000 yards, both with considerable air remaining (meaning that they could have gone farther).⁷⁸ Armstrong’s heated Fiume III** torpedoes, with little difference between the converted and purpose-built models, made roughly 36 knots for 2,000 yards and 32 knots for 3,000 yards, as compared to roughly 27.5 knots and 20 knots for cold versions of the same torpedoes, meaning that the heater

⁷⁶ Briggs to Jellicoe, 13 June 1907, T 173/257, TNA.

⁷⁷ ART07/25–30, ART08/18.

⁷⁸ Hardcastle to Gamble, 29 September 1908, enclosed in Hardcastle to Robertson, 15 April 1926, T 173/257, TNA.

added roughly 8–10 knots in speed.⁷⁹ Armstrong’s performance for 3,000 yards was close to Hardcastle’s performance with a Fiume III** torpedo, but significantly worse than Hardcastle’s performance with a Mark VI* torpedo. The trials of Hardcastle’s superheater in the Mark VI* torpedo were not complete, however, and the Whitehead Company was prepared to guarantee 40 knots for 1,000 yards and 32 knots for 3,000 yards using Armstrong’s superheater, substantially better than any of the Navy’s cold torpedoes.⁸⁰ Accordingly, the Torpedo Design Committee recommended that 50 cold torpedoes—46 Fiume III** and 4 RGF Mark VI*—be converted to take the Armstrong superheater.⁸¹

Procuring Heated Torpedoes

In October 1907, based on the completed trials of the Armstrong superheater and the ongoing trials of the Hardcastle superheater, the Assistant Director of Torpedoes, Bernard Currey, wrote a minute which set the course of the Admiralty’s procurement policy for heated torpedoes for the next two years. “It is needless to point out the enormous value of large increase in speed to the torpedo for use in destroyers or submarines,” Currey reminded his colleagues.

Every knot of increase renders speed and course of enemy less difficult to allow for, and therefore deliberate avoidance of the enemy more hopeless.

For our large ships, increase of range of the torpedo will be a valuable addition, since it will tend to prevent close action, and, therefore, accentuate gunnery skill. Moreover, with numbers of ships in close formation the target even at 4,000 yards is by no means a small one.

At all events, it is necessary for us to be in the van of all improvements in torpedo warfare.⁸²

⁷⁹ ART06/23.

⁸⁰ Gamble to Jellicoe, 28 October 1907, T 173/257, TNA.

⁸¹ Gamble to Jellicoe, 28 October 1907, T 173/257, TNA. These were the 50 Fiume III** torpedoes referred to in ART 07/30.

⁸² Minute by Currey, 22 October 1907, G16396/07, PQ/09/3345/156–57.

He therefore submitted that the Navy request money for two purposes. One was to convert 100 of the Navy's present cold torpedoes to heated torpedoes capable of making the longest possible range at 35 knots so as to obtain "varied seagoing experience." The other was to construct six new heated torpedoes—two each for the Armstrong, Hardcastle, and Brotherhood systems—capable of making 50 knots at 1,000 yards.⁸³

The Director of Naval Ordnance, John Jellicoe, strongly backed the Assistant Director of Torpedoes. "I am most anxious to obtain approval" for Currey's recommendations, Jellicoe wrote.

It is impossible to over emphasise the enormous importance of a very fast torpedo for our destroyers, and it is unnecessary to dwell on the tactical importance of long range torpedoes for the Fleet. I fully realise that the experiments are not final, but they should be pushed on with great energy. We must take the lead in this matter, and allow no one to be on the same level as ourselves.⁸⁴

John Fisher, the First Sea Lord, "fully" concurred, and the policy was approved.

Accordingly, for fiscal year [FY] 1907/08, the Navy ordered the conversion of 29 RGF Mark VI* torpedoes to take the Hardcastle superheater, plus the construction of the six experimental torpedoes recommended by the Assistant Director of Torpedoes; and for FY 1908/09, it ordered the conversion of another 12 RGF Mark VI* torpedoes to take the Hardcastle superheater, plus 50 Fiume III** torpedoes to take the Armstrong superheater recommended by the Torpedo Design Committee.⁸⁵ These were the only Fiume III** torpedoes converted to the Armstrong superheater before the Hardcastle superheater so decisively proved its superiority that the Admiralty ordered conversions of only RGF

⁸³ These six torpedoes must be identical with the six Mark VII torpedoes mentioned in ART 08/7 as being carried over from FY 1907/08.

⁸⁴ Minute by Jellicoe, 22 October 1907, G16396/07, PQ/09/3345/156-57.

⁸⁵ ART07/30.

Mark VI* torpedoes to the Hardcastle superheater in the future.⁸⁶ Because the weakness of the engines prevented converted torpedoes from going faster than 37 knots, the superheater was used to increase their range rather than their speed, and they were allocated to ships rather than torpedo craft, which needed higher-speed torpedoes.⁸⁷

The drop in torpedo orders while the Admiralty considered its procurement policy hurt private industry. Having purchased more than 600 torpedoes in FY 1905/06, and more than 550 in FY 1906/07, the Admiralty ordered just 113 in FY 1907/08.⁸⁸

Armstrong, the new owners of the Whitehead Company, keenly felt the decline. In April 1907, the manager of the Weymouth works informed the Admiralty that he would have to disband his labor force unless the Admiralty placed more orders.⁸⁹ In May, the Armstrong board learned that the Weymouth works had received only a quarter of the previous year's previous orders.⁹⁰ Weymouth's first order from the United States, for 50 torpedoes, eased but did not overcome the crisis resulting from the lack of British orders.⁹¹ By the next year, the situation still had not improved much, and the Armstrong board discussed the gloomy outlook at a meeting in June 1908.⁹² Two weeks after the board meeting, Armstrong informed the Admiralty of its belief that Hardcastle's patents infringed Sodeau's.⁹³ The timing of this bombshell supports Hardcastle's later contention that it was a ploy to pressure the Admiralty into ordering more torpedoes from the Whitehead

⁸⁶ "Paper prepared by the Director of Naval Ordnance for the Information of his Successor." 1909, 22.

⁸⁷ Minute by DNO, 29 February 1908, G3264/08, PQ/09/3346/157-58. See also ART08/18 on allocation policy.

⁸⁸ ART 05/12, ART 06/8, ART 07/8.

⁸⁹ Lees to SecAdm, 13 April 1907, enclosed in Lees to Albert Vickers, 13 Apr 1907, microfilm M306, VA.

⁹⁰ Armstrong board minute of 30 May 1907, Accession 130/1267 (Minute Book #2), T&W.

⁹¹ Armstrong board minute of 25 July 1907, Accession 130/1267 (Minute Book #2), T&W.

⁹² Armstrong board minute of 18 June 1908, Accession 130/1267 (Minute Book #2), T&W.

⁹³ This letter, dated 2 July 1908, was not found, but it is dated and described in a minute by the Director of Contracts, 17 October 1908, CP Patents 229, quoted in Admiralty Awards Council, Report 26, "Award to Engineer Lieutenant S. U. Hardcastle, R.N.," ADM 245/1, TNA.

Company.⁹⁴

The Admiralty's relationship with its other torpedo supplier—the War Office, which ran the RGF—was also changing. In 1903, due to the lack of ranges long enough for adjusting future long-range torpedoes, the Admiralty began planning for a new range near the great dockyard of Chatham, on the east coast near the Thames estuary, which would have been much closer to the RGF at Woolwich than the existing RGF range on the south coast at Portland.⁹⁵ The price tag of £700,000 for the Chatham range was too high for the Admiralty, however, and it began searching for another location.⁹⁶ It found one slightly to the northwest of Glasgow in Loch Long. Owing to the distance from Woolwich, and to the desirability of taking control of naval ordnance from the War Office, the Admiralty decided to build a new factory in the nearby town of Greenock along with its new range.⁹⁷ The coincidence of the factory idea with the arrival of Fisher as First Sea Lord was undoubtedly no accident, but part of Fisher's long-running effort to secure control of naval ordnance for the Admiralty. Due to delays in transporting machinery to the new factory and in securing housing for workers, the new Royal Naval Torpedo Factory (RNTF) did not begin producing torpedoes until late 1910 or early 1911.⁹⁸

Notwithstanding this industrial dislocation, trials of Hardcastle's wet superheater

⁹⁴ Hardcastle to SecAdm, 22 November 1922, enclosed in Hardcastle to Robertson, 15 April 1926, T 173/257, TNA.

⁹⁵ "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," 31 December 1903, 18.

⁹⁶ "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," 1907, 42.

⁹⁷ "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," February 1905, 22; "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," 1907, 42.

⁹⁸ See the undated article "Clyde Torpedo Factory. Progress of Work at Greenock. Difficulties regarding Housing," and Acklom, "Notice. Transfer to Greenock," 8 September 1910, in SUPP 5/177, TNA.

in the RGF Mark VI* torpedo were completed in February 1908.⁹⁹ Hardcastle took out a third secret patent (GB 27,347/1908) in December 1908, which described his mature system. The heart of this patent was the combustion chamber, which Hardcastle termed “a special continuous pressure fluid generator.” In many ways, it was similar to the combustion chamber described in patent 16,929/1906, but unlike the earlier patent, which mentioned water injection almost as an after-thought and solely in the context of reducing temperatures in the combustion chamber, patent 27,347/1908 emphasized water injection, in the context not only of reducing temperatures but also of increasing the volume of the working fluid in the engine. It retained Hardcastle’s idea of a “swirler” for helping to vaporize the fuel and air from both of his earlier patents.

Yet again, lack of documentary evidence unfortunately hampers precise dating of the Admiralty’s commitment to the Hardcastle superheater. Since the official trials of Hardcastle’s wet superheater in the RGF Mark VI* torpedo were not completed until February 1908, the Admiralty must have been very optimistic indeed to have ordered the conversion of 29 Mark VI* torpedoes in late 1907 for FY 1907/08.¹⁰⁰ The performance of the Hardcastle superheater fully justified its confidence, taking the RGF Mark VI* torpedo from a cold 20 knots to a hot 34.25 knots for 4,000 yards, nearly a 15-knot gain in speed, and roughly 10 knots faster than the Armstrong superheater’s 24.5 knots for 4,000 yards.¹⁰¹ The Admiralty’s order of only 12 more Mark VI* torpedoes for FY 1908/09, placed after the trials had been complete for several months, reflected not a lack

⁹⁹ Hardcastle to Gamble, 29 September 1908, enclosed in Hardcastle to Robertson, 15 April 1926, T 173/257, TNA.

¹⁰⁰ Hardcastle to Gamble, 29 September 1908, enclosed in Hardcastle to Robertson, 15 April 1926, T 173/257, TNA.

¹⁰¹ For the cold Mark VI* speed, see ART06/14. For the heated Mark VI* speed, see ART08/18. For the heated Fiume III** speed, see ART08/18.

of confidence in the Hardcastle superheater, but the delaying effect of a debate over the desirable range and speed for the converted torpedoes. The first 50 Mark VI* torpedoes were converted to have the maximum possible speed at the expense of range (34.5 knots for 4,000 yards), but since they were being issued to ships, which needed range more than speed, it was decided to maximize their range instead of their speed (29 knots for 6,500 yards).¹⁰² This decision required the balance chambers of the Mark VI* torpedoes to be lengthened to allow them to carry more fuel and water for the superheater, and Mark VI* torpedoes with the lengthened balance chambers were re-designated Mark VI**. Having made a decision on the range question, the Admiralty ordered the conversion of 196 Mark VI** torpedoes for FY 1909/10.¹⁰³

In addition to converting cold torpedoes, the Admiralty was also developing new heated torpedoes. Again, the story is difficult to trace. The Admiralty ordered six experimental torpedoes in FY 1907/08, intending to try the Armstrong, Hardcastle, and Brotherhood systems in two each. The Brotherhood internal combustion engine seems never to have made it into a torpedo, however, while the Whitehead Company brought out a new 18-inch torpedo, the Weymouth I (not to be confused with the 14-inch Weymouth I discussed in Chapter 2), built around the Armstrong superheater and capable of making an impressive 41 knots for 1,000 yards or 28.5 knots for 4,000 yards.¹⁰⁴ The Navy ordered 20 Weymouth I torpedoes in FY 1908/09, but no more, since their performance was swiftly eclipsed by the combination of the Hardcastle superheater with

¹⁰² "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," 1909, 22; ART 09/11.

¹⁰³ ART 09/7.

¹⁰⁴ ART08/19.

the experimental torpedoes ordered in 1907/8.¹⁰⁵ Trials of these torpedoes seem to have succeeded very quickly, since the Navy ordered 119 of them in FY 1908/09. Of these 119 torpedoes, 79 were designated the 18-inch RGF Mark VII, while 40 were designated the Mark VII*, the asterisk indicating a slight change in the proportion of fuel to air to increase the range covered at 30 knots.¹⁰⁶ The Mark VII and VII* torpedoes made approximately 41 knots for 3,000 yards or 29 knots for 6,000 yards.¹⁰⁷ With some changes, the Mark VII* remained the primary 18-inch torpedo in the Navy's arsenal until World War I.

As favorably as these numbers for heated 18-inch torpedoes compared to those of cold torpedoes, they in turn paled in comparison to those of a still more revolutionary development, the 21-inch heated torpedo. Because of their greater size, 21-inch torpedoes were able to carry much more air than 18-inch torpedoes, which greatly extended their range. Their engines were "merely adaptations" of those for the 18-inch Mark VII.¹⁰⁸ The Navy ordered two experimental 21-inch torpedoes from the RGF and two from the Whitehead Company in FY 1908/09. The Whitehead Company proved unable to get satisfactory results with its 21-inch torpedo and agreed to cancellation of the order, but the RGF 21-inch torpedo met with greater success.¹⁰⁹ Passing into service in 1909 as the 21-inch RGF Mark I, these torpedoes could make 45 knots for 3,500 yards and 30 knots for 7,500 yards—the lower speed being one which the Navy had struggled to sustain for

¹⁰⁵ "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," 1909, 22.

¹⁰⁶ ART 08/7, ART 09/7. On the meaning of the asterisk, see "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," 1909, 22.

¹⁰⁷ ART 09/11.

¹⁰⁸ Minute by DNO, 7 March 1908, G3264/08, PQ/09/3346/157–58.

¹⁰⁹ "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," 1909, 24.

1,000 yards less than a decade earlier.¹¹⁰ Experiments with a modified 21-inch Mark I, which would become the 21-inch Mark II, were already underway in 1908.¹¹¹ The Mark II would be the Navy's first 10,000-yard torpedo, a 1,000% increase over the effective ranges of just a decade earlier.

Due to the superiority of the RGF torpedoes with their Hardcastle heaters over those of the Whitehead Company, the Navy decided to manufacture only RGF heated torpedoes, to be built by the RGF and the Whitehead Company.¹¹² In order to preserve the secrecy of the Hardcastle heater, the Navy had the Whitehead Company manufacture the torpedoes complete except for their balance chamber and heater fittings, passed the torpedoes cold, sent the torpedoes to the RGF to be fitted with heaters, and then passed them hot.¹¹³ After years of buying Whitehead Company patterns—the cold 14-inch Weymouth I, the cold 18-inch Fiume III, and the hot 18-inch Weymouth I—the decision to manufacture only RGF torpedoes marked a return to the pattern-unification policy of 1894–1898. In contrast to the first iteration, the superiority of the RGF patterns, thanks to their Hardcastle heaters, seems to have been real, not merely imagined. The return to the pattern-unification policy was accompanied, as the original had been in 1894/5, by the dissolution of the Torpedo Design Committee.¹¹⁴

Compensating Hardcastle

While the Admiralty's procurement policy for heated torpedoes took shape, the

¹¹⁰ ART09/11.

¹¹¹ Minute by ADT [Currey], 17 December 1908, G18178/08, SC224/F34, BF.

¹¹² "Paper prepared by the Director of Naval Ordnance for the Information of his Successor," 1909, 22.

¹¹³ Ibid.

¹¹⁴ See minutes on G18020/07, PQ/08/3329/124.

question arose of whether and how Hardcastle should be compensated for his services. In April 1908, two months after the conclusion of trials with Hardcastle's wet superheater, the captain of *Vernon* recommended that Hardcastle be promoted as a reward for his invention.¹¹⁵ The Assistant Director of Torpedoes, Currey, observed that the value of the superheater "could scarcely be over-estimated," but he attempted to arrive at an estimate by comparison with what the Admiralty had agreed to pay for the two competing systems: a royalty of £10 each for Brotherhood's internal combustion engine, and a probable price increase of £20-25 per Whitehead torpedo fitted with Armstrong's superheater.¹¹⁶ The Admiralty had never purchased the former, and the latter was inferior to Hardcastle's superheater. During the three years that Hardcastle had spent developing his superheater, Currey added, his pay had been "rather less than he would have drawn elsewhere." The Director of Naval Ordnance, R. H. Bacon, supported *Vernon's* recommendation that Hardcastle receive early promotion.¹¹⁷ The Engineer-in-Chief chimed in that ordinarily Hardcastle would not receive promotion until 1915 at the earliest and would pass over 132 officers if promoted immediately; he instead suggested that Hardcastle's name be considered for early promotion after reaching the senior list in 1911.¹¹⁸ Naval Branch, which handled personnel questions and reported to the Second Sea Lord, shifted the debate away from promotion and back to a monetary award, noting that Hardcastle's invention was "to some extent outside the usual work of an Engineer Officer"—an

¹¹⁵ Minute by Gamble, 10 April 1908, A4321/08, described in Admiralty Awards Council, Report 26, "Award to Engineer Lieutenant S. U. Hardcastle," ADM 245/1, TNA.

¹¹⁶ Minute by Currey, 30 April 1908, A4321/08, described in Admiralty Awards Council, Report 26, "Award to Engineer Lieutenant S. U. Hardcastle," ADM 245/1, TNA.

¹¹⁷ Minute by Bacon, 30 April 1908, A4321/08, described in Admiralty Awards Council, Report 26, "Award to Engineer Lieutenant S. U. Hardcastle," ADM 245/1, TNA.

¹¹⁸ Minute by Engineer-in-Chief, undated, A4321/08, described in Admiralty Awards Council, Report 26, "Award to Engineer Lieutenant S. U. Hardcastle," ADM 245/1, TNA.

important point, because it implied that Hardcastle had conducted the work with limited government assistance.¹¹⁹ The Second Sea Lord concurred with the suggestion of a monetary award instead of promotion and recommended that the issue be referred to the Patents Committee, which probably reported to the Director of Contracts.¹²⁰ Orders to this effect were duly given.

The Armstrong Company's challenge to the validity of Hardcastle's patents arrived in the midst of the Patent Committee's deliberations. Around October 1908, the Admiralty received replies from two experts it had consulted on the patent question. One was the Treasury Solicitor, who provided legal counsel to all government departments.¹²¹ Although the Admiralty had a Naval Law Branch, it lacked in-house counsel on matters relating to civil law and therefore had to rely on the Treasury. It was happy to do so, for reasons explained by the Admiralty Secretary in 1902:

[T]o create a Legal Department in the Admiralty at all commensurate with that of the Treasury Solicitor's Department ... would involve an expenditure (at the cost of the Navy Vote) virtually prohibitive.... [This course] would deprive the Admiralty of the very favourable conditions under which at present thoroughly responsible legal advice is obtained at once without cost to this Department.¹²²

Fiscal realities constituted a powerful impediment to bureaucratic empire-building. In addition to the Treasury Solicitor, the other expert consulted by the Admiralty was a "Mr.

¹¹⁹ Minute by Naval Branch, 21 May 1908, A4321/08, described in Admiralty Awards Council, Report 26, "Award to Engineer Lieutenant S. U. Hardcastle," ADM 245/1, TNA.

¹²⁰ Minute by Second Sea Lord, undated, A4321/08, described in Admiralty Awards Council, Report 26, "Award to Engineer Lieutenant S. U. Hardcastle," ADM 245/1, TNA. Admiralty letters were preceded by a letter or letters indicating the branch which wrote them—"G" for Gunnery, "M" for Military, etc. One prefix was "CP (Patents)." "CP" presumably referred to the Contract and Purchase Department, headed by the Director of Contracts, and the "(Patents)" probably referred to a section within the Contract and Purchase Department. The Patents Committee probably reported to this section.

¹²¹ Admiralty Awards Council, Report 26, "Award to Engineer Lieutenant S. U. Hardcastle," ADM 245/1, TNA.

¹²² Evan MacGregor, 10 December 1902, "Admiralty. War Organization of Staff. Secretary's Report," Docket "Admiralty, War Organization of Staff," ADM 1/7658, TNA. Thanks to Nicholas Lambert for calling my attention to this report.

Swinburne,” who was almost certainly the same James Swinburne, patent attorney, consulted by the Admiralty in 1913 in regard to Arthur Pollen’s fire control system.¹²³ According to the Director of Contracts, Swinburne argued that the Armstrong patents were “bad for want of subject matter,” meaning that they were invalid and therefore that Hardcastle could not have infringed them.¹²⁴

The Assistant Superintendent of the Royal Gunpowder Factory, Lieutenant Cecil R. Acklom, also contributed to the debate over rewarding Hardcastle. Acklom’s rank clearly did not reflect his importance, and no doubt the Admiralty found some other way of compensating him. He essentially ran the RGF’s torpedo shop, which was primarily a manufacturing job but necessarily involved a good deal of participation in design and experimentation work. When the Navy moved torpedo manufacturing from the RGF to the Royal Naval Torpedo Factory [RNTF], Acklom became the superintendent of the RNTF. From January 1907 through 1908, while Hardcastle was stationed at the RGF, Acklom was his *de facto* supervisor. Acklom praised Hardcastle’s superheater as a great success and noted that it could be used for commercial purposes other than torpedoes, such as impact-wheel turbines and high-speed boats and motor cars. Hardcastle was “entirely responsible for the invention,” and although he had “of course been greatly assisted by his position and by the use of public money,” he would lose “the commercial value of the invention.”¹²⁵ The juxtaposition of the contradictory claims that Hardcastle was “entirely responsible” for the invention, on the one hand, and that he was “greatly

¹²³ See Jon Sumida, *In Defence of Naval Supremacy: Finance, Technology and British Naval Policy, 1889–1914* (Boston: Unwin Hyman, 1989), 238.

¹²⁴ Director of of Contracts, 17 October 1908, CP(Patents) 229/08, described in Admiralty Awards Council, Report 26, “Award to Engineer Lieutenant S. U. Hardcastle,” ADM 245/1, TNA.

¹²⁵ Remarks by Acklom, 3 October 1908, described in Admiralty Awards Council, Report 26, “Award to Engineer Lieutenant S. U. Hardcastle,” ADM 245/1, TNA.

assisted” with the invention, on the other, reflected one of the difficulties in dealing with command technology. The question of “status”—meaning how much government assistance had contributed to Hardcastle’s invention—obviously affected the question of rewarding Hardcastle.

If one difficulty was separating Hardcastle’s work from the government’s work, another difficulty was pricing the invention, regardless of who had done the work. The superheater’s monetary value was “not easy to assess,” Acklom observed, and the best metric was “to consider what the British Government would be likely to pay to an outside inventor for such apparatus [sic].” The Armstrong superheater added 6.5 knots, while Hardcastle’s added 15 knots. Acklom put the royalty value of the Armstrong superheater (which Armstrong did not charge as royalty, but undoubtedly built into the price of the torpedo) at £15, and the royalty value of the Hardcastle superheater at £40, these figures being roughly proportional to the speed differential. Since the Admiralty had a superheater similar to Armstrong’s and capable of producing a similar performance without any question of royalties two years ago—this may have been a reference to the earlier dry version of Hardcastle’s superheater, but it is unclear—Acklom deducted the £15 royalty for the Armstrong results from the £40 royalty for the Hardcastle results to arrive at a net royalty value of £25 per Hardcastle superheater. The average annual torpedo order was 392, which would produce net royalties of £9,800 (392 x £25) per year. With orders for war material being so uncertain, that average number might hold good for only five years, for which period the total royalties would be £49,000. Conversions of old torpedoes to take the superheater would generate further revenue at a rate of £100 per torpedo (this sum representing the royalty value of £25 plus an estimated £75 for the

work of adapting the torpedo to take the superheater), which would add an additional £12,000 if 120 torpedoes were converted over that five-year span. Thus Acklom's hypothetical outside inventor would make a total of £61,000 off the Hardcastle superheater over a five-year period. Of course, Hardcastle was not an outside inventor, but had received some £15,000 worth of assistance, Acklom estimated, from the government in developing his superheater. Deducting this sum from the £61,000 would leave Hardcastle with £46,000. To account for the facts that the "details" of the superheater "were worked out as a part of the general work of the [RGF]," and that the "idea ... came to Mr. Hardcastle as a Naval Officer," however, Acklom would slash two-thirds off the £46,000 for Hardcastle, leaving him with an award of £15,000.¹²⁶

The question of an award to Hardcastle was referred to the Admiralty Awards Council on 16 October 1908, and it delivered its recommendations on 3 November 1908. The Awards Council's members, for Hardcastle's case, at least, were the Director of Naval Ordnance (R. H. Bacon), the Director of Naval Construction (Philip Watts), the Director of Contracts (F. W. Black), and the Assistant Director of Contracts (C. A. Oliver). The Awards Council decided to use a different metric from Acklom's for evaluating Hardcastle's superheater. "We prefer not to consider the case in the light of the ultimate success of the invention which has undoubtedly been materially helped and accelerated by the assistance afforded by the A.S.R.G.F. [Assistant Superintendent of the Royal Gunpowder Factory] and his Staff," the Awards Council explained, "but rather from the point of view of what would have been a reasonable sum to have promised the inventor in

¹²⁶ Acklom to Bacon [DNO], 19 October 1908, described in Admiralty Awards Council, Report 26, "Award to Engineer Lieutenant S. U. Hardcastle," ADM 245/1, TNA.

the event of success at the time of his originally submitting his ideas to the Admiralty with a view to their development at the public expense.” This metric avoided the difficulty of separating Hardcastle’s work from the government’s, but only to substitute another problem, namely, determining what ideas Hardcastle had submitted, and when. This determination was not necessarily easy to make, since Hardcastle had reason not to submit all his ideas at once for fear that they would be stolen.

The Awards Council ignored this complication, however, and imposed an artificially simple solution. When Hardcastle submitted his ideas to the Admiralty, “the invention was entirely the property of the inventor,” the Awards Council argued, “but all subsequent work may be looked on as a performance of his duty, in that he was specially appointed to the ‘VERNON’ and Torpedo Factory to develop the invention and was paid his service pay for the work performed.” Instead of considering what Hardcastle could have obtained commercially for his finished invention, the Awards Council considered “what sum an outside firm would have been likely to have given for the crude invention before the details had been worked out and the ultimate practical success obtained.” The Awards Council dismissed Acklom’s quantification of the government assistance (£15,000) given to Hardcastle on the grounds that it was “considerable and impracticable of assessment.” Using its preferred metric rather than Acklom’s, and taking into account the Second Sea Lord’s promise that Hardcastle would be eligible for early promotion, the Awards Council recommended that Hardcastle be awarded £5,000—a third of the sum recommended by Acklom.¹²⁷

¹²⁷ Admiralty Awards Council, Report 26, “Award to Engineer Lieutenant S. U. Hardcastle,” ADM 245/1, TNA.

Hardcastle learned of his fate in December 1908. The Admiralty informed him that he would be noted for early promotion, that he would receive an award of £5,000 “in full discharge of all claims which he may have in respect of this invention” (subject to Treasury approval), and that he must keep the award strictly secret.¹²⁸ Hardcastle confirmed “that the award of a grant of £5,000 will be accepted in full discharge of all claims in respect of this invention and every effort will be made to keep the matter strictly secret as directed.”¹²⁹ The Treasury approved the £5,000 award, and Hardcastle was promoted early to Engineer Commander in 1912.¹³⁰

Was £5,000 and early promotion a fair reward? The answer depends on the metric used to determine the value of the superheater. Acklom used one (the commercial value of the mature version of the superheater), while the Awards Council used another (the commercial value of the earliest version of the superheater). Each of these metrics had its advantages and disadvantages: Acklom’s avoided the need to estimate the value of an experimental technology, at the cost of trying to untangle Hardcastle’s and the government’s development work; while the Awards Council’s avoided the latter only by over-simplifying the distinction between Hardcastle’s and the government’s work. It is noteworthy that both Acklom and the Awards Council tried to establish the commercial value of the device, that is, what Hardcastle might have received for it as a private inventor on the open market, and neither justified the award with reference to Hardcastle’s existing salary. The sum of £5,000 would have been an enormous financial

¹²⁸ SecAdm to CINC Portsmouth, 3 December 1908, CP Patents 237/43255/08, forwarded to Hardcastle on 4 December, T 173/257, TNA.

¹²⁹ Hardcastle to SecAdm, 8 December 1908, T 173/257, TNA.

¹³⁰ Minute by Toop [Engineer Admiral, Personnel], 6 January 1922, on Treasury letter S11342/22, T 173/257, TNA.

windfall for a naval lieutenant, amounting to at least a decade's worth of salary. The unspoken calculation was what Hardcastle might make if he bolted the Navy for greener private pastures. "You must remember that the inventor may be lured away from the Government service for his brains," the superintendent of the RGF reminded the inter-departmental committee investigating service inventors in 1905, "and then the Government will have to pay a very much higher price for his inventions."¹³¹ The Admiralty had to make it worth Hardcastle's while to stay in, and for that calculation, the relevant metric was not Hardcastle's existing naval salary but his potential commercial profits. By that standard, if Acklom's calculations were correct, then the Admiralty got Hardcastle's superheater on the cheap.

Hardcastle later concluded that the Admiralty had not awarded him adequately and appealed for more money. On the surface, he had no grounds to complain, since he had accepted the £5,000 "in full discharge of all claims." The Admiralty's lawyer put the case against Hardcastle this way:

[I]f the Admiralty or any Government Department and an inventor are to be in the position of two bargaining forces, or bargaining parties, one can always consider the possibility of an arrangement by which something in the nature of an interim award is made, that is to say, a smaller award would naturally be offered to an inventor if he were at the same time given the right again to approach the awarding body for a further award, having regard to the subsequent history of his invention.... [B]ut where one has a case where it is definitely stated that the sum given is in full discharge of all obligations of one side to the other, in my respectful submission that means that a larger sum has been offered, and would naturally be offered where there is to be no right to come back for further consideration.... [T]hat is exactly the position in this case. What is a Government Department to do in future?... [I]f a claimant is to come and have a further award

¹³¹ Testimony of Colonel H. C. L. Holden (Superintendent of RGF), 25 October 1905, Appendix VII, "Report of the Inter-Departmental Committee Appointed to Consider the Regulations as to the Taking out of Patents by Officers and Subordinates in Government Employment, with Appendices, 1905-06," WO 32/5080, TNA.

it is a case really of ‘Heads I win, tails you lose.’¹³²

That argument was persuasive, Hardcastle’s lawyer countered, if the inventor and the government department were analogous to free agents in a private, competitive market—but Hardcastle was no free agent: “the true position of subordinate officers dealing with such departments” means that “there is no bargain.”¹³³ Much as experimental command technology was not an ordinary commercial product, so an inventor in government employ was not an ordinary commercial agent, and he was therefore incapable of making an ordinary commercial bargain.

Even more important, perhaps, than the justice of the outcome was the process that produced it. In particular, the existence of the Admiralty Awards Council, and its function to make government employment financially competitive with private employment, was highly significant. It meant that the Admiralty had a system to incentivize innovation. Although the Admiralty might spend £5,000 to buy ten torpedoes without batting an eyelash, a request for £5,000 to be paid to an individual officer was sure to raise Treasury eyebrows, and the Admiralty cannot have made it lightly. Fairness to Hardcastle aside, the Admiralty was serious about technological change.

Torpedoes and Naval Architecture: The Protection Problem

As the gyroscope and nickel-steel air flask increased the range and speed of torpedoes, an experiment conducted in 1903 underlined the vulnerability of capital ships to these ever more powerful weapons. In June 1902, the Controller, William May,

¹³² Argument by Whitehead [no apparent relation to the inventor of the torpedo], 4 April 1927, Hardcastle’s RCAI claim, pp. 85–87, T 173/649, TNA.

¹³³ Argument by Moritz, 4 April 1927, Hardcastle’s RCAI claim, p. 15, T 173/649, TNA.

proposed experiments to determine the vulnerability of capital ships to underwater explosion. “Considering the far reaching effect of such an explosion on the structure of ships as at present built, the enormous cost of the modern ships and the increasing range and improved accuracy of the Torpedo,” May told the Director of Naval Construction,

I am most firmly impressed with the view that we should make every effort to safeguard our ships from the destructive effect of Torpedoes. I look upon this problem as by far the most important that the Designer has to overcome, and I consider no trouble or expense should be spared in carrying out experiments that may possibly gradually lead up to the protection of a large ship from submarine explosion.¹³⁴

After back-and-forth over securing a suitable target, which turned out to be the *Belleisle*, May circulated the idea to the rest of his colleagues.¹³⁵ The First Lord, Selborne, concurred: “I believe this experiment to be the most important we have yet tried.”¹³⁶

When the experiment was finally carried out in October 1903, the results were discouraging.¹³⁷ It was “apparently impossible with plates and angles of the sizes at present in use and with our present system of riveting to construct a side capable of withstanding the explosion of such a large charge of gun cotton.”¹³⁸ With regret, May told his colleagues that “with our present knowledge it is not possible to make a ship invulnerable against the attack of the 18” Whitehead, without going to a prohibitive

¹³⁴ Minute by May, 30 June 1902, G6604A/02, Docket “Proposed Experiments with the view of finding the best means of protecting bottoms of ships against explosive effects of Torpedoes,” ADM 1/7687, TNA.

¹³⁵ Minute by May, 26 January 1903, G1064/03, Docket, “Belleisle. Plan of Target for Torpedo Attack. Proposed further experiment,” ADM 1/7687, TNA.

¹³⁶ Minute by Selborne, 1 February 1903, G1064/03, Docket, “Belleisle. Plan of Target for Torpedo Attack. Proposed further experiment,” ADM 1/7687, TNA.

¹³⁷ Admiral Superintendent Portsmouth to SecAdm, 17 October 1903, G13107/03, Docket, “HMS ‘Belleisle.’ Report of Torpedo Experiments,” ADM 1/7687, TNA.

¹³⁸ Berry [for DNC] to May, 1 December 1903, G13107/03, Docket, “HMS ‘Belleisle.’ Report of Torpedo Experiments,” ADM 1/7687, TNA.

size.”¹³⁹ May preserved the secrecy of this conclusion by ordering the results of the experiments to be “defaced” from the *Belleisle* before the ship was sold, and the report not to be printed.¹⁴⁰

Not long after the *Belleisle* experiments confirmed that better construction could not protect capital ships from torpedo attack, the ability of small craft to deliver torpedo attacks improved. In 1904, the Navy figured out a way to fire torpedoes fitted for submerged discharge from above-water tubes, which meant that destroyers, whose torpedo-carrying capacity was limited, could borrow torpedoes from capital ships.¹⁴¹ At the same time, another potential defense against torpedo attack was stripped away. In January 1904, the Ordnance Committee (a joint War Office-Admiralty committee) reported that 9.2-inch guns firing shrapnel shells with special fuses could sink a torpedo boat even without making a direct hit—“but she would probably float long enough,” the Director of Naval Ordnance gloomily elaborated, “to get off her torpedoes.”¹⁴² In any case, he thought the method impracticable due to issues with the fuse. Therefore, he concluded, in a fleet action “you would have to rely on your own fire from as many small Q.F. [quick-firing] guns as were still available, manoeuvring the fleet so as to bring the attacking boats astern, and above all on the counter attack of your own destroyers.”

The performance of the *River* class destroyers ordered in 1902 suggested that they

¹³⁹ Minute by May, 7 December 1903, G13107/03, Docket, “HMS ‘Belleisle.’ Report of Torpedo Experiments,” ADM 1/7687, TNA.

¹⁴⁰ Minutes by May, 30 December 1903, and anonymous, n.d., G13107/03, Docket, “HMS ‘Belleisle.’ Report of Torpedo Experiments,” ADM 1/7687, TNA. See also the discretion at work in ART03/37.

¹⁴¹ Boatswain (T) J. McCarthy to Commander Hubert Brand, 5 July; Brand to Captain (D) E. Charlton, 6 July; Charlton to CINC Home Fleet, 11 July 1904, ART04/Appendix E.

¹⁴² The contents of this Committee’s report are described in a minute by DNO, 25 March 1904, G4421/04, PQ/04/3067/310–11. The quotation comes from minute by DNO, 25 March 1904, G4421/04, PQ/04/3067/310–11.

could be relied on to perform this mission. A withering attack on the class in 1903 by the bumptious new Parliamentary and Financial Secretary, H. O. Arnold Foster, forced a review of British destroyer design. He argued that the *River* class, which had been partly inspired by the seaworthiness of German destroyers, had not kept pace with German development: the Germans' new destroyers managed to achieve speeds of 29 knots without sacrificing strength and weight, as compared to the 25.5 knots of the *River* class.¹⁴³ The Construction Department sharply opposed his claims about German performance and defended the *River* class.¹⁴⁴ Commanders of the *River* class destroyers lent their support to the Department's argument, confirming that these destroyers were capable of accompanying a fleet without towing.¹⁴⁵ In theory, the seaworthiness of the *River* class improved its ability to defend a fleet from enemy torpedo boats.

As reports praising the sea-keeping abilities of the *River*-class destroyers poured in, however, so too did a gloomy assessment of destroyers' gunnery, and by implication, of their ability to defend a fleet from attack by torpedo craft. In October 1904, the captain of *Excellent*, the gunnery school, and the captain of a destroyer flotilla jointly reported on experiments with the light, quick-firing, anti-torpedo craft armament carried by destroyers. They concluded that the effect of vibration would make it impossible to shoot accurately at speeds over 15 knots and that it would be impossible to distinguish between a hit and a miss against another destroyer over 1,000 yards.¹⁴⁶ Accordingly, they defined the range within which light quick-firing guns stood a reasonable chance of hitting their

¹⁴³ Minute by Arnold Foster, 16 February 1903, S5661/03, SC184/F94, BF.

¹⁴⁴ There are many examples of the DNC's opposition in SC184, but see, e.g., minute by Deadman, 19 March 1903, S5661/03, SC184/F94, BF.

¹⁴⁵ See SC184b/F88, F115, and F172, BF.

¹⁴⁶ Erksine and Charlton to CINC Portsmouth, 28 October 1904, G15020/04, PQ/05/3145/500–508.

targets as 1,000 yards—which was well within the range of gyroscopic torpedoes (and close to the range of even non-gyroscopic torpedoes). The situation was even worse at night, because the effective range of existing searchlights was only 500 yards. Moreover, even if destroyers could make hits, the captains pointed out, referring to the Ordnance Committee experiments of 1901–1902, hits from 12-pounder and smaller guns could not be relied on to stop destroyers. Therefore, they recommended the development of a new gun that could be relied on to stop destroyers.

The Admiralty acted on their recommendation in late 1905 and early 1906 by commissioning designs of a new 4-inch gun.¹⁴⁷ A low-velocity version with relatively weak recoil was intended to equip new destroyers, whose hulls were not strong enough to withstand heavy recoils, while a high-velocity version was intended for new unarmored cruisers and armored ships.

The Admiralty's decision to commission a new design came none too soon. In January 1906, the Admiralty had experiments carried out against the old destroyer *Skate*, fitted out to represent a new French destroyer.¹⁴⁸ The Director of Naval Ordnance, Jellicoe, analyzed the results for his colleagues.¹⁴⁹ To begin with, he pointed out that anti-torpedo craft armament needed to be able to inflict heavy damage quickly, partly to prevent its targets from advancing after they were hit, and partly because, in night actions, searchlights would not be able to keep the target in sight for very long. The *Skate* experiments revealed that the 4-inch gun alone was capable of doing so, not the 12-

¹⁴⁷ Minutes on G17235/05, PQ/06/3246/731–33, and G189/06, PQ/06/3247/734–35.

¹⁴⁸ Report by Superintendent of Experiments [Ordnance Committee], 31 January 1906, G2116/06, PQ/06/3210/630–34; minute by DNO [Jellicoe], 8 May 1905, G6789/05, SC128b/F155, BF. Note that while German destroyers served as an inspiration for British designs, French destroyers still served as a threat—in 1906, two years after the conclusion of the Anglo-French entente.

¹⁴⁹ Minute by Jellicoe, 12 February 1906, G2116/06, PQ/06/3210/634–38.

pounder (3-inch) or 3-pounder (47-millimeter). As a result, “[T]he conclusion is forced on the mind that the anti-torpedo boat armament of future ships should consist of 4-inch guns” firing new 31-pound shells instead of the old 25-pound shells, especially since new French destroyers carried one-inch armor around their engine and boiler rooms. It might be objected, Jellicoe observed, that the high rate of fire obtainable with the smaller 12-pounder and 3-pounder guns would compensate for the small effect of each hit, but this argument “falls to the ground when it is realised that with the fire under proper control the number of rounds that can be fired per minute from 3-pr., 12-pr., or 4-inch is very much the same.” Recent practice had shown that fire control was necessary to obtain good effects, as well as “the extraordinarily small chance of hitting a torpedo boat at night even under the most favourable conditions, and therefore the absolute necessity for obtaining the maximum possible effect from a hit.” In fact, the speeds of torpedo craft, combined with limits on British searchlights, meant that one hit might be all that could be obtained. Accordingly, Jellicoe recommended that 12-pounder and smaller anti-torpedo armament be abandoned, and that the high-velocity and low-velocity 4-inch gun take their place on ships and destroyers, respectively. The Director of Naval Construction and the Controller endorsed his views, and the First Sea Lord and First Lord approved.¹⁵⁰

The Probability of Hitting, Torpedo Settings, and Torpedo Craft Missions

A basic assumption underlying these decisions about anti-torpedo craft armament was that torpedo craft would be engaged at short ranges. The extent to which assessments of enemy tactical intentions influenced this assumption is unclear, but it is

¹⁵⁰ Minutes on G2116/06, PQ/06/3210/634–38.

clear that the Admiralty did not expect its own torpedo craft to fire torpedoes at long ranges. The rationale for this decision had its roots in a 1904 report by the Torpedo Design Committee, which investigated the tactical scenarios in which torpedoes might be used in order to lay down standards for torpedo speeds and ranges.¹⁵¹ The Committee's logic regarding speed was straightforward: the speed of modern battleships meant that the minimum speed for torpedoes should be 20 knots, though further increases were desirable, since higher speeds meant higher probabilities of hitting (or, put differently, higher speeds meant that errors in estimating target bearing, range, and/or speed would have less effect). Notably, the Committee's explicit use of probability theory began and ended there. It is possible that the Committee was implicitly using 20 knots as a sort of proxy for a given probability of hitting, having discovered by calculations that torpedoes at least as fast as battleships corresponded to a certain probability of hitting, but there is no explicit evidence for this interpretation.

The Committee's logic regarding range was less clear, whether due to confusion of thought or imprecision of wording. The Committee began by noting that in daylight, vulnerability to gunfire would force vessels to fire torpedoes at long ranges, while at night, relative invisibility would permit them to fire torpedoes at shorter ranges. Battleships would use torpedoes only during a daytime fleet action, at longer ranges, while torpedo craft would use them mostly in surprise night-time attacks, at shorter ranges, but would need to retain a capability to fire them at longer ranges in a daytime fleet action. For firing torpedoes at single ships, the Committee fixed the maximum range at 2,000 yards, reasoning that the Navy could not accurately estimate target course and

¹⁵¹ Second Report of TDC, n.d., ART04/134–36.

speed beyond that limit. Why the Committee contemplated the use of torpedoes against single ships out to 2,000 yards, instead of contemplating the use of torpedoes against groups of ships at all ranges, or instead of limiting the range for single-ship use more sharply, is unclear. It is noteworthy that the factor limiting the range to 2,000 yards was not internal to the torpedo—like the strength of the air flask—but external, namely, an incapacity to estimate target course and speed. Until that capacity improved, once the 2,000-yard range was reached, the Committee recommended that future increases in the torpedo's power go toward increasing its speed rather than its range.

The privileging of speed over range was an important point, and probably a sensible one, given the existing limitations on the Navy's ability to estimate target course and speed, on the one hand, and the increasing effect of errors as ranges lengthened, on the other. In fleet torpedo practice, errors in estimating the target course and speed were the most frequent causes of failures to hit.¹⁵² For instance, firing on the beam at a target 400 feet long and steaming on a parallel course—optimal firing conditions, in other words, because the target, presenting its broadside, was at its largest—at a range of 1,500 yards, misestimating the target course by merely half a point (5.625 degrees) and its speed by one knot would cause a miss.¹⁵³ Increasing the speed of torpedoes directly increased the tolerance for error in estimating target course and speed. For instance, if the target speed was misestimated by one knot, a 20-knot torpedo would miss the point aimed at by 300 feet, while a 40-knot torpedo would miss by only 150 feet.¹⁵⁴ In this scenario, if the target was 400 feet long (the approximate length of capital ships), the 20-

¹⁵² ART04/66, ART06/10, ART07/10.

¹⁵³ *Torpedo Manual for Her Majesty's Fleet, in Three Volumes*, vol. 3 (1909), 323–24.

¹⁵⁴ *Ibid*, 325.

knot torpedo would probably miss, while the 40-knot torpedo, despite the error, would probably hit.

While the Committee, for these reasons, considered 2,000 yards to be the maximum range at which torpedoes should be used against single ships, the limit for use against groups of ships was much higher—3,500 yards, which the Committee called the “full effective limit.” Its terminology naturally begs the question of how it defined “effectiveness,” and the answer is that it did not, at least not explicitly. Clearly it assumed some distinction between effective range when used against single ships and effective range when used against groups of ships. The implicit logic behind this distinction was undoubtedly that the probability of hitting was much higher when the target was a group of ships rather than a single ship, due both to the relative size of the target and to the relative ease of estimating target course and speed. This logic lacked the precision of a quantitatively expressed probability of hitting, however. Thus, while it is clear that the Committee’s definition of effective range was two-tiered, one for single-ship targeting and the other for group targeting, and that its definition had to do with probability calculations, what probability it calculated as effective, or if it so calculated, is unclear.

Based on its vision of the future battlespace, the Committee recommended a multi-tiered system of adjusting torpedoes. For older torpedoes used at long range in a fleet action, the longest range that they could run without falling below the minimum speed of 20 knots was 1,500 yards when fired from battleships and cruisers, and 2,000

yards when fired from torpedo craft.¹⁵⁵ Because torpedo craft might fire their torpedoes at shorter ranges in other scenarios, their torpedoes should also have a short-range adjustment for 1,000 yards, which they could cover in the high-20 knots. Newer torpedoes with nickel-steel air flasks capable of being charged to higher pressures, including the then-prospective 18-inch RGF Mark VI, should be adjusted for 2,000 yards for use from battleships and cruisers, which they could cover in the high-20 knots; and dual-adjusted for 1,000 and 2,000 yards for use from torpedo craft. The counters of all torpedoes should be capable of adjustment for 3,500 yards, though the range between 2,000 and 3,500 yards would be run at a diminishing speed.

The partially dissenting member of the Committee, the ubiquitous Lieutenant Acklom, Assistant Superintendent of the RGF, challenged the majority on several points.¹⁵⁶ To begin with, Acklom disagreed with the majority's contention that battleships would fire torpedoes at single ships; he thought that most firing by battleships would target the enemy battle line, which he called "browning," although he thought that they might have opportunities to fire at single battleships that accidentally blundered into torpedo range. Noting that "it is incomparably more difficult to judge speed and course of a ship by herself than of one of a line," he reasoned that ranges would be too long for sufficiently accurate estimates of single-ship course and speed, but he did not specify the range he had in mind, or whether he thought gunnery or torpedoes would be responsible for lengthening it. Unlike battleships, he argued, light cruisers and torpedo craft would fire at shorter ranges, presumably reasoning that they would discharge them either in

¹⁵⁵ The discrepancy in range was due to the fact that battleships and cruisers fired their torpedoes from submerged tubes, for which the torpedoes needed special fittings whose weight slowed them and/or lessened their range, whereas torpedo craft fired their torpedoes from above-water tubes.

¹⁵⁶ Acklom's partial dissent, Second Report of TDC, n.d., ART04/136-39.

surprise attacks at night, relying on darkness for defense, or in dashes between dueling battle lines by day, relying on enemy confusion or inattention for defense. Reflecting growing uncertainty about the role of armored cruisers, which were becoming more and more like battleships in terms of armor, armament, and displacement, he thought that torpedo fire by armored cruisers would be split evenly between longer ranges like battleships and shorter ranges like light cruisers and torpedo craft. In agreement with the majority's premise that speed and range were antagonistic, he argued that battleships' torpedoes should sacrifice speed for range, while light cruisers' and torpedo craft's torpedoes should sacrifice range for speed; the adjustment of the reducer would govern whether speed or range was favored. For the future, he suggested that a reducer be developed with dual settings, one for high speed / short range, the other for low speed / long range.

Unlike the majority of the Committee, Acklom also attempted to quantify the probability-of-hitting issue. Acknowledging that opinion as to what constituted a "fair" probability of hitting was divided, he posited that, against a single ship, it was a 40% probability, based on "lengthy calculations" which took into account "money value and small number of torpedoes carried, probability of getting within range, speeds of ships and torpedoes, &c."¹⁵⁷ It is unfortunate that Acklom did not expand upon his tantalizing mention of "lengthy equations" or prioritize his laundry list of variables, as it would be very interesting to know how he weighted them and perceived their interactions. Acklom thought that this 40% probability should govern the speed and range adjustments of torpedoes for use against single ships. For use against multiple ships, by contrast, Acklom

¹⁵⁷ Acklom's partial dissent, ART04/138.

abandoned his probability-of-hitting approach and agreed with the Committee majority that the speed of the target, not a certain probability of hitting, should govern the adjustments of torpedoes, with the difference that he thought the speed of torpedoes should be 20% higher than that of the target, whereas the majority said equal speed was sufficient.

Based on his different vision of likely tactical scenarios and on his probability-of-hitting requirement, Acklom recommended a different set of adjustments from the majority of the Committee. Unlike the majority recommendation of just one adjustment for torpedoes used from large ships, Acklom argued that all torpedoes, whether used from the submerged tubes of large ships or the above-water tubes of torpedo craft, should have two adjustments, one high-speed / short-range setting for use against single ships and one low-speed / long-range setting for use against multiple ships. Until a device for switching between adjustments was invented, however, Acklom said that the torpedoes of large ships should be adjusted for high speed and short range, corresponding to use against single ships. This recommendation seemed to contradict his earlier statement that large ships would rarely get chances to fire at single ships and therefore should keep their torpedoes adjusted for “browning” multiple ships, that is, for low speed and long range, but Acklom reasoned that the roughly 500-yards-longer range gained by lowering the speed would matter little in battle, on the grounds that fleets determined to stay outside torpedo range would stay much more than 500 yards outside torpedo range.

In forwarding Acklom’s and the majority’s reports, the president of the Committee and captain of *Vernon*, G. le C. Egerton, explained why the majority did not agree with Acklom’s views. First, the majority thought that his 40% probability-of-hitting

requirement was too high: given that the damage inflicted by torpedoes if they struck ships was so high, and given that fleets would rarely close the range sufficiently to enable a 40% chance of hitting, the majority considered it too great “a loss of opportunity” to hold fire until a 40% chance of hitting was obtained. Second, the Committee majority disagreed with Acklom’s suggestion that large ships should keep their torpedoes adjusted for higher speeds and shorter ranges (until a device for switching between adjustments was invented), on the grounds that most officers would choose a lower speed for 2,000 yards over a higher speed for 1,500 yards, privileging range over speed.

Notwithstanding these differences, the majority and Acklom agreed more than they disagreed. Torpedoes should be adjusted to run at uniform speeds for the first 1,500-2,000 yards of their run, and at a diminishing speed thereafter. Their counters should be altered to allow them to run for as long as their air held out. Torpedoes for use from torpedo craft should be capable of dual adjustment, one for lower speeds over longer ranges and one for higher speeds over shorter ranges. In 1906-1907, the assumption that torpedoes would run at diminishing speeds up to 3,500 yards was replaced with a formal extreme-range reducer setting of 4,000 yards for the modern 18-inch nickel-steel torpedoes in the Navy’s arsenal (RGF Marks V*-VI*, Fiume III-III**), which they could run at speeds of 19-22 knots, with enough air left over to take them another 500 yards at diminishing speeds.¹⁵⁸ The 18-inch Mark VI*, the last cold torpedo in the Navy’s arsenal, had three settings: short-range (1,000 yards) at 35.25 knots, long-range (2,000 yards) at 29 knots, and extreme-range (4,000 yards) at 22 knots.

It should be borne in mind that the Admiralty intended the extreme-range setting

¹⁵⁸ ART06/14, ART07/18.

for use by battleships “browning” the enemy fleet, not by torpedo craft. The Admiralty did not intend for torpedo craft to stay with capital ships outside enemy gun range to fire their torpedoes. On at least one occasion, the Admiralty scolded its own torpedo craft commanders for firing torpedoes beyond 1,000 yards.¹⁵⁹ The fact that it was necessary to scold them, however, suggests that some commanders were deliberately challenging Admiralty policy as to the proper range for them to fire their torpedoes (although it may simply have reflected their inability to estimate when they were inside torpedo range, rather than deliberate disobedience).

At the very least, aside from the question of whether torpedo craft should fire their torpedoes from inside or outside enemy gun range, opinion certainly remained divided as to their role in battle. In a work written shortly before his death in 1904, B. W. Walker—the former Assistant Director of Torpedoes, then commanding the Cruiser Division of the Mediterranean Fleet—echoed Fisher’s complaint, discussed in Chapter 2, that destroyers were being misused as cruisers, a practice “somewhat like employing a racehorse to haul coal.”¹⁶⁰ When the Channel Fleet conducted tactical exercises in 1907, the second-in-command, Reginald Custance (previously encountered as the Director of Naval Intelligence), complained that destroyers “do not appear to appreciate the work which they are more immediately required to do, which to my mind is not to torpedo the enemy’s battleships, but to deal with his destroyers.”¹⁶¹ Lord Charles Beresford, commander in chief of the Channel Fleet, also pointed to the confusion surrounding

¹⁵⁹ SecAdm letter of 27 April 1906, G5299/1906/06, ART06/28–29.

¹⁶⁰ Walker, *The Employment of Cruisers and Destroyers* (Admiralty: Intelligence Department, 1906), 38, Eb 164, AL.

¹⁶¹ Custance to Beresford [CINC Channel Fleet], 7 July 1907, enclosure in Beresford to SecAdm, 1 August 1907, Docket “Tactical Exercises. Channel Fleet, 5th Cruiser Sqdn. Scouts and Destroyers. June and July 1907,” D675/1907, ADM 1/7795, TNA.

destroyers' missions, and urged that "some fundamental principles be tried and established without delay."¹⁶² The commander of the Home Fleet's destroyers, Lewis Bayly, emphatically agreed with Custance's view that priority for destroyers was to deal with enemy torpedo craft, not with enemy capital ships, and with Beresford's view that this principle needed to be inculcated in them during peacetime in order to prepare them for war.¹⁶³ While agreeing with Bayly as to the prioritization of destroyers' duties, the Director of Naval Intelligence, Edmond Slade, nevertheless argued that destroyers might sometimes need to attack enemy capital ships, and he resisted Beresford's and Bayly's suggestion to dictate destroyers' missions on the grounds that it would unduly limit fleet commanders' freedom of action.¹⁶⁴ Thus, not only was there disagreement over the range at which torpedo craft should attack enemy capital ships, there continued to be disagreement over whether they should attack enemy capital ships at all.

The Tactical Implications of Heated Torpedoes

For capital ships determined to stay outside torpedo range, the storm raging over the role of torpedo craft was beside the point. The development of gyroscopic torpedoes had significantly increased effective torpedo range. This increase had important

¹⁶² Memorandum by Beresford, 30 July 1907, enclosure in Beresford to SecAdm, 1 August 1907, Docket "Tactical Exercises. Channel Fleet, 5th Cruiser Sqdn. Scouts and Destroyers. June and July 1907," D675/1907, ADM 1/7795, TNA.

¹⁶³ Bayly, "Duties of Destroyers in War," n.d. but enclosed in CINC Home Fleet [Bridgeman] to SecAdm, 10 November 1907, SC242/F11a, BF.

¹⁶⁴ Minute by Slade, 12 December 1907, SC242/F11a, BF. Although the loaded and complex issue of fleet commanders' freedom of action is beyond the scope of the present work, it may be noted that Beresford's role in this dispute fits closely with Nicholas Lambert's interpretation of the Fisher-Beresford controversy; see Lambert, *Sir John Fisher's Naval Revolution, 186–94*, and "Strategic Command and Control for Maneuver Warfare: Creation of the Royal Navy's 'War Room' System, 1905–1915," *Journal of Military History* 69, no. 2 (April 2005): 385–9. The key to Lambert's interpretation is that the controversy between the two men concerned fundamental questions of what would now be called command-and-control (both tactical and strategic) and doctrine; it was about much more than personality and politics.

implications for British gunnery policy. Since naval officials sought to keep capital ships outside effective torpedo range (plus a buffer zone, as discussed in Chapter 2), their guns had to be able to hit at ever longer ranges.¹⁶⁵ By 1906, according to Jon Sumida, the Admiralty “had increased its estimate of likely battle ranges from 6,000 to 8,000 yards, ordered that battle practice be carried out at ranges of 6,000 to 7,000 yards, and extended the notion of long battle range from 8,000 to 9,000 yards.”¹⁶⁶ In general, although the details were extremely complicated and the trend not unobstructed, the increase in battle ranges worked to the advantage of a faction interested in developing a sophisticated fire control system invented by Arthur Pollen. At ranges beyond 5,000 yards, continuously or even frequently observing the fall of shot to correct for gun-aiming errors was impossible. This inability put a premium on the ability to calculate ranges mechanically based on infrequent range observations, as Pollen’s system promised to do.¹⁶⁷

Like gyroscopic torpedoes, heated torpedoes changed British tactical assumptions and gunnery policy dramatically. In late 1907, before the experiments with Hardcastle’s superheater were completed, the Assistant Director of Torpedoes, Currey, had observed that long-range torpedoes “will tend to prevent close action, and, therefore, accentuate gunnery skill.”¹⁶⁸ In late 1908, after the Navy had completed experiments with and placed a large-scale order for the Mark VII torpedo, and while it was experimenting with the 21-inch Mark I and Mark II torpedoes, Currey went a step farther: “In considering the use such long range torpedoes in ships can be put to it is pointed out that a ‘Fleet’s

¹⁶⁵ Jon Sumida, “The Quest for Reach: The Development of Long-Range Gunnery in the Royal Navy, 1901–1912,” in Stephen D. Chiabotti, ed., *Military Transformation in the Industrial Age* (Chicago: Imprint, 1996), 50–51, 59–60.

¹⁶⁶ *Ibid.*, 59.

¹⁶⁷ *Ibid.*, 66.

¹⁶⁸ Minute by Currey, 22 October 1907, G16396/07, PQ/09/3345/156–57.

broadside of torpedoes' fired at the centre of an opposing Fleet would be a very formidable means [of?] offence at a commencement of a battle *before even the guns come into action.*"¹⁶⁹ The Director of Naval Ordnance, Reginald Bacon, seconded that emotion: "We have it now in our power to construct a torpedo which should effect considerable damage on a line of ships outside practical gunnery range."¹⁷⁰ For Bacon, though not for many other officers, the conviction that British guns would not be able to out-range torpedoes constituted a powerful argument against further increases in battle ranges and continued development of Arthur Pollen's sophisticated but expensive fire-control system, and a correspondingly powerful argument in favor of developing Frederick Dreyer's inferior but cheaper alternative.¹⁷¹

Flotilla Defense and the Fisher Synthesis

Although tactics remained unclear in the face of the increasingly long-range torpedoes, a revolutionary strategic consensus was emerging around them. When Fisher took over as First Sea Lord on Trafalgar Day (October 21), 1904, his main task was to reduce naval expenditures. A lower budget meant that the Royal Navy might have to sacrifice one of its two traditional missions, protecting the home islands and defending the empire (namely its trade and communications). Indeed, Arthur Marder interpreted two of Fisher's major reforms—the so-called redistribution of the fleet, which removed capital ships from distant stations to concentrate them in home waters, and the scrapping

¹⁶⁹ Minute by Currey, 17 December 1908, G18178/08, SC224/F34, BF. Emphasis added. I am grateful to Jon Sumida and Nicholas Lambert for drawing my attention to this folio. Sumida discusses it in "The Quest for Reach," 74.

¹⁷⁰ Minute by Bacon, 17 December 1908, G18178/08, SC224/F34, BF.

¹⁷¹ Sumida, "The Quest for Reach," 74.

policy, which eliminated smaller vessels that could be used for commerce protection—in just these terms, as analogous to Rome’s recall of the legions.¹⁷² The conventional wisdom established by Marder holds that Fisher abandoned imperial defense in order to concentrate on the German threat to the home islands.

Subsequent scholarship, however, has shown that Fisher was up to something very different. Fisher formed his strategic views during his command of the Mediterranean from 1899 to 1902, not in the North Sea.¹⁷³ The Mediterranean was the linchpin of the British empire, and the enemies there were France and Russia, not Germany. Rapid changes in British diplomacy (the Japanese alliance in 1902, the French entente in 1904) hardly disposed Fisher to think in terms of permanent threats. Instead of focusing on a particular enemy, he wanted to build flexible capabilities that could respond across a range of scenarios. He believed that technology would allow him to do so despite reductions in the Navy’s budget. The central actors in his vision were not battleships—slow, expensive battleships that were extremely vulnerable to torpedoes—but torpedo craft, battlecruisers fitted with superior fire control systems, and revolutionary communications and command-and-control systems.¹⁷⁴

In a scheme known as flotilla defense, torpedo craft (destroyers and submarines, a.k.a. flotilla craft) would deny the Channel, North Sea, and Mediterranean to enemy

¹⁷² Marder, *The Anatomy of British Sea Power: A History of British Naval Policy in the Pre-Dreadnought Era, 1880–1905* (Hamden: Archon Books, 1964; first edn. 1940), 489–91, and *From the Dreadnought to Scapa Flow: The Royal Navy in the Fisher Era, 1904–1919*, Vol.1, *The Road to War, 1904–1919* (London: Oxford University Press, 1961), 38–43

¹⁷³ See Ruddock Mackay, *Fisher of Kilverstone* (Oxford: Clarendon Press, 1973), 224–72.

¹⁷⁴ Battlecruisers had the armament of battleships but less armor, which made them faster than battleships.

vessels, deterring them from invasion and interference with imperial trade.¹⁷⁵ Calling Admiral Tirpitz's "risk fleet" bluff, Fisher accepted that British capital ships could not risk entering the North Sea, and then he turned Tirpitz's logic on the Germans: so long as the Germans could not enter the North Sea either, then Britain would achieve its end. A torpedo-based strategy of deterrence could achieve that objective just as effectively—and much more cheaply—than a gun-based strategy of decisive battle. In short, Fisher answered the risk fleet with a risk flotilla.

While torpedo craft defended the narrow waters in the Channel, North Sea, and Mediterranean, battlecruisers would control the high seas elsewhere. If the battlecruisers got caught in a battle with enemy capital ships, they would use their superior speed and fire-control systems to hit the enemy while remaining outside the enemy's range, so that their weaker armor protection would not be a problem.¹⁷⁶ An extraordinary series of innovations known as the War Room System would track enemy merchant vessels and guide the battlecruisers to them. Marrying advances in telegraphy with more centralized command-and-control, the War Room System would allow the Admiralty to replace blockade of the enemy's coast with global economic warfare.

Far from recalling the legions, Fisher created a new fiscal-technological-strategic synthesis that would allow the Navy to continue performing its traditional missions more effectively and possibly for less money. It fundamentally redefined the metrics of naval

¹⁷⁵ Nicholas Lambert uncovered the strategy of flotilla defense, and this account relies entirely on his work. See Lambert, "Admiral Sir John Fisher and the Concept of Flotilla Defence, 1904–1909," *Journal of Military History* 59, no. 4 (October 1995): 639–60; and Lambert, *Sir John Fisher's Naval Revolution*, 120–26.

¹⁷⁶ Jon Sumida did the path-breaking work on Fisher's ideas about battlecruisers and fire control, first publishing his findings in "British Capital Ship Design and Fire Control in the Dreadnought Era: Sir John Fisher, Arthur Hungerford Pollen, and the Battle Cruiser," *Journal of Modern History* 51, no. 2 (June 1979): 205–30, and expanding them in *In Defence of Naval Supremacy*, in which see especially pp. 37–51, 89–100.

power. Instead of measuring naval power in big guns and battleships, it measured power in torpedoes, torpedo craft, battlecruisers, fire control, and communications. Instead of seeking command of the sea through decisive battle, Fisher sought denial and control of the sea through flotilla defense, battlecruisers, and the War Room System.

Fisher was happy to let others believe that he believed in battleships. In a period of financial retrenchment, Fisher's main goal was to preserve the Navy's budget—and particularly its construction budget—from Army depredations. Thus he publicly played up the German threat in the North Sea and Britain's corresponding need to build capital ships, even as he took a very different line in private. "[T]he English Navy is *now* four times stronger than the German Navy," he cheerfully informed the king, "but we don't want to parade all this, because if so we shall have Parliamentary trouble.... [I have recently read a paper] convincingly showing that we don't want to lay down any new ships at all—*we are so strong*. It is quite true!"¹⁷⁷ By catering to the crudest metrics of naval power, Fisher fooled not only contemporary politicians but also historians into thinking he believed his own propaganda.¹⁷⁸

Conclusion

Torpedo development from 1903 through 1908 was a double-edged sword for the Royal Navy. Gyroscopes made torpedoes more accurate, but they required new practice regimes and safety devices for reliable use. The Hardcastle superheater increased torpedoes' range and speed, but it created friction with the Armstrong Company and

¹⁷⁷ Fisher to King Edward VII, 4 Oct 1907, quoted in Lambert, *Sir John Fisher's Naval Revolution*, 142.

¹⁷⁸ On historians' errors, see also Jon Sumida, "Sir John Fisher and the *Dreadnought*: The Sources of Naval Mythology," *Journal of Military History* 59, no. 4 (October 1995): 619–37.

eventually with Hardcastle himself. The relocation of the torpedo factory from Woolwich to Greenock gave the Navy control of this vital piece of naval ordnance, but it disrupted the supply base at an important moment. Torpedoes made possible the strategy of flotilla defense, which enabled the Royal Navy to perform all its traditional missions despite budget cuts, but they created severe tactical headaches. None of these dilemmas would go away.

Chapter 5: American Torpedo Development, 1909-World War I

“[T]he patent laws were intended for the protection of the inventor and produce, and not for the oppression of the consumer.”
– G. W. Williams, 1912¹

Introduction

From 1909 up to World War I, the Bureau of Ordnance suffered the consequences of its earlier errors in dealing with McNeillian command technology—and it repeated the errors. First, the Bureau’s dispute with the Bliss Company over superheater royalties, which had been simmering since 1907, boiled over, culminating in a lawsuit. Next, the Bliss Company called the Bureau’s Clause 19 bluff regarding the balanced turbine, leading the government to file a lawsuit that went all the way to the Supreme Court. As both parties grappled with the consequences of their earlier actions, the pace of technological development offered them no respite. A new invention known as the wet superheater, which enabled dazzling new speeds and ranges, developed the problems that almost inevitably attended command technology. To stimulate the Bliss Company, the Bureau invited another firm, the Electric Boat Company, to design torpedoes with wet superheaters, only to be sued again for patent infringement, in another case that went all the way to the Supreme Court. Thus, by 1914, the government was involved in three torpedo-related lawsuits. In its quest for legal victory, and under cover of so-called

¹ Williams to Twining, 23 January 1912, BuOrd 25562/3, RG74/E25/BB198, NARA.

national security imperatives, the government cynically disregarded private property rights—arguably the most fundamental civil liberty—with damaging implications for the liberal political philosophy supposedly under-girding the United States.

The 21-inch Mark III and 18-inch Mark VI Torpedo Contracts

In late 1908, the Navy indicated its openness to a new 21-inch torpedo contract with the Bliss Company, but it also refused to negotiate for more 18-inch torpedoes until the Company had developed a reliable model. In early 1909, the Bureau and the Company quickly negotiated two small contracts for 21-inch torpedoes, which were designated Mark III.² The 21-inch Mark III torpedoes, which had balanced turbines and dry outside superheaters, were essentially similar to the last 250 torpedoes (Mark II and Mark II Mod. 1) ordered under the November 1905 contract.³

Negotiations for a new lot of 18-inch torpedoes were slower but relatively smooth. In May 1909, the Company informed the Bureau that its new 18-inch model was ready for trial.⁴ After a series of trials, the Bureau and the Bliss Company signed a contract for 100 Mark VI torpedoes on 22 October 1909.⁵ This torpedo involved an important change in design. All previous Bliss-Leavitt torpedoes had their turbine engines mounted so that their axes were in the torpedo's longitudinal axis and their planes of rotation were in the torpedo's transverse-vertical plane. In the Mark VI torpedo, the turbine was mounted with

² The negotiations can be followed in BuOrd 17761, RG74/E25/B842-44, NARA. Copies of the two contracts, dated 20 April and 16 June 1909, can be found in NTS B64-213.

³ For a list of the differences, see Hellweg to Mason, 1 April 1909, B64-213, NTS.

⁴ Page to Mason, 25 May 1909, BuOrd 20065/17, RG74/E25/B979, NARA. This letter confusingly refers to the torpedo as the Mark VII but it was the model that would become the Mark VI, not the Mark VII.

⁵ The original contract can be seen under a marked-up version as an enclosure to BuOrd 23873/3, RG74/E25/B1229, NARA.

its axis in the torpedo's transverse-vertical axis and its plane of rotation in the torpedo's horizontal plane (see Figure 5.1).

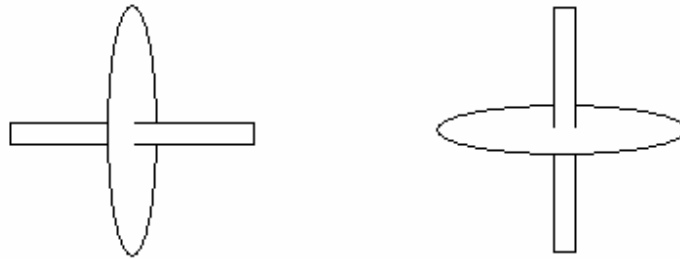


Figure 5.1: Mounting the turbine.

In the figure on the left, the turbine wheels are mounted with their axes in the torpedo's longitudinal axis and their planes of rotation in the torpedo's transverse-vertical plane (as in all Bliss-Leavitt torpedoes before the 18-inch Mark VI).

In the figure on the right, the turbine wheels are mounted with their axes in the torpedo's transverse-vertical axis and their plane of rotation in the torpedo's horizontal plane (as in the 18-inch Mark VI torpedo).

Like the 21-inch Mark II and Mark II Mod. 1 torpedoes, the Mark VI had an outside instead of an inside superheater; it was the last Bliss-Leavitt torpedo to feature a dry superheater.

Royalty Pains and the Continuing Supply Crisis: The Torpedo Factory, the Whitehead Company, and the Bliss Company, December 1908–February 1911

At the very end of 1908, the simmering dispute over superheater royalties discussed in Chapter 3 erupted. In July 1908, the Bureau had ordered another 130 torpedoes from the Whitehead Company, and it had obtained the right to build, free of

royalty charges, 75 Whitehead torpedoes at the Torpedo Factory except for gyroscopes and superheaters.⁶ Unlike the 1907 contract for 50 Whitehead torpedoes, made under special waiver of its superheater rights from the Bliss Company, the 1908 contract rested on no such waiver. Accordingly, it sparked a controversy.

On 22 December 1908, the Company objected to the Bureau's purchase of Whitehead torpedoes not covered by the special 1907 waiver.⁷ Since the 1907 contract, when the Whitehead Company recognized the Bliss Company's rights to the use of the Armstrong superheater in torpedoes furnished to the United States, the Bliss Company wrote, "the Whitehead Company appears to have become less scrupulous." Instead of the Bureau buying Whitehead torpedoes from the Whitehead Company, the Bliss Company made the radical suggestion that the Bureau buy Whitehead torpedoes from the Bliss Company instead—a return to the arrangement prevailing before the development of the Bliss-Leavitt torpedo. Shortly after receiving this bombshell, the Bureau placed its first order with the Torpedo Factory, for the 20 torpedoes authorized by Vickers in January 1908, having ordered 20 superheaters for these torpedoes from the Bliss Company in June 1908 (see pages 173–74 above).⁸ Just a couple weeks later, in mid-January 1909, Bliss Company representatives met with the Secretary of the Navy to discuss a test suit against the government for infringing their patent rights by purchasing Whitehead torpedoes abroad.⁹ A week after that, the Bliss Company's patent lawyers proposed that instead of turning to the courts, the legal status of the Bliss Company could be established

⁶ See "Contract for Torpedoes," 7 July 1908, Clauses 1 and 16, enclosure to BuOrd 21723/29, RG74/E25/B1086, NARA.

⁷ Page to Mason, 22 December 1908, BuOrd 17761/393 (Dept 26817-8a), RG74/E25/B844, NARA.

⁸ Mason to SecNav, 6 January 1909, BuOrd 21017/88-LS472/171–72, RG74/E25/B1043, NARA.

⁹ A test suit, or test case, is one brought to "test" the law where it seems unsettled and to establish precedent.

by submitting the issue to the Attorney General, whose opinion would guide the Department.¹⁰

Asked to comment, N. E. Mason, the chief of the Bureau of Ordnance, took a firm line. “In neither contract [the 1907 and 1908 contracts with the Whitehead Company] has the Bureau in any way infringed the rights or patents of the E.W. Bliss Company,” Mason informed the Department, “and the Bureau is not in any way involved in the question brought up by the attorneys for the E. W. Bliss Company in the within letter.”¹¹ For the 1907 contract, the Bureau had obtained the Bliss Company’s permission to order torpedoes with superheaters, and for the 1908 contract, the Whitehead Company took the position that it had the right to furnish torpedoes with superheaters without the Bliss Company’s permission—and it obligated itself, by Clause 9 of the 1908 contract, to protect the United States against patent claims. Since the United States was not involved in infringing any patents—the logic being that if there was an infringing party, it was the Whitehead Company—Mason concluded that the matter rested with the Bliss, Armstrong, and Whitehead Companies, and that the Attorney General could not give an opinion without statements from the two British firms. Presumably based on Mason’s opinion as to the government’s non-involvement, the Department informed the Bliss Company’s patent attorneys that the case presented no legal question on which it could seek the advice of the Attorney General.¹² The issue temporarily died down.

It was not going away, however. A year later, on 24 January 1910, gearing up to

¹⁰ Fraser & Usina to SecNav, 23 January 1909, BuOrd 17761/403 (Dept 26817-8), RG74/E25/B844, NARA.

¹¹ Endorsement by Mason to SecNav, 6 February 1909, BuOrd 17761/403 (Dept 26817-8), RG74/E25/B844, NARA.

¹² Winthrop [AsstSecNav] to Bliss Co., 13 March 1909, BuOrd 17761/403 (Dept 26817-8), RG74/E25/B844, NARA.

order more torpedoes from the Torpedo Factory, Mason asked the Bliss Company what royalties it would charge for the right to make 50 Bliss-Leavitt torpedoes, including superheaters.¹³ On 28 January, the Bliss Company replied that it would charge a royalty of \$750 per torpedo, the same number it had quoted in December 1906 and November 1907.¹⁴ Mason thanked it for the offer and promptly proceeded to order 25 Whitehead torpedoes from the Torpedo Factory, the first of the 75 authorized by the July 1908 contract with the Whitehead Company.¹⁵ In October 1910 and February 1911, the Bureau ordered the remaining 50 torpedoes under the July 1908 contract from the Torpedo Factory.¹⁶

The Bureau knew from the start that these 75 torpedoes presented potential patent problems. On 16 March 1910, a month after ordering the first 25, Mason asked the Torpedo Station to investigate the subject of superheater rights.¹⁷ Mark Bristol, the commander of the Station, suggested that the Department also consult the Patent Office, and it did, but he also ventured his own interpretation.¹⁸ He considered the Bliss Company's royalty of \$500 on superheaters to be "exorbitant [sic]" and "out of proportion," given that it accounted for two-thirds of the \$750 royalty on the entire torpedo, and the Company's price of \$650 for superheaters to be "excessive," given that the Torpedo Station could make superheaters for \$150 each (as indeed could the Bliss

¹³ Mason to Bliss Co., 24 January 1910, BuOrd 21017, RG74/E25/B1043, NARA.

¹⁴ Page to Mason, 28 January 1910, BuOrd 21017/105, *ibid*.

¹⁵ Mason to Bliss Co., 31 January 1910, BuOrd 21017/105-LS538/264; Mason to Bristol, 1 February 1910, BuOrd 21017-LS538/368, *ibid*.

¹⁶ Mason to Bristol, 20 October 1910, BuOrd 21017 (ordering 30 torpedoes); and Mason to Bristol, 11 February 1911, BuOrd 21017-LS600/494, *ibid*. A copy of the letter of 20 October was not found, but it is described in Bristol to Mason, 16 February 1911, BuOrd 21017/132, *ibid*.

¹⁷ A copy of this letter was not found, but its date is given in, and its contents can be inferred from, Bristol to Mason, 19 March 1910, BuOrd 21017/108, RG74/E25/B1043, NARA.

¹⁸ See Bristol to Mason, 19 March 1910, BuOrd 21017/108; Bristol to Mason, 19 April 1910, BuOrd 21017/111, *ibid*.

Company, since \$650 – royalty of \$500 = production cost of \$150). Therefore, he suggested that the Bureau ask the Bliss Company to lower its charges; that if the Company's response was still unreasonable, a board of naval officers decide the charge after hearing both sides of the case; and that if the Company disliked the naval board's decision, "this Station proceed with the manufacture any way, and the Bliss Company be required to recover the royalty through the Court of Claims."¹⁹ When asked to lower its royalty on superheaters, the Bliss Company refused.²⁰ The royalty of \$500 "is not based on cost of manufacture," the Company informed the Bureau, but rather on "its value in improving the weapon, of which it forms a small part."²¹ Private and public metrics of value and price conflicted, just as they had in regard to the balanced turbine, as discussed in Chapter 3.

A week after this failed attempt to convince the Bliss Company to reduce its royalty charges, the Patent Office finally delivered its opinion on superheater rights.²² The (dry outside) superheater used in the Whitehead torpedoes ordered in 1907 and 1908, it held, was "dominated" by two patents (Nos. 835,262 and 944,975, both dry outside heaters) assigned to the Armstrong Company. Since the Bliss Company controlled the rights to these two patents by virtue of its 1905 agreement with the Armstrong Company, the implication of the Patent Office's ruling was that the Bureau would have to pay royalties on superheaters used in these torpedoes. On 18 April 1911, the Bureau

¹⁹ Bristol to Mason, 8 December 1910, BuOrd 21017/121, RG74/E25/B1043, NARA.

²⁰ Mason to Bliss Co., 12 December 1910, BuOrd 21017/120; this letter was not found, but its date is given in, and its contents can be inferred from, Leavitt to Mason, 20 December 1910, BuOrd 21017/122, *ibid.*

²¹ Leavitt to Mason, 20 December 1910, BuOrd 21017/122, *ibid.*

²² Moore [Commissioner of Patents] to SecNav, 12 January 1911, BuOrd 21017/127 (Dept 8247-66i6), *ibid.*

purchased 75 superheaters from the Bliss Company at \$650 each.²³

The Patent Office ruling, dated 12 January 1911, arrived in the midst of a renewed torpedo supply crisis. Two weeks earlier, the Bliss Company had requested an extension on its 18-inch Mark VI torpedoes, and Mason had threatened to cancel the contract and purchase abroad if the Company did not hurry up (these two letters, both dated 28 December 1910, actually crossed each other in the mail).²⁴ Days later, the Bliss Company went over Mason's head and appealed to the Secretary of the Navy.²⁵

Fed up, Mason turned back to the Whitehead Company. After meeting with Mason, the Company's American representative, H. C. Sheridan, made an offer on 200 Whitehead torpedoes, including gyroscopes and superheaters.²⁶ Mason wanted to buy 200, but the obligation to pay duty—which went into the Treasury, leading Bristol to observe dryly, “It certainly does seem peculiar to take something out of one pocket and put it in the other”—meant that the Bureau could afford only 180, and that was the number contracted for on 29 March 1911.²⁷ This contract also granted the Bureau the right to make 100 Whitehead torpedoes free of royalty charges at the Torpedo Station.²⁸

New leadership found the supply situation no more satisfactory. N. C. Twining, who replaced Mason as chief of the Bureau in May 1911, privately confided that “the torpedo situation is very unsatisfactory and I don't see my way clear yet of making it any

²³ No record of this purchase was found, but it is mentioned in the Bliss Company's petition of 29 May 1914 in *E. W. Bliss Co. v. United States* (53 Ct. Cl. 47, 1917), pp. 7–8, a copy of which can be found as BuOrd 28200/12 in RG74/E25/BBB316, NARA.

²⁴ Mason to Bliss Co., 28 December 1910, BuOrd 22866-LS592/429–30; Page to Mason, 28 December 1910, BuOrd 22866/60, RG74/E25/B1173, NARA.

²⁵ Page to SecNav, 17 January 1911, BuOrd 22997/12, RG74/E25/B1180, NARA.

²⁶ Sheridan to Mason, 24 January 1911, BuOrd 24126/1, RG74/E25/B1249, NARA.

²⁷ Mason to Sheridan, 6 February 1911, BuOrd 24126/1-LS599/418–19; Mason to SecNav, 11 February 1911, BuOrd 24126/2-LS1/33–34, RG74/E25/B1249, NARA; Bristol to Mason, 11 February 1911, B72-204, NTS.

²⁸ See “Contract for Torpedoes,” 29 March 1911, B72-204, NTS.

less so. So far as I can see, all the ships will have to live from hand to mouth in the matter of torpedoes for the next year or more.”²⁹ The Department was also unhappy with the situation. “I know there is an impression in the Secretary’s mind, and in the minds of other people,” Twining acknowledged to the Secretary’s aide, “that the Bureau has not been keeping up to the mark in several ways for some time past.”³⁰ In October 1911, evidently on his own initiative, and presumably out of impatience, the Secretary ordered Twining to solicit a bid from the Whitehead Company for 50 torpedoes.³¹ Twining did so, the Company complied, and another contract was signed on 25 October 1911, which, together with the March 1911 contract, gave the Navy 230 torpedoes under contract with the Whitehead Company.³²

The Development of the Steam Torpedo and the Continuing Royalty Dispute, Mid-1910 to Late 1912

After Leavitt’s invention of the first inside dry superheater in 1900, and its installation in the first marks of Bliss-Leavitt torpedoes—the 18-inch Marks III-IV, and the 21-inch Mark I—the next major step in the evolution of the technology was the switch to an outside dry superheater in the 21-inch Mark II and Mark II Mod. 1 torpedoes. The Bliss Company also installed the outside superheater in its then-experimental 18-inch torpedo, which would become the Mark VI.³³

²⁹ Twining to Glennon, 24 June 1911, RG74/E26/B1B/VG/PP50–51, NARA.

³⁰ Twining to Andrews, 21 July 1911, RG74/E26/B1B/VG/PP122–29, NARA.

³¹ See endorsement by Mason to SecNav, 13 October 1911, BuOrd 24733/1 (Dept 26548-89), RG74/E25/B1267, NARA.

³² See Sheridan to Twining, 12 October 1911, BuOrd 24733/1, *ibid*; “Contract for Torpedoes,” 25 October 1911, B77-314, NTS.

³³ McCormick to Mason, 25 October 1907, BuOrd 20065/2, RG74/E25/B979, NARA.

The first glimmerings of the new superheater's obsolescence arrived within a year. In March 1908, courtesy of the Brazilian naval attaché in Washington, the Bureau received a copy of the January 1908 issue of the *Revista Maritima Brasileira* ("Brazilian Maritime Journal"), which contained an article describing a *wet* superheater being experimented with by the Whitehead Company at Fiume.³⁴ This wet Fiume superheater, which should not be confused with the dry superheaters jointly developed by its sister company in Weymouth working with the Armstrong Company, was based on the work of Johann Gesztesy, an officer in the Austrian navy. Gesztesy held both Austrian and British patents. The earliest, which contained little detail, was dated September 1905; a more mature version of the system was described in Austrian and British patents taken out in April 1907.³⁵

Exactly what happened after the Bureau received the magazine article is difficult but important to establish, given the importance of the chronology in subsequent legal proceedings. It is certain that the Bureau sent the article to the Torpedo Station on 20 March 1908, but what the Station did in response, and what communications passed between the Bureau and the Bliss Company, are unclear.³⁶ A summary of correspondence created for the legal proceedings indicated that the Bureau sent the article or a copy to the Bliss Company on 26 March 1908, and that the Company acknowledged receipt on 4

³⁴ See Mason to Gleaves, 20 March 1908, BuOrd 21715-LS432/257, RG74/E25/B1086, NARA. An original copy of this article can be found with that letter; an English translation can be found in the "Addition to the Record" before the Supreme Court in *Electric Boat Co. v United States* (263 U.S. 621).

³⁵ Austrian Patent 21315, issued 11 September 1905; Austrian Patents 24150 and 28050, issued 10 May 1906 and 10 April 1907, respectively. The latter of these two patents was taken out with Julius von Petravic, of gyroscope fame, and it was identical to a British patent that the two men applied for in March 1906 and were awarded in March 1907 (7,390/1906).

³⁶ Mason to Gleaves, 20 March 1908, BuOrd 21715-LS432/257, RG74/E25/B1086, NARA.

April 1908.³⁷ These dates are plausible, but it should also be noted that neither of these two letters was among the evidence accepted in the relevant lawsuit.³⁸

The Gesztezy/Fiume wet superheater was only one of five internationally. Two others were British—one developed by the Armstrong Company, jointly with the Whitehead Company’s Weymouth branch, and the other by the British Admiralty, working from a design by an engineer officer named S. U. Hardcastle, discussed in Chapter 4. The Bliss Company owned the American rights to the Armstrong wet superheater through its 1905 agreement with the Armstrong Company. The latter applied for its first American wet superheater patent in January 1908, which was issued as No. 964,574 in July 1910.³⁹ Armstrong’s development work apparently continued apace, since it applied for a second wet superheater patent in July 1910, which was issued as No. 1,008,871 in November 1911.⁴⁰ The remaining two superheaters were American in origin: one by the Electric Boat Company (better known for its role in American submarine development), working from a design by G. C. Davison; and the other by the Torpedo Station, working from a design by an Ordnance Engineer (a civilian employee of the Navy) named Harvey. D. Williams.

The Bureau unquestionably began to investigate wet superheaters independently of the Bliss Company, but it is unclear when exactly that investigation began, and how it

³⁷ Norton to Twining, 26 May 1914, BuOrd 25373/39 (Dept 26266-417-1), para. 3, RG74/E25/BB156, NARA.

³⁸ For the list of evidence, see “Transcript of Record: Index” in *E. W. Bliss Company v. United States* (248 U.S. 37).

³⁹ This patent was equivalent to Sodeau’s GBP 6,081/1907. The delay between application and issue suggests that a battle over competing wet superheater patents was raging behind the scenes. Armstrong/Sodeau had previously taken out a string of American patents for a dry inside superheater (827,891 and 828,432) and then a dry outside superheater (835,262, 850,307, and 944,975).

⁴⁰ Whether the Bliss Company was using the superheater described in the first or second iteration of the superheaters described in these two patents by mid-1910 is unknown.

related to another initiative undertaken by the Bureau in late 1907 or early 1908, namely, the design of a Bureau alternative to the Bliss-Leavitt and Whitehead torpedoes. This initiative was closely associated with H. D. Williams.⁴¹ The first documented reference to a torpedo designed by Williams appeared in August 1907, when Williams was still at the Bureau.⁴² In May 1908, he was ordered to the Torpedo Station, and given a draftsman named O. A. Thelin as an assistant.⁴³ Over the course of the next year, two torpedoes were constructed according to Williams' design; one of them was lost.⁴⁴ The first detailed report on Williams' activities appeared in September 1909, when Bristol, the Commander of the Torpedo Station, wrote semi-officially to Mason pleading him to let Williams stay on at the Station. "It is evident now that when Mr. Williams took up the question of the design of an experimental torpedo he was very little equipped for the work," Bristol allowed, "and thus far he has been eliminating wrong ideas, without making much progress; but now the whole question looks more favorable, and we are beginning to make some advances."⁴⁵ Bristol also noted that Williams was trying to design a superheater cooled by air instead of water in order to save weight—suggesting that the Station had previously tried experimenting with wet superheaters, probably after receiving the Brazilian article. By November 1909, Williams had given up on the idea of cooling the combustion chamber sufficiently without injecting water, and the Station's

⁴¹ On Williams, see "Cornell Alumni News," Vol. 33, No. 23 (16 March 1931), p. 277; downloaded from http://ecommons.library.cornell.edu/bitstream/1813/3548/13/033_23.pdf, 23 July 2009.

⁴² Gleaves to Mason, 7 August 1907, BuOrd 18172/20, RG74/E25/B873, NARA.

⁴³ Mason to Gleaves, 8 May 1908, BuOrd 21017-LS442/472, RG74/E25/B1043, NARA.

⁴⁴ Bristol to Mason, 5 August 1909 (Annual Report, FY 1908), para. 31A, B66-173, NTS.

⁴⁵ Bristol to Mason, 28 September 1909, *ibid.*

experiments with wet superheaters resumed.⁴⁶ The next detailed report on Williams' work did not appear until June 1910, by which time two new torpedoes of his design had been built, more mature than the two constructed in 1908/09.⁴⁷

The other American wet superheater was being developed by the Electric Boat Company, better known for its control of the Holland submarine patents. The Electric Boat Company's torpedo work was led by a familiar name: G. C. Davison, who resigned from the Navy on 1 January 1908 to become a vice president at the Electric Boat Company. The torpedo design community having been a small one (not unlike the torpedo history community of today), he was followed in June 1909 later by O. A. Thelin, the draftsman who had been assigned as H. D. Williams' assistant at the Torpedo Station.⁴⁸ Davison also took his notebooks containing information derived from experiments conducted at government expense.⁴⁹ Although Davison had assigned the patent for the balanced turbine to the government, he would assign all his subsequent patents to the Electric Boat Company.

By mid-1910, the three lines of American development—Williams at the Torpedo Station, the Bliss Company (courtesy of the Armstrong Company), and Davison at the Electric Boat Company—had progressed sufficiently that Mason ordered the Torpedo Board to consider what characteristics the next generation of torpedoes should possess.⁵⁰

⁴⁶ This chronology is deduced from Yarnell [ACNTS] to Bristol, 25 June 1910, BuOrd 21017/114, RG74/E25/B1043, NARA.

⁴⁷ Williams to Yarnell, 24 June 1910, enclosed in BuOrd 21017/114, *ibid.*

⁴⁸ The date of Thelin's departure is given in Norton to Strauss, 26 May 1914, BuOrd 25373/39 (Dept 26266-417-1), para. 3, RG74/E25/BB156, NARA.

⁴⁹ Endorsement by Williams, 11 October 1913, BuOrd 25373/30, *ibid.*

⁵⁰ Mason to Bristol, 20 July 1910, BuOrd 18172-LS568/213-14, RG74/E25/B873, NARA.

The Board delivered its report on 26 July 1910.⁵¹ For armored cruisers, it recommended the development of 18-inch turbine torpedoes capable of 26 knots for 4,000 yards. In an international context, such a performance was unimpressive, considering that the 18-inch torpedoes ordered from the Whitehead Company's Weymouth branch in July 1908 were guaranteed to make 26 knots for 4,000 yards.⁵² In the domestic context, however, the goal of 26 knots for 4,000 yards represented an advance, since the then-latest 18-inch Bliss-Leavitt torpedoes (Mark VI) were guaranteed for only 2,000 yards.⁵³ To meet the goal of a 26-knot, 4,000-yard torpedo, the Board recommended that the Bureau try to develop three different models: first, by adapting the 2,000-yard Bliss-Leavitt Mark VI into a 4,000-yard torpedo; second, to develop the Williams torpedo into a reliable weapon; and third, to invite the Electric Boat Company to design an experimental 18-inch type.

The Board's ideas about 18-inch torpedoes paled in comparison with its plans for 21-inch torpedoes. It recommended that the Bureau try to develop a longer (21-foot instead of 5-meter) 21-inch torpedo capable of 30 knots for 10,000 yards.⁵⁴ This was a radical proposal: the most recent 21-inch Bliss-Leavitt torpedo, the Mark III, was guaranteed to make only 26 knots for only 4,000 yards. Suggesting that work with the Williams torpedo focus on perfecting an 18-inch model, the Board recommended that the

⁵¹ Torpedo Board [Bristol, Norton, Williams, Hellweg, McCrary] to Mason, 26 July 1910, BuOrd 18172/41 (Dept 24003-4), RG74/E25/B874, NARA. The Board actually convened on 26 July and did not finish writing its report until adjourning on 28 July, but the Bureau and the Department always used the convening date when referring to the report in subsequent correspondence, so I have adopted their convention.

⁵² See Davison to Mason, 8 August 1910, BuOrd 23713/1, RG74/E25/B1223, NARA.

⁵³ See "Specifications for the Manufacture of Bliss-Leavitt Automobile Torpedoes, 5.2 Meters by 45 Centimeters, Mark VI," October 1909, Ord. Pam. 42, enclosed in BuOrd 23873/3, RG74/E25/B1229, NARA.

⁵⁴ Why the Navy abandoned the metric system is unclear, but the long 21-inch torpedo was known as the 21-foot torpedo instead of as the 6.3-meter torpedo, while the standard 21-inch torpedo continued to be known as the 5-meter instead of as the 17-foot torpedo.

Bliss Company and the Electric Boat Company be asked to develop 21-inch x 21-foot designs. These will be referred to hereafter as 21-foot torpedoes instead of 21-inch torpedoes, so as to distinguish them from 21-inch x 5-meter torpedoes.

Mason acted quickly on the Board's recommendations. On 5 August 1910, the Bureau interviewed Davison to discuss the possibility of the Electric Boat Company getting into the torpedo business.⁵⁵ Three days later, Davison opened the written negotiations with two letters. One dealt with pricing an experimental a 5.2-meter x 18-inch torpedo. As had been evident with the early Bliss-Leavitt torpedo contracts, the question of price was fraught for experimental work. Since the work was experimental, Davison explained, the Electric Boat Company was unwilling to make ambitious performance guarantees, while the Bureau was unwilling to pay for experimental work (as opposed to a finished product). To reduce the Bureau's risk to a level that it would accept, Davison suggested taking the price and performance of the Bureau's best recent torpedoes—the 18-inch Whitehead Mark V and the 21-inch Bliss-Leavitt Mark III—as a base, and then adding premiums for better performance. He proposed a minimum of \$5,000 for a minimum of 26 knots for 4,000 yards.⁵⁶

Davison called this proposal "liberal" to the Bureau, and indeed it was. The Bureau was guaranteed to get a torpedo at least as good as its present torpedoes for the same price. The Electric Boat Company bore all the risk, namely, that if its torpedoes failed to meet the guaranteed performance, it would get no remuneration for its expenditures on experimental work; and even if it exceeded the guaranteed performance,

⁵⁵ This interview is mentioned in Davison to Mason, 8 August 1910, BuOrd 23713/1, RG74/E25/B1223, NARA.

⁵⁶ Davison to Mason, 8 August 1910, BuOrd 23713/1, *ibid.*

it was unlikely to recover more than a fraction of those expenditures. Of course, Davison did not offer this “liberal” scheme out of generosity. “Our object in making this offer is to demonstrate the torpedo with a view to future orders,” Davison frankly stated, and “[w]e also assume that the Bureau in ordering an experimental torpedo, would do so with a view to placing further orders in event of a satisfactory demonstration.”⁵⁷ The justification for taking on so much risk was the possibility of big rewards in the future—but the assumption as to the Bureau’s purpose was a dangerous one. Instead of bringing a new manufacturer into the business, the Bureau’s purpose could just as plausibly have been (as Davison later concluded it was) to stimulate its existing manufacturer (Bliss). And if the Company was being used as a pawn, not tested on its merits, then its risk-reward calculus rested on a fundamentally flawed assumption.

The other, and eventually more important, letter that Davison sent the Bureau after the interview on 5 August dealt with the superheater itself, separate from the experimental torpedoes. Davison offered to sell the exclusive American rights to the Company’s wet superheater for \$100,000 cash, plus royalties of \$1,200 each for the first 100 torpedoes containing the device, \$950 each for the second 100 torpedoes, \$750 each for the third 100 torpedoes, and \$600 torpedoes for all torpedoes thereafter, the agreement to last for 15 years. The cash payment was to be contingent upon the Company demonstrating the superheater’s ability to meet performance requirements in either a Company-built torpedo or in one loaned to it by the government, and the agreement was to include an escape clause for the Company if the royalties failed to amount to \$25,000 in any year. For the exclusive international rights, Davison explained that the price would

⁵⁷ Davison to Mason, 8 August 1910, BuOrd 23713/1, *ibid.*

have to be “very much higher,” since the volume of potential foreign sales greatly exceeded that of potential American sales.⁵⁸ Negotiations for the superheater alone were not resumed for another year, but this letter was important as the first word on the subject.

Thus far, Davison had only dealt with the possibility of building an 18-inch [diameter] experimental torpedo. On 6 September, Mason asked the Electric Boat Company to bid on a 21-foot [length] experimental torpedo.⁵⁹ Davison replied that the Company had not undertaken any detailed plans of a 21-foot torpedo, but that the range and speed could be extrapolated from estimates of the 18-inch [diameter] torpedo’s performance. Based on what the Bureau had paid for previous 21-inch [diameter] Bliss-Leavitt torpedoes, Davison said that the lowest price the Electric Boat Company would accept for a 21-foot torpedo was \$7,500 for a guarantee of 26 knots for 5,000 yards. After some bickering over the price, specifications, and delivery date, the Bureau and the Electric Boat Company reached agreement on both the 18-inch and 21-foot experimental torpedoes.⁶⁰ The base price was \$5,000 for 26 knots over 4,000 yards for the 18-inch torpedo, and \$7,500 for 26 knots over 5,000 yards for the 21-inch torpedo. The Company agreed to deliver the former within 12 months and the latter within 18 months.⁶¹ The

⁵⁸ Davison to Mason, 8 August 1910, BuOrd 23712/1, RG74/E25/B1223, NARA.

⁵⁹ Mason to Electric Boat Co., 6 September 1910, BuOrd 23754-LS574/165–66, RG74/E25/B1226, NARA.

⁶⁰ Capehart [Acting CoO] to Electric Boat Co., 6 September 1910, BuOrd 23713/1-LS574/169–71, RG74/E25/B1223, NARA; Davison to Mason, 9 September 1910, BuOrd 23713/2, *ibid*; Mason to Davison, 6 October 1910, BuOrd 23713/2-LS579/288–91, *ibid*; Davison to Mason, 10 October 1910, BuOrd 23713/3, *ibid*; Davison to Mason, 10 September 1910, BuOrd 23754/2, RG74/E25/B1226, NARA; Mason to Davison, 6 October 1910, BuOrd 23754/2-LS579/280–82, *ibid*; Davison to Mason, 10 October 1910, BuOrd 23754/5, *ibid*.

⁶¹ For the 18-inch torpedo, see “Contract for the Manufacture of One Davison 5.2m. x 45cm., Type Torpedo, for the United States Navy,” B73-315, NTS. A copy of the 21-inch contract was not found, but the price scale can be found in Mason to Electric Boat Co., 6 October 1910, BuOrd 23754/2-LS579/280–82, RG74/E25/B1226, NARA. In that letter, the Bureau requested delivery within 12 months, but the Company demanded 18 months (Davison to Mason, 20 October 1910, BuOrd 23754/5, RG74/E25/B1226, NARA);

contracts were signed on 17 and 23 January 1911, respectively.

The Bureau was also negotiating with the Bliss Company. In September 1910, a month after opening negotiations with the Electric Boat Company, the Bureau asked the Bliss Company to bid on experimental 18-inch and 21-inch torpedoes, proposing the same terms that it was hammering out with the Electric Boat Company.⁶² The Bureau gleefully exploited the leverage it acquired from placing another firm in competition with the Bliss Company—leverage that the Bureau had lacked in negotiating the first Bliss-Leavitt contracts in 1903. “It is imperative that this question shall be taken up at as early a date as possible,” Mason wrote, “as the Bureau is in a position to make contracts with another firm for similar experimental torpedoes.”⁶³ The Bliss Company swallowed its objections and signed contracts for experimental 18-inch and 21-foot torpedoes on 16 February 1911.⁶⁴

The Davison Steam Torpedoes and Superheater

After signing the contracts for two experimental steam torpedoes in January 1911, the Electric Boat Company spent roughly nine months working on them quietly. In October 1911, however, Davison made a new proposition: independent of the experimental torpedoes, he again offered to sell the rights to his wet superheater (also known as his “steam generator”), which could then be installed in Whitehead or Bliss-Leavitt torpedoes to convert them from hot-air to steam torpedoes. Forwarding a drawing

while no agreement to the Company’s demand was found, the fact that the Company signed the contract indicates that it was agreed to.

⁶² Mason to Bliss Co., 6 September 1910, BuOrd 23754-LS574/167–68; Capehart to Bliss Co., 9 September 1910, BuOrd 23753-LS574/172–73, RG74/E25/B1226, NARA.

⁶³ Mason to Bliss Co., 6 October 1910, BuOrd 23754/3-LS579/231–32, *ibid.*

⁶⁴ Leavitt to Mason, 7 February 1911, BuOrd 23754/12, *ibid.*

of his wet superheater, he proposed to fit it in a torpedo for trial, after the Bureau agreed to pay royalties of \$1,000 on each of the first ten torpedoes containing the device, \$900 on each of the next ten, and \$800 on each torpedo thereafter.⁶⁵ This offer differed somewhat from the one that Davison had made in August 1910. He made no mention of the exclusive American rights, and the royalties were named for lots of ten instead of one hundred torpedoes.

Asked to comment on Davison's proposal, G. W. Williams, the commander of the Torpedo Station, advised against accepting it.⁶⁶ To begin with—this was important from a later legal perspective—Williams said that the drawing forwarded by Davison showed insufficient detail to judge whether and how it differed from wet superheaters being tested by the Bliss Company and the Torpedo Station. Without more knowledge, Williams continued,

it is not considered wise to enter into an agreement with the Electric Boat Co. by which the Bureau agrees to pay the Electric Boat Co. a royalty for the use of a device in torpedoes presumably similar to devices made by other companies, and to one which is in course of development at the Torpedo Station, as by that action the Bureau would, in the opinion of the Torpedo Station, possibly involve itself in dispute, if not in litigation, with the other companies, and would be estopped [i.e., prevented] from further development of its own superheater.

As it turned out, William's concern as to future disputes, "if not litigation," was most prescient.

The Bureau did not share his concern, however, due to a mixture of carelessness and patent law. The Bureau, Williams was told, had been "given to understand that this generator is not in any sense a superheater, that it has been patented, and it is believed not

⁶⁵ Davison to Twining, 20 October 1911, BuOrd 23712/2, RG74/E25/B1223, NARA.

⁶⁶ Endorsement by Williams to Twining, 27 October 1911, BuOrd 23712/2, *ibid.*

to conflict with the present superheater rights.”⁶⁷ Just who had been giving the Bureau this (incorrect) understanding was left unsaid, but it was probably Davison. Patent law prevented the Bureau from checking the validity of Davison’s claims: until World War I, no government department besides the Patent Office could see patent applications (or attempt to have a patent classified as secret).⁶⁸ Thus, even if the Bureau had wanted to exercise due diligence, its options were limited. Given these limits, Williams wisely continued to argue against believing Davison’s claims “until the details of this device are thoroughly well known, and it is clearly established that the device is different from other patented devices of the same nature.”⁶⁹

As if to underscore the wisdom of Williams’ warning, Davison wrote the Bureau on 16 December 1911 with a list of the patents and patent applications that the proposed shop license (so-called because it would license the Navy to build the devices in its own “shop”) would cover, noting “that three of these applications have not yet been issued.

A number of claims, however, have already been allowed under each of these applications and the delay in issuing the patents is due to arguments now pending in relation to certain claims which have been rejected. The protection afforded, however, is the same as if the patents had been issued.”⁷⁰

Davison’s first wet superheater patent was not issued until August 1912.⁷¹

Despite Williams’ warnings, despite Davison’s own indication that his patent claims were controversial, despite not seeing the patent applications that would be covered by any agreement, and despite its bruising encounters with the Bliss Company

⁶⁷ Endorsement by Norton [Acting CoO] to Williams, 4 November 1911, BuOrd 23712/2, *ibid.*

⁶⁸ See Gustavus Weber, *The Patent Office: Its History, Activities and Organization* (Baltimore: The Johns Hopkins Press, 1924), 32–39, 51–52.

⁶⁹ Endorsement by Williams to Twining, 27 October 1911, BuOrd 23712/2, *ibid.*

⁷⁰ Davison to Twining, 16 December 1911, BuOrd 23712/5, *ibid.*

⁷¹ Note that the Court of Claims incorrectly credited this patent to Davison, not Gillmor; see *Electric Boat Company v. United States* (57 Ct. Cl. 497), para. 10.

over property rights, the Bureau nonetheless forged ahead, sending Davison the terms on which it would agree to have him install his superheater in two 18-inch Whitehead torpedoes.⁷² Davison accepted the Bureau's offer.⁷³ Because of some confusion over the ownership of patents assigned to a subsidiary of the Electric Boat Company, the agreement was not signed until April 1912, but the Bureau shipped the two torpedoes in January 1912.⁷⁴ The contract for the two Whitehead conversions became known as the "shop license agreement;" no copy has been found, but other documents date it to 3 April 1912. Lacking a copy, the precise delivery date guaranteed in the contract is unknown, but it was probably in early June 1912. Together with the January 1911 contracts, the shop license agreement meant that the Electric Boat Company was working on four torpedoes: building two experimental Davison torpedoes (one 18-inch, one 21-foot), and converting two Whitehead torpedoes (both 18-inch) to take Davison's wet superheater.

The Bliss-Leavitt Steam Torpedoes

Although the Bliss Company signed the contracts after the Electric Boat Company, it had its experimental torpedoes ready sooner, in November 1911—a ten-month turnaround. Given its greater experience in torpedo manufacturing, beating the Electric Boat Company was not surprising, but its speed was still remarkable, and probably owed

⁷² The Bureau's letter, dated 9 November, was not found. Its date and a very general idea of its contents can be learned from Davison's reply of 6 December, BuOrd 23712/3, RG74/E25/B1223, NARA.

⁷³ See the court's opinion (by Justice Oliver Wendell Holmes) in *Electric Boat Company v. United States* (263 U.S. 621). The Bureau's letter, dated 9 November, was not found. Its date and a very general idea of its contents can be learned from Davison's reply of 6 December, BuOrd 23712/3, RG74/E25/B1223, NARA.

⁷⁴ For the confusion over ownership, see Twining to Electric Boat Co., 1 February 1912, BuOrd 25373/6-2/11; Davison to Twining, 5 February 1912, BuOrd 25373/7; endorsement by Winthrop [Acting SecNav] to Twining, 26 March 1912, BuOrd 25373/?, RG74/E25/BB156, NARA. For the shipment of the torpedoes, see Norton [Acting CoO] to Electric Boat Co. Inspector, 10 January 1912, BuOrd 25373/1-0, *ibid.*

much to the fact that the Bliss Company did not have to develop its wet superheater but instead imported it from the Armstrong Company. On 19 November 1911, the Torpedo Board witnessed runs of both experimental torpedoes at Sag Harbor, where the Bliss Company's range was located.⁷⁵ Due to the difficulties of laying out longer ranges, most of the runs were made over a 4,000-yard range, at which the 21-foot torpedo performed well, but it also made a 10,000-yard run at an estimated 27.76 knots. The 18-inch torpedo showed large increases of speed and range over the 18-inch Mark VI torpedo, even though the Company was still tinkering with the fuel and water supply of its superheater system. The Bureau began negotiating for the purchase of 50 of the 21-foot torpedoes, and 70 of the 18-inch torpedoes.⁷⁶ The actual contracts, signed in June 1912, were for 240 Bliss-Leavitt 18-inch steam torpedoes (Mark VII) and for 50 Bliss-Leavitt 21-foot steam torpedoes (Mark VIII).⁷⁷

In the meantime, the Bliss Company had also built a steam version of its 21-inch by 5-meter Mark III torpedo. The Torpedo Board witnessed its official demonstrating runs in June 1912, at which it made 26 knots for 7,000 yards (as compared to the hot-air Mark III's 26 knots for 4,000 yards).⁷⁸ This torpedo was the prototype for the Bliss-Leavitt Mark IX (then known as the Mark III Mod. 1), which, together with the 18-inch Mark VII and 21-foot Mark VIII, would become the backbone of the Navy's torpedo

⁷⁵ Torpedo Board [Norton, Sawyer, Williams, Knox, Ogan] to Mason, 19 November 1911, BuOrd 18172/48, RG74/E25/B874, NARA.

⁷⁶ Norton [Torpedo Desk, BuOrd] to Bliss Co., 17 January 1912, BuOrd 25325/3-0, RG74/E25/BB145, NARA; Twining to Bliss Co., 18 January 1912, 18 January 1912, BuOrd 25145-1/27, RG74/E25/BB64, NARA.

⁷⁷ The first 120 x 18-inch torpedoes kept their Mark VII designation, while the second 120 became known as Mark VII Mod. 1, due to their different reducers. The 50 Mark VIII torpedoes were originally known as Mark IV, the logic being that they were the next 21-inch mark after the 21-inch Mark III torpedoes, but they were eventually re-designated as Mark VIII on account of their longer length.

⁷⁸ Torpedo Board [Norton, Williams, Sawyer] to Twining, 13 June 1912, BuOrd 26969/1, RG74/E25/BBB135, NARA.

arsenal through World War I and the inter-war period. The prototype Mark IX, however, had trouble with depth-keeping, horizontal direction-keeping, and uniformity of speed, and by the time the Bliss Company was ready to offer it as a mature weapon in December 1912, other developments over-shadowed it.⁷⁹

The Williams and “Standard” Torpedoes, the Station Superheater, and Royalty Pains Redux

Sometime in early 1911, for unknown reasons and under unknown circumstances, H. D. Williams resigned from the Navy.⁸⁰ Nevertheless, the Torpedo Station continued to develop his two experimental torpedoes begun in 1909 or 1910, requesting an additional \$5,000 in February 1911 and submitting a progress report in March.⁸¹ There the paper trail on the Williams torpedo abruptly ends, and the fate of his torpedoes is unknown.

For several months, no trace of a Station-designed torpedo or superheater appears in the record, although it is likely that the Station continued to experiment with the wet superheater that had originated with Williams in the hope of avoiding royalty payments to the Bliss Company. Then, in December 1911, a new project appeared, the development of a Navy “Standard” torpedo. In a general way, this project probably arose from the same impulse to develop a design independently of the Bliss Company that had given rise to the Williams torpedo, but it was quite distinct from the Williams project, and it may have had something to do with the arrival of new leadership at the Bureau and the Torpedo

⁷⁹ See Sawyer’s endorsement of 30 August 1912, BuOrd 26969/8; Friedrick [Asst Bliss Insp] to Sawyer, 14 September 1912, BuOrd 26969/10, RG74/E25/BBB135, NARA.

⁸⁰ His departure must have occurred before 8 February 1911, when Bristol described him in a letter as “the ex-Ordnance Engineer”; see Bristol to Mason, 8 February 1911, B72-204, NTS.

⁸¹ Bristol to Mason, 8 February 1911, BuOrd 21017/131; Yarnell [ACNTS] to Mason, 3 March 1911, BuOrd 21017/133, RG74/E25/B1043, NARA.

Station. In May 1911, N. C. Twining had replaced Mason as chief of the Bureau, and G. W. Williams (not to be confused with H. D. Williams) replaced Bristol as commander of the Torpedo Station. In December 1911, the Bureau asked the Station to consider designing a torpedo by mixing-and-matching the best parts regardless of the manufacturer, even at the cost of paying royalties.⁸² Williams liked the idea and thought that royalties could be avoided altogether, “except as regards possibly the superheater, and it is probable that a new superheater may be devised with details different from the present superheater, so as to make the royalty paid a question of equity rather than one to be decided arbitrarily.”⁸³ The Station had in mind a torpedo with a dry superheater (or “hot-air” torpedo) rather than a torpedo with a wet superheater (or “steam” torpedo).

On 30 December 1911, the Bureau ordered the Torpedo Factory to build 75 torpedoes, probably as part of the 100 torpedoes authorized by the March 1911 contract with the Whitehead Company.⁸⁴ For the last 75 torpedoes built by the Torpedo Factory, it will be recalled, the Bureau had ordered superheaters from the Bliss Company in April 1911. On 23 January 1912, Williams proposed a different solution: he suggested that the Bureau re-open the question of superheater rights. The Bliss Company’s rights had never been judicially confirmed, he argued, and even if they had been, the size of the royalty would still be open. While recognizing that the patent rights of inventors were protected by laws enacted under specific authorization of the Constitution (specifically, Article 1, Section 8), Williams submitted

that the whole tenor of the Constitution is that the relations between the

⁸² Norton to Williams, 1 December 1911, BuOrd 24824, RG74/E25/B1268, NARA.

⁸³ Williams to Twining, 11 December 1911, BuOrd 24824/2, *ibid.*

⁸⁴ Twining to Williams, 30 December 1911, 21017/173. This letter was not found, but it is described in Williams to Twining, 23 January 1912, BuOrd 25562/3, RG74/E25/BB198, NARA.

government and the individual and between individuals shall be subject to the rules of equity; that the written laws themselves are but a codification of the rules of equity, and that it was never intended by the framers of the Constitution or the framers of the law made in pursuance of constitution authorization that inventors or others should receive an unjust compensation. It is believed that the patent laws were intended for the protection of the inventor and produce, and not for the oppression of the consumer. This would seem to be a reasonable assumption in any case, and in view of the history of the development of the superheater it is thought that the consumer—in the case at issue, the government—should be exempt from an exorbitant charge as a matter of equity, even should *the right of eminent domain* be held as not applicable to property consisting of patent rights. [Emphasis added]

To explain why the government should be equitably exempt from high royalties, Williams reviewed the history of superheater development. The increase in power due to heating air had “long been recognized,” and the Torpedo Station had experimented with applying this insight to torpedoes as early as 1876. Leavitt had been responsible for the “idea” of burning a combustible (alcohol) in the impulse air to increase the energy, and his “method” consisted of burning alcohol in the air flask. The government had paid high prices for early Bliss-Leavitt torpedoes to support the development of the torpedo, effectively investing in experimental technology. Around the time that first 21-inch Bliss-Leavitt torpedoes were delivered, the Armstrong Company invented the outside superheater, and except for the fact that it heated the impulse air and had a similar ignition system, “it was a totally different device.” Between subsidizing experimental work through high prices and furnishing the Bliss Company with information, Williams concluded that the government had made the Bliss Company’s development of the superheater possible, and thus it should be allowed to build superheaters free of royalty. He suggested that the Bureau try to reach an equitable understanding with the Bliss Company by agreement or through arbitration, and that if that effort failed, the Bureau

would be “ethically and legally” justified in manufacturing superheaters without the Company’s consent, leaving settlement of the Company’s claims to the Court of Claims if the Company insisted on them.⁸⁵

Williams’ letter was astonishing for its legal and philosophical ambition. Eminent domain, which refers to the right of the state to all property within the state, including the power to expropriate private property for public use, was an old doctrine that was incompatible with the liberal political philosophy on which the United States was supposedly founded. Fundamentally, eminent domain rested on the assumption that the state temporally and spatially precedes society and property in nature, which are authored, and therefore authorized, by the state. Classical liberal political theory, as formulated by John Locke in the seventeenth century, altered this relationship.⁸⁶ Locke argued that society precedes the state and property is independent of the state in nature: society authors the state by contract, and labor (not the state) authors property. Notwithstanding the current tendency to think of civil liberties instead of natural rights, and to think of free speech and religion as the quintessential civil liberties, for Locke, natural rights were effectively equivalent to civil liberties, and the quintessential natural rights were not free speech and religion, but the rights to create property and make contracts. Hence, to limit the power of the state, Locke struck at its control of its control of property and contracts. By eliminating the state’s ability to author society and by severely limiting its ability to author property, Locke’s theory undermined the state’s claim to property rights.

Nevertheless, the Lockean social contract had two loopholes by which the state

⁸⁵ Williams to Twining, 23 January 1912, BuOrd 25562/3, RG74/E25/BB198, NARA.

⁸⁶ See Locke, Chapter 5 (“Of Property”), *Second Treatise of Government* (1690). This is also discussed in Chapter 3.

could claim property rights. First, because Locke vested the authorship of property in labor, not in society, he left room for the state to author property by its own labor—like Williams’ claim that the government had participated in the creation of the Bliss-Leavitt torpedo. Second, the state could claim to act within the limits of the social contract, without appealing to non-existent natural rights, by reference to the same common interest which authored the social contract—like Williams’ claim that the government was obliged to prevent the oppression of the many (consumers), even at the expense of the rights of the few (inventors/producers). Functionally, the latter was a return to eminent domain by new means: the state could still infringe private property rights, but by reference to the social contract rather than to its divine rights. Indeed, Jean Jacques Rousseau’s reformulation of social contract theory allowed the state to do so in the name of the “general will.”⁸⁷

If the problems that Williams was trying to solve and the solutions he was proposing were very old, the type of property at issue was newer. When the doctrine of eminent domain originated in medieval times, the most important type of property within the state’s eminent domain was land. The financial and industrial revolutions created equally important new types of property, but they were still forms of *physical* property. The type of property contemplated by Williams, by contrast, was *intellectual* property (patents). Williams clearly understood the novelty of his proposition; hence his statement that “the right of eminent domain [might] be held as not applicable to property consisting of patent rights.”⁸⁸

⁸⁷ See Rousseau, *The Social Contract* (1762), Book I, Chapter 6 (“The Social Compact”).

⁸⁸ Williams to Twining, 23 January 1912, BuOrd 25562/3, RG74/E25/BB198, NARA.

By early February 1912, the general lay-out of the “Standard” torpedo was complete, but the impressive performances of the Bliss-Leavitt experimental torpedoes, the signing of a contract for the Davison superheater, and progress with its own wet superheater prompted the Station to suggest waiting on developments with steam torpedoes before proceeding further with its hot-air design.⁸⁹ The Bureau agreed with the Station’s suggestion, noting “that the method of increasing the range used by the E. W. Bliss Company has been experimented with for some time by the Naval Torpedo Station, and so far as the Bureau is informed this method is not patented and could be used by the Bureau if the other methods of steam generation should fail after the completions of the experiments.”⁹⁰ Accordingly, in lieu of developing a torpedo design, the Station reported, on 19 February 1912, it would experiment with the wet superheating methods used by the Bliss Company and Whitehead Company.⁹¹

This seemingly mundane statement was actually a very curious one: how could the Station experiment with Whitehead wet-superheating methods, given that the Navy’s most recent Whitehead torpedoes used dry superheaters, and Whitehead’s American patent for wet superheaters was not issued until May 1912?⁹² The likely answer was that the Torpedo Station was working from a description and detailed drawings of the Whitehead wet superheater pirated in the fall of 1911 by Mark Bristol, who, after leaving the Station, became the Bureau’s inspector at the Whitehead Company’s Weymouth

⁸⁹ Williams to Twining, 9 February 1912, BuOrd 25940/1, RG74/E25/BB284, NARA.

⁹⁰ Endorsement by Norton to Williams, 17 February 1912, BuOrd 25940/1, *ibid.*

⁹¹ Endorsement by Hart [ACNTS] to Twining, 19 February 1912, BuOrd 25940/1, *ibid.*

⁹² USP 1,028,037, applied for 14 October 1910, issued 28 May 1912.

works, as well as its unofficial roving spy.⁹³

As the Station prepared to infringe the Whitehead Company's property rights, it searched for a way around the Bliss Company's. Acting on Williams' suggestion, Twining asked the Bliss Company to reduce its superheater royalties.⁹⁴ When the Company refused, Twining submitted a long memorandum to the Department on the subject of superheater royalties, quoting long passages verbatim from Williams' letter of 23 January 1912, and emphasizing the Bureau's willingness to let the Court of Claims handle the matter.⁹⁵ Sometime between late March and early June 1912, the Department granted the Bureau authority to build the superheaters without further reference to the Bliss Company, and the Bureau ordered the Station to build 75 superheaters on 17 June 1912.⁹⁶ The issue of superheater royalties to the Bliss Company died down for a year.

The Bureau and the Bliss Company Go to Court, Winter 1912/3 to World War I

In November 1912, the Bureau learned that the Bliss Company was trying to sell the rights to its torpedoes to the Whitehead Company, and a major crisis resulted, culminating in a lawsuit that went all the way to the Supreme Court. To understand the crisis, a brief digression is necessary.

Between 1907 and 1911, the Bureau had placed a series of orders with the Whitehead Company which gave it reason to keep an inspector at the Weymouth works. In May 1911, Mark Bristol became the Bureau's inspector, followed by J. V. Babcock in

⁹³ The detailed drawings and description were not found, but Bristol alludes to them in Bristol to Twining, 25 September 1911, BuOrd 24587/11, pp. 13-14, RG74/E25/B1263, NARA.

⁹⁴ Twining to Bliss Co., 13 March 1912, BuOrd 25562-3/25, RG74/E25/BB198, NARA.

⁹⁵ Page to Twining, 19 March 1912, BuOrd 25562/9 (Dept 17755-13); Twining to SecNav, 22 March 1912, BuOrd 25562-4/15, *ibid*.

⁹⁶ Twining to Williams, 17 June 1912, BuOrd 25562/14, B70-290, NTS.

August 1912. Both men were familiar with torpedoes and the Navy's torpedo situation, and therefore they were eminently well qualified to perform not only their official duty of inspecting torpedoes, but also their unofficial duty of spying for the Bureau.

Bristol's detachment from the Torpedo Station coincided with Twining's assumption of leadership at the Bureau, and Bristol soon began writing unofficially to him about foreign torpedo and ordnance matters. In June 1911, about a month after taking over at Weymouth, Bristol suggested that the Bureau sponsor him on an unofficial intelligence cruise in the fall. The American naval attaché in London struggled to get information "because he is attaché," Bristol explained, "and if one attaché gets any thing all others from the different countries expect the same. You can see how this handicaps the attaché."⁹⁷ The Director of Target Practice agreed, gushing to Twining, "You cannot get stuff of this kind [i.e., the kind that unofficial spies like Bristol got] in our Office of Naval Intelligence."⁹⁸ Bristol and Babcock scored several intelligence coups: Bristol procured drawings of the Fiume wet superheater, while Babcock made off with drawings of the Ulan depth mechanism, and with drawings of what was perhaps the holy grail of torpedo intelligence, the British Hardcastle superheater.⁹⁹ The information they gathered on these devices was sufficiently detailed that the Torpedo Station managed to build and experiment with all three, and even went so far as to consider putting the Hardcastle superheater in American torpedoes.¹⁰⁰

⁹⁷ Bristol to Twining, 25 June 1911, RG74/E26/B1L, NARA.

⁹⁸ T. T. Craven [Director of Target Practice] to Twining, 12 December 1911, RG74/E26/B1B/VR, NARA. For a similar sentiment, see Twining to Bristol, 4 August 1911, RG74/E26/B1B/VG/PP167-68, NARA.

⁹⁹ See Babcock to Craven, 21 December 1912, RG74/E26/B1B/VR, NARA.

¹⁰⁰ On the Fiume superheater, see Bristol to Twining, 25 September 1911, BuOrd 24587/11, pp. 13-14, RG74/E25/B1263, NARA. On the Ulan gear, see Babcock to Twining, 20 October 1911, BuOrd 23839/5, NTS B77-314, and Hart [ACNTS] to Twining, 15 October 1912, B73-315, NTS. On the Hardcastle

By mid to late 1911, it was apparent to Bristol that the two centers of gravity for foreign long-range torpedo development were the Whitehead Company's Fiume branch and the Royal Navy, and he and Babcock kept a particularly close watch on them.¹⁰¹ In September 1912, shortly after taking over as the lead inspector at Weymouth, Babcock began sending in a series of remarkable reports about Fiume and the Royal Navy.¹⁰² He was convinced that both were struggling with their reciprocating engines in long-range steam torpedoes. By mid-1911 at the latest, the Bureau had learned that the Fiume branch was working its own two-cylinder, horizontal alternative to the usual Brotherhood four-cylinder engine.¹⁰³ In September 1912, Babcock reported that the Royal Navy was experiencing trouble with the lubrication of Brotherhood engines in Hardcastle torpedoes.¹⁰⁴

Babcock enjoyed excellent personal relations with the director of the Whitehead Company's Weymouth branch, Edgar Lees, and with the director of the Fiume branch, Edward A. Jones. "Through personal acquaintanceships and resulting confidences

superheater, see Babcock to Craven, 21 December 1912, RG74/E26/B1B/VR, NARA. In this letter, Babcock refers to "BIR-5," his fifth intelligence report, which was not found, but it was probably dated sometime in November 1912, since his BIR-4 was dated 30 October 1912. "I have finally managed to walk off with the whole British famous Hardcastle torpedo," Babcock crowed of BIR-5. "I think this with my previous reports on the same subject undoubtedly is the first authentic information that has escaped the inner circles." On the Torpedo Station's consideration of using the Hardcastle superheater in its torpedoes, see Williams to Twining, 11 February 1913, BuOrd 25940/2, RG74/E25/BB284, NARA.

¹⁰¹ See Bristol to Twining, 25 June 1911, RG74/E26/B1L, NARA, for the elimination of the rest of Europe, and Babcock to Twining, 29 August 1912, RG74/E26/B1B/VR, NARA, for the elimination of the Whitehead Company's Weymouth branch.

¹⁰² See Babcock to Twining, 1 September 1912 (BIR-1), B73-315, NTS; Babcock to Twining, 14 September 1912 (BIR-3), B73-315, NTS; Babcock to Twining, 21 September 1912 (see Confidential Appendix), BuOrd 25082/104, RG74/E25/BB37, NARA; Babcock to Twining, 2 October 1912, RG74/E26/B1B/VR, NARA; Babcock to Twining, 30 October 1912 (BIR-4), B68-229, NTS; Babcock to Twining, 7 February 1913 (BIR-12), BuOrd 25415, RG74/E25/BB164, NARA; and Babcock to Twining, c. 7 February 1913 (BIR-16), BuOrd 25415, RG74/E25/BB164, NARA.

¹⁰³ Bristol to Twining, 25 July 1911, BuOrd 24587/4, RG74/E25/B1263, NARA.

¹⁰⁴ Babcock to Twining, 1 and 14 September 1912, B73-315, NTS; see also Babcock to Twining, 30 October 1912, B68-229, NTS.

therefrom,” Babcock unofficially informed Twining on 22 November 1912, “there is reason to believe that the Bliss Company do [sic] not view torpedo developments for us in such a way that they would hesitate in delegating foreign rights of manufacture.” In view of the trouble being experienced with reciprocating engines, he suspected that the Bliss Company was trying to sell its turbine torpedoes abroad. As to the Company’s possible motives, Babcock speculated,

Bliss are [sic] undoubtedly prompted in such procedure from reasons of financial profit, as their patents built abroad means royalties or at least reciprocal treatment in a similar way. Such a course perhaps is natural from their standpoint, but it strikes me that we are vitally interested parties and should be consulted.... Experimental and development work is of course costly, but it would appear that although we do not pay for it as such, still it is sufficiently included in the contract price of finished article [sic] as not to cause much loss to them, and that hence we have some degree of claim on the disposal of such accomplishments to any but ourselves.

“Although unsupported by direct evidence,” he continued, “I consider it a possibility that if Bliss either now has, or does later obtain, long range results with a turbine, unless obstructed, they are liable to sell or otherwise dispose of their accomplishments abroad.” If the Bliss Company did so, “it would simply mean that important developments in work for us and with our financial support, would pass into the hands of the principle [sic] foreign services as a commercial article.”¹⁰⁵

Several days after alerting Twining, Babcock learned that Jones and Lees, the Whitehead Company directors, would be visiting the United States. “There is no question in my mind but that the biggest obstacle confronting these people abroad (all Governments and firms) in developing the long range torpedo problem,” Babcock reminded Twining,

¹⁰⁵ Babcock to Twining, 22 November 1912, RG74/E26/B1B/VR, NARA.

lies in the propulsive power plant ... and I doubt seriously whether they will ever solve it with a reciprocating engine. There is of course nothing to stop them taking up the turbine if they so choose, but such a departure for them will prove very expensive indeed, unless they are able to simply take our present development and proceed on from there.

I, of course, may be wrong, but cannot avoid the conviction that such is the real object of the approaching visits of two such leading torpedo men.¹⁰⁶

Babcock worried that the Bliss Company might give demonstrations of turbine torpedoes to the Whitehead representatives without the Bureau's knowledge or authorization.

Letters from Europe took roughly ten days to reach the Bureau, so Twining must have acted immediately upon receiving Babcock's letter of 27 November, probably telephoning the Bureau's inspector at the Bliss Company, F. L. Sawyer, for information.¹⁰⁷ On 6 December, a Friday, Sawyer reported that he had asked the Company's vice-president, F. C. B. Page, who said that Lees and Jones were expected to arrive on Monday and that the Company would communicate with the Bureau.¹⁰⁸ On Monday, without waiting for the Company's letter, the Bureau cabled Sawyer to inform the Company that it had to comply with Clause 19/20 (Clause 19 was renumbered as Clause 20 in later contracts, so it is referred to hereafter as Clause 19/20 to avoid confusion), especially in regard to the balanced turbine.¹⁰⁹ Sawyer communicated the Bureau's position to the Company.¹¹⁰

The next day, 10 December, Leavitt sent the promised communication to the Bureau. This important letter deserves careful consideration, because, among other things,

¹⁰⁶ Babcock to Twining, 29 November 1912; see also Babcock to Twining, 27 November 1912, RG74/E26/B1B/VR, NARA.

¹⁰⁷ The interval can be deduced by comparing the date of authorship with the receipt date stamped on incoming official letters.

¹⁰⁸ Sawyer to Twining, 6 December 1912, BuOrd 26775/4, RG74/E25/BBB113, NARA.

¹⁰⁹ Twining to Sawyer, 9 December 1912, BuOrd 26775/4-0, *ibid.*

¹¹⁰ Sawyer to Bliss Co., 9 December 1912, enclosure to BuOrd 26775/5, *ibid.*

it laid out all the major arguments that the Company would use to defend itself in a lawsuit six months later. “In view of the rights claimed by us and conceded in clause 2 of the contract,” Leavitt wrote, “we did not consider that our invitation to visitors to inspect the torpedoes, which are our property,” could be construed as being hostile to the Bureau’s interests.¹¹¹ The clause to which Leavitt referred had first appeared in the 1912 contracts for Mark VII and Mark VIII torpedoes. The relevant portion, with the passage on which Leavitt based his claim italicized, read:

[T]he drawings, plans, and specifications ... contain information of a confidential character that can not be made public without detriment to the Government’s and the contractors’ interests, and they are to be treated as confidential by the parties to this contract, *it being understood, however, that nothing in this clause shall be construed as depriving [the Bliss Company] of the right to make and sell such torpedoes to any other party or government whatsoever, except as limited by [Clause 19/20] of this contract.*¹¹²

The Company advanced several lines of argument as to why Clause 19/20 did not cover the balanced turbine. First, it claimed that the first turbine torpedo built by the Company, in 1898, contained a balanced turbine, because Leavitt had been worried about the unbalanced torque of an unbalanced turbine. Although the torpedo had been wrecked in the summer of 1899, the Company said that drawings of its turbine were available for inspection, and could be used to “easily” overthrow Davison’s 1907 patent for the balanced turbine. Second, the Company challenged the validity of the government’s notification of Clause 19/20 protection for the balanced turbine, charging straight at the crucial three months from October 1906 through January 1907, discussed in Chapter 3. The Company claimed that it had begun independently experimenting with its own

¹¹¹ Page to Twining, 10 December 1912, BuOrd 26775/6, *ibid.*

¹¹² See “Contract for the Manufacture of One Hundred and Twenty (120) Torpedoes for the U. S. Navy, Bliss-Leavitt, 5.2-meter by 45-centimeter, Mark VII,” 12 June 1912, B75-316, NTS.

contra-rotating turbine in the summer of 1906 and decided to adopt it in all torpedoes then on order (21-inch Mark II). Not until January 1907 did the government furnish the Company with a blueprint of a balanced turbine, and even then it contained just a few changes to the Company's original design to make the wheels contra-rotate. Finally, the Company argued that by taking out a patent on the balanced turbine, the government had nullified any claims to the importance of secrecy under Clause 19/20. If the government prohibited the Company from demonstrating its turbine torpedo in the United States, the Company concluded, it could simply take the torpedo abroad for demonstration, but it asked that the government save it the inconvenience of doing so by lifting the prohibition.

Twining, the chief of the Bureau, refused to do so. The Bureau "must insist on these restrictions [in Clause 19/20] being complied with in their broadest and most complete sense," he informed the Company, "in that no device containing turbine engines of the so-called balance turbine *principle* [emphasis added] with rotors revolving in opposite directions shall be in any way exhibited or described or any information given in regard to it." Responding to the Company's claim that the government had never notified the Company that it wanted Clause 19/20 to cover the balanced turbine, Twining referred to two pieces of correspondence from the Bureau to the Company: a letter of 9 November 1906, stating that the Bureau would furnish the Company with plans of the balanced turbine and wanted Clause 19/20 to apply; and an endorsement of 9 January 1907, forwarding blueprints of the balanced turbine developed by the Torpedo Station. Twining said that the Company's stamp indicated that it had received the correspondence, a point that the Company would later challenge in court. The Navy's possession of a turbine torpedo placed it at a "decided advantage" over other navies, but if the visiting Whitehead

representatives obtained information as to the balanced turbine, the United States would be placed “at a decided disadvantage.” As for the Company’s notice/threat to take the torpedo abroad if prohibited from demonstrating it in the United States, Twining replied that the Navy Department believed that the restrictions imposed by Clause 19/20 were “so far reaching as to prohibit the exportation, without the Government’s sanction, of any device that may be used for war purposes manufactured in this country embodying the principle of balanced turbines.”¹¹³

Clearly sensing that the issue was not going away, the Bureau undertook two initiatives. First, it began combing its files for records related to the development of the balanced turbine. On 13 December, A. L. Norton, the Bureau’s torpedo officer, summarized his historical findings, which were very similar to those presented in Chapter 3 of the present work.¹¹⁴ After recapitulating the Bureau’s work on the balanced turbine from its beginning in late 1905, Norton dealt with the Bureau’s attempt to secure Clause 19/20 protection. The chronology and pieces of correspondence that Norton referred to became a cornerstone of the government’s case in court.

The Bureau’s second initiative was to ask the Bliss Company, in a meeting on 18 December, to submit an offer for the exclusive international rights to the Bliss-Leavitt torpedo—the same right that the Bureau had decided against purchasing in May 1904 (see Chapter 3). The next day, Page offered to sell the rights for \$1.5 million, the same price the Company had named in 1904, even though it believed that the rights had become more valuable with the maturing of the weapon. Recalling that the Bureau had

¹¹³ Twining to Bliss Co., 13 December 1912, BuOrd 26775/5-0, RG74/E25/BBB113, NARA.

¹¹⁴ Norton to Twining, 13 December 1912, BuOrd 26775/9, *ibid.*

decided against the purchase of the exclusive rights in 1904 in part because it believed that the publication of patents had made the preservation of secrecy impossible, Page wrote that the failure of other governments to produce torpedoes like the Bliss-Leavitt despite their best efforts “clearly demonstrated that the publication of those patents or later patents in no way prevented the matter from being kept secret.”¹¹⁵

The Bureau forwarded the Company’s offer to the Department on 26 December.¹¹⁶ This was the first time since 1906, when Mason had inquired about patenting the balanced turbine and preventing American citizens from transmitting plans of technology to foreign powers (see Chapter 3), that the Bureau had brought the balanced-turbine issue to the Department, and two noteworthy changes had occurred in the interim. First, the position of Navy Solicitor had been established in 1908, as a civil counterpart to the Judge Advocate General. The Department had new administrative machinery at its disposal, and Twining directed his inquiry to the Solicitor.

Second, potentially relevant legislation was available. In 1906, the only possible legal means that the Secretary could think of for preventing the export of technological plans to foreign powers was Section 5335 of the Revised Statutes, which was based on the 1799 Logan Statute (see Chapter 3). In March 1911, Congress passed a measure called the National Defense Secrets Act, or National Defense Act—not to be confused either with the National Defense Act of 1916, to which it bore only an indirect relation, or with the Espionage Act of 1917, to which it was a direct precursor. The 1911 Act read in part:

¹¹⁵ Page to Twining, 19 December 1912, BuOrd 27741/1, RG74/E25/BBB238, NARA.

¹¹⁶ Endorsement by Twining to Solicitor, 26 December 1912, BuOrd 27741/1-1/3, *ibid.*

[W]hoever ... without proper authority, obtains, takes, or makes, or attempts to obtain, take, or make, any document, sketch, photograph, photographic negative, plan, model, or knowledge of anything connected with the national defense to which he is not entitled; ... or whoever, being lawfully intrusted with any such document, sketch, photograph, photographic negative, plan, model, or knowledge, willfully and in breach of his trust, so communicates or attempts to communicate the same, shall be fined not more than one thousand dollars, or imprisoned not more than one year, or both.

It should be noted that the law dealt with both unlawfully and lawfully obtained information.

Although the 1911 Act mirrored the 1799 Logan Statute insofar as both dealt with the international communication of information, they had different intents: the latter meant to regularize diplomacy, while the former meant to prevent espionage. In reporting on the proposed bill in 1911, the House Judiciary Committee described its purpose as follows:

The effect of this bill is to protect the Nation against spying in time of peace.

The necessity for such protection has increased with the growing importance of national preparation for war in time of peace.

... In this contest of preparations, the question of knowledge on the part of the enemy is of vital importance, particularly in the case of the location of forts, of batteries, of mines and torpedoes. Such knowledge may indeed actually settle the contest.

To prevent the acquisition of this information, nearly all of the nations of the world with any developed system of national defense, except the United States, have upon their statute books stringent laws under which they can restrain and to a degree prevent spying by inflicting punishment upon persons found guilty. America alone has no such law and our national defense secrets as a consequence have no protection against spies.¹¹⁷

The examples of espionage that the report went on to provide made clear that Congress had in mind a particular kind of information, that bearing on the location of the nation's physical defenses, and a particular kind of espionage, traditional state-on-state spying.

¹¹⁷ House Committee on the Judiciary, Report 1942, *Bill To Prevent the Disclosure of National Defense Secrets*, H.R. 26656, 61st Cong., 3d sess. (19 January 1911), 2.

The Bureau of Ordnance saw an opportunity to apply the Act to very different information, actors, and purposes than Congress had intended. Aside from information relating to physical defenses, the Bureau sought to include intellectual (i.e., non-physical) information relating to national defense; instead of traditional state-on-state espionage, the Bureau sought to control the complex public-private nexus that was the international arms market; and instead of preventing espionage, the Bureau sought to regulate proprietary and commercial rights. Under patent law, “[h]as not the Navy Department the exclusive rights to dictate as to the uses to which material including the principle of Balanced Turbine Engines may be put,” Twining asked the Solicitor, “and, under the National Defense Act, the power to enforce such dictation?”¹¹⁸ In other words, instead of bringing a civil suit against the Company for damages for patent infringement, could the government instead bring a criminal prosecution against the Bliss Company with fines and imprisonment as possible penalties? Using the National Defense Act—instead of patent law—to enforce patent rights was a novel idea, and clearly not what Congress had intended.

In its assumptions about property, contracts, and the relationship between state and society, Twining’s suggestion to apply the National Defense Act to balanced turbine rights echoed Williams’ suggestion in January 1912 to apply eminent domain to superheater rights. Twining proposed that the state use the National Defense Act to expropriate property not created by its own labor, just as if the state claimed property by natural right or eminent domain. Although the instrument was a specific statute, not a

¹¹⁸ Endorsement by Twining to Solicitor, 26 December 1912, BuOrd 27741/1-1/3, RG74/E25/BBB238, NARA.

medieval political doctrine, the underlying assumptions and desired results were the same. Twining's suggestion that legislation created by the state (in 1911) could retro-actively affect, even supersede, a contract entered into by the private sector (in 1905) reversed the Lockean notion that society's right to dispose of its property by contract precedes, and therefore supersedes, the state, replacing it with Rousseau's emphasis on the right of the state to act on behalf of the general will—say, for the common defense. In Twining's conception, the National Defense Act was the offspring of an unholy union between eminent domain and Rousseau's social contract theory.

On 10 January 1913, the Department decided in the Bureau's favor, holding that Clause 19/20 covered the balanced turbine, that the government could apply the penalties prescribed by the clause if the Bliss Company exhibited or sold torpedoes containing the balanced turbine, and that the government could also seek equitable remedies necessary to protect its interests.¹¹⁹

No sooner had the Department handed down its decision on the balanced turbine than the Bureau stepped into a new mess. Since early 1911, the Bliss Company had struggled to maintain uniform horsepower and speed, first in its hot-air Mark VI torpedoes and then in its steam torpedoes.¹²⁰ To deal with the problem, the assistant inspector at the Bliss Company, E. Friedrich, had suggested trying a two-stage reducer (which became known as the "double" or "compound" reducer) in place of the existing one-stage reducer, and the Torpedo Station began working on the idea.¹²¹ An impasse

¹¹⁹ See Twining to Sawyer, 10 January 1913, BuOrd 27741/1-0, *ibid*.

¹²⁰ See Page to Twining, 5 June 1912, BuOrd 26862/4, and endorsement thereon, RG74/E25/BBB125, NARA.

¹²¹ For the Mark VI horsepower problems, see Sawyer to Mason, 21 February 1911, BuOrd 22866/83, RG74/E25/B1173, NARA. Friedrich's proposal was not found, but Sawyer to Twining, 14 January 1913,

developed: the Company complained that it could not meet the contract requirements as to uniformity of horsepower, but the Bureau refused to change the requirements.¹²² On 14 January 1913, four days after the Department handed down its decision on the balanced turbine, the Bureau's inspector at the Company, F. L. Sawyer, reported that he had finally convinced the Company to experiment with a double reducer, and that the results were promising. The Bliss Company, he wrote, "had been furnished *verbally* with the *idea* [emphasis added]," and the Bureau had furnished the same in writing on 4 January 1913. In order to comply with the requirements of Clause 19/20, Sawyer "urgently recommended that the Bureau inform the E. W. Bliss Company in writing that this device, method or idea be considered as falling within the meaning of Clause 20 of the contract."¹²³ The Bureau so notified the Company on 18 January, quoting Sawyer's letter of 14 January verbatim.¹²⁴

The Bureau's handling of the double reducer in 1911–1913 was almost an exact replay of its handling of the balanced turbine in 1905–1907, and in both cases, it botched the job. Clause 19/20 required the Bureau to "state to the [Bliss Company] in writing, at the time when the said device or design is itself conveyed to the [Bliss Company] by written communication from the [Bureau], that the [Bureau] considers that the said device or design is embraced within the provisions of this clause." Where the contract required *written* communication of a *device or design*, Bureau representatives had

BuOrd 25698/102, B80-232, NTS, dates it as 9 March 1911. For the Torpedo Station, see Endorsement by Williams to Twining, 24 October 1911, BuOrd 24587/11, RG74/E25/B1263, NARA; and Torpedo Board to Twining, 23 April 1912, Para. 17, BuOrd 26542/6, RG74/E25/BBB86, NARA.

¹²² Leavitt to Twining, 12 December 1912, BuOrd 25698/92, B80-232, NTS.

¹²³ Twining to Bliss Co., 4 January 1913, BuOrd 25698/92-1/15; Sawyer to Twining, 14 January 1913, BuOrd 25698/102, B80-232, NTS.

¹²⁴ Twining to Bliss Co., 18 January 1913, BuOrd 25698/102, *ibid.*

verbally communicated to the Bliss Company the *idea* of the balanced turbine in October 1906 and the *idea* of the double reducer with the Bliss Company in 1911–1912. More than stupidity was at work here, however. As noted in Chapter 3, the Bureau had drafted the provision in such a way as to make it impossible to meet, no matter how intelligently observed, because of the dynamics of McNeillian command technology: the provision required the communication of a mature design, when command technology required the collaboration of private industry to make it mature. The Bureau had set itself up for failure.

And the Bliss Company knew it. On 10 February 1913, on the advice of legal counsel, the Company rejected the Department’s decision that Clause 19/20 covered the balanced turbine and suggested a meeting.¹²⁵ A week later, the Company responded to the Bureau’s application of Clause 19/20 to the double reducer. Calling attention to the above-quoted proviso in the clause regarding notification, the vice-president of the Company, F. C. B. Page, wrote,

We regard it as perfectly clear from the language of the contract that it has no application to mere intangible ideas or principles, and that it applies solely to a device embodied either in a model, or in a working drawing constituting a design illustrating such device. Furthermore we regard it as necessarily implied by the language of the contract that the device or design to be furnished to us by the Bureau in order to be covered by said clause must be one of which we are not already in possession, and must be something essentially novel, since obviously to include matters of common knowledge or ordinary shop expedients, would be contrary to the spirit of the contract. It clearly was not intended that this clause should entitle the Bureau to notify us of things already known or used, or of mere intangible ideas and thereby to put us under any restriction concerning such things. In our view the intent of the clause in question was that in the event that the Bureau should at any time work out any new improvement and embody it either in an operative device or in a drawing or design of such device, and should communicate it to us, that such device or design should be within the prohibition

¹²⁵ Page to Twining, 10 February 1913, BuOrd 27741/5 (Dept 17755-144-2), RG74/E25/BBB238, NARA.

of Clause 20th, if the proviso giving us notice thereof was also complied with. Any interpretation obligating us beyond this we cannot accept.¹²⁶

Although the Company had seemed to acquiesce in the Bureau's application of Clause 19/20 to the balanced turbine (not a genuine acquiescence, but probably a ploy to allow itself to argue later that it had never received the Bureau's notice of application), its eruption over the Bureau's application of the clause to the double reducer covered the case of the balanced turbine equally well.

After the winter storm, the next couple months were quiet. The calm ended in May 1913, with two letters from the Bliss Company. On 2 May, the Bliss Company demanded the payment of royalties on superheaters used in the Whitehead torpedoes built or purchased by the Bureau.¹²⁷ The Company had let this issue lie since December 1910, probably because others had dominated its relationship with the Bureau, and the timing of its resurrection was undoubtedly an effort either to make the Bureau wilt under the combined onslaught of the superheater and balanced-turbine cases, or to gain leverage in the balanced-turbine case. A week later, on 9 May, the Bliss Company informed the Department that would sell the foreign rights to the Bliss-Leavitt torpedo to the Whitehead Company unless enjoined (i.e., prevented by an injunction) by 1 June 1913.¹²⁸

As for the Company's letter of 2 May, dealing with superheater royalties, Twining made his recommendations to the Department on 22 May. He divided the Company's claims into two categories. Twining dismissed the first, dealing with royalties on the

¹²⁶ Page to Twining, 18 February 1913, BuOrd 25698/127, defendant's Exhibit 67, "Transcript of Record," *E. W. Bliss Company v. United States* (248 U.S. 37), p. 376.

¹²⁷ Page to SecNav, 2 May 1913, BuOrd 28200/1 (Dept 17755-15). This letter was not found; its date is given and its contents are described in the endorsement by Twining to SecNav, 22 May 1913, BuOrd 28200/1, RG74/E25/BBB316, NARA.

¹²⁸ Page to SecNav, 9 May 1913, BuOrd 27741/6 (Dept 17755-14-5), RG74/E25/BBB238, NARA.

Whitehead torpedoes purchased from the Whitehead Company, by referring to the clause in the Bureau's contract with the Whitehead Company which obliged the Company to hold the Bureau harmless from patent infringement claims—meaning that the Bliss Company's claim regarding these torpedoes was between it and the Whitehead Company, not involving the Bureau. The second category of the Bliss Company's claims concerned the Whitehead torpedoes built by the Bureau rather than purchased from the Whitehead Company. Twining dismissed these claims by quoting verbatim from Williams' long letter of 13 January 1912, the one that had raised the issue of eminent domain. He reminded the Department that in June 1912 it had authorized the Bureau to manufacture superheaters for 75 Whitehead torpedoes being built by the Torpedo Station, and repeated the recommendation that he had made on that occasion, namely, that the Department let the Bliss Company turn to the courts before it recognized the latter's superheater claims.¹²⁹ The issue of royalty payments to the Bliss Company then lapsed again for almost a year, probably because other issues dominated the relationship between the Company and the Bureau.

As for the Company's letter of 9 May, threatening to sell the foreign rights to the Bliss-Leavitt torpedo unless enjoined, the Department immediately asked the Attorney General to seek an injunction.¹³⁰ On 27 May, the Bureau produced a brief for the guidance of the District Attorney for the Eastern District of New York, which contained Brooklyn and formed part of the Second Circuit.¹³¹ Much of it recapitulated the

¹²⁹ Endorsement by Twining to SecNav, 22 May 1913, BuOrd 28200/1, RG74/E25/BBB316, NARA.

¹³⁰ See Franklin Roosevelt [Acting SecNav] to Twining, 14 May 1913, BuOrd 27741/6 (Dept 17755-14-5), RG74/E25/BBB238, NARA.

¹³¹ Norton [BuOrd officer] to Youngs [District Attorney], 27 May 1913, BuOrd 27741, RG74/E25/BBB238, NARA.

chronology of relevant correspondence dating back to the conception of the balanced turbine in 1905 presented in Norton's memorandum of 13 December 1912, previously discussed, except that the Bureau now took the story back to the idea of using the turbine in torpedoes, claiming that it originated with the Bureau in 1901. (In fact, as demonstrated in Chapter 1, the idea went back to 1898, and the Bureau and the Bliss Company seem to have reached it independently at roughly the same time.) From its summary of correspondence, the Bureau asked the District Attorney to note

that the idea of turbine propulsion was conceived in the Bureau of Ordnance, and that the improvements for which the United States holds assigned patent rights for causing the turbines and their gear to revolve in opposite directions, thereby placing the entire propelling mechanism in dynamic balance, was the principle or method [emphasis in the original] whereby the application of turbine propulsion of [sic] torpedoes was made possible, and that this principle and method is so covered by the patents assigned to the United States that any application of turbine propulsion whereby turbine wheels and their interconnecting gearing, by which the propellers are driven, is caused to be in dynamic balance by means of having the turbines revolve in oppose directions, is covered by the restrictions of Clause 19 in the earlier contracts and Clause 20 in the later contracts.

Aside from its historical inaccuracy, the Bureau's statement contained two other errors. First, it conflated "principle" and "method." These were in fact distinct—"principle" meant a general idea, whereas "method" meant a particular arrangement of mechanical details—and the distinction was a key one, as this lawsuit and others would show. Second, the Bureau conflated patent law and contract law. Though the syntax of the passage was hard to follow, the Bureau stated that the balanced turbine was so covered by the patents that it was covered by the contracts—a false statement, since patent rights do not confer contract rights.

In the federal court system, the United States is divided into circuits, which are sub-divided into districts. District courts are trial courts, circuit courts are appellate courts, and the Supreme Court is the highest appellate court.

On top of its brief to the District Attorney, the Bureau called in support from the Torpedo Station, which submitted a “Compilation of Data on the Development of B[liiss].L[eavitt]. Torpedoes through Government Effort.”¹³² The major points in it had been made before, and need not be repeated here. It should be noted, however, that the Bureau had asked the Station to search its files for information relating not only to the balanced turbine, but to the whole Bliss-Leavitt torpedo. The resulting compilation of data proved useful in more than one lawsuit.

United States v. E. W. Bliss Company

On 27 May, the District Attorney filed a formal bill of complaint (“Complaint,” for short) at the district court, which subpoenaed the Bliss Company and ordered it to show cause why an injunction should not be issued. Over the next two months, the government filed an amended Complaint, the Bliss Company’s attorneys filed an Answer to the amended Complaint, and the judge, Van Vechten Veeder, issued a temporary injunction while the case was pending.¹³³

The government’s amended Complaint, dated 24 June 1913, set the terms of the case.¹³⁴ To begin with, the government brought the case in equity, a term of art distinguishing it from a case in law. Equity was a common-law tradition which generally supplemented civil law (written statute) where the latter did not exist or was inapplicable, and the choice of equity over law had important implications for the type of claims that the government could make, for the jurisdiction of the district court to hear those claims,

¹³² Williams to Twining, 29 May 1913, BuOrd 28200/3, RG74/E25/BBB316, NARA.

¹³³ The “Complaint” and “Answer to the Complaint” should not be confused with briefs, which the parties did not submit until November, after testimony was taken at trial.

¹³⁴ Youngs, “Bill of Complaint as Amended,” 24 June 1913, in “Transcript of Record,” 1–8.

and for the remedies that the government could seek. In its Complaint, the government singled out two contracts as being at issue: the November 1905 contract for 300 x 21-inch Bliss-Leavitt torpedoes and a June 1912 contract for 120 x 18-inch Mark VII Bliss-Leavitt torpedoes, quoting Clause 19/20 (appearing in both contracts) and Clause 2 (appearing only in the later contract). Although the Complaint averred that the government had contributed to nine distinct parts of the torpedo, including three distinct aspects of the gyroscope, making eleven contributions in all, the crux of the government's case concerned the balanced turbine. "[T]he efficiency and value of the several torpedoes above mentioned [in the 1905 and 1912 contracts] is entirely due," the government claimed, "to the use therein of turbines revolving in opposite directions for the propulsion of the torpedo, to wit: the balanced turbine method of propulsion." The government further claimed that the Bureau of Ordnance had conceived "this feature" in late 1906 and early 1907 and that the Bureau had "duly informed" the Bliss Company that Clause 19/20 applied. As evidence for its claim to have invented the balanced turbine, the government noted Davison's patent. The government charged the Bliss Company not only with violating the contracts, but also with violating the National Defense Act.¹³⁵ In sum, the government's case rested on the three related but distinct pillars of patent, contract, and statute.

In its amended Answer to the Complaint, dated 24 June 1913, the Bliss Company

¹³⁵ The government made the technical but important argument that the district court had jurisdiction to hear claims under the National Defense Act in equity (as opposed to in law). Distinguishing between two kinds of relief—damages, which are sought in a law action, and injunctions, which are sought in an equity action—the government averred that, because the injury caused by the Bliss Company violating the National Defense Act would be so large and irreparable, it could not be relieved by damages under a law action, but only by an injunction under an equity action. This argument was counter-intuitive, insofar as equity was supposed to supplement civil law, not to govern where a statute existed, but the government's claim was that the statute failed to provide adequate relief.

counter-attacked on a number of fronts. First, it demurred from the government's contention that the efficiency of the Bliss-Leavitt torpedo "is entirely due, or is due in great measure" to the balanced turbine. Second, it argued that the principle of the balanced turbine had been widely known before 1906, that it had conceived a balanced turbine before the government, and that it, not the government, had designed the particular balanced turbines used in Bliss-Leavitt torpedoes—these claims bore on both the contract question and the patent question. Third, it denied that the government had duly applied Clause 19/20 protection to the balanced turbine. Fourth, while admitting that it had embodied some of the Bureau's contributions in the superheaters of torpedoes built under the 1905 contract, it denied embodying any of those contributions in the torpedoes built under the 1912 contract. The foregoing were largely questions of fact; the Company also challenged the government's interpretation of the law. It denied violating either the contract or the National Defense Act. Moreover, it moved to dismiss that portion of the government's Complaint resting on the National Defense Act, on the grounds that the government could not bring such an action in equity—the idea being that equity was inapplicable where a statute existed. As for the patent aspect of the government's case, the Company sought to turn it against the government: by taking out the Davison patent, the government compromised the secrecy of the balanced turbine, effectively nullifying its attempted application of Clause 19/20; and by buying the rights to Davison's foreign patents, the Company had the same rights to the balanced turbine abroad as the government claimed to have in the United States. In sum, the Company argued that the government had mis-applied the contract, sought to turn Davison's patent against the government, and tried to remove the pillar of the National Defense Act.

On 10 November 1913, the trial of *United States v. E. W. Bliss Company* began. Since records survive from the case that tell the Company's side of the story in its own words, it seems opportune to narrate here from the Company's perspective instead of the government's, which has dominated so far due to the reliance on government archives. In 1898, the Company claimed, with implications for the contract and patent aspects of the government's case, it had invented a balanced turbine and applied it to the experimental torpedo that was wrecked in the summer of 1899 (see Chapter 1). Leavitt explained what had led him to switch from the balanced turbine in the experimental 1898 torpedo to the unbalanced turbine in the experimental 1903 torpedo and subsequent Bliss-Leavitt torpedoes (see Chapter 3). Leavitt believed that an unbalanced turbine would be mechanically simpler, but before adopting one for the 1902 experiments, to assure himself that gyroscopic action would not cause the torpedo to roll, Leavitt ran the same experiment the government later ran in 1906, hanging the torpedo from its nose and running the turbine at full speed, whereupon he did not notice "any [gyroscopic action] at all."¹³⁶ He also carried out mathematical calculations which convinced him that the gyroscopic tendency (measured as the wheels' sum of inertia) was "so slight in proportion to the whole mass of the big heavy torpedo ... [that] the gyroscopic effect would be negligible." Leavitt then went through the experimental 1903 torpedo and the report of the Chambers Board thereon, which stated that the torpedo did not sheer, to the serious sheer problem with the 18-inch Mark III torpedoes. If both the experimental 1903 torpedo and the Mark III torpedoes had unbalanced turbines, and the 1903 torpedo had not sheered, the Company's attorney asked, why had the Mark III torpedoes sheered?

¹³⁶ Leavitt's testimony, 18 November 1913, "Transcript of Record," 180; see also 183–84.

“[T]here were all sorts of opinions expressed,” Leavitt replied; “my opinion always was that it was not due to [the unbalanced turbine].”¹³⁷

Consistently with Leavitt’s skepticism as to the utility of the balanced turbine, Leavitt and Page argued that the Company’s balanced turbine—which it claimed to predate and differ from the design proposed by the government—was actually Page’s initiative. Bulldozing through the loophole created by the Bureau’s careless communications with the Company in October 1906, Page testified that the balanced turbine was a matter of “general talk” that fall. Having had the “thought” of the balanced turbine for some time, Page made his first effort to put it into a “practical design” on 1 November 1906, immediately after returning from the crucial 30 October meeting of the Torpedo Board.¹³⁸ The Company offered into evidence several drawings of a balanced turbine which it claimed to have made in the first week of November 1906; the government attacked their authenticity.¹³⁹ As for the letter of 9 January 1907, in which the government claimed to have forwarded a design of the balanced turbine to the Company, the Company claimed never to have received it, intimating that the inspector’s clerk, not the Company’s secretary, had put the receipt stamp on it.¹⁴⁰

The government volleyed back that such formalities were beside the point. “The Government’s contention is that under the language of the contract, a design may be disclosed to those skilled in the art verbally,” one of its attorneys stated, “without the necessity of its being necessarily a drawing.”¹⁴¹ This was (or should have been) a jaw-

¹³⁷ Leavitt’s testimony, 18 November 1913, “Transcript of Record,” 184–85.

¹³⁸ Page’s testimony, 18 November 1913, “Transcript of Record,” 148.

¹³⁹ Page’s testimony, 18 November 1913, “Transcript of Record,” 149–52.

¹⁴⁰ Cross-examination of Moses O’Brien, 11 November 1913, “Transcript of Record,” 63–64.

¹⁴¹ Comment by Coles, 20 November 1913, “Transcript of Record,” 204.

dropping comment, considering that the contract *explicitly* stated that a drawing was needed to trigger Clause 19/20 protection. Apparently the government believed that a thousand words are worth a picture.

The notification issue was straightforward compared to related questions of what the balanced turbine was and what it did. Was it a principle or a design? Was it the turbine wheels alone, or did it include the gearing and shafting? Was it defined by its construction or by its function? The debate over these questions, though difficult, is crucial to come to grips with, so as to avoid the error of allowing the limits of understanding, rather than the arguments, to determine interpretation of the debate.

Evidence of this error was ample in the testimony of the official who had examined Davison's balanced turbine patent application at the Patent Office, Delbert Decker, a witness for the government. On direct examination, Decker claimed that he understood "the operation of the mechanism disclosed" in Davison's patent, which was the "same" as the balanced-turbine design sent by the Torpedo Station to the Bureau in January 1907, and that the Davison design "dominate[d] the structure" of the balanced turbine used in the 18-inch Mark VII torpedo. On cross-examination, the Company's attorney asked Decker what he meant by "balanced turbine." Decker replied, "I mean [the term] to apply to a turbine in which different stages [i.e., wheels] are mounted *upon the same axis* to rotate in opposite directions [emphasis added]." Already, this definition was problematic, because Davison's patent for a so-called balanced turbine showed a construction not only in which the wheels turned in opposite directions on the same axis, but also one in which the wheels turned in opposite directions on parallel axes. The Company's attorney elicited from Decker the further statement that it was "essential" to

make the speed of rotation and weight of the wheels such that their moments of inertia would be equal. The attorney then directed Decker's attention to the part of the construction which governed the speed of rotation, namely, the gearing. Decker replied, "I do not consider the connecting gearing as part of the balanced turbine." How could the turbine be balanced, the attorney asked, if the wheels did not rotate at equal speeds? "That would be a matter of design, of mechanical design," Decker replied, undoubtedly meaning that the weights of the wheels could be changed or redistributed to compensate for unequal speeds. "You have not examined the gearing as to its gearing ratio to determine in either instance whether the counter-speeds are alike, have you?" the attorney asked. "I have not," Decker confirmed, "my examination has been made of the balanced turbine per se in each of the three instances."

Q: You differ from the statements made by Mr. Davison in his patent that to accomplish the results intended he equalizes the opposite moments of inertia of the respective parts; you consider that unnecessary, do you?

A: As far as this question here is concerned as to whether or not a balanced turbine is used.¹⁴²

The attorney had laid a trap, and Decker had fallen in. To stay true to his argument that the gearing did not matter, Decker had to argue that the moments of inertia, which depended in part on the gearing, did not matter, but his argument that the moments of inertia did not matter contradicted his earlier statement, as well as Davison's statement in the patent, that equality of moments of inertia was "essential" to the balanced turbine. Decker had to admit either that he had approved a patent missing an essential component (details of gearing), or that an essential component of the patent as he had approved it (equality of inertias) was actually inessential.

¹⁴² Decker's testimony, 11 November 1913, "Transcript of Record," pp. 64-73.

The point of the Bliss attorney's trap was to show that the balanced turbine had to be defined as a particular design, not as a principle, and that the Davison patent, as embodying only a principle, was invalid. Without such a showing, the Company's contentions that it, not the government, did the hard work in designing the turbine, and that this labor entitled it to claim the balanced turbine as its own property, were largely irrelevant. With it, the Company's contentions were persuasive.

Bypassing the distinction between principles and designs and focusing on the difference between construction and function, the Company also sought to show that the balanced turbine failed to remedy the problems that it was meant to solve, namely, initial roll and sheer. It offered two pieces of powerful evidence. One was that the 10 x 21-inch Mark I torpedoes with balanced turbines run by the government at Pensacola in the winter of 1907/8 had shown a tendency to roll and sheer (see Chapter 3). The other was that the 18-inch Mark VI torpedoes, which also contained balanced turbines, also showed a tendency to roll. Interestingly, both the 21-inch Mark I and 18-inch Mark VI torpedoes were submerged-fire torpedoes. According to the government's theory of initial roll worked out in the fall of 1905, it was while moving through the air when fired above-water that torpedoes were most susceptible to roll; the water, once they were in it, offered more resistance to the rolling tendency. Therefore, by the government's theory, even with *unbalanced* turbines, the Mark VI torpedo, as a submerged-discharge torpedo (it was issued to submarines), should not have been prone to roll. In fact, G. W. Williams admitted in court, even with balanced turbines, it was subject to "very heavy rolling."¹⁴³

The Company did not stop at undermining the government's link between the

¹⁴³ Williams' testimony, 11 November 1913, "Transcript of Record," 51.

balanced turbine and initial roll, but offered an alternative explanation. The explanation was not new: the Company had first proposed it in January 1908 (see Chapter 3), but its value as a signal was probably lost amidst the government's noise about the balanced turbine. It was that the exhaust from the torpedo issued directly into the space where the propellers turned, causing partial cavitation (a la Davison's original theory).¹⁴⁴ The Company fixed the problem simply by adding a bulkhead which redirected the exhaust.

Taken together, the Company's evidence amount to a powerful case that the balanced turbine did not really matter that much. Why, then, had the government placed this technology at the center of its suit? It is difficult to say, and undoubtedly different government officials had different reasons. Without knowing more specifically what the different officials thought, it cannot be said whether the government was cynically suppressing its knowledge or sincerely ignorant: it may have really thought that the molehill was a mountain. There is certainly good reason to believe that naval officials did not fully understand the science behind gyroscopic forces.¹⁴⁵

In his opinion, Judge Veeder took both sides of the principle-vs.-design, essence-vs.-function debate without knowing that he did. "[M]y criterion has been: do the essential features and function of the device appear?" Veeder wrote. "If they do, then mechanical alterations, though they add to its efficiency or even improvements which disclose invention, are immaterial."¹⁴⁶ This phrasing was non-sensical. If the essence was all that mattered, then Veeder's dismissal of mechanical alterations made sense. But if, as

¹⁴⁴ Leavitt's testimony, 21 November 1913, "Transcript of Record," 229–31.

¹⁴⁵ See Bristol to Twining, 21 July 1911, BuOrd 24587/1, and endorsements thereon RG74/E25/B1263, NARA; Craven to Twining, 12 June 1913, BuOrd 28298/1, and endorsements thereon, RG74/E25/BBB324, NARA. These exchanges show a remarkable diversity of opinion on the gyroscopic properties, or lack thereof, in the turbine.

¹⁴⁶ Veeder's opinion, 14 April 1914, *United States v. E. W. Bliss Company*.

he stated, the function also mattered, then he could not dismiss mechanical alterations which improved the functioning. There was another contradiction. If, as Veeder implied in one clause, invention consisted of developing new essence, then how, as he stated in the next clause, could inessential mechanical alterations also disclose invention?

The problems with Veeder's opinion did not end there. To resolve the tension between the contract and patent portions of the government's case, he pretended that the patent portion did not exist. "It seems necessary to point out that this suit is based upon contract, not patent infringement," Veeder wrote. While that distinction was true in one sense—the government was not suing for patent infringement, but for breach of contract and violation of the National Defense Act—it was false in another sense, namely, that the government had cited the issuance of Davison's patent as evidence that it had invented the balanced turbine and therefore could justly claim Clause 19/20 protection for it. In other words, it was not only the Company, but also the government, that linked Clause 19/20 applicability to patentability.

Veeder's error on the patent portion of the case paled in comparison to his treatment of the contract portion. He was aware that his decision might "bear heavily upon the defendant.... But if the consequences of its formal agreement were at all relevant to the issue," Veeder continued, "it would be reasonable to suppose that they were carefully considered in the formation of its very valuable business relations with the Government." In effect, he meant that the Company should have anticipated that a judge would hand down Veeder's decision. Contra Veeder, it was much more reasonable to suppose that after careful consideration, the Company concluded that the contract had abundant loopholes it could exploit, and considered plugging the loopholes to be the

government's responsibility, not its own. Only the most perverse interpretation of business relationships could hold that one party is duty-bound to correct the errors of another party rather than to exploit them. "[I]n any event," Veeder perversely continued, "it would be obviously inequitable to permit [the Company] to use [the balanced turbine], for a period of years, in making torpedoes for the Government, and then when it seeks to sell the developed torpedo to other persons or Governments, to raise for the first time an issue of prior knowledge or prior art." On the contrary, if there was any inequity, it was the government using Clause 19/20 to secure the exclusive rights it had been unwilling to purchase at the Company's asking price. Moreover, if the Company was responsible for anticipating and accounting for the possibility of an adverse judicial decision, then the government was equally responsible for anticipating and accounting for the Company's resistance to its application of Clause 19/20. Veeder applied a double standard.

Veeder did get one thing right, and that was to reject the government's application of the National Defense Secrets Act. He did so, however, not for the substantive reason that it was unjust to add the Act to the contract *ex post facto*, but for the technical reason that a court of equity lacked jurisdiction to enjoin a crime. He did not say that the government was wrong to try the Act, in other words, but only that it was going about the attempt in the wrong way. In 1918, the Supreme Court affirmed Veeder's decision.

E. W. Bliss Company v. United States

No sooner had the government won its case against the Bliss Company than the Company exhumed a buried issue: its claim to royalties on the superheaters of Whitehead torpedoes built or purchased by the government. Sometime in April, probably, the

Company asked the Department to state how many Whitehead torpedoes it had purchased or built, a sure sign that it was contemplating suit.¹⁴⁷

The case was an interesting one—intrinsically, from the perspective of legal history, and from the perspective of the developing legal fora in which private individuals or groups could bring claims against the government. But because the court's decision turned much more on an abstruse legal point—whether the Bliss Company was a licensee or an assignee under the terms of its 1905 agreement with the Armstrong Company, and, as such, whether it had standing to sue for patent infringement—than on the merits or demerits of the Bliss Company's claim, the case is not sufficiently interesting from the perspective of the present work to warrant detailed discussion. The court's ruling, issued in December 1917, was that the Bliss Company was a mere licensee and therefore lacked standing—in other words, the court again ruled for the government.

The Davison Torpedoes, the Superheater Shop License, and the Origins of *Electric Boat Company v. United States*, Winter 1912/3 to World War I

As of late 1912, when the Bureau's dispute with the Bliss Company over the visit of the Whitehead representatives was unfolding, the Electric Boat Company had four outstanding torpedoes under contract: one 18-inch Davison torpedo, one 21-inch Davison torpedo, and two 18-inch Whitehead torpedoes for conversion to the Davison superheater. In November 1912, the Electric Boat Company sent both of the Whitehead torpedoes to

¹⁴⁷ No letter from the Company was found, but a reply from the Department was found (Roosevelt [Acting SecNav] to Bliss Co., 27 April 1914, BuOrd 28200/6 (Dept 17755-15), RG74/E25/BBB316), NARA, and the probable date of the incoming letter can be inferred from the reply.

the Torpedo Station for testing.¹⁴⁸ On 10 January 1913, the Company informed the Station that it had executed its Whitehead contract and would make no further demonstrating tests, and on 14 January, the Company asked the Bureau for payment.¹⁴⁹ Just what had happened with the two torpedoes between November 1912 and January 1913 became the subject of a dispute which again revealed the difficulties of dealing with command technology.

In its letter of 14 January requesting payment, the Company argued that despite the poor condition of the two torpedoes that the Bureau had sent it for conversion, the addition of the Davison wet superheater had enabled them to demonstrate their ability to meet the contract range and speed requirements in the dynamometer tank. Williams, the commander of the Torpedo Station, disagreed. The torpedoes, especially the engines, had developed flaws due to the Davison superheater, not to their original condition; the dynamometer runs had been informal tuning-up runs, not official demonstrating runs; and runs in the water, not only in the dynamometer tank, were necessary to satisfy the terms of the contract.¹⁵⁰

The Bureau agreed with Williams and refused the Company's request for payment. The contract, it pointed out, had called for the installation of the wet superheater in two Whitehead torpedoes and continued,

The installation of steam generating device [i.e., wet superheater] shall cause these torpedoes to have an increased range of at least... 6,000 yards *on their demonstration* at the Naval Torpedo Station; it being understood that this device is to be capable of increasing the range to... 8,000 yards. The requirement of 6,000 yards minimum range is the lowest that will be considered as fulfilling the above

¹⁴⁸ See Davison to Williams, 10 January 1913, B73-315, NTS.

¹⁴⁹ Davison to Williams, 10 January 1913, B73-315, NTS; Davison to Twining, 14 January 1913, BuOrd 25373/18, RG74/E25/BB156, NARA.

¹⁵⁰ Endorsement by Williams to Twining, 20 January 1913, BuOrd 25373/18, RG74/E25/BB156, NARA.

services for the conversion of the two torpedoes *submitted for test and demonstration*. [Emphasis added]

The Bureau argued that the torpedoes had not demonstrated their ability to meet the contract range and speed requirements.¹⁵¹

In his return volley a couple days later, Davison tried a novel approach. The Bureau's intent in making the contract had been not to secure a torpedo of a particular range and speed, Davison argued, but to stimulate competition. The Company had been "undoubtedly the first in the field with a device on [the wet superheater] principle, as is shown by the dates of our patents," and its experiments had been the first to show the potential of wet superheating to increase speed and range. Because of its trailblazing in the field—not because of demonstrated ability to meet particular range and speed requirements—the Bureau awarded a contract to the Company. As for the Bureau's complaints that his superheater caused the engines to deteriorate, Davison responded that he had adopted the arrangement which caused the deterioration as a matter of expediency, "since, in any case, [the superheaters] were regarded as experimental and merely for the purpose of demonstrating to the Bureau what could be accomplished." Where the Bureau argued that it had contracted for an ordinary developed commercial article, Davison was arguing that it had contracted for an extraordinary experimental one—exactly the same argument that the Bliss Company had made from 1905 to 1907 about the Bliss-Leavitt torpedo. Given that the intent of both parties had been to show the device's potential rather than to achieve a specific performance, the Company "assumed that by delivering the torpedoes at Newport we had fulfilled our contract." If so, it was an unjustified

¹⁵¹ Twining to Electric Boat Co., 23 January 1913, BuOrd 25373/18, *ibid*.

assumption, since the contract explicitly called for demonstration after delivery. More justified was the Company's assumption that the government, not itself, would bear the responsibility for making any demonstrations. "So far as the wording of the contract is concerned," Davison noted, "there is nothing which calls upon us to make any tests," and the Company, knowing the risks and expenses of testing, would never have agreed to the contract if it expected to conduct the tests itself. The most that the Bureau could require the Company to help with was dynamometer tests; the idea that the Company was responsible for open-water tests, which required an extensive supporting apparatus of boats, personnel, and ranges, was absurd.¹⁵² On 11 February 1913, however, the Bureau informed Davison that it would not budge.¹⁵³

Probably crossing the Bureau's letter in the mail was a letter from the Company dated 12 February about the 21-foot Davison torpedo. The Company had originally undertaken development of the two experimental Davison torpedoes in response to encouragement from the Bureau, Davison explained, and with every reason to believe that if the torpedoes did well, the Company would receive a large volume of orders. Since the Company's 21-foot torpedo was bound to be similar in design to its 18-inch torpedo, and the latter was farther along, the Company decided to finish and test the latter to make sure that the design was successful before proceeding with the former. The 18-inch torpedo was nearly ready for test, but the Company did not want to complete the 21-foot torpedo in view of changed market conditions: instead of competing on an open playing field, its 21-foot torpedo would be competing against an already successful model, the

¹⁵² Davison to Twining, 25 January 1913, BuOrd 25373/20, *ibid.*

¹⁵³ Twining to Davison, 11 February 1913, BuOrd 25373/20-2/25, *ibid.*

Bliss Company's. "We believe that, due to the conditions existing," Davison continued, "we rendered to the Bureau a real service merely by undertaking this work." Here he was implying, as he had with regard to the two converted Whitehead torpedoes, that his Company's willingness to accept the contract, regardless of its torpedoes' performances, had stimulated competition which led to the development of better products. This claim of indirect responsibility for the products of other companies was obviously problematic, but it was not absurd. Accordingly, Davison asked the Bureau to compensate the Company for the work it had done on the 21-foot torpedo, even though the Company would not finish it, and in return the Company would turn over its drawings, material, and patents associated with the 21-foot torpedo (excluding superheater patents) to the Bureau for unrestricted use.¹⁵⁴

Davison's proposal intrigued the Bureau, which asked the Department for conditional approval and hosted a meeting with Davison on 17 March 1913.¹⁵⁵ Based on that meeting, Davison supplemented his offer regarding the 21-foot torpedo by offering to turn over drawings of the 18-inch torpedo as well.¹⁵⁶ On 20 March 1913, the Bureau probably informed Davison that it wanted the Company to complete and demonstrate the 21-foot torpedo.¹⁵⁷ Davison expressed surprise, stating that the Bureau's offer was "entirely different" from what had been discussed at the 17 March meeting, but he complied—reserving his right to modify the offer contained in his letter of 12 February, since the value of the property covered in that letter would increase with successful

¹⁵⁴ Davison to Twining, 13 February 1913, BuOrd 25145/16, RG74/E25/BB64, NARA.

¹⁵⁵ Endorsement by Twining to DeptNav, 24 February 1913, BuOrd 25145/16-3/5; Davison to Twining, 17 March 1913, BuOrd 25145/18, *ibid*.

¹⁵⁶ Davison to Twining, 17 March 1913, BuOrd 25145/18, *ibid*.

¹⁵⁷ BuOrd to Electric Boat Co., 20 March 1913, BuOrd 25145/16-3/29, *ibid*. This letter was not found; its contents are a guess based on inference from Davison's reply.

demonstrating runs.¹⁵⁸

In April 1913, trials of the two converted Whitehead torpedoes resumed, and those of the 18-inch Davison torpedo began, at the Torpedo Station.¹⁵⁹ In late July, having gotten disappointing results, the Station suspended trials of all three. It recommended that the Bureau give up on the two Whitehead torpedoes and send the 18-inch Davison torpedo back to the Electric Boat Company for more work.¹⁶⁰ Several days later, on 4 August 1913, Davison sent the Bureau a long letter reviewing his Company's position on all four torpedoes. For the most part, he recapitulated the familiar arguments that his Company was first in the American field of wet superheaters, that the Company had performed a service to the Bureau by stimulating competition, that the Company had not accepted any responsibility for demonstrating runs, and that the two Whitehead torpedoes sent by the Bureau for conversion had been in poor shape. He made a new and ominous point, however, which hinted at a patent dispute in the offing. When the Company had made the shop license agreement for its wet superheater with the Bureau in April 1912,

the Bureau had no steam generator [i.e., wet superheater] working on this principle in sight. Since that time, the Bliss Company has developed a heater or steam generator which works virtually on the same principle and the Torpedo Station is now experimenting with a very similar device. Just how much assistance the knowledge of our generator was to the Torpedo Station, it is difficult to say, but it is a fact that experiments were not begun at the Torpedo Station until after our device had been made known to the Bureau.

In sum, he concluded, the Company had spent a great deal of money to perform work of value to the Bureau, and it did not wish to spend any more. Therefore, he asked the Bureau to cancel the contracts for all four torpedoes after arranging to buy such work

¹⁵⁸ Davison to Twining, 5 April 1913, BuOrd 25145/19, RG74/E25/BB64, NARA.

¹⁵⁹ See Norton [for CoO] to Davison, 10 April 1913, BuOrd 25373/22-4/22, RG74/E25/BB156, NARA.

¹⁶⁰ Williams to Twining, 29 July 1913, BuOrd 25724/7, RG74/E25/BB245, NARA.

(drawings, materials, patents) on them as the Company had produced, and to reconsider the shop license agreement.¹⁶¹

The Bureau promised to have the Torpedo Board take up the whole subject of contracts with the Electric Boat Company at its next meeting; in the meantime, it ordered experiments with the two converted Whitehead torpedoes, but not the 18-inch Davison torpedo, at the Torpedo Station to continue.¹⁶² A month later, in early September 1913, before the Torpedo Board had met, Williams, the commander of the Torpedo Station, reported that one of the two converted Whitehead torpedoes had sunk, and he ordered work with the other one to stop for fear of involving the Bureau in claims for damages.¹⁶³ On 6 September, Twining informed the Company that the Bureau, in view of the disappointing performance of the converted Whitehead torpedoes and expense of testing them, planned to stop testing them at the end of the month unless the Company could justify continuing.¹⁶⁴ In his reply of 8 September, Davison, complaining that the Bureau had dealt “very harshly” with the Company, repeated his arguments that the Company deserved payment.¹⁶⁵ On 12 September, Williams and Davison reached a temporary armistice, agreeing to run the remaining (i.e., un-sunk) Whitehead torpedo several times in the dynamometer and the water.¹⁶⁶ It managed a run of 27 knots for 6,050 yards, the first successful run by any of the Company’s four torpedoes, and Williams was sure that the Company would re-declare victory and demand payment. To the contrary, he argued,

¹⁶¹ Davison to Twining, 4 August 1913, BuOrd 25145/21, RG74/E25/BB64, NARA.

¹⁶² Twining to Electric Boat Co., 8 August 1913, BuOrd 25145/21, *ibid.*

¹⁶³ Williams to Twining, 2 September 1913, B73-315, NTS.

¹⁶⁴ Twining to Electric Boat Co., 6 September 1913, BuOrd 25373/28-9/20, RG74/E25/BB156, NARA.

¹⁶⁵ Davison to Twining, 8 September 1913, BuOrd 25373/29, *ibid.*

¹⁶⁶ Agreement between Davison and Williams, 12 September 1913, B73-315, NTS. This document has only Davison’s name on it, but it reads like an agreement and makes sense as one in the context.

the Company had not met “the understood object of the contract—the fitting up of a practicable torpedo.”¹⁶⁷ Davison, of course, had consistently maintained that the object of the contract, as understood by both parties, was not to fit up a practicable torpedo but to show the potential of the Company’s superheater and to stimulate competition in the torpedo design market.

In the midst of the brewing crisis over the Company’s four torpedoes, Davison touched off a new crisis. On 16 September 1913, he forwarded the Bureau a copy of an opinion by the Electric Boat Company’s patent attorneys, Pennie, Davis, & Goldsborough.¹⁶⁸ Davison had sent the attorneys sketches of both the Torpedo Station’s wet superheater and the Bliss Company’s wet superheater, along with a sketch of his own wet superheater, and asked whether the former designs infringed the latter. The attorneys held that they did. Both the Station’s and the Bliss Company’s superheaters “involve the *idea* of burning fuel with the air in a combustion chamber so as to produce products of combustion of high temperatures, and injecting water into the products of combustion to reduce their temperature and increase their volume [emphasis added].” Davison had applied for his first wet superheater patent, No. 1,030,080, in March 1909. The “primary object” of that patent was to produce a device that would generate the desired range and speed, with sufficient reliability and safety of operation, and the “characteristic idea” of the patent was to make the water and the fuel supplies mutually depend on the same source of pressure, subsidiary to the main air supply, thereby achieving the desired objects of performance, reliability, and safety. “The patent contains specific claims, as is

¹⁶⁷ Endorsement by Williams to Twining, 18 September 1913, BuOrd 25373/29, RG74/E25/BB156, NARA.

¹⁶⁸ Davison to Twining, 16 September 1913, BuOrd 25373/30, *ibid.*

usual, for this refinement of the invention,” the attorneys argued, “but it also contains broader claims which cover the underlying idea above stated.”¹⁶⁹ This statement, that an idea could dominate specific claims, was absolutely crucial to the attorneys’ case—and, as it turned out, highly dubious. They acknowledged that, “[s]trictly speaking,” the Bliss and Torpedo Station superheaters differed in certain mechanical principles and details (for instance, which pressures governed the fuel and water supply), but they argued that the details of Davison’s superheater that the other superheaters avoided infringing were not “essential” to Davison’s claims, which were not “limited” to these particular details. Therefore, it was “quite clear,” they concluded, that the Bliss and Torpedo Station superheaters infringed Davison’s patent.¹⁷⁰ And so it was—as long as their claim that a general idea could be patented and held to dominate various arrangements of details was unchallenged.

Asked to comment on Davison’s demand for royalties, Williams quoted from the superheater section of the “Compilation of Data” that the Torpedo Station had put together in May 1913 for use in the Bureau’s injunction suit against the Bliss Company. Information on Davison’s superheater work while at the Station was scarce, Williams explained,

due to the fact that Mr. Davison kept the records of his official investigations in a note book, which he took away with him when he was detached from the Torpedo Station. He had this notebook in his possession at a date not in the remote past. This notebook appeared to be of the type and grade furnished by the Government for the use of Officers at the time of Mr. Davison’s tour of duty at the Torpedo Station.¹⁷¹

¹⁶⁹ “Claims” in this context was a term of art, referring to the “claims” section that concluded every patent.

¹⁷⁰ Pennie, Davis, & Goldsborough to Electric Boat Co., 19 August 1913, BuOrd 25373/30, *ibid*.

¹⁷¹ Endorsement by Williams to Twining, 11 October 1913, BuOrd 25373/30, RG74/E25/BB156, NARA.

The implication, of course, was that Davison had effectively stolen commodified information gained at government expense and used it in developing his superheater at the Electric Boat Company, thereby giving the government a claim to have participated in the development of his superheater even after he left the Station.

On 27 September, the Torpedo Board took the comprehensive look at the Bureau's contracts with the Electric Boat Company that Twining had promised Davison in August. The Board recommended canceling the contracts for the four torpedoes without penalty to the Company, but it was unable to decide whether the Company should be compensated for the work it had performed by purchasing its drawings, material, and patents. This question was "intimately connected" with the shop license agreement of April 1912 covering the Davison wet superheater, "and in the consideration of this connection there arose questions of contract and patent law which the Board found itself unable to decide without the assistance of specialist attorneys." Notwithstanding this acknowledged lack of expertise, the Board believed that "a true and equitable decision in regard to the rights in these matters can only be reached after a thorough judicial investigation"—i.e., by going to court—and it recommended that the Bureau make no payments for the four torpedoes to the Company until such an investigation of the superheater occurred, lest the Bureau compromise its rights in any way.¹⁷²

The Bureau approved the Board's report and communicated its decision to the Electric Boat Company, explaining that the issue of the wet superheater was so intertwined with the four torpedoes that the Company should submit a proposition

¹⁷² Torpedo Board [Norton, Williams, Procter, Defrees, McCrary, Babcock] to Twining, 27 September 1913, BuOrd 26542/10, RG74/E25/BBB86, NARA.

covering not only the four torpedoes, but also the terms on which the Department could cancel the April 1912 shop license and purchase the wet superheater rights for a lump sum.¹⁷³

While the Bureau awaited the Company's reply, *United States v. E. W. Bliss Company* went to trial in Brooklyn.

Davison replied on 18 November 1913. His argument as to why the Company should be compensated for its work on the four torpedoes was familiar—the work was experimental and the Company had stimulated competition—but other points in the letter were new. The Company could not agree with the Bureau's view, Davison explained, that the issue of wet superheater rights was so intimately connected with the settlement of the torpedo contracts as to require canceling the shop license and reaching a new agreement: the shop license could govern the payment of royalties on wet superheaters in any Davison torpedoes built by the government, while the Company was not asking for royalties on any other part of the torpedo, merely a one-time purchase of the drawings, material, and patents (excluding the superheater). Nevertheless, the Company was willing to agree to cancellation of the shop license and payment of a one-time lump sum for its superheater rights, so long as the lump sum was adequate—meaning that it could not merely reimburse the Company for its expenses in developing the superheater, but also had to account for the sacrifice of income from potential royalty agreements with others. Given that the Company considered its superheater rights “very important,” and the potential income from them large, the minimum lump sum that it would consider was

¹⁷³ Endorsement by Twining to Norton, 4 October 1913, BuOrd 26542/10, RG74/E25/BBB86, NARA; Clark [Acting CoO] to Electric Boat Co., 4 October 1913, BuOrd 25145/21, RG74/E25/BB64, NARA.

\$1.5 million.¹⁷⁴

The letter regarding a lump-sum payment for the superheater rights was not the only one that Davison sent on 18 November. Having notified the Bureau in September that its patent attorneys considered the Bliss Company's and Torpedo Station's wet superheater to infringe Davison's patents, Davison now demanded payment of royalties under the shop license of April 1912. He understood that the Bureau doubted the validity of the Company's claims, so he asked the Bureau to consult "the highest expert authority in the country, namely, the Commissioner of Patents, and obtain his personal opinion thereon." In a statement of the Company's position for transmission to the Commissioner, Davison traced the Company's development of the wet superheater back to 1908 (the same year that he had resigned from the Navy and joined the Company), explained the practical problems that the Company had overcome in the development of its superheater, and noted that the Bureau's contracts with his Company predated the Bureau's contracts for steam torpedoes with the Bliss Company.¹⁷⁵

In an endorsement for the Department dated 20 December 1913, the Bureau went straight at the Company's key contention that a principle, as opposed to a particular mechanical arrangement, was patentable, attacking on other fronts as well. If the "essential" "idea" of wet superheaters was to use a mixture of air, fuel, and water for motive power, then the first patent for a wet superheater was not Davison's, but one (No. 641,787) taken out by Hudson Maxim in 1900. The idea was also the same as the "principle" of the Gesztesy superheater, which the Bureau had described to the Bliss

¹⁷⁴ Davison to Strauss, 18 November 1913, BuOrd 25145/27, *ibid.*

¹⁷⁵ Davison to Twining, 18 November 1913, BuOrd 25373/34 (Dept 26817-43), RG74/E25/BB156, NARA.

Company in March 1908 (by sending it the article from the *Revista Brasileira Maritima*). Contra Davison's claim to have been first in the American field of wet superheater development, therefore, others had beaten him, while the Bureau and the Bliss Company had at least tied him. Moreover, even if the date of Davison's claim was conceded, his responsibility had not been clear. At the Torpedo Station in 1906–1907, “[Davison] was in a position where it was his duty to obtain and use to advantage all information relative to the improvement of torpedoes,” the Bureau observed, “and he undoubtedly used much of the data and information obtained at the Torpedo Station in the development of the [wet superheater]”—information which, the Bureau did not need to add, had been obtained at government expense. Despite the benefit of this information, talent, and capital, the Electric Boat Company had not been able, starting at the same time as the Bliss Company, to meet its minimum contract requirements, while the Bliss Company had succeeded. There were differences between the Davison, Bliss, and Torpedo Station superheaters, “and the question of infringement of the patents, in the opinion of the Bureau, can only be settled by the courts.”¹⁷⁶

On 6 January 1914, two weeks after firing off this broadside to the Department, the Bureau turned its epistolary guns on the Electric Boat Company, replying to Davison's two letters of 18 November 1913. Davison's view that the government had benefited merely by the Company taking on the contracts and stimulating competition, regardless of its failure to fulfill the contract, the Bureau argued,

can hardly be considered sound. Contracts were entered into with the Company, and depending on the success of the Company, both parties were supposed to benefit. Had the Company been successful, it would have been in the field with a

¹⁷⁶ Strauss to DeptNav, 20 December 1913, BuOrd 25373/34-12/31 (Dept 26817-43), *ibid.*

torpedo presumably valuable enough to afford a good market for the Company's product and they [sic] would have profited accordingly. In other words, it was an ordinary business venture which depended for its reward on the skill, perseverance, and capital of the firm, and which, failing these necessary factors, might result in loss and this loss can not be borne by the Navy Department.

As for the Company's offer to sell its superheater rights for \$1.5 million, the government had to determine the validity of the patents in question before it could determine their value, and therefore would take no further steps in the matter "until a careful legal investigation has made it clear whether the Company has any rights at stake."¹⁷⁷

The author of the endorsement to the Department of 20 December 1913 and of the letter to the Company of 6 January 1914 was Joseph Strauss, who had replaced Twining as chief of the Bureau on 21 October 1913. Although it is entirely possible that Twining would have taken as hard a line as Strauss did, nevertheless the novelty of Strauss's position may have affected his conduct. If Davison's emphasis on the intent of the contracts placed by the Bureau with the Electric Boat Company was justified, then Strauss's non-participation in the history of the contracts was important. And if there was a learning curve for the Bureau chief to understand the complexities of dealing with command technology, then Strauss's depiction of the contracts as "an ordinary business venture"—which, as Davison kept correctly insisting, they were not—can be as plausibly attributed to the newness of his job as to a cynical negotiating ploy.

In the dispute between the Bureau and the Electric Boat Company over superheater rights, there were two striking ironies, which arose in large part from the twisted *menage-à-trois* among the Bureau, the Electric Boat Company, and the Bliss Company. To review, the government was accusing the Bliss Company of infringing

¹⁷⁷ Strauss to Electric Boat Co., 6 January 1914, BuOrd 25145/27, RG74/E25/BB64, NARA.

Davison's balanced turbine patent, while the Electric Boat Company was accusing the government of infringing Davison's superheater patent in Bliss-Leavitt torpedoes, while the Bliss Company was accusing the government of infringing its Armstrong superheater patents in Whitehead torpedoes. On the Electric Boat Company's side, the irony was that the breadth of Davison's patent claims, which he intended as a strength, could be turned into a source of weakness. The Company had written its superheater patents with "sufficient scope to fully protect our interests"—in other words, not so much to describe the invention as constructed as to prevent others from patenting anything like it.¹⁷⁸ On the government's side, the irony—more like flagrant hypocrisy—concerned its argument about the patentability of principles. Even as it argued against the Electric Boat Company that a principle could not be patented (where it did not control the relevant patents), it argued against the Bliss Company that a principle could be patented (where it did control the relevant patents).

After receiving the Bureau's letter of 6 January 1914, the Company evidently disengaged for several months. On 29 April 1914—probably just a few weeks after the Bliss Company demanded the payment of royalties for the Armstrong superheaters used in the government's Whitehead torpedoes—Davison re-engaged, tersely demanding payment of royalties under the shop license agreement for the wet superheaters used in Bliss-Leavitt torpedoes purchased by the government.¹⁷⁹

To counter the claim, A. L. Norton, the Bureau's torpedo officer, produced a 77-page memorandum. After reviewing the history of the superheater, Norton spent the bulk

¹⁷⁸ Davison to Twining, 24 September 1913, BuOrd 25145/24, *ibid.*

¹⁷⁹ Davison to Strauss, 29 April 1914, BuOrd 25373/36, RG74/E25/BB156, NARA.

of the memorandum analyzing the differences between Davison's and the Bliss Company's wet superheaters in excruciating detail. This was precisely the level of detail that the Electric Boat Company's attorneys had failed to engage, because they believed that the general principle of Davison's superheater dominated the details, rendering them irrelevant. The Bureau was trying to demolish this argument (even as it used the same argument in its case against the Bliss Company). Based on this detailed review, Norton argued that "[t]he specific method of introduction of water as used by Mr. Davison and claimed as a novelty and in which claim patent was granted does not appear in either the operation, construction or principle" of the Bliss wet superheater, and therefore the Electric Boat Company's claim for royalties on the Bliss superheater were invalid. Norton suspected, however, that the Electric Boat Company did not really care about the merits of the claim, but rather was using it "in order to force the Bureau of Ordnance to purchase certain material"—namely, the drawings, material, and patents associated with the two Davison torpedoes. Insofar as "the LEGAL rights" of the government were concerned, Norton recommended that the Bureau not succumb to Company's ploy, but instead refuse to pay royalties, refuse to buy the material associated with the Davison torpedoes, and cancel the contracts without penalty to the Company. "However there is another aspect to the situation, that is one of moral obligation or equity," Norton continued:

Without doubt there is much in the claim of Mr. Davison that the undertaking of contracts by the Electric Boat Company spurred on other contractors to a more rapid development of a long range torpedo. Also it is a fact that the Electric Boat Company has expended a considerable sum (without recompense) in the development of their steam generator and their type of torpedo, including much of the valuable time of Mr. Davison.

Although the Company had undertaken the contracts “well knowing” these risks, there was “a middle ground on which the Navy Department might with justice and without prejudice to the Government’s interest meet the Electric Boat Company, and perhaps reach an adjustment which would recompense that Company for its outlay in the development of its torpedo.” The Department could cancel the shop license agreement, purchase the 18-inch Davison torpedo which was finished but had not met its contract requirements, and purchase the drawings and material associated with the unfinished 21-foot Davison torpedo. The price would be a lump sum not to exceed \$50,000, and in exchange, the Company’s would agree to quit its claims for royalties by assigning its patent rights to the government.¹⁸⁰ If the Company rejected this proposal made out of “moral obligation or equity,” then the government should behave in accordance with its “LEGAL rights.”¹⁸¹

On 16 June 1914, the Department finally decided to cancel the Electric Boat Company’s contracts, reserving its decision on penalties pending the Bureau’s negotiations with the Company.¹⁸² The next day, Davison and Strauss met to negotiate. Among other things, Strauss probably proposed to buy the experimental torpedo material and patent rights for \$50,000, as Norton had suggested, and he evidently invited the Electric Boat Company to undertake new contracts for torpedoes—a surprising invitation, in the context of the Bureau’s deteriorating relationship with the Company, but unsurprising in the context of the peculiar torpedo market, where the Bureau’s

¹⁸⁰ Davison had stated that the Company’s expenditures on the two Davison torpedoes were \$56,356.65 (Davison to Twining, 29 September 1913, BuOrd 25145/25, RG74/E25/BB64, NARA), by which standard Norton’s proposed \$50,000 was low, but not grotesquely so.

¹⁸¹ Norton to Strauss, 26 May 1914, BuOrd 25373/39 (Dept 26266-417-1), *ibid.*

¹⁸² Roosevelt [Acting SecNav] to Strauss, 16 June 1914, BuOrd 25145/28, *ibid.*

relationship with its most important supplier (the Bliss Company) had deteriorated even further. On 23 June 1914, Davison replied that the invitation was “attractive”—and that whatever reimbursement the government paid for its experimental torpedoes would contribute to the capital necessary for the enterprise.¹⁸³ Having again been advised by the Company’s patent attorneys that his patents dominated the Bliss wet superheater, however, he was unwilling to give up the Company’s superheater patent rights for a small lump sum and insisted on the payment of royalties, though he was willing to negotiate lower royalties than those contained in the April 1912 shop license agreement. On 1 July 1914, through its attorneys, the Company offered to reduce its royalty charges by 25%, from \$800 to \$600 per superheater.¹⁸⁴ No reply from the Bureau was found, and on 29 July 1914, the Company filed suit in the Court of Claims to recover royalties on the superheater used in Bliss-Leavitt torpedoes purchased by the government. The case would eventually go to the Supreme Court, but in the meantime, World War I began.

Conclusion

While the performance of American torpedoes improved during this period thanks to the invention of the wet superheater, the performance of their human developers lagged. The same pattern that characterized the Bureau’s dealings with private industry from 1903 to 1908 repeated itself from 1909 to World War I. Instead of learning from earlier mistakes in dealing with the Bliss-Leavitt torpedo, for instance, Bureau officials repeated them in dealing with the double reducer and blundered into a second dispute

¹⁸³ Davison to Strauss, 23 June 1917, BuOrd 25145/29, *ibid.*

¹⁸⁴ Johnson [Electric Boat Co. attorney] to Strauss, 1 July 1914, BuOrd 25145/31, *ibid.*

over superheater rights, despite clear and prescient warnings from the commander of the Torpedo Station. Remarkably, the Bureau managed to get itself involved on the opposite sides of two lawsuits—in one, defending the patentability of principles; in the other, challenging the patentability of principles—yet to win both. These victories testified to the power of the government rather than to the intelligence of its officials. No matter how many resources private arms manufacturers possessed, governments had more. Where the Electric Boat Company relied on attorneys who were unable or unwilling to grasp the sophisticated technology involved in superheaters, the government had Commander Norton produce a long memorandum analyzing the relevant technology in great detail. Might did not make right, however. The Bureau displayed persistent disregard for private property rights, resorting to the medieval doctrine of eminent domain despite the damage done to the liberal political philosophy on which the United States supposedly rested. According to this philosophy, property rights were the fundamental civil liberty; hence the government's effort to use the National Defense Act to infringe property rights constituted an assault on civil liberties in the name of national security. However unfamiliar the technology at issue, the government's conduct was familiar indeed.

Chapter 6: British Torpedo Development, 1909-World War I*

“[W]e are left with a very bad gap in the torpedo
armament of the Navy.”
– *Vernon*, 1914¹

Introduction

By 1909, the Royal Navy had entered the wet superheater age. After converting some 18-inch Fiume III** torpedoes to take the Armstrong dry outside superheater, which enabled them to make 4,000 yards at 25 knots, and purchasing 20 troubled 18-inch Weymouth I heated torpedoes, the Admiralty realized the superiority of Hardcastle’s wet superheater and decided to end its use of the Armstrong superheater. Thereafter, it converted 18-inch RGF Mark VI*-VI** torpedoes to take Hardcastle’s superheater, so that they could make 6,000 yards at 29 knots; and it developed the Navy’s first heater torpedoes, the 18-inch RGF Mark VII and VII* torpedoes, which could make 6,000–6,500 yards at 29 knots or 3,000 yards at 41 knots. It also completed successful trials of the Navy’s first 21-inch torpedo, the Mark I, which could make 3,500 yards at 45 knots or 7,500 yards at 29 knots; and it began testing a longer 21-inch torpedo, which would become the Mark II.

* In the following chapter, torpedoes converted from cold to hot are referred to as “converted” and denoted by an “H” after the mark designation, e.g., 18-inch Mark VI** H. New heated torpedoes are referred to as “heater” torpedoes, and the “H” after their mark designation is omitted, as per the Navy’s convention.

¹ ART14/36.

The Hardcastle superheater proved remarkably mature, undergoing only minor changes from 1909 to the war, but it created problems with torpedoes' vertical and horizontal direction-keeping that were not entirely solved when the war broke out. The proper speed and range settings of the heater torpedoes were not obvious, and the issue was tied up with difficult tactical questions. The development and introduction of angled gyroscopes also created new tactical possibilities, but the Navy struggled to develop torpedo control systems that would allow it to exploit them. The performance of heater torpedoes made it desirable to increase torpedo allowances at the same time as the Navy was dealing with the removal of the torpedo factory from Woolwich to Greenock, and the result was a supply shortage. For fear of exacerbating the shortage by losing torpedoes in practice firings, the Navy limited the use of torpedoes in exercises, hindering the collection of data about torpedoes' likely effects in battle. Still, the Navy knew enough about the threat from long-range heater torpedoes to develop new tactics which neutralized the threat while promising decisive gunnery results. The continuing torpedo threat and the return of stringent financial conditions also impelled the Navy to adopt Fisher's plan of flotilla defense (described in Chapter 4) on the eve of World War I.

Gaps in the documentary record loom especially large for this period. The Admiralty case files which enabled detailed recounting of the gyroscope in Chapter 2 were nowhere to be found for the superheater story told in Chapter 4, but the latter could at least be partially reconstructed through records from the post-war Royal Commission for Awards to Inventors and from corporate archives. Similar records for the period from 1909–1914 are unavailable, forcing almost complete reliance on just four sources for understanding angled gyroscope development, heater torpedo development, the

procurement policy for heater torpedoes, and torpedo fire control: the annual reports of *Vernon*, the papers drawn up by departing Directors of Naval Ordnance for their successors, the *Principal Questions Dealt with by the Director of Naval Ordnance*, and ships' covers (see Appendix C). Even basic information like the price and delivery dates of various torpedoes is missing from these sources. Still, careful reading of them can at least tell us more than we currently know about torpedo development in this period, while the work of Jon Sumida and Nicholas Lambert permits this newfound knowledge to be placed in larger tactical and strategic context.

Standing the Heat

The 21-inch Mark I torpedoes tried by the Navy in 1908 were limited to a length of 18.5 feet so that they could fit in existing torpedo tubes.² The increase in length to 22 feet for the 21-inch Mark II torpedoes allowed a 34% increase in the weight of air carried.³ The Navy ordered four Mark II torpedoes in 1909 and experimented with them in 1910, though it was sufficiently confident of success, and desirous of permitting manufacturers to accumulate material in advance, to order 224 Mark II torpedoes in 1909, before the four experimental torpedoes had been tried. It paid for the order from a supplement to the fiscal year [FY] 1909/10 budget and from the 1910/11 budget.⁴ As it turned out, depth-keeping problems at speeds above 45 knots prevented the projected speed of 50 knots from being attained, and the greater air charge of the Mark II was used

² ART09/22.

³ ART09/11.

⁴ "Paper Prepared by the Director of Naval Ordnance [Bacon] for the Information of his Successor [Moore]," 24 November 1909, G19535/09, 24.

to attain a 2,500-yard increase in range, but not an increase in speed, over the Mark I.⁵

The approved speeds and ranges for the Mark II were 45 knots for 4,500 yards and 28–29 knots (depending on whether the torpedo was fitted for submerged discharge) for 10,000 yards.⁶ Despite the slightly disappointing speed performance, the 21-inch Mark II was the Navy's first 10,000-yard torpedo.

Notwithstanding the impressive speed and range of the converted and heated torpedoes, two problems bedeviled them: poor direction-keeping and poor depth-keeping. The converted 18-inch Mark VI** H torpedo suffered from zig-zagging (but not depth-keeping problems), while the heated 18-inch Mark VII-VII* torpedoes and both 21-inch torpedoes displayed bad depth-taking and depth-keeping (but not zig-zagging).⁷ (Depth-taking referred to a torpedo's ability to "take" its proper depth at the beginning of its run, while depth-keeping referred to its ability to "keep" its proper depth over the course of its run.) The first problem to be solved was the bad depth-keeping of the Mark VII-VII* torpedoes, which was overcome by the substitution of a heavier pendulum weight in the depth mechanism in 1909.⁸ This solution of the depth-keeping problem did not fix the depth-taking problem, which arose from excessive vibration in the balance chamber and was not fixed until 1910.⁹

Uncertainty over the causes of zig-zagging in the converted 18-inch Mark VI** H torpedoes slowed the development of a cure.¹⁰ At first, *Vernon* suspected that the gyroscope was to blame, since zig-zagging was an exaggeration of the normally mild

⁵ ART11/36.

⁶ ART11/36.

⁷ ART09/12.

⁸ ART09/12.

⁹ ART10/16.

¹⁰ ART11/29–30.

sinuosity of the torpedo's course due to corrections applied by the gyroscope. Upon discovering that torpedoes with perfectly adjusted gyroscopes still zig-zagged, *Vernon* looked elsewhere. Extensive experiments carried out in 1911 showed that the real culprit was two-fold: rolling of the torpedo as it was discharged, and toppling of the gyroscope. The former could be almost eliminated by reducing the size of one of the gyroscope rudders, while the latter could be entirely eliminated by better manufacturing of an important valve.

The depth-taking and depth-keeping problems in the 21-inch torpedoes proved most intractable of all. Part of the problem—the torpedoes' tendency to break the surface and remain on it after discharge—was solved in 1911 by increasing the clearance of certain pivots in the balance mechanism by a mere 0.02 inches. “This cure, though somewhat unscientific,” *Vernon* sheepishly admitted, “has proved most efficacious.”¹¹ It was also a remarkable example of mechanical miniaturization and precision engineering. A more fundamental problem remained unresolved, however. The ignition of the superheater caused a rapid acceleration of heated torpedoes shortly after discharge, rendering proper adjustment of the depth mechanism's locking gear very difficult, the torpedoes liable to rise or dive sharply upon discharge, and recovery of their proper depth unlikely.¹² To solve the problem, *Vernon* began experimenting in 1911 with a depth gear known as the Ulan gear after its inventor, but could not get it to work satisfactorily and stopped trying in 1914.¹³ At the same time, *Vernon* began experimenting with a “double-beat” (instead of single-beat) hydro-static valve, the idea being that the additional valve

¹¹ ART11/17.

¹² ART11/17.

¹³ ART11/18–19, ART12/13–14, ART13/17, and ART14/25.

would be able to correct for more severe deviations from the proper depth.¹⁴ Although it worked well in an 18-inch torpedo in 1911, it was not perfected for 21-inch torpedoes until 1912, whereupon it was approved for both diameters.¹⁵ Evidently it was not a complete success, however, since British torpedoes suffered serious depth problems in the first year of the war.¹⁶

The design of the Hardcastle superheaters remained basically unchanged. Their igniters were gradually made more reliable, and the generator (i.e. combustion chamber) was improved.¹⁷ The introduction of a new type of valve called the combined non-return valve controlled the rate at which fuel and air were permitted to mix more effectively and increased the range of torpedoes to which they were fitted by 500 yards.¹⁸

Engine technology also remained fairly stable in this period—strikingly so, considering the much higher heat to which the engines of heater torpedoes were subjected. The Navy was apparently satisfied with the ability of reciprocating engines to withstand the heat. The Director of Naval Ordnance reported to his successor in 1909 that after 35,000 cumulative yards of running, the engine of a heated 18-inch Mark VII torpedo was in perfect condition except for cracks to the engine belt which did not interfere with the efficiency of the engines.¹⁹ The metal of the engines was occasionally found to have turned blue from the intense heat of the exhaust gases, but *Vernon* solved the problem in

¹⁴ ART11/17–18.

¹⁵ ART12/13.

¹⁶ ART15/vii, 29, 44–45.

¹⁷ On the igniter, see ART10/27, ART11/32, ART12/21–22, ART13/24–25, ART14/27–28; on the generator, see ART11/30, ART12/20–21.

¹⁸ ART10/30, ART12/21.

¹⁹ “Paper Prepared by the Director of Naval Ordnance [Bacon] for the Information of his Successor [Moore],” 24 November 1909, G19535/09, 24.

1910 by adding a pump to cool the exhaust chamber.²⁰ The oil used to lubricate the engine parts was a continual target of trial-and-error experimentation, but the difficulty arose primarily from the variation in climates and water temperatures in which the Navy stored and used torpedoes, rather than from the heat generated by the superheater, and in any case the issue was not unique to reciprocating engines.²¹ A more serious problem which did arise directly from the high heat was damage to the springs controlling various engine valves. To address it, *Vernon* began experimenting in 1913 with a tappet- (instead of poppet-) valve engine, in which the tappet valves protected the springs from exposure to heat, but the experiments were not completed before the war.²² Notwithstanding these issues, a telling measure of the Navy's satisfaction with its reciprocating engines was *Vernon's* quick rejection of a "well thought out" design of a combined generator (i.e., combustion chamber) and turbine engine, on the grounds that turbines had to discharge their exhaust into a vacuum to be efficient but would have to discharge their exhaust against pressure in torpedoes.²³

The Gyroscope: New Impulses, New Directions

The Navy had begun experimenting with an angled gyroscope capable of curving the torpedo from its initial line of fire in 1907, but the effort faltered. As discussed in Chapter 1, a significant implication of the angled gyroscope was that it allowed large surface ships to fire their torpedoes from fixed submerged tubes regardless of helm. The significance of angled gyroscopes was even greater for submarines, at least in theory.

²⁰ ART10/24.

²¹ ART10/23–24, ART10/60–61, ART11/22, ART14/26.

²² ART13/19, ART14/26.

²³ ART11/21.

Until the E Class submarines of 1912, Royal Navy submarines carried fixed torpedo tubes only in the bow and stern, not on the beam; ships, by contrast, carried at least two fixed tubes on the beam, in addition to a stern tube. A vessel that carried tubes on three of four sides was likelier to get a shot than one carrying tubes on only two of four sides; or, if the former had to turn to bring a tube to bear on the target, she would probably have had to turn through a smaller angle than the latter to do so. To compound the difficulty, submarines were harder to maneuver than surface ships. Thus, submarines had a greater need for a device that would obviate the need to maneuver.

At the initiative of the head of the submarine service, the Navy directed its first attempts at developing angled gyroscopes in 1907 towards submarines rather than surface ships.²⁴ Three different designs evolved, including two by the RGF and Whitehead Company capable of deflecting the torpedo 45° or 90° from its initial line of fire. Trials showed that the device was unsuitable for submarines, however, due to the large and unpredictable “advance” of the torpedo along its initial line of fire before the gyroscope began to curve it.²⁵ Because submarines fired torpedoes at short ranges—no more than 1,500 yards, and usually closer to 500 yards—from their targets, a large and unpredictable advance would have left them uncertain as to whether a torpedo would complete its curve and steady on its ultimate course before reaching its target. Since ships fired at longer ranges, however, a large and unpredictable advance was less problematic,

²⁴ ART07/30.

²⁵ ART09/20, “Paper Prepared by the Director of Naval Ordnance [Bacon] for the Information of his Successor [Moore],” 24 November 1909, G19535/09, 25; minute by ADT [Nicholson], 10 June 1910, SC251/F134, BF.

and therefore the Navy turned to trying the angled gyroscope from ships.²⁶

Before trials on a ship occurred, the Navy began investigating the possibility of a barless training (as opposed to fixed) tube as an alternative to the angled gyroscope. As discussed in Chapter 4, the Navy's dissatisfaction with the bar originated with its desire to increase the rate of fire in 1903, when it experimented with leaving the bar out instead of running it back in after every shot. By 1909, it wished to dispense with the bar altogether, and its reasons had changed. Instead of increasing the rate of fire, the Navy was chiefly motivated by the appearance of a barless tube in a foreign cruiser, and probably more importantly, by the desire to build a training submerged tube, for which dispensing with the bar was a prerequisite.²⁷ In addition, the officer commanding the Navy's submarines, Sydney Hall, saw that barless discharge was necessary for broadside tubes on submarines, probably because they lacked the space for a motor to run the bar in and out.²⁸ He regarded the advantages of broadside discharge for submarines as "enormous" and so "obvious" that he did not identify them, but he undoubtedly had in mind the fact that broadside tubes would require submarines to maneuver less to get a shot and would allow them to attack from other directions than bows-on, which required them to turn at least eight points to make their escape.²⁹

The idea of barless tubes preceded the idea of barless training tubes.³⁰ Preliminary experiments with barless discharge in 1909 were promising: with the firing ship, *Furious*,

²⁶ ART09/20, "Paper Prepared by the Director of Naval Ordnance [Bacon] for the Information of his Successor [Moore]," 24 November 1909, G19535/09, 25.

²⁷ ART09/25.

²⁸ Minute by Hall, 11 August 1909, CN0936/09, SC291/F1, BF.

²⁹ Minute by Hall, 12 November 1909, CN0936/09, SC291/F1, BF.

³⁰ For this chronological sequence, see minute by Nicholson, 19 November 1909, CN0936/09, SC291/F1, BF.

moving at speeds up to 17 knots, torpedoes cleared the tube and ran correctly. Although the torpedoes suffered varying degrees of damage in the course of discharge, *Vernon* attributed the damage largely to the fact that a regular tube was used, and expected that a purpose-built tube would eliminate the problem.³¹ Another round of experiments was carried out in *Spartiate* in early 1910; again, the torpedoes suffered some damage, but again, *Vernon* believed that a purpose-built tube would solve the problem.³²

As a result of these trials, the Admiralty convened a conference in May 1910 to discuss the design of a barless training tube.³³ The key change for a purpose-built barless tube was bell-mouthing. In a typical tube, the bar guided the torpedo as it left the tube, preserving its trim and preventing its after end from clanging against the mouth of the tube. In a barless tube, higher impulse pressures could compensate for the lack of a guide bar to some degree, but a bell-mouth gave the torpedo a larger margin for error in losing its trim as it left the tube (see Figure 6.1).

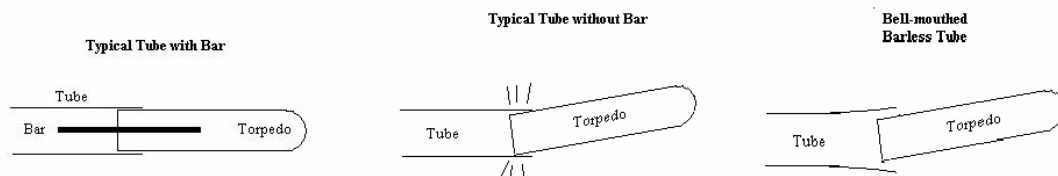


Figure 6.1: Bell-mouthing torpedo tubes.

Aside from bell-mouthing, the conference also decided that the barless tube's arc of training should be 35° before and 20° abaft the beam. It requested authorization for the

³¹ ART09/25; see also minute by Captain of *Vernon* [Phipps Hornby], 30 October 1909, CN0936/09, SC291/F1, BF.

³² ART10/40.

³³ Report of Conference, 4 May 1910, G0303/10, SC257m/F13, BF.

Portsmouth navy yard to design a tube embodying these features.

Before approving the conference's request, the Controller, John Jellicoe, asked for an update on the development of the angled gyroscope, which was clearly an alternative to the training tube.³⁴ In the spring of 1910, *Vernon* had carried out trials of the angled gyroscope from *Furious*.³⁵ Unlike the gyroscope used in the 1907 submarine trials, the model used in the 1910 trials could deflect the torpedo at angles of 10°, 20°, 30°, and 40° from its initial line of fire instead of just 45° and 90°. The trials were successful, the Assistant Director of Torpedoes informed Jellicoe, but even so, he wanted to proceed with the design of a training tube, since he was not sure that angled gyroscopes could be used in very high-speed torpedoes.³⁶ His uncertainty probably related to the poor direction- and depth-keeping of some early high-speed heater torpedoes, previously discussed. In any case, Jellicoe approved the idea of a barless training tube, and the order went out to Portsmouth Yard in August 1910.³⁷

In December, *Vernon* reported that the design was ready and asked for a conference, which was held in March 1911.³⁸ The participants proposed a number of modifications to Portsmouth Yard's design and asked for £10,000 to manufacture a prototype.³⁹ The First Sea Lord, A. K. Wilson, quashed the idea. "The object to be attained by the training tube has been, to some extent, met by the successful trials of the angled gyro," Wilson minuted. "I do not think the probable advantages are sufficient to

³⁴ Minute by Jellicoe, 6 June 1910, G0303/10, SC257m/F13, BF.

³⁵ ART10/46-48.

³⁶ Minute by Nicholson, 8 June 1910, G0303/10, SC257m/F13, BF.

³⁷ Minute by Jellicoe, 8 June 1910, G0303/10; SecAdm to Admiral Superintendent Portsmouth, 10 August 1910, G0303/18344/10, SC257m/F13, BF.

³⁸ Phipps Hornby to Adm Supt Portsmouth, 9 December 1910, G0719/10, SC257m/F17, BF.

³⁹ Minutes by ADT [Nicholson], 22 December 1910, and ADT [Charlton], 10 March 1911, G0719/10, SC257m/F17, BF.

justify the expense of proceeding further with these trials for which the £10,000 now asked for would only be the first instalment [sic].”⁴⁰ The disappointed Captain of *Vernon*, R. S. Phipps-Hornby, protested Wilson’s decision, arguing that a barless tube was desirable even if it did not train, particularly since the bar’s omission would make the tube stronger and allow the use of higher impulse pressures. These were desirable in connection with the development of the new “Mark A” 18-inch torpedo, almost certainly a reference to the 18-inch Mark VIII torpedo then being designed especially for submarines, which needed to use higher impulse pressures to launch the torpedo to make up for the absence of the bar.⁴¹ The Assistant Director of Torpedoes, Edward Charlton, chimed in on Phipps-Hornby’s behalf, observing that the omission of the bar would eliminate the need for heavy torpedo fittings that guided torpedoes along the bar, increasing their speed by 1–2 knots.⁴² Wilson refused to budge, however, at least until the “Mark A” torpedo had been assessed.⁴³ And so the idea of a barless training tube died.

The fine performance of angled gyroscope doubtless helped to kill the barless training tube. A further round of successful trials from *Furious* in November 1910 persuaded *Vernon* to recommend the limited issue of angled gyroscopes to ships for sea-going trial.⁴⁴ In anticipation of favorable results, the Admiralty ordered that all 21-inch Mark II torpedoes intended for issue to ships be fitted so as to allow them to take the angled gyroscope.⁴⁵ When the limited sea-going trials of the angled gyroscope occurred in 1912, they vindicated the Admiralty’s faith in the device, and it was approved for all

⁴⁰ Minute by Wilson, 31 March 1911, G0719/10, SC257m/F18, BF.

⁴¹ Phipps-Hornby to CINC Portsmouth, 27 April 1911, G0306/11, SC257m/F19, BF.

⁴² Minute by Charlton, 15 May 1911, G0306/11, SC257m/F20, BF.

⁴³ Minute by Wilson, 21 June 1911, G0306/11, SC257m/F20, BF.

⁴⁴ See minute by ADT [Nicholson], 12 December 1910, G0721/10, SC257m/F17, BF.

⁴⁵ ART11/25.

torpedoes intended for submerged discharge from ships.⁴⁶ The only further significant change to the concept of the angled gyroscope before the war was to reduce the gradation of the angles from 10° to 5°.⁴⁷ The Admiralty did not reverse its 1907 decision against fitting angled gyroscopes to submarines' torpedoes, going only so far as to approve fittings for submarines' torpedo tubes that would make it possible for them to work with the angled gyroscope.⁴⁸

Although the angled gyroscope was a success, a variant on it known as gyroscope control gear was not. The idea of gyroscope control gear was to cause the torpedo to run in a circle or zigzag once it had reached the estimated range of the target, so that it would cross the target's track multiple times instead of once, increasing its chances of hitting. In 1912, an officer named F. H. Sandford invented both circular and zigzag gyroscope control gears.⁴⁹ The circular gear was useful chiefly for firing at a line of ships, since succeeding ships would cross the track of the circling torpedo, while the zigzag gear was most promising for firing at single ships, since it would follow or converge on the target if it missed at first. The Admiralty authorized the manufacture of two circular gears and two zigzag gears for experiment. The zigzag gear proved too complicated, but the ship to which the circular gear was issued reported on it favorably, noting that it would greatly increase the probability of hitting at long ranges.⁵⁰ Despite the gear's promise, the outbreak of war and the pressure of other work forced the suspension of its development

⁴⁶ ART12/16.

⁴⁷ ART13/21, ART14/27.

⁴⁸ ART14/46.

⁴⁹ ART12/20.

⁵⁰ ART13/23–24.

in 1914. Thus it was not embodied in the torpedoes with which the Navy began the war.⁵¹

The adoption of angled gyroscopes was not the only major development in gyroscope technology during this period. In 1907, the same year that the Navy began experimenting with angled gyroscopes, it also began experimenting with air-driven gyroscopes.⁵² As distinct from purely spring-driven gyroscopes, in which the gyroscope wheel received a powerful initial impulse but no subsequent impulses, air-driven gyroscopes relied on a spring for the initial impulse but then on air to accelerate and maintain the velocity of the wheel's rotation. The Navy likely began investigating air-driven gyroscopes for fear that spring-driven gyroscopes could not provide a sufficiently long spin time for heater torpedo ranges, even though both *Vernon* and the Director of Naval Ordnance claimed in 1909 that the conventional spring-driven gyroscope was satisfactory at then-maximum ranges.⁵³ The Navy may also have hoped that the continuing air impulse would remove a frequent cause of dangerous gyroscope failure. If the spring of a spring-driven gyroscope failed to release, generally due to a failure to cock it, the gyroscope wheel would not spin and the gyroscope rudders would go hard over one way, producing a circular run that might endanger friendly vessels. If the spring of an air-driven gyroscope failed to release, however, the air would still spin the wheel, not acting quickly enough to keep the torpedo on its initial line of fire, but exerting enough directive force on the gyroscope rudders to prevent them from going hard over and causing a circular run. This safety benefit was certainly realized by 1911, if not earlier.⁵⁴ Finally, air

⁵¹ ART14/27.

⁵² ART07/17.

⁵³ ART09/20; ART09/20, "Paper Prepared by the Director of Naval Ordnance [Bacon] for the Information of his Successor [Moore]," 24 November 1909, G19535/09, 25

⁵⁴ ART11/24.

impulse enabled a higher rotational speed than the spring alone, thereby increasing the gyroscope's directive power.

After the 1907 experiments with an air-driven gyroscope, the results of which did not warrant changes to the existing type, the Navy seems to have dropped the matter in 1908 before picking it back up in 1909, when it carried out experiments with an air-driven gyroscope designed by the Whitehead Company.⁵⁵ In 1910, *Vernon* tried an air-driven gyroscope of RGF design, which gave good results over ranges at which spring-driven gyroscopes proved unreliable.⁵⁶ In 1911, after additional experience with the RGF model, *Vernon* recommended its limited issue to ships for sea-going trial and stopped experimenting with the Whitehead Company's design due to its inferiority.⁵⁷ In 1912, after the ships which received the limited-issue air-driven gyroscopes reported enthusiastically, the Navy ordered the large-scale adoption of the air-driven models, at the same time as it approved the adoption of angled gyroscopes.⁵⁸ The relative safety of air-driven gyroscopes compared to spring-driven gyroscopes allowed *Vernon* finally to end its decade-long search for a gyroscope safety gear.⁵⁹

In addition to its work with air-driven gyroscopes, the Navy also experimented with air-spun gyroscopes. The difference between air-driven and air-spun gyroscopes was that the latter received both its initial and subsequent impulses from air, while the former received its initial impulse from a spring and only subsequent impulses from air. The chief appeal of the air-spun gyroscope was that it could cause the gyroscope to start

⁵⁵ ART07/17; ART09/20.

⁵⁶ ART10/50.

⁵⁷ ART11/24.

⁵⁸ ART12/16.

⁵⁹ ART12/18.

spinning more quickly than a spring impulse.⁶⁰ In the 1909 experiments with barless tubes discussed previously, *Vernon* discovered that torpedoes fired from a moving ship deflected 1°-2° abaft their line of fire before their gyroscopes gained sufficient rotational speed to take over.⁶¹ This unpredictable but small deflection mattered little when ranges were short, but it probably became a concern as ranges lengthened due to heater torpedoes. For instance, a 2° deflection would cause an error of only 35 yards at a range of 1,000 yards, but it would cause an error of 350 yards at a range of 10,000 yards.⁶² The Navy's desire to develop a barless tube also must have lent urgency to its quest for a faster gyroscope release.

Vernon first tested an air-spun gyroscope designed by the RGF in 1910.⁶³ The new Royal Naval Torpedo Factory (RNTF) took over the RGF's work in 1911, and the manufacture of experimental air-spun gyroscopes was approved in 1912.⁶⁴ When tried in 1913, however, they were not a success, and further trials were suspended due to the pressure of other work.⁶⁵ Nevertheless, *Vernon* managed to salvage one idea from the air-spun attempt, namely, the early release of the gyroscope to take up its proper direction. Spinning up the gyroscope while the torpedo was still in the tube was only a partial remedy to the problem of the torpedo deflecting before the gyroscope could take over its direction; unless the gyroscope was freed from the clutch which held it in place to ensure that the air impulse hit it at the correct angle, it could not take up its proper direction.⁶⁶

⁶⁰ ART10/51.

⁶¹ ART09/26.

⁶² $\tan(2^\circ) = x / 1000$ or $x / 10000$; x = the displacement at 1000 or 10000 yards.

⁶³ ART10/51-52.

⁶⁴ ART11/25, ART12/18.

⁶⁵ ART13/21.

⁶⁶ ART12/17-18.

By reducing the size of a gyroscope part called the driving sector, *Vernon* was able to shorten the time lag between the tripping of the air lever and the release of the clutch. (Gyroscopes with their driving sectors reduced were known as “short-release” gyroscopes.) Short-release gyroscopes reduced the average horizontal deviation at 2,000 yards by more than half, and the short-release feature was approved for future air-driven gyroscopes in 1913.⁶⁷

Supply, Allocation, and Lots of Demand

The advent of converted and heater torpedoes posed new procurement challenges: what vessels would get the new weapons? To answer this question, the Navy made assumptions about the tactical uses of the torpedoes. Because destroyers would fire torpedoes at shorter ranges against single ships and therefore needed higher speeds to minimize the effects of errors in estimating enemy course or speed, while capital ships would fire torpedoes at longer ranges against the enemy battle-line and therefore could afford greater errors in estimation, converted 18-inch heaters whose engines could not withstand the high speeds enabled by superheaters were issued to ships rather than destroyers.⁶⁸ The heated 18-inch Mark VII and VII* torpedoes, whose engines were designed to withstand higher speeds, went to torpedo craft.⁶⁹ The short 21-inch Mark I torpedoes went to the *Beagle*-class destroyers of the 1908/9 building program, since their construction was too far advanced to allow the lengthening of their tubes to take the 21-

⁶⁷ ART12/17; ART13/21.

⁶⁸ Minute by DNO [Bacon], 16 April 1909, G5891/09, PQ/08–11/3360/178–80; “Paper Prepared by the Director of Naval Ordnance [Bacon] for the Information of his Successor [Moore],” 24 November 1909, G19535/09, 23; “Paper Prepared by the Director of Naval Ordnance and Torpedoes [Moore] for the Information of his Successor [Tudor],” 30 May 1912, G0596/12, 2.

⁶⁹ ART09/14.

inch Mark II torpedoes first ordered in financial year 1909/10.⁷⁰ For the time being, submarines, which fired their torpedoes at very short ranges, continued to be supplied with cold 18-inch Mark V* torpedoes adjusted to run 1,000 yards at 32.5 knots.⁷¹

As will be recalled from Chapter 4, the conversion of cold torpedoes to heaters began in FY 1908/09, when money for 100 conversions was appropriated.⁷² Half of these conversions were of the much inferior 18-inch Fiume III** torpedo, useless both for destroyers due to its limited speed and for ships due to its limited 4,000-yard range (at only 21 knots). Thus only 50 conversions were left over for the much superior 18-inch RGF Mark VI* torpedo, also useless for destroyers due to its limited speed but useful for ships due to its 6,000-yard range at roughly 29 knots—although it was believed in early 1908 that the maximum range of the converted RGF torpedoes was only 3,000 yards. In February 1908, the Admiralty approved a proposal by the Director of Naval Ordnance to expand the program for converting RGF torpedoes in order to supply the Navy's 45 large ships with two converted torpedoes each. As a result, the number of conversions increased sharply from 50 Mark VI* conversions in FY08/09 to 196 Mark VI** conversions in FY 1909/10.⁷³ This increase was borne solely by the RGF: although the Whitehead Company as well as the RGF built heater torpedoes of RGF design, only the RGF carried out conversions of RGF torpedoes, and the Royal Naval Torpedo Factory (RNTF) was not yet up and running.

⁷⁰ "Paper Prepared by the Director of Naval Ordnance [Bacon] for the Information of his Successor [Moore]," 24 November 1909, G19535/09, 22.

⁷¹ ART11/51.

⁷² See minutes on G16396/07, PQ/09/3345/156–57. But note that ART08/7 suggests that 29 of the Mark VI* conversions were carried on the FY07/08, not FY08/09, budget.

⁷³ See minutes on G3264/08, PQ/09/3346/157–58. It is unclear what classes the DNO was including in the "45 large ships."

In April 1909, the Director of Naval Ordnance, R. H. Bacon, proposed another major expansion of the conversion program. Noting that the Navy had heater torpedoes “very superior, so far as is known” to foreign ones, and that converted torpedoes on ships would be “invaluable for use during a fleet action, and would give us a very great advantage over our possible enemies should they only possess 4,000 yard torpedoes,” he suggested a five-fold increase in the allowance of converted torpedoes, from 2 to 10 per ship, going all the way back to the pre-dreadnought battleships of the *King Edward VII* class and including the three *Invincible*-class battlecruisers. His proposal probably had something to do with learning that the 3,000-yard range assumed for both Fiume III** and RGF Mark VI* torpedoes in the February 1908 allocation scheme was 50% too low for the converted RGF torpedoes. There were obstacles to expanding the conversion program, however. The money for converting old torpedoes was the sum left over after spending on new torpedoes, and the new heated 18-inch and 21-inch torpedoes had turned out to be more expensive than anticipated, so there was little money available for conversions. Unless the pace of conversion increased, Bacon informed his colleagues, the expanded scheme would require seven years for completion. To increase the pace without providing additional money in FY 1909/10 would throw the brunt of the work on FY 1910/11, more than could be handled that year. Therefore, Bacon requested an additional £20,000 to spend in FY 1909/10.⁷⁴ His request was approved, with the First Lord, Reginald McKenna, adding that he should raise the matter again as soon as the supplemental £20,000 was spent.⁷⁵ The expansion and acceleration of the conversion

⁷⁴ Minute by Bacon, 16 April 1909, G5891/09, PQ/08–11/3360/178–80.

⁷⁵ Minute by McKenna, 21 May 1909, G5891/09, PQ/08–11/3360/178–80.

program increased the burden on the RGF.

Increases in the allowance of new heater torpedoes added to the RGF's burden. In December 1908, the Assistant Director of Torpedoes, Bernard Currey, had proposed that, due to the greater effectiveness of heated over cold torpedoes, ships with two broadside tubes carry the same number of torpedoes that they had carried when they had four tubes (i.e., 9 per tube instead of 5 per tube), and that destroyers carry at least two instead of one torpedo per tube.⁷⁶ In general agreement with Currey, the Director of Naval Construction, Philip Watts, determined that although it was too late to exchange 18-inch for 21-inch torpedoes in the lone battleship in the 1908/9 program, *Neptune*, her allowance of 18-inch torpedoes could be increased to 18 instead of 10; that battleships of the following year's program (the 1909/10 *Colossus* class) could carry 21-inch Mark II torpedoes, and that their allowance should be increased; and that destroyers of the 1909/10 program (the *Acorn* class) could carry two 21-inch Mark II torpedoes per tube.⁷⁷ The increase in allowance meant that the Navy would need almost double the previous number of torpedoes to outfit new construction.

On top of the increase in torpedo allowances to each vessel, in November 1911, the new First Lord, Winston Churchill, urged that the Navy's torpedo reserves be brought up to full establishment.⁷⁸ Informing him that ships had no reserves beyond what they carried, Bacon's successor as Director of Naval Ordnance, A. G. H. W. Moore, suggested that their allowance be increased; agreed that the reserves for destroyers be increased; and further proposed that the allowance for future destroyers (i.e., the 1911/12 *Acasta/K*

⁷⁶ Minute by Currey, 17 December 1908, G18178/08, SC224/F34, BF. The tactical contents of this minute were discussed in Chapter 4.

⁷⁷ Minute by Watts, 12 January 1909, G18178/08, SC224/F34, BF.

⁷⁸ Minute by Churchill, 14 November 1911, PQ12/F43/P330, Ja397, AL.

class) be increased from 6 to 8.⁷⁹ Due to the difficulties of expanding production, Moore planned to prioritize the *Acasta* class before turning to the allowance of older destroyers, and even then to limit the increase to destroyers carrying 21-inch torpedoes. Based on Moore's estimate that 100 torpedoes would be required for this program, the Superintendent of Ordnance Stores calculated that the proposed increases would cost £131,200, plus an extra £43,000 if the increased allowance was to include destroyers of the 1912/13 program (the *Laforey/L* class). In March 1912, the Board approved the increases for both the 1911/12 and 1912/13 classes.⁸⁰

In September 1912, the new Director of Naval Ordnance, F. C. T. Tudor, broached the topic of reserves and allowances again. Hoping to expand the allowance increase to include older destroyers once the new ones were outfitted, Tudor proposed that all destroyers back to the 1908/09 *Beagle* class receive the same increase from 6 to 8. In addition, he proposed to increase the allowance for submarines from 7 to 10 for each pair of tubes, plus an extra 6% for replacements; to create a 10% general reserve for ships and destroyers; and then to increase the 18-inch torpedo allowance for *Tribal*- and *River*-class destroyers from 6 to 8.⁸¹ The Financial Secretary, noting pointedly that only one of Tudor's proposals—the increase for the *Beagle* class—had been contemplated in the March 1912 increase, calculated that Tudor's program would cost a colossal £470,500.⁸² Even so, in November 1912, the Board approved the program in its entirety, except that it set the general reserve at 5% instead of 10%.⁸³

⁷⁹ Minute by Moore, 22 December 1911, PQ12/F43/P330–36, Ja 397, AL.

⁸⁰ Note at the bottom of PQ12/F43/P336, Ja 397, AL.

⁸¹ Minute by Tudor, 28 September 1912, G01080/12, PQ12/F43/P330–36, Ja 397, AL.

⁸² Minute by Macnamara, 23 October 1912, G01080/12, PQ12/F43/P330–36, Ja 397, AL.

⁸³ Note on G01080/12, PQ12/F43/P330–36, Ja 397, AL.

A major dislocation in the supply base exacerbated the potential impact of these several increases in demand. As they occurred, the Navy's torpedo factory was being moved 450 miles from the RGF in Woolwich to the new RNTF in Greenock. The Admiralty seems to have under-estimated both the difficulties involved in the transfer and the ability of its existing supply base to meet demand. In late 1909, the Director of Naval Ordnance (Moore) predicted that only a month of production would be lost as a result of the transfer, but the effects were still being felt years later, and the RNTF did not begin production until late 1910 or early 1911.⁸⁴

These delays doomed a proposal made by the commander-in-chief of the Home Fleets (Admiral George Callaghan) in 1912 to re-arm capital ships back to *Dreadnought* with 21-inch torpedoes in lieu of 18-inch torpedoes.⁸⁵ "It would be practically impossible to get these additional 21-inch Torpedoes within a reasonable period," the Superintendent of Ordnance Stores minuted, "in view of the large orders to be placed, and of the fact that we are limited to two sources of supply," namely the Whitehead Company and the RNTF.⁸⁶ The Assistant Director of Torpedoes, Edward Charlton, agreed that the supply shortage was the "chief objection" to Callaghan's idea, "although no doubt it would be advantageous."⁸⁷

The supply situation also handicapped the Navy's efforts to carry out realistic long-range torpedo practice. As discussed in Chapter 4, fleet torpedo practice was not

⁸⁴ "Paper Prepared by the Director of Naval Ordnance [Bacon] for the Information of his Successor [Moore]," November 1909, G19535/09, 26. On the dates, see the undated article "Clyde Torpedo Factory. Progress of Work at Greenock. Difficulties regarding Housing," and Acklom, "Notice. Transfer to Greenock," 8 September 1910, in SUPP 5/177, TNA.

⁸⁵ Minutes on G01247/12, PQ13/F5/PP44-51, Ja397, AL.

⁸⁶ Minute by SOS, 24 December 1912, G01247/12, PQ13/F5/P46, Ja397, AL.

⁸⁷ Minute by ADT, 8 February 1913, G01247/12, PQ13/F5/P49, Ja397, AL.

designed to simulate real battle conditions. Tactical fleet exercises (PZ exercises) were more realistic, but they forbade destroyers from firing torpedoes and required them to fire lights indicating a hypothetical launch instead, for fear of that the destroyers would be unable to recover their torpedoes in the confusion inherent to a tactical exercise. In August 1912, the commander-in-chief of the Home Fleet, Callaghan, informed the Admiralty that he wanted to carry out exercises in which destroyers “browned” the battleline with real torpedoes, rather than merely firing lights to indicate when torpedoes would have been fired, “in order that actual and not merely suppositious [sic] results may be arrived at.”⁸⁸ The cheeky commander of one of the destroyer flotillas in the Home Fleet chimed in, “In view of the fact that the Battle Practice of a Battle Ship costs about the same as a 21 inch Heater Torpedo and that we accept this expenditure by the Battleship without comment, why not accept a percentage loss of Torpedoes and write them off annually whether they are lost or not?”⁸⁹

The Admiralty had a different perspective. The effect of losing a torpedo, observed the Director of Naval Ordnance, Tudor, was “not directly commensurate with the money value of the torpedo.” With the factories at full output, if torpedoes were lost in practice, it might not be possible to complete the torpedo outfits of new construction, let alone to complete recently approved increases in the reserves. Tudor proposed a compromise: half of the participating destroyers could fire lights, as usual, while the other half could fire their torpedoes to run a fraction of the range to the battleline, and

⁸⁸ Callaghan to SecAdm, 3 August 1912, Docket “Maneuvers 1912,” ADM 1/8269, TNA. Callaghan planned for destroyers to carry out browning attacks from their own battleline not only in practice but also in war; see Sumida, “Expectation, Adaptation, and Resignation: British Battle Fleet Tactical Planning, August 1914–April 1916.” *Naval War College Review* 60, no. 3 (Summer 2007): 104.

⁸⁹ Henderson to Commodore (T) [Lambert], 8 August 1912, Docket “Maneuvers 1912,” ADM 1/8269, TNA.

follow them to recover them.⁹⁰

Callaghan was having none of it. “[I]t is not considered that satisfactory results could be obtained in the manner proposed,” he informed the Admiralty. “Whenever torpedoes are fired they should be fired to hit; little value can be placed on calculated results, the data for which would, at best, be unreliable.”⁹¹ The Admiralty refused to budge, however. While “generally” concurring with his argument, the Admiralty thought it “perhaps not altogether applicable” to the situation at hand. Since destroyers were almost as fast as torpedoes, observing their action in following their torpedoes would indicate whether their torpedoes would have crossed the track of the battle-line. Observations thus gained could be collated with data gained from fleet practice, which showed that the probability of striking a ship between the van and rear of the battle-line roughly equaled the proportion of ship space to water space. Then the overall probability of hitting a ship in a browning attack by destroyers could be calculated, presumably by multiplying the probability of a torpedo reaching the target area by the probability of it striking a target if it reached the target area (see Figure 6.2 below).⁹²

⁹⁰ Minute by Tudor, 20 January 1913, Docket “Maneuvers 1912,” ADM 1/8269, TNA.

⁹¹ Callaghan to SecAdm, 21 January 1913, Docket “Maneuvers 1912,” ADM 1/8269, TNA.

⁹² SecAdm to Callaghan, 7 April 1913, M0158/13, PQ13/F2/PP2-8, Ja 397, AL.

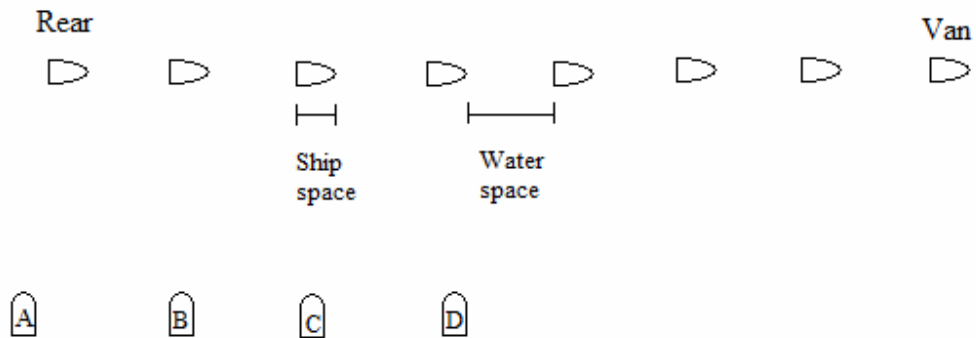


Figure 6.2: Calculating the probability of hits.

Let there be 8 ships in the enemy battle-line and 4 torpedoes (A-D) fired in a browning attack by own destroyers (not shown).

Say that torpedoes B-C will cross the enemy's track between the rear and van of the line, meaning that there is a 75% probability that torpedoes fired in such a browning attack will cross the enemy's track between the rear and van of the line.

Say that the ratio of ship space to water space in the enemy battle-line is 1:3, meaning that there is a 33% probability that torpedoes which cross the enemy's track between the rear and van of the line will strike a ship.

Thus the overall probability of a torpedo fired in such a browning attack striking an enemy ship is $75\% \times 33\% = 25\%$.

The reliability of the Admiralty's method seems doubtful, however, since the destroyers would have followed their torpedoes only 2,500 yards or so, leaving another 7,500 yards over which their course would have been projected, not actual. Though more realistic than having all destroyers fire lights, the compromise of having half the destroyers fire their torpedoes over part of the range was hardly as realistic as having all destroyers fire their torpedoes over the whole range, not least because it failed to account for the possibility of the target altering course to avoid the torpedoes. The results would still have to be "calculated," to use Callaghan's term, but instead of placing "little value" on them, both Callaghan and the Admiralty seem to have placed a good deal of value on them (see below).

Finally, the supply shortage hampered efforts to develop realistic expectations about the control of torpedo fire in action. In late 1912 or early 1913, the Inspector of Target Practice proposed firing torpedoes during gunnery battle practice, as the results “up to date point to the necessity of more opportunities of combined firing of guns and torpedoes being afforded.”⁹³ The Director of Naval Ordnance, Tudor, was open to the idea so long as adequate arrangements for recovering torpedoes could be made, but John Jellicoe, back at the Admiralty as Second Sea Lord, doubted that adequate arrangements were possible and proposed to defer combined gun-and-torpedo battle practice until the torpedo reserves were in a better condition.⁹⁴ The potential significance of this lost opportunity is discussed below.

Torpedo Settings and Tactics

In April 1912, the Director of Naval Ordnance, Tudor, floated the idea of re-adjusting the long-range setting of the 18-inch RGF converted (Mark VI*** H) and heater (Mark VII*) torpedoes aboard ships (as opposed to destroyers) to run 10,000–12,000 yards at 22 knots instead of 6,500 yards at 29 knots, and of changing converted torpedoes’ single adjustment (low speed / long range) to a dual adjustment (adding lowest speed / extreme range), and heated torpedoes’ double adjustment (high speed / short range and low speed / long range) to a triple adjustment (adding lowest speed / extreme range).⁹⁵ In easier visual form, the three options were:

- high speed, short range

⁹³ Minute by DNO [Tudor], 24 January 1913, G097/13, PQ13/F3/PP9–10, Ja397, AL..

⁹⁴ Minute by Jellicoe, 27 January 1913, G097/13, PQ13/F3/PP9–10, Ja397, AL..

⁹⁵ Tudor to SRNTF and Captain of *Vernon*, 3 April 1912, PQ13/F5/P16, Ja397, AL.

- ~3,000 yards at 41 knots, for 18-inch Mark VII*
- ~3,500 yards at 45 knots, for 21-inch Mark II
- low speed, long range
 - ~6,000 yards at 28 knots, for 18-inch Mark VI*** H and Mark VII*
 - ~10,000 yards at 28 knots, for 21-inch Mark II
- lowest speed, extreme range
 - ~10,000 yards at 22 knots, for 18-inch Mark VI*** H and Mark VII*
 - ~12,000 yards at 22 knots, for 21-inch Mark II

The Superintendent of the RNTF, C. R. Acklom, replied that the torpedoes could run just under 10,000 yards at 22 knots, or 12,000 yards if the speed was reduced to 20 knots, and that triple adjustments could be obtained by redesigning the combustion chamber, but he worried that triple adjustments would increase the percentage of bad shots. He also questioned whether such long range was desirable at such low speeds on tactical grounds, noting that enemy speed and the limits on spotting at extreme ranges should fix the framework within which the probability of hitting the target from various bearings should determine the minimum acceptable speed. He suggested referring the question to the War College.⁹⁶

The Captain of *Vernon*, W. C. M. Nicholson, opposed the conversion of one-speed Mark VI*** H torpedoes to two speeds, on the grounds that the expanded conversion program undertaken in the summer of 1909 (see above)—of which more than a third remained outstanding—had over-strained the Navy’s existing supply capacity, causing a “serious arrears” in new manufacture.⁹⁷ Nicholson also objected to triple adjustments for Mark VII* torpedoes, partly because depth-keeping and reducer action would be poor at the lowest speeds proposed, and partly because extreme-range lowest-speed torpedoes would not make many more hits than long-range low-speed torpedoes given the speed of

⁹⁶ SRNTF to Tudor, 4 May 1912, PQ13/F5/PP16–17, Ja397, AL.

⁹⁷ Nicholson to DNO, n.d. but May 1912, PQ13/F5/PP16–17, Ja397, AL.

modern battlefleets. Despite his doubts, Nicholson agreed with the Superintendent of the RNTF that the issue should be referred to the War College. He further suggested that the War College consider whether the high-speed / short-range setting should be abolished in future 21-inch and 18-inch torpedoes for ships. He noted that a single adjustment would allow reductions in the weight of the engine, which would in turn allow a gain in range. Implicit in his suggestion was that torpedoes built for ships should differ from those built for destroyers and submarines, thereby reducing the inter-changeability of parts.

Acklom questioned the wisdom of such a step, however. He pointed out that the torpedoes carried by ships were regarded to some extent as a reserve for destroyers, and abandoning the high-speed setting would make them much less useful to the latter. It would also complicate the re-distribution of out-dated patterns in the future. Nevertheless, he allowed that a ship's torpedo built for a single low-speed adjustment could gain an extra 1,300 yards at 29 knots thanks to the savings in weight, with the possibility of even greater gains in range if the weight saved was used to strengthen the air flask to allow a greater charge of air to be carried.⁹⁸

Examining the issue from a tactical perspective, the commander of the War College, H. B. Jackson, reached more or less the same conclusions as the Captain of *Vernon* and the Superintendent of the RNTF. He observed that while an extreme-range torpedo could be fired with some chance of hitting on more bearings than could a long-range torpedo, its chances of hitting would decline rapidly as the bearing passed abaft the enemy beam. That is, if the firing ship was before the enemy's beam, the enemy was moving towards it, making up for the extreme-range torpedo's lack of speed by closing

⁹⁸ SRNTF to DNO, 13 June 1912, PQ13/F5/P22, Ja397, AL.

the range; but if the firing ship was on or abaft the enemy's beam, the target was moving away, and a higher-speed torpedo would have the advantage, the more so as the target's speed increased. Turning from a purely theoretical analysis of the probabilities of hitting based on the "practical" variables of torpedo speed, target speed, and target bearing, Jackson considered variables that would obtain in reality, such as visibility, the duration of the torpedo's run, and errors in estimating the target's course and speed, all of which worked in favor of the higher-speed torpedo. Given the speed of modern battlefleets, he thought that torpedoes should have a minimum speed of 30 knots. Accordingly, he recommended against an extreme-range setting at 22 knots, but he suggested that the Admiralty seek the advice of officers with recent command experience at sea before making any decisions.⁹⁹

Acklom re-entered the debate. Championing the tactical utility of the extreme-range setting, he argued that although the long-range setting seemed superior on certain bearings, the ranges at which that setting achieved its superiority were so short as to be inadmissible from a gunnery perspective. Acklom added, despite his concerns over the complication inherent in a triple-adjustment torpedo, that he would prefer that option to sacrificing the inter-changeability of ships' and destroyers' torpedoes.¹⁰⁰

With the opinions of shore officers in hand, the Admiralty turned the question over to the Navy's premier battlefleet, the Home Fleet, for seagoing opinions. Jellicoe, commanding the 2nd Battle Squadron, which was effectively the Fleet's tactics-development unit, argued against any extreme-range setting at only 22 knots. He feared

⁹⁹ Rear Admiral commanding RNWC to CINC Portsmouth, 1 July 1912, PQ13/F5/PP23–27, Ja397, AL.

¹⁰⁰ SRNTF to DNO, 11 July 1912, PQ13/F5/PP28–32, Ja397, AL.

that such slowness would make the allowable error in estimating target course and speed too small, and it would give the target too much time to take evasive action during the torpedo's time of flight.¹⁰¹ His ideal torpedo would have dual adjustments for short range of 4,500 yards at 45 knots and long range of 10,000 yards at 30 knots. He did not want the short-range setting to exceed 5,000 yards, meaning that any potential increase in the torpedo's power should go towards increasing the speed up to that range. He opposed building single-adjustment torpedoes of different patterns for ships and destroyers not only on supply and distribution grounds, but also on the tactical grounds that ships might find the high-speed setting at 4,500 yards "of great value" in certain circumstances.¹⁰² This tactical rationale is significant, because it lends support to Jon Sumida's thesis, discussed at greater length below, that Jellicoe envisioned taking a fleet well within enemy torpedo range, and it suggests that Jellicoe contemplated not only a decisive gunnery advantage at medium ranges, as Sumida argued, but also firing a torpedo salvo before turning away.¹⁰³

For the same reasons as Jellicoe, the commander-in-chief of the Home Fleet, Callaghan, agreed that the proposed extreme-range setting for 21-inch torpedoes was undesirable, and therefore he opposed the triple-adjustment idea.¹⁰⁴ Doubting that 18-inch torpedoes with the present 6,000-yard long-range setting would be useful to ships, on the grounds that battlefleets would close to so short a range only late in an action, by which time the equipment needed to aim torpedoes would have been wrecked by gunfire, he

¹⁰¹ See Jon Sumida, "A Matter of Timing: The Royal Navy and the Tactics of Decisive Battle, 1912–1916," *Journal of Military History* 67, no. 1 (January 2003): 103–4.

¹⁰² Jellicoe [VA2BS] to Callaghan [CINC Home Ft], 11 October 1912, G01247/12, PQ13/F5/PP41–43, Ja397, AL.

¹⁰³ Sumida, "A Matter of Timing," 85–136.

¹⁰⁴ Callaghan to SecAdm, 22 October 1912, G01247/12, PQ13/F5/PP38–40, Ja397, AL.

suggested re-arming all capital ships back to *Dreadnought* with 21-inch torpedoes capable of 10,000 yards; as discussed above, this proposal foundered on the supply shortage. As for the short-range settings, Callaghan thought that the 4,500-yard / 45-knot setting of the 21-inch Mark II would be useful to ships in dark or misty weather, but that the 3,000-yard / 41-knot setting of 18-inch Mark VII* torpedoes would be too short-range to be useful to ships. Since destroyers would need the short-range setting on 18-inch torpedoes, however, he recommended keeping it for the sake of inter-changeability and re-distribution in later years. The Admiralty accepted Jellicoe's and Callaghan's recommendations to stick with the double-adjustment system and to seek increases in speed at present ranges rather than increases in range.¹⁰⁵

Torpedo Fire Control: Equipment and Tactics

The application of the superheater and the angled gyroscope to torpedoes greatly increased their potential tactical utility—but the theoretical ability to hit meant little without an effective targeting system. While gunnery targeting in this period has received careful attention from historians, torpedo targeting has not. The following section represents an exploratory effort to outline the parameters of a complex and difficult problem that merits further study.

The Navy basically had three different types of vessels capable of delivering torpedo attacks (putting aside the vexed question of the role of scouts and light cruisers): capital ships, destroyers, and submarines. As a general rule, capital ships were expected to fire their torpedoes at long range in a “browning” attack on the enemy battleline;

¹⁰⁵ Minutes on G01247/12, PQ13/F5/PP44–51, Ja397, AL.

destroyers were expected to fire their torpedoes at medium range against single ships; and submarines were expected to fire their torpedoes at short range against single ships.

These expectations were not set in stone, however. As discussed in previous sections, Jellicoe contemplated capital ships firing torpedoes at medium range. A proposal to outfit submarines with heater torpedoes capable of covering medium ranges was put forward after the 1912 maneuvers.¹⁰⁶ Perhaps most controversial of all was Callaghan's idea of using his destroyers to make a long-range browning attack, which provoked an energetic debate at the Admiralty.¹⁰⁷ Uncertainty over what vessels would attack what targets at what range must have made the procurement of equipment for aiming torpedoes very difficult.

Even without knowing the precise conditions of use, there was clearly a trade-off between firing against single ships at short range and browning attacks at long range. On the one hand, the small size of a single-ship target made targeting more difficult. On the other hand, the shorter range in the case of single-ship targeting facilitated observation and estimation of target course and speed, and reduced the probability that errors in estimating the target course and speed would cause a miss. Therefore, both single-ship and browning attacks could reasonably claim the greater need for accuracy in targeting; whether one had a greater claim than the other could be determined only by a more thorough investigation of the effects of error under various conditions of attack than the present work can undertake.

As discussed in previous chapters, the Navy's basic equipment for torpedo

¹⁰⁶ Brandt to CINC Home Flt, 22 July 1912, Docket "Maneuvers 1912," ADM 1/8269, TNA.

¹⁰⁷ See SC284/F112, BF. For a summary of the issue, see Nicholas Lambert, *Sir John Fisher's Naval Revolution* (Columbia: University of South Carolina, 2002), 216–21.

targeting was the director. When the director was mounted directly above the tube, the range of the target did not have to be known. When the director was mounted away from the tube, however, the range had to be known in order to account for parallax between the tube and the director. The correction for parallax was applied on an extra piece of the director called the tangent bar by moving a sight (the rear sight) a certain distance along the tangent bar: instead of looking straight along the line-of-sight bar through the (fore) sight on the end of the sight bar, the director officer looked through the corrected line of sight between the tangent bar's rear sight and the sight bar's fore sight. Figure 6.3 illustrates the principle on which the tangent bar worked.

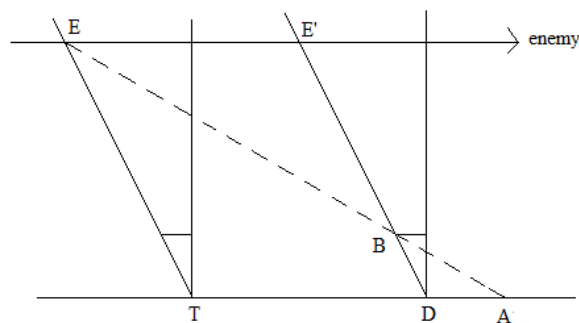


Figure 6.3: Setting the tangent bar on the director.

- T = location of torpedo tube
- D = location of director
- E = correct point of aim
- E' = incorrect point of aim, if not adjusted for parallax
- TE = true line of sight
- DBE = false line of sight
- AD = distance that rear sight must be moved along tangent bar
- DB = length of sight bar (known constant of 17 inches)
- AT = distance from director position to torpedo tube position (this would have been a known constant, roughly 32 yards)
- TE = range to point of aim (must be estimated)
- DBE must be pivoted through B so as to point at E.
- Now ATE and ADB are similar triangles, such that $AD / DB = AT / TE$. If this

equation is re-arranged to solve for AD, then $AD = (AT \times DB) / TE$, or, with substitution, (distance that rear sight must be moved along tangent bar) = [(distance from director position to torpedo tube position) x (length of sight bar) / (estimated range to point of aim)]. Thus, for example, if the estimated range is 2,000 yards, the length of the sight bar is 17 inches, and the distance from the director position to the torpedo tube position is 32 yards, then the rear sight must be moved 0.272 inches along the tangent bar.

The required input data for the director was the speed of the torpedo; the speed and course of the firing ship; the speed and course of the target; and, if the director was not mounted directly over the torpedo tube, the range of the target. Of these data, the easiest to get was the speed of the torpedo, which was a known constant. Own course was the next easiest, and then own speed, but here it should be borne in mind that the ease of ascertaining and transmitting own speed was changing in the period under discussion. The Navy did not acquire an electric log (the Forbes' speed log) for continuously measuring own speed until roughly 1912.¹⁰⁸ Speed and course of the enemy had to be either estimated by direct observation or calculated from a plot representing at least two observations. The former was easier, since, aside from the inconvenience of having to make a calculation, plotting required knowledge of the range. The equipment for finding, keeping, and transmitting the range to various control positions in the vessel was also changing.

The introduction of the angled gyroscope complicated the director and required additional input data, especially when the director was not mounted directly over the tube. All directors for use with angled gyroscopes were changed so as to swivel around a

¹⁰⁸ Norman Friedman, *Naval Firepower: Battleship Guns and Gunnery in the Dreadnought Era* (Annapolis: Naval Institute Press, 2008), 28.

individual torpedoes. The significance of this variation in terms of causing error is unclear. It can also be seen in Figure 6.4 that the distance which the torpedo traveled from the tube before beginning its turn—also known as the “advance”—had to be known. This distance varied with the impulse pressure used to discharge the torpedo from the tube. In theory, the advance was a known constant for a given impulse charge. On the one hand, it seems unlikely that variation in this constant could have been a significant cause of error, given that the advance must have been small compared to the remaining distance covered by the torpedo on its way to the target. On the other hand, it will be recalled that the reason the Navy abandoned the angled gyroscope for submarines was the impossibility of allowing “with sufficient accuracy for the large and variable advance” of the torpedo along its initial line of fire.¹⁰⁹ Again, the significance of error in accounting for the advance is difficult to gauge. In any case, the theory for adjusting the tangent bar to account for angle fire could be applied for the various angles at which torpedoes could be fired and a table made up for each director position showing the angle at which the tangent bar should be set (which did not vary with the range) and the distance which the rear sight had to be moved along the tangent bar (which did vary with the range).

Error could creep into the torpedo targeting process at a number of points. For all directors, whether mounted directly above or at a distance from the torpedo tube, mis-estimating own or target speed and course would cause the torpedo to be fired too early or too late. These errors also affected directors mounted away from the torpedo tube, as did mis-estimating the target range, or deviation by an individual torpedo from the

¹⁰⁹ “Paper Prepared by the Director of Naval Ordnance [Bacon] for the Information of his Successor [Moore],” 24 November 1909, G19535/09, 25.

supposed constants of advance and turning radius, any of which would have thrown off the tangent-bar setting and the line of sight, again causing the torpedo to be fired too early or too late.

On top of errors in estimating and inputting data, there was also potential for errors in transmitting data. Unless the transmission of the data was automated, there was bound to be a time lag between the generation and receipt of data, during which the accuracy of the data might degrade. In addition, the manual transmitter (i.e., a human being) might make a mistake. As the instruments for acquiring data like range and bearing for the sake of gunfire became more effective, the temptation to use the same data for torpedo purposes must have grown. The needs of gunnery and torpedo fire control were at odds in at least two ways, however. To fire torpedoes from fixed submerged tubes on the correct bearing without angled gyroscopes, it was necessary to turn the whole ship—but it was practically impossible to maintain accurate gunfire during a turn. In theory, the Argo Clock Mark V of 1913 might have offered a way out of this dilemma by providing the Royal Navy with helm-free gunnery fire-control equipment, i.e., capable of keeping the target range while own ship was turning (under helm). The Argo Clock Mark V was not adopted, however.

The angled gyroscope offered another potential way out of the tension between gunnery and torpedo needs, at the cost of creating a different tension. It allowed torpedoes to be fired from fixed submerged tubes without turning the whole ship—but it exacerbated the competition for skilled fire-control personnel.¹¹⁰ In 1910, a conference was held at the Admiralty to determine the fire-control arrangements of future armored

¹¹⁰ I am grateful to Jon Sumida for suggesting this possibility to me.

ships, after which the Director of Naval Ordnance, Moore, circulated a list of the personnel needed to man the armored tower in which the torpedo as well as gunnery targeting instruments were located.¹¹¹ He provided just one officer for torpedo purposes, to man the director.¹¹² Effectively, this one officer was responsible not only for adjusting the director, but also for acquiring the input data needed to adjust the director and for working the telegraph which sent the correct gyroscope angles to the torpedo tubes. If he wanted to acquire input data from the gunnery instruments instead of by direct observation, he had to work a phone to the transmitting station where gunnery data was collected and calculated. To perform the same collection, calculation, and transmission functions for gunnery purposes, at least a dozen men were provided. Even if adequate personnel for torpedo control had been provided, the Navy would have had to practice them in conjunction with their gunnery counterparts in order to make them effective, practice which it was unwilling to undertake due to the same supply shortage which prevented Callaghan from carrying out long-range destroyer exercises.

One way to avoid these problems was to develop instruments for ascertaining the input data needed for the torpedo directors—target course and speed—especially for torpedo purposes, instead of relying on hand-me-downs from the gunnery equipment. The first serious attempt to develop such an instrument for torpedo purposes was a so-called “speed and course of enemy indicator” designed by a midshipman named Macnamara in 1906.¹¹³ The instrument did poorly in trials at first, but *Vernon* re-issued it

¹¹¹ Minute by Moore, 18 August 1910, G0655/10, PQ12/F5/PP29–35, Ja 397, AL.

¹¹² Minute by Moore, 21 December 1910, G0655/10, PQ12/F5/PP29–35, Ja 397, AL.

¹¹³ ART06/21–22.

in modified form for trial at sea.¹¹⁴

Officers in the battleship *Bellerophon* reported unfavorably on the modified Macnamara's indicator in 1910. Target bearings could not be taken from the instrument itself but had to come from the compass; the application of the bearings was limited; and the bars for representing own speed and enemy course sometimes fouled each other. As a plotting instrument, the indicator was "rudimentary." In a sweeping statement, *Bellerophon's* officers argued that

a separate plotting system for torpedo work is necessary, as the most suitable ship to fire torpedoes in action is not necessarily, or usually, the one the guns are firing at; this plotting system should be self-contained, *i.e.*, independent of range-finders used for gunnery purposes, and the necessary staff for working it should be at the torpedo officer's disposal.¹¹⁵

It is noteworthy that this proposal came from a capital ship instead of a destroyer.

Although the target for capital ships in a browning attack was very large—a battleline could stretch for miles—*Bellerophon* evidently felt that a better system than estimating target course and speed by eye or than relying on gunnery instruments for the data was needed.

To create such a system, the Navy experimented with a number of instruments before the war. In 1912, an officer named A. M. Y. Brown proposed a partial method for adjusting the director called deflection plotting.¹¹⁶ From the scant details given in *Vernon's* annual reports, it seems that "deflection" referred to the angle at which the director's sight bar was fixed relative to the bar indicating the path of the torpedo, rather than to its gunnery meaning of "rate-across." If so, then the goal of plotting the deflection

¹¹⁴ ART09/22.

¹¹⁵ ART10/34.

¹¹⁶ ART12/27.

was presumably to find the slope of a line connecting the plotted points, which slope would have corresponded to the rate at which the deflection was changing, in order to be able to predict the correct deflection during periods when direct observation of the target was impossible. Deflection plotting may also have been an attempt to get around the need for knowing the range. The idea of using plotting for torpedo control, instead of relying exclusively on observations of target course and speed, indicated dissatisfaction with existing methods for predicting the target's location (position-keeping). Another officer, named W. M. James, invented a combined deflection-plotting board and slide rule so that the necessary deflection could be read directly off the board. A third officer, named B. E. Reinold, invented a system for automatically setting James' instrument with data obtained from a range-finder, gyro-compass receiver, and Forbes' speed log.¹¹⁷ James' and Reinold's ideas indicated a desire to mechanize and automate the process of torpedo control.

In its annual report for 1913, *Vernon* made its first attempt at laying out a comprehensive policy for torpedo control. Its important statement deserves to be quoted at length. "The advantages of deflection plotting, notably its simplicity, have led to its very general adoption in the Fleet in one form or another," *Vernon* began.

A considerable number of methods of ascertaining the director angle or deflection, and of applying them when found, have been proposed from various quarters.

In some cases these consist of means for finding the bearing rate [i.e., the rate at which the target bearing changed] to be afterwards [used as the basis for calculating other necessary data]; in others, instruments are used which aim at eliminating even the small amount of calculation involved in that process.

There is no doubt that, in action, calculations of any kind by the use of slide rules or otherwise, will be extremely liable to error; consequently methods which avoid calculations, provided they are sufficiently accurate, are much more

¹¹⁷ ART12/27.

likely to be successful.

The majority of these [non-calculating] methods, however, rely for their accuracy on the taking of two observations of the bearing of the enemy, with a time interval between. With the present facilities for taking bearings, even in ships fitted with gyro compasses, the accuracy with which bearings can be taken is much too small for two observations only to give results of any value; though in certain cases a spurious accuracy is attained by the failure to realise the exactness requisite in taking bearings, more particularly at long ranges.

Thus in these [non-calculating] methods, accuracy is sacrificed to simplicity.

Several proposed methods obtain accuracy at the cost of unwieldiness or obvious impracticability under the conditions likely to obtain in action.

These attempts at dealing with the problem continue to show the necessity for automatic means of finding the enemy's course and speed, director angle, or deflection, if the accuracy of the means of controlling torpedo fire is to be commensurate with the accuracy attainable with the weapons themselves.¹¹⁸

In *Vernon's* opinion, the combined deflection-plotter and slide-rule invented by James fell short of requirements: it could not give any more accurate results than a series of bearings taken with existing equipment, and it, like any form of slide-rule calculator, would be difficult to use in action.¹¹⁹

More promising, from *Vernon's* perspective, was a device invented by an officer named J. R. Middleton for automatically indicating when torpedoes should be fired, without manual calculations to find the bearing rate or to derive the deflection from the bearing rate.¹²⁰ It consisted of hand gear for training a telescope to keep on the target. The hand gear was connected to a shaft which turned a roller, which in turn rotated on the surface of a disc driven at constant speed by a motor. The roller took up a position at the center of the disc proportional to the rate at which the hand gear was turned. A mechanical calculator in two parts calculated the total deflection due to the bearing rate

¹¹⁸ ART13/29–30.

¹¹⁹ ART13/30.

¹²⁰ ART13/30.

(which reflected changes in both own and target course and speed) and the deflection due to course and speed of only own ship; the two deflections were added or subtracted depending on whether the target was drawing ahead or astern, and each had a pointer. A gyro-compass receiver worked on a differential gear in the telescope rod to eliminate the effect of own-ship's yaw. The input data necessary for the calculator was speed of own ship, torpedo speed, and mean range. Once it was entered, the operator kept the telescope trained on the enemy by turning the hand gear, and fired when the pointers on the two parts of the calculator came into line and rang a buzzer.

The ingenious disc-roller arrangement at the heart of Middleton's device was known as a variable-speed drive. These drives exploited the fact that objects at different distances from the center of a rotating disc moved at different speeds: an object on the outer edge of a rotating disc turns through a larger distance than one closer to the center in the same amount of time. Variable-speed drives had been a staple of Navy gunnery fire-control instruments since 1906.¹²¹ The idea of using hand gear to "tune" the variable-speed drive was undoubtedly borrowed from gunnery fire-control equipment designed by Frederick Dreyer, and it was surely no coincidence that the Navy asked the same firm, Elliot Bros., which built Dreyer's equipment to manufacture prototypes of Middleton's.¹²² The prototypes were still being constructed when the war broke out.¹²³

Neither Middleton's device nor deflection plotting offered a way to determine the range at any given moment or to predict it, i.e., a way to keep the range. *Vernon* noted that the only way to achieve range-keeping was to know the rate at which the range was

¹²¹ Friedman, *Naval Firepower*, 41–42.

¹²² Friedman, *Naval Firepower*, 48.

¹²³ ART14/31.

changing (the range rate), but it considered the range rate less important than deflection, “particularly as it is probable that in many cases in action torpedo fire will be directed at ships in a line at which gun-fire is being directed, so that data obtained by the gun control using all rangefinders which are intact will be available for both purposes.”¹²⁴ For reasons already discussed, the assumption that gunnery data could be used for torpedo purposes was overly sanguine.

The Navy experimented with other methods for determining deflection based on the bearing rate. One was a gyrostatic bearing plate worked off the training gear of the rangefinder for torpedo control; another was a Dumaresq modified for torpedo purposes.¹²⁵ A third possibility was to keep the target on a constant bearing, but that method was difficult with existing compasses and made own ship an easy gunnery target.¹²⁶

When the war broke out, most ships lacked any such instruments beyond extemporizations, and the only equipment being readied for new ships was the two prototypes of Middleton’s device, which offered no guarantee of success.¹²⁷ The situation was “very far from satisfactory,” *Vernon* and the commanders of the Grand Fleet agreed.

It goes without saying that any ship having long-range torpedoes should have something better to set directors by than estimation. Rate of change of bearing [bearing rate] is as important to the Torpedo Officer as rate of change is to the Gun Officer, yet while the latter is supplied in every ship with a complete set of instruments for determining this, the Torpedo Officer gets practically nothing even in ships fitted with the gyro compass.

In the ordinary course of events the whole matter would have in due

¹²⁴ ART13/30.

¹²⁵ ART12/27, ART13/32; ART13/30–31. The Dumaresq, named after the naval officer who invented it in 1902, was a device for representing own and target positions. It could be used to generate the range and bearing rates. See Friedman, *Naval Firepower*, 29–31.

¹²⁶ ART14/32.

¹²⁷ ART14/36.

course solved itself, the various extemporised instruments at sea being gradually evolved and eliminated until a satisfactory instrument was found. The outbreak of war has completely knocked this process on the head and we are left with a very bad gap in the torpedo armament of the Navy.¹²⁸

Why this “very bad gap” came to exist is an important question without obvious answers. This section has attempted to identify the factors which a search for answers would need to comprehend: the interaction between torpedo technology and torpedo fire control; the methods and equipment of torpedo fire control; the tolerance for error in torpedo fire control; and the interaction between gunnery and torpedo fire-control equipment and personnel.

Battle Tactics and War Plans

These related subjects have been covered by Jon Sumida and Nicholas Lambert for the half-decade preceding World War I. The present work will review the conventional interpretation from which Sumida’s and Lambert’s work differs, identify the flaws of the conventional interpretation, review Sumida’s and Lambert’s findings, and indicate how the present work supports them.

As with so many things, Arthur Marder established the conventional interpretation of battle tactics and war planning in the Royal Navy before World War I in the first volume of his series *From Dreadnought to Scapa Flow*. As for war planning, Marder proposed that the Navy planned to conduct amphibious operations and to establish a blockade of the German coast, in support of which it planned to seize a base in the North

¹²⁸ Ibid.

Sea.¹²⁹ As for battle tactics, Marder argued that the Navy was dominated by the desire for centralized command-and-control, a rigid battle-line, and the achievement of gun and torpedo fire superiority by capping the enemy line (“crossing the T”).¹³⁰

Major weaknesses in Marder’s theses are evident. First, his treatment of the Navy’s war planning was superficial. For instance, he noted that the Admiralty’s policy varied among close, observational, and distant blockade from 1910 to 1914 without investigating the reasons behind such major changes in policy.¹³¹ His account of the Navy’s interest in amphibious operations rested on plans drawn up in just three years—1905, 1908, and 1911—as though the other years before the war did not matter.¹³²

Marder’s account of battle tactics suffered from inconsistencies. He began his section on tactics by stating that there were two “unchallenged” tactical “fetishes” in the Royal Navy: rigid reliance on the line of battle and centralized command.¹³³

Notwithstanding this “fetish” for centralized command, there were “important exceptions,” such as William May, George Callaghan, John Jellicoe, and David Beatty.¹³⁴ These four “exceptions” held command of the Navy’s premier fleet for all but one year from 1909 to 1918, begging the question of just how “exceptional” their views were, and just how “fetishistic” and “unchallenged” the Navy’s commitment to the principle of centralized command was. Having made the Navy out to be monolithic, Marder lamented

¹²⁹ Marder, *From Dreadnought to Scapa Flow: The Royal Navy in the Fisher Era, 1904–1919*, vol. 1, *The Road to War* (London: Oxford University Press, 1961) [hereafter *FDSF I*], 367–95.

¹³⁰ Marder, *FDSF I*, 395–404.

¹³¹ Marder, *FDSF I*, 369–72.

¹³² Marder, *FDSF I*, 383–95.

¹³³ Marder, *FDSF I*, 395.

¹³⁴ Marder, *FDSF I*, 397–98.

its “lack of uniformity of thought” several pages later.¹³⁵ The one exception to the lack of uniformity was a commitment to “crossing the T” of the enemy in order to concentrate gun and torpedo fire on the enemy’s van.¹³⁶ The fact that the Navy adopted this tactic in order to concentrate gunfire belies Marder’s claim on the following page that “[n]o effort was made to co-ordinate tactics and gunnery,” as does the existence of a two-inch-thick docket in the Admiralty archives entitled “Gunnery... possibility of concentration of fire etc. of new developments in Fleet Tactics,” of which Marder was evidently unaware.¹³⁷

Marder attributed tactical troubles in the Royal Navy to “the ascendancy of the ‘*materiel*’ school.” By contrast, it was “the ‘historical’ school” that “correctly saw that the ‘sublime’ aspects of the profession, strategy and tactics, went undernourished in comparison with the energies focused upon the ship, the gun, and the torpedo.”¹³⁸ This interpretation uncritically assumed that tactics were insulated from technological change over time. Marder accepted slanders against the intellect of members of the “material” school—especially Fisher—by a school of self-identified “historical” reformers (most notably Herbert Richmond) who had an obvious self-interest in making others look bad. Marder seems to have unreflectively assumed that the study of history was or should have been important to naval officers at the time. He did not seriously consider the possibility that Fisher’s characterization of history as “a record of exploded ideas” was actually correct, at least in this context.¹³⁹

Sumida and Lambert have offered far more persuasive interpretations of battle

¹³⁵ Marder, *FDSF I*, 399.

¹³⁶ Marder, *FDSF I*, 400.

¹³⁷ Marder, *FDSF I*, 401; ADM 1/8051.

¹³⁸ Marder, *FDSF I*, 401.

¹³⁹ See Sumida’s criticisms of Marder’s interpretation of tactics in “Expectation, Adaptation, and Resignation,” 102.

tactics and war planning. As Marder's own evidence suggested, the Navy was highly fragmented over battle tactics—there were no “fetishes.” Some advocated the use of destroyers offensively against the enemy fleet; others wanted destroyers confined to a defensive role protecting their own fleet. Some wanted to adopt divisional tactics (in which the fleet operated in divisional units instead of in a single line); others thought that limits on existing command-and-control capabilities made divisional tactics foolish. Some proposed to deal with the torpedo threat by fighting at very long ranges or by maneuvering; others had different ideas.¹⁴⁰

The most imaginative solution came from Jellicoe, contrary to the reputation for caution earned by his disengagement at Jutland. The problem with fighting at long ranges or with maneuvering to avoid torpedoes, Jellicoe realized, was the inability to achieve decisive results with existing gunnery fire control capabilities.¹⁴¹ Arthur Pollen's fire control system might have allowed the Navy to achieve decisive results under such difficult conditions, but in 1910, the Admiralty decided to adopt Frederic Dreyer's fire control system instead of Pollen's. Dreyer's system was cheaper, but its general performance was inferior to Pollen's. It could not cope well with the high and changing change of range rates (range rates) that fleets engaging and maneuvering to avoid torpedoes would encounter. Nevertheless, it had some attractive features for dealing with easier conditions. Improved range-finders, introduced in 1912, enabled more accurate range observations to be taken, which could then be plotted on paper. The range plot

¹⁴⁰ See Sumida, “A Matter of Timing,” 88–92.

¹⁴¹ This entire account of Jellicoe's solution draws on Sumida, *In Defence of Naval Supremacy*, 218–20, and especially on two of Sumida's path-breaking articles: “A Matter of Timing,” 93–104, and “Expectation, Adaptation, and Resignation,” 104–107. Norman Friedman supported Sumida's findings in *Naval Firepower*, 84–91.

could be averaged quickly to produce a number called the “mean range-finder range of the moment.” From the range plot, a range rate could also be estimated. If the range was changing, the mean range-finder range of the moment could be fed into a machine (a “clock”) which used the estimated range rate to generate the estimated range at any given moment, and this estimated range could be used to set the gun-sights. The estimated ranges were automatically plotted on paper, where they could be checked against a plot of observed ranges, and the clock could be manually adjusted if the two plots did not coincide. The combination of the plotting system with the clock was known as the Dreyer Table.

When ranges were within 10,000 yards, which was the effective limit of the new range-finders, and when the range rate was not changing, the combination of the improved range-finders and the Dreyer Table could produce ranges so accurate that only one or two shots to check the range (“ranging shots”) were necessary, after which the fire became so accurate that continuous spotting to check the fall of shots was unnecessary. The system of setting the sights from the Dreyer Table without continuous spotting, based on the mean range-finder range of the moment, was known as “range-finder control.” While guns had to fire in simultaneous salvos (i.e., not independently) if spotting was necessary, because the splashes from independent shots made spotting impossible, obviating the need to spot meant that the guns could fire independently, rather than in salvos, and as rapidly as possible. This method was known as “rapid-independent fire.” If the gun-layers could also overcome wave action, roll, and yaw to keep their guns continuously on the target (a method known as “continuous aim”), then they could, in theory, maintain a devastating fire.

To work, the system depended on several conditions. The enemy had to be visible and within 10,000 yards, so that the range-finders could take accurate initial ranges. The seas had to be calm enough, or the mechanical training of the guns adept enough, to keep the guns continuously on the target. Finally, the enemy fleets had to be steaming in straight lines in the same direction (though not necessarily parallel) so that the range rate was not changing rapidly, because the Dreyer Table could not generate sufficiently accurate ranges when the range rate was changing rapidly. But the need to steam on a straight line within 10,000 yards of the enemy raised serious problems from a torpedo perspective: one's own fleet would be highly vulnerable to a "browning" attack from the enemy. How could the Royal Navy achieve decisive results given the limitations in its gunnery without intolerably exposing itself to long-range torpedoes?

Beginning in 1912, Jellicoe developed a novel answer to the question. At the start of the engagement, the British fleet would rapidly approach the enemy fleet. During this phase, the range rate would be high, and neither fleet would have the fire-control capabilities to inflict serious damage on the other. Once the British fleet reached medium range, it would turn onto a course parallel with the enemy, such that the range would be constant. (The British expected the Germans to engage in similar tactics.) While the courses were parallel, the guns would adopt range-finder control and rapid-independent continuous-aim fire to inflict decisive damage on the enemy fleet. Given existing torpedo speeds of 30 knots for 7,000+ yards, an 8-gun broadside, a heavy-gun firing interval of 30 seconds, and accurate initial range observations, the British fleet would be able to steam on a parallel course for 5–8 minutes, during which time each heavy gun would be able to make 24–38 hits. Before the browning torpedoes inevitably fired by the enemy could

reach the British fleet, it would execute a simultaneous turn-away and simply out-run the torpedoes. Even if torpedoes managed to reach the British line after the turn-away, it would be in line abreast, offering its ends rather than its broadsides, and thus greatly reducing the probability of torpedo hits.

This “technical-tactical synthesis” became secret Admiralty policy in 1912. Several factors account for the timing. The first large-scale order for 21-inch Mark II torpedoes capable of making 10,000 yards had been placed in 1909, but the supply bottleneck, discussed previously, probably prevented them from entering service in large numbers until 1911 or so. In 1911, Jellicoe took over command of the Home Fleet’s Second Division (re-named the Second Squadron in 1912), which served as the Navy’s technological-tactical laboratory.¹⁴² Assisted by Dreyer, Jellicoe experimented with various fire control systems, including Dreyer’s, and with 21-inch torpedoes. Long-range firing with 21-inch torpedoes in 1912 suggested that 75% would be “dangerous to the enemy.” To deal with the torpedo threat, Jellicoe tried divisional tactics, but he found that they presented insuperable command-and-control problems. The elimination of divisional tactics left a turn-away as the best option for dealing with the torpedo threat. In late 1912, Jellicoe rejoined the Admiralty as Second Sea Lord, and within two weeks of his return, the Admiralty informed Pollen that it was rejecting his fire-control system on “unspecified tactical grounds.” Presumably, Jellicoe had convinced his fellow Board members that the technical-tactical synthesis built around Dreyer’s system, range-finder control, and the turn away would work.

While Jellicoe’s “technical-tactical synthesis” offered the Royal Navy hope of

¹⁴² This remainder of this paragraph is based on Sumida, “A Matter of Timing,” 103–5.

achieving decisive results in battle despite the long-range torpedo threat, others planned to deal with the torpedo threat by avoiding battle altogether and finding other ways to apply naval power. These plans signified a return to Fisher's ideas, discussed in Chapter 4. Given the risk of losing capital ships, plus its irrelevance to imperial defense, there seemed little reason to seek battle in the North Sea, and much reason to avoid it. As a former Director of Naval Intelligence, Edmund Slade, put the matter in 1913:

The German policy seems to be perfectly clear. She is endeavouring to frighten Great Britain into concentrating all her forces in the North Sea and so leave the communications of the Empire open to attack.... Now no increase in the number of Battleships and no victories in the North Sea will save us from the danger which threatens our trade in distant seas. Our very existence depends upon, not only the maintenance, but also the increase of this trade in war, and if it is neglected we shall fall more certainly than if we lose a battle.¹⁴³

At the same time, a renewed financial crisis in late 1913 gave the Admiralty compelling reasons to revisit Fisher's plans for applying naval power on a budget.¹⁴⁴ By the eve of the war, the highest reaches of the Navy's leadership had accepted the discounted value of battle and battleships. The First Lord, Winston Churchill, with the full backing of his professional advisers, planned to replace two battleships in the 1914/15 building program with flotilla craft, chiefly submarines, which he planned to use to deny the North Sea to German naval and merchant vessels. This plan meant a return to Fisher's conception of flotilla defense, but the outbreak of war complicated its implementation.

Torpedo development is at the center of Sumida's and Lambert's interpretation of British tactics and strategy, and it belongs there. The development of increasingly long-range and accurate torpedoes made traditional battle tactics based on a close-order

¹⁴³ Report by Slade in Docket "HM Ships. Duties in Peace—Types required +c. Report of Hopwood Committee, 1913," ADM 1/8328, TNA.

¹⁴⁴ This account is based on Lambert, *Sir John Fisher's Naval Revolution*, 296–303.

gunnery engagement at short range suicidal, and it stimulated the search for new tactics, some of which assigned torpedoes a significant auxiliary, if not a primary, role. The development of small craft to deliver torpedo attacks, first in the form of surface torpedo boats and in most devastating form as submarines, rendered the Navy's traditional strategy of close blockade equally impractical, and forced it to search for new methods of applying naval power.

Conclusion

Torpedo development confronted the Royal Navy with extremely difficult problems from 1909 to World War I. Although the Hardcastle superheater was a great success, undergoing remarkably minor changes during this period, the Navy did not solve the depth-keeping problems caused by high torpedo speeds before the outbreak of war. It introduced angled gyroscopes in 1912, but the vessels that needed them most—submarines—did not get them. Moreover, limitations on torpedo fire control prevented the Navy from fully exploiting the angled gyroscope. The Navy's failure to develop torpedo fire control as energetically as it developed torpedoes left it with "a very bad gap," in the words of *Vernon* and the Grand Fleet's commanders, when World War I broke out.

The Navy did better at accounting for limitations in its gunnery fire control systems. Jellicoe developed a novel technical-tactical synthesis which held out the hope of inflicting decisive gunnery damage despite the long-range torpedo threat. The conditions required for this synthesis to work did not obtain at the Battle of Jutland, however. Instead of engaging at medium range with low range rates, the fleets engaged at

long range with sometimes high range rates. When the German fleet disengaged, Jellicoe did exactly what two decades of British tactical thinking suggested he do, and turned away. He may have lost his chance at immortality—but he did not lose any of his capital ships to the torpedoes fired by the retreating German fleet.¹⁴⁵

¹⁴⁵ For an analysis of German torpedo fire, see Andrew Gordon, *The Rules of the Game: Jutland and British Naval Command* (Annapolis: Naval Institute Press, 1996), 454, 461–62.

Conclusion

The Torpedo and Naval Power: Perception and Reality

In *The Structure of Scientific Revolutions*, Thomas Kuhn famously introduced the concepts of scientific “paradigms” and “anomalies,” which historians of technology and war have adapted to speak of technological and strategic paradigms.¹ Torpedoes have generally been depicted as anomalies within tactical and strategic paradigms defined in Mahanian terms, in which capital ships with heavy guns sought command of the sea through decisive battle.² Or, to use the language of today’s armed forces, the torpedo presented an asymmetrical threat to a conventionally powerful navy, much as improvised explosive devices (IEDs) present an asymmetrical threat to conventionally powerful armies today. According to this logic, the U.S. Navy, as a relatively weak power seeking to revise the naval status quo, had every reason to embrace the torpedo; while the Royal Navy, as the hegemon seeking to conserve the status quo, had every reason to reject the torpedo. Given the small size and cheapness of torpedoes and torpedo vessels compared to big guns and battleships, casting the former as Davids to the latter’s Goliaths has a

¹ Kuhn meant something very particular by “paradigm” and “anomaly,” but there are enough affinities between his and my uses of the terms to justify the allusion. See Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1996; first edn. 1962), especially pp. 10–11, 23–24, 52–53, 64–65; William McBride, *Technological Change and the United States Navy, 1865-1945* (Baltimore: Johns Hopkins University Press, 2000), 5–7.

² See, e.g., Robert Love, *History of the U.S. Navy, 1775-1941* (Harrisburg: Stackpole Books, 1992), 373–76; Arthur Marder, *From the Dreadnought to Scapa Flow: The Royal Navy in the Fisher Era, 1904–1919*, Vol.1, *The Road to War, 1904–1919* (London: Oxford University Press, 1961), 329–30.

superficial logic.

Beneath the surface, however, this logic breaks down. To begin with, the dichotomy of torpedoes and torpedo vessels versus big guns and capital ships is false. Battleships carried torpedoes as an integral part of their armament, after all, and naval officers generally limited torpedo vessels to secondary roles in battle, like charging in for the kill after the guns had wounded their prey, leaving the primary importance of capital ships unchallenged. In these contexts, torpedoes were adjuncts to, not anomalies within, the capital-ship paradigm. In other contexts, to be sure, torpedoes could topple the paradigm. Both the American and British navies flirted with the idea of using destroyers to launch torpedoes at capital ships during the early stages of a battle, giving primacy to torpedoes rather than to guns. Neither navy, however, went so far as to contemplate a battle fleet composed solely of torpedo vessels, which would have been the ultimate challenge to the paradigm.

Torpedoes delivered on their paradigm-shattering potential at the strategic rather than the tactical level—but not for the nation that the conventional wisdom would suggest. By making battles riskier for capital ships and by making close blockades impossible, torpedoes threatened the two traditional foundations of naval strategy. It might be thought that the British, who especially relied on these foundations, would therefore prove especially hostile to torpedoes, but something closer to the reverse was true. Granted, examples of hostility to torpedoes can be found in British naval circles—recall First Naval Lord Richards' comment, for instance, that “no man did his country a worse service” than Robert Whitehead (see Chapter 2). Even where it existed, however, hostility did not prevent Richards and others from investing enough resources to stay at

the forefront of torpedo development. In any case, the hostility disappeared entirely when Fisher became First Sea Lord in 1904. Fisher believed that he could use torpedoes and torpedo craft, along with advances in capital-ship design, communications, and fire control, to carry out the Navy's traditional missions in the face of budget cuts. Instead of seeking command of the sea through decisive battle, Fisher sought control and denial of the sea in the service of home and imperial defense.

Both Fisher's contemporaries and most historians have conflated the propaganda that Fisher peddled for budgetary reasons with his real policy. Fisher proved particularly adept at manipulating the Liberal government that took power in 1905. The higher taxes that paid for the butter in the People's Budget of 1909 also paid for more guns: naval expenditure in 1910 leapt above £42 million, higher than it had ever been under the Conservatives.³ Unlike his Liberal successors, Conservative leader Arthur Balfour followed naval affairs closely and kept up a robust correspondence with Fisher, who repaid Balfour's interest with honesty about his plans for flotilla defense. Hence the supposedly militaristic Tories brought Fisher in with a mandate to reduce the naval budget, while the supposedly pacific Liberals allowed him to increase it.

Naval officials had reason to camouflage their real views about the morality as well as the power of torpedoes, and historians have proven gullible in crediting their attempts to stigmatize torpedoes as "illegitimate" or the "weapons of the weak." No doubt some British naval officers regarded torpedoes as sneaky and uncivilized, and yet any moral qualms they may have had did not prevent them from spending large sums of

³ Sumida, *In Defence of Naval Supremacy*, Table 3, "British Naval Expenditure, 1889–90 to 1914–15"; see also pp. 185–96, 335–7.

money to stay in the forefront of torpedo development. Moreover, officers without moral qualms had excellent reason to pretend that they did. Delegitimizing torpedoes might discourage other nations from developing them, removing a threat to Britain's naval hegemony (based as it was on capital ships), and reducing Britain's need to spend money on torpedoes in order to stay abreast of foreign development. The Royal Navy pursued a similar strategy when it came to submarines, feigning disinterest and loudly denouncing them, even as it carefully monitored foreign development and made plans to leapfrog the competition.⁴ Although torpedoes certainly could be the weapon of the weak, they could also be the weapon of the strong, as Fisher realized. Perhaps this very strength gave the British the self-confidence to embrace the torpedo.

Indeed, the American experience suggests that torpedoes were not so much weapons of the weak as weapons of the insecure and financially comfortable. Compared with the Royal Navy, the U.S. Navy was an ambitious pipsqueak—prime candidate, if torpedoes were really the natural weapons of the weak, to embrace the torpedo wholeheartedly. And yet something closer to the opposite occurred. Whereas naval circles in Britain embraced torpedo-based flotilla defense as a means to cut costs without sacrificing strategic ends, politicians interested in cutting the budget forced it on a reluctant navy in the United States, and then only to a limited degree. The U.S. Navy was so determined to preserve its budget, and perhaps to prove itself as a major power, that it mimicked the behavior it associated with naval hegemony (building capital ships) and rejected the behavior of the real naval hegemon (flotilla defense). The U.S. Navy was

⁴ See Nicholas Lambert, *Sir John Fisher's Naval Revolution* (Columbia: University of South Carolina Press, 2002), 38–55.

proof that the Royal Navy's efforts to persuade other navies that it embodied an ideal even as it acted contrary to that ideal succeeded.

It is all too easy to fall back on technological determinism as an explanation of historical change without carefully investigating the details of torpedo development and considering the motives behind naval officials' pronouncements on the subject. Historians need to look beneath the surface of rhetoric to understand them.

The Pace of Technological Change

The thesis that the dominant navy within a particular paradigm embraced anomalous technology more than the weaker navy seems to run into trouble when it comes to the pace of technological change. The Americans adopted the gyroscope and superheater before the British, who did not adopt the turbine engine at all. If the Royal Navy was so keen on torpedoes, why did it adopt new torpedo technology more slowly than the U.S. Navy? The answer has to do with material resources and the balance of power.

Both navies adopted the gyroscope, but they did so at different paces and for different reasons. Tactically, the main impetus for American interest in the gyroscope was that it would facilitate submerged torpedo fire; for the British, it was that the gyroscope would allow torpedoes to be fired outside gun range. At the time, the Royal Navy had much less reason than the Americans to be worrying about submerged fire: it had fired thousands of submerged shots, while the Americans had fired zero. Inexperience primed the Americans to emphasize an implication of the gyroscope that experience allowed the British to de-emphasize.

In addition to differences in tactical motivation, the two navies adopted mechanically different gyroscopes. Both navies experimented with spring-driven and air-driven gyroscopes on the one hand, and with pivot and ball bearings on the other. The Americans could not find a spring or ball bearings that satisfied them, while the British did. Springs and bearings are hardly the stuff of legend, but these small details reveal three important lessons. First, substantial technological change can result from incremental mechanical changes rather than conceptual paradigm shifts (see below). Recall, for instance, the 0.02-inch change to certain pivots in the balance mechanism which alleviated the depth-keeping problems of some British torpedoes (see Chapter 6). Second, incremental technological change plays to the advantage of those with superior R&D resources, because they can test minor changes till they find one they like. Third, Britain's industrial ability was evidently superior to the United States' in this particular instance: because ball bearings had to be very hard and very fine, they were not easy to manufacture, and American industry was not up to the task.

The two navies also moved at different paces in their negotiations over and adoption of the gyroscope. The U.S. Navy worked through an intermediary, the Bliss Company, and on the basis of trials with one gyroscope lasting eight days in late 1897, ordered the gyroscope to be installed in all 159 torpedoes then under contract. By contrast, the Royal Navy purchased several trial gyroscopes for itself from the Whitehead Company, not working through an intermediary, and it put the device through several phases of trials, including limited issue to seagoing ships, which the Americans skipped. Britain placed its first bulk order in late 1898, a year later than the Americans had made a comparable commitment. Only in late 1899 did it move to paying a lump sum, which the

Americans never did.

The pattern repeated itself with the superheater. The Americans adopted Leavitt's original dry outside superheater in 1901. When the Bliss Company offered to sell the superheater to the Admiralty, a naval officer noted with horror that that supposedly "exhaustive" American trial "only rests on 22 runs!" (see Chapter 2). The Admiralty turned down the Bliss Company's offer and instead began to conduct its own superheating experiments in 1904. These were rapidly superseded by Hardcastle's and the Armstrong Company's efforts in 1905. Just when the U.S. Navy was introducing the dry outside superheater—imported from a British firm, the Armstrong Company, via the Bliss Company—the Royal Navy was finalizing the details of Hardcastle's wet outside superheater. It entered service in 1908, two years before the Americans even began to solicit wet superheater proposals from the Bliss Company and the Electric Boat Company, and four years before the Americans placed contracts for steam torpedoes with the Bliss Company. Even then, with the failure of the Electric Boat Company to produce a home-grown wet superheater, the U.S. Navy still had to rely on a British firm, the Armstrong Company, for the wet superheaters used in Bliss-Leavitt torpedoes. While building up two sources of domestic supply, the British managed to leap-frog the Americans, skipping two steps—the dry inside and dry outside superheaters—that the Americans passed through. The time thus saved helped the British to beat the Americans to the wet outside superheater by four years, despite their later start in superheater development.

Also helping the British was their decision to stick with the reciprocating engine, despite periodically flirting with the idea of the turbine engine. The U.S. Navy committed prematurely to the turbine engine in 1902 and then had to spend the next six years

making it work. The process involved much wasted effort on unnecessarily balancing the turbine, when in fact errant exhaust was to blame for the torpedoes' tendency to roll, and it generated great friction with the Bliss Company, culminating in a lawsuit that went all the way to the Supreme Court. These efforts dominated the U.S. Navy's experimental and industrial agenda and came with a high opportunity cost. In late 1905, for instance, while Hardcastle was having the first inklings of his superheater ideas, the Americans were struggling to fix the turbine engine while wrestling with the Bliss Company over property rights in relation to the balanced turbine. Absent the opportunity cost that came with committing to the turbine, the Royal Navy was free to concentrate on superheater development.

The relative weakness of the U.S. Navy explains its relative openness to change in a very particular sense. The explanation is not that the torpedo was the "weapon of the weak" (see above), but that the U.S. Navy was weak in R&D resources. This weakness hampered the U.S. Navy's efforts to compete with the Royal Navy in torpedo development. Perhaps counter-intuitively, given the tendency to think of torpedoes as asymmetrical weapons of the weak, the U.S. Navy's interest in torpedo development was *symmetrical*: the Navy compared its torpedoes to other torpedoes, not to capital ships. In an asymmetrical competition of torpedoes against capital ships, the Royal Navy's superiority in the latter was a weakness. In a symmetrical competition of torpedoes against torpedoes, by contrast, the Royal Navy's superiority in R&D resources was a strength. To compensate, the U.S. Navy had to find an area in which it enjoyed a comparative advantage. The only possible candidate was theoretical design work, which did not require the same experimental infrastructure as a trial-and-error approach to

technological change: brains were cheap compared to torpedo ranges, testing barges, and personnel. Poor in the latter, the Americans could never hope to compete with the British if torpedo technology changed through an incremental, empirical process. Their only hope was to change torpedo technology through bold leaps in design, trusting to the drafting room rather than the testing range. Unable to look before they leapt, they paid for their poverty with a troublesome turbine and corresponding delay in superheater development.

Lack of infrastructure explains why none of the three really successful wet superheaters—the Armstrong, Hardcastle, and Gezstesy models—were American. The Americans could compete at the relatively primitive level of dry superheaters, but their lack of R&D resources crippled them when it came to the much more advanced technology of wet superheaters. Granted, the basic science behind wet superheaters was not much more advanced than that behind dry superheaters: for both, the idea was that hot air was better than cold air. Applying the basic science, however, was much more difficult for wet superheaters than for dry superheaters. Whereas it was comparatively simple to gin up a working design for a dry superheater, optimizing fuel flows and the like in wet superheaters required extensive trial and error. Neither the U.S. Navy nor the Bliss Company had the facilities to undertake such experiments. The Royal Navy did, and what is more, two private companies (Armstrong and Whitehead) were able to undertake R&D work on a greater scale than the U.S. Navy (let alone the Bliss Company).

In different ways, both Robert K. Merton and Thomas Kuhn offered the beginnings—but only the beginnings—of a theory that accounted for the role of R&D resources in scientific and technological innovation. Both scholars were trying to

understand the phenomenon that Merton called “multiples”—ideas discovered more than once by different parties.⁵ A theory which emphasized the genius of single individuals as the main factor behind innovation seemed unable to account for “multiples.” Both scholars instead pointed to the importance of environment in fostering innovation and “multiples.” Merton argued for a “sociological” theory of innovation, which attributed innovation to environment, as opposed to a “psychological” (or “heroic”) theory, which attributed innovation to individual men of genius.⁶ Kuhn also accepted the existence of what Merton called “multiples,” and he attributed them to the power of “paradigms”—quintessentially sociological, rather than psychological, phenomena—in directing scientific research.⁷ Merton noted that scientists’ efforts to establish priority of discovery implicitly testified to their belief that “all scientific discoveries are in principle multiples [rather than singletons],” while Kuhn argued that the existence of multiples was “a symptom of something askew in the image of science that gives discovery so fundamental a role.”⁸ As against the “heroic” theory of innovation, with its emphasis on “discovery,” Kuhn pointed out that the majority of scientists spend most of their time not on revolutionary breakthroughs, but on “mopping-up” the implications of a minority’s revolutionary breakthroughs.⁹ In these “mopping-up operations,” Kuhn realized, material

⁵ Merton, “Singletons and Multiples in Scientific Discovery: A Chapter in the Sociology of Science,” *Proceedings of the American Philosophical Society* 105, no. 5 (October 1961): 470–86; Kuhn, *The Structure of Scientific Revolutions*. Note that these seminal works were published within a year of each other, so the authors did not have the opportunity to put their work in dialogue.

⁶ Merton, “Singletons and Multiples in Scientific Discovery,” 475, 484.

⁷ Kuhn, *The Structure of Scientific Revolutions*, 65 (“[A] significant scientific novelty so often emerges simultaneously from several laboratories”).

⁸ Merton, “Singletons and Multiples in Scientific Discovery,” 477; Kuhn, *The Structure of Scientific Revolutions*, 54. In his tenth type of evidence testifying to scientists’ belief that innovation occurs multiply rather than singly—“the institutional expedients designed to protect the scientist’s priority of conception”—Merton might well have included patent systems (Merton, 482).

⁹ Kuhn, *The Structure of Scientific Revolutions*, 24.

resources were key, as his frequent references to scientific apparati make clear—and yet he, like Merton, focused on intellectual rather than material resources.¹⁰

Merton's and Kuhn's models did not account sufficiently for the difference between basic and applied science, and therefore they did not assign a sufficiently explicit role to material resources.¹¹ With torpedo technology, basic science needed brains more than material resources. Applying the basic science so that a prototype could successfully be produced on a mass scale, however, required an extensive R&D infrastructure, consisting of servant technology, ranges, barges, and testing personnel, to name just a few components. Regardless of how brilliant the intellects behind innovation were, when the science and technology at issue were complex and expensive, multiples (like the wet superheater) were unlikely to occur without a strong R&D infrastructure, and the momentum of singletons (like the turbine engine) was difficult to sustain. Take Leavitt and the turbine engine. His intellect was enough to identify an anomaly and build a prototype, but it took many intellects—salaried and outfitted with expensive instruments—to carry out the “mopping-up operations” that went to make up most of “normal” technology within the new turbine paradigm.¹² The United States was on a relatively even playing field with Britain when it came to basic torpedo science, but it was at a severe disadvantage when it came to applied science, due to its weaker R&D

¹⁰ See, e.g., Kuhn, *The Structure of Scientific Revolutions*, 65.

¹¹ Or, in Joel Mokyr's language, the difference between “episteme” and “techne”; see Mokyr, *The Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton: Princeton University Press, 2002), 4–15. Merton, in particular, tended to elide the distinction by using “discovery” and “innovation” interchangeably—but they are not really synonyms. “Discovery” implies learning something that already exists, while “innovation” implies creating something new.

¹² As part of a larger effort to adapt Kuhn's work on science to his own on technology, Edward Constant adapted Kuhn's notion of “normal science” to “normal technology”; see Constant, *The Origins of the Turbojet Revolution* (Baltimore: Johns Hopkins University Press, 1980), 6–12.

infrastructure. A full sociological theory of innovation must account for material as well as intellectual resources.

In theory, the U.S. Navy's efforts to escape the limits of its material infrastructure, however ineffectual, were the result of a rational push/pull dynamic. The push was the recognition that the Americans would remain at a comparative disadvantage in the status quo, because they lacked the R&D resources necessary to exploit fully the technology that defined the status quo. The pull was the hope that they could exploit their theoretical, as opposed to empirical, designing abilities to invent better technology, and with it a new status quo in which they enjoyed a comparative advantage. The Americans' underestimation of the difficulty involved in perfecting designs of the gyroscope, the superheater, and the turbine was a by-product of their rational fear that they would remain at a comparative disadvantage in the technological status quo, and of their rational hope that they would come out at a comparative advantage by trying to revise the status quo.

As hegemon within the status quo, Britain experienced a different, but not quite inverse, push/pull dynamic. The push was the fear that change would lead to relative loss. In connection with this prospect of relative loss, the British had to account for one variable much more carefully than did the Americans, namely, the pace of foreign development. The American Navy was sufficiently far off the lead that, in relative terms, it effectively had nowhere to go but up; accordingly, there was almost no chance that foreign advances would destabilize its relative position. For the hegemonic British, by contrast, there was a very high probability that foreign advances would destabilize its relative position. But the Royal Navy considered the positive as well as the negative implications of change, especially the possibility that the Navy might be able to exploit

change to widen its relative lead; this was the “pull” for Britain. The fact that technological change *simultaneously* offered the prospects not only of net loss and no gain *but also of net gain* is crucial to understanding the Admiralty’s calculations. Moreover, the prospect of net gain was not negligible, because the same existing infrastructure that gave the British more to lose than any other nation also meant that it was better positioned than any other nation to turn change to its advantage.

This kind of retrospective theorizing about the role of material resources in determining torpedo development is one thing, but it is another to establish what naval officials at the time believed to be determining their decisions. The latter task is complicated, in a comparative work like this one, by differences in the primary source bases caused by differences in institutional culture. Consider British and American decision-making about the gyroscope, for instance. In the Admiralty, a report on gyroscope trials at Fiume went all the way up to the First Lord, who used it to meditate on the nature of British hegemony and then circulated it to the Assistant Director of Torpedoes, the Director of Naval Ordnance, the Director of Naval Construction, the Director of Naval Intelligence, the Controller, the Secretary of the Admiralty, and the Senior Naval Lord. By contrast, when the report of the American Fiume Commission that witnessed trials of the gyroscope at Fiume arrived in the Office of the Secretary of the Navy, the Secretary did not send it on to the Bureau of Ordnance with an endorsement meditating on the gyroscope’s implications for the standing of the United States in the balance of power; rather, the Bureau of Ordnance, in consultation with the Torpedo Station, made

decisions about the gyroscope without drawing in other parts of the Navy Department.¹³

The American naval bureaucracy was vertical and compartmentalized where the British naval bureaucracy was horizontal and consultative.

These historical differences create a historiographical problem. On the British side, it is possible to substantiate the push/pull theory of technological change with primary sources. The exchange of minutes about the gyroscope clearly shows that perceptions of material resources and the naval balance of power influenced British naval officials. In the absence of such an exchange, caused by the absence of a consultative culture that impelled officials to spell out the considerations affecting their decisions, it is impossible to show that American naval officials were thinking in the same terms.

That said, even if American officials did not consciously think in those terms, material shortages and their second-tier position in the naval balance of power may have determined their decisions unconsciously. Proving the power of the unconscious is difficult if not impossible, and perhaps a task for the psychologist rather than the historian. It is possible, however, to make more or less educated guesses about the factors affecting naval officials unconsciously, and there are several potential explanations. One is that Americans developed torpedo technology quickly because the asymmetrical threat presented by torpedoes suited their weakness in battleships. This thesis was discussed and dismissed at length above. Another possibility is that Americans developed new

¹³ The consultative nature of Admiralty decision-making may have reflected financial constraints: with money hard to come by, the Admiralty had to be sure it appreciated the financial consequences of its decisions, and this imperative required robust debate. I am indebted to Jon Sumida for making this point to me.

technology quickly because of their attraction to the “technological sublime.”¹⁴ The records used for this study do not support that hypothesis. Torpedoes provided American naval officials with more headaches than aesthetic pleasure, and changing torpedo technology appealed as a relief, not as a value in its own right. In this case, it seems more accurate to think of technological change as an exercise in problem-solving rather than as a cultural characteristic, and the push/pull theory is compatible with this conception. For the Americans, changing torpedo technology quickly addressed the problems of R&D shortages: they adopted new technology quickly because they lacked the means to test it adequately.

Although the difference between the British and American primary-source bases complicates the task of substantiating theories, it performs the crucial function of sensitizing readers to the contingency of historical judgment. The greater richness of the Royal Navy’s official documentary record, thanks to its more consultative decision-making process, exposes it more, for worse or for better, than the U.S. Navy. On the one hand, it makes it possible to notice inconsistencies in an official’s logic over time, as was the case with Walker, the Assistant Director of Torpedoes (see Chapter 2). On the other hand, it shows a canny group of minds at work, which grasped most implications of the gyroscope, ranging from the tactical to the grand strategic. By contrast, the American Navy, with a less consultative system, fewer responsibilities, and fewer resources, grasped and funneled the largest part of its energy towards just one tactical implication of the gyroscope, its facilitation of submerged fire.

¹⁴ This is David Nye’s famous term, adapted from Burke’s notion of the aesthetic category of the sublime; see Nye, *American Technological Sublime* (Cambridge: MIT Press, 1994). Robert O’Connell’s thesis about American naval officials’ love of battleships is largely a variant on Nye’s thesis; see O’Connell, *Sacred Vessels: The Cult of the Battleship and the Rise of the U.S. Navy* (Boulder: Westview Press, 1991).

Given the asymmetry in institutional style and source bases, it would be unfair to apply symmetrical standards of judgment. Without a comparative alternative, it is difficult, if not impossible, to detect either the nature of the British or American decision-making process or the dependent interpretive bias. The consultative nature of the Admiralty and the compartmentalized nature of the Navy Department were so pervasive as to be invisible, so continuous as to hide their contingency. It takes a comparative approach, the introduction of a relative frame of reference, to realize that their natures were neither inevitable nor absolute, that there were existing alternatives.

Property Rights and the National Security State

“Our arms must be mighty, ready for instant action,” President Dwight D.

Eisenhower famously warned his fellow citizens in his 1961 Farewell Address,

so that no potential aggressor may be tempted to risk his own destruction.... This conjunction of an immense military establishment and a large arms industry is new in the American experience.... [W]e must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex.

Although the scale of the military-industrial complex was new in Eisenhower’s time, the phenomenon itself was not. It had its origins in the late nineteenth century, when industrialization and the emergence of what William McNeill called “command technology” transformed the existing military-manufacturing relationship into the military-industrial complex.

Previously, when governments purchased naval technology from the private sector, it was a finished commercial product. The new command technology was so expensive and sophisticated, however, that private firms could not successfully develop it by

themselves. Thus the government could not buy the technology as a finished commercial product but had to invest in research and development (R&D) by the private sector. By changing the dynamic from conventional purchasing to interaction throughout the development process, command technology may be said to have put the complex in the military-industrial complex.

The present work draws out three significant implications of McNeill's brilliant thesis. First, it shows how command technology put a premium on the development of "servant technology," that is, technology which generated information for improving the performance of command technology. Dynamometers, rolling registers, and testing tanks were all examples of servant technology. Second, the information generated by servant technology was a commodity unto itself, because it had the power to affect market relationships by offering insight into the value of command technology. Moreover, this commodified information was also a new kind of property. It was not a physical form of property, like command technology, nor was it the same as traditional forms of intellectual property. The acquisition of information-generating servant technology meant a stronger position in the information-commodity market, giving servant technology some value independent of its contributions to command technology. The third and most important implication of McNeill's thesis relates to property rights. By definition, the invention of command technology involved both the public and private sectors, instead of one or the other as previously. With two parties replacing one, it became much more difficult to establish who had invented what and when. Command technology therefore created thorny problems regarding intellectual property rights.

Not every piece of torpedo technology was an example of command technology.

The gyroscope, for instance, fit into the old paradigm. In the United States, gyroscope development by the Navy and the Bliss Company proceeded separately, as did development by the Whitehead Company and the Royal Gunpowder Factory in Britain: the public investment in private R&D which characterizes command technology did not apply. The superheater and the turbine engine, by contrast, were examples of command technology—but not in both countries. Only in the United States did the Navy invest in the Electric Boat Company’s experimental wet superheater and the Bliss Company’s experimental turbine. In Britain, the Navy did not adopt the turbine engine, and it developed the Hardcastle superheater internally, not in collaboration with a private firm. While Armstrong’s superheater patent infringement lawsuit against the Admiralty was the rough British equivalent of the Electric Boat Company’s and Bliss Company’s superheater lawsuits against the Navy Department, the Royal Navy did not have to deal with an equivalent to the American lawsuit over the turbine engine. In short, Britain avoided the worst legal headaches of torpedo command technology.

It achieved this outcome for three reasons. One was the greater extent of its R&D infrastructure. Neither the public nor private sectors in the United States could match the experimental facilities of the Royal Gunpowder Factory, Royal Navy Torpedo Factory, Whitehead Company, or Armstrong Company—let alone the merger of Whitehead’s and Armstrong’s resources after 1906, which probably created industrial laboratories on a scale more commonly associated with the interwar period and World War II than the pre-World War I period.¹⁵ Because the British government itself had greater resources and

¹⁵ See Kendall A. Birr, “Science in American Industry,” in *Science and Society in the United States*, ed. David D. Van Tassel and Michael G. Hall (Homewood: The Dorsey Press, 1966), 66–70.

could contract with private firms possessing greater resources, it had less need to collaborate with the private sector in developing new technology. By contrast, lacking resources on a comparable scale in either the public or private sectors, the American government had to assist private firms in developing particularly expensive and sophisticated new technology.

The second reason that the Royal Navy avoided the worst headaches of command technology was its internal structure for incentivizing innovation. The Admiralty Awards Council provided incentives for innovation within the service. To reward its leading superheater expert (Hardcastle) for his invention, for instance, the Admiralty Awards Council granted him £5,000 and accelerated promotion. The U.S. Navy lacked a similar body and gave its leading superheater expert (Davison) nothing. What happened? Hardcastle stayed in the Royal Navy while Davison bolted for the private sector—taking his government notebooks with him and then suing the government, for good measure. Keeping Hardcastle was well worth £5,000 and early promotion.

By institutionalizing incentives for innovation in the form of the Admiralty Awards Council, the Royal Navy kept one of its brightest minds from fleeing to the private sector. The Royal Navy could therefore support Hardcastle's efforts internally, instead of having to invest in private experimental efforts to maintain a relationship with Hardcastle. Avoiding investment in the private sector meant that it avoided one of the common pitfalls of command technology: a dispute between the public and private sectors over property rights. To maintain a relationship with Davison, by contrast, the U.S. Navy had to invest in experimental efforts by the Electric Boat Company, and a lawsuit resulted.

Of course, the Royal Navy's method of internalizing invention did not prevent disputes altogether: it merely kept them from involving the private sector. Hardcastle later concluded that he had been exploited and put in a claim for additional compensation. As Davison's case shows, the relevant comparison for Hardcastle's award was not his naval salary (by which standard the award was exceedingly generous) but what he could have made in the private sector (by which standard the award was much less generous, if not niggardly). Contrary to what one might expect, Admiralty and Awards Council officials never suggested that Hardcastle should be grateful for what he got: they accepted the need to measure his award against the private sector, not against his naval salary. Given this acceptance, the award may not have been generous, but it nevertheless reflected a sophisticated understanding of the military-industrial complex and technological change, or at least a more sophisticated understanding than the U.S. Navy possessed.¹⁶

The third reason that Britain avoided the worst headaches of command technology was its legal system, specifically its patent laws and anti-espionage legislation. Since 1852, the British government could classify patents as secret, and since 1889, it had an Official Secrets Act. By contrast, the United States lacked any provision for secret patents until World War I, when Congress authorized the classification of patents related to national security. This improvised measure lapsed at the end of the war but was reinstated at the start of World War II. Only in 1951 did Congress put this ad hoc approach

¹⁶ Understanding the Admiralty's policy further undermines the hoary stereotype of the Admiralty as technologically conservative, which historians such as Jon Sumida, Nicholas Lambert, and John Beeler have disproved.

on permanent footing, with the passage of the Invention Secrecy Act.¹⁷ Furthermore, the United States lacked any equivalent to Britain's Official Secrets Act until the National Defense Act of 1911. The Americans lagged a century behind the British when it came to secret patents and several decades behind them when it came to anti-espionage legislation.

This lag put the American government at a disadvantage in dealing with command technology. Secret patents allowed the British government to respond effectively to two characteristic difficulties of command technology: establishing property rights in a potentially collaborative process of invention, and maintaining secrecy in a competitive industrial and international environment. Hardcastle's secret patents established prior discovery against future claimants without publicizing his work. The American government could not do the same for Davison's work on turbines and superheaters, even if he had remained in government service. In the case of the balanced turbine, the government had Davison take out a (public) patent to protect itself from rival claims by the Bliss Company, despite its desire to keep the technology secret. The Bliss Company recognized that the government was on the horns of a dilemma and exploited its vulnerability: how could the government claim that the balanced turbine was secret, the Bliss Company reasonably asked, when it had published the technology in the form of a patent? The inability to take out secret patents exposed the American government to attack.

Like secret patents, anti-espionage legislation was an important weapon for the state in dealing with command technology. Thanks to Britain's superior R&D

¹⁷ Herbert N. Foerstel, *Secret Science: Federal Control of American Science and Technology* (Westport: Praeger, 1993), 165.

infrastructure, which enabled private firms to develop sophisticated torpedo technology without government assistance, and to the Admiralty's institutionalization of incentives for innovation, which enabled it to keep Hardcastle in the Navy, the British government did not have to threaten anyone with the Official Secrets Act in regard to torpedo technology. Its reticence had nothing to do with character, however, and everything to do with lack of opportunity. When opportunity knocked, as it did in the case of Arthur Pollen's fire control system, the British government proved perfectly willing to use anti-espionage legislation to regulate proprietary and commercial rights.¹⁸ The American government was equally predatory, and thanks to its comparative mishandling of torpedo technology, it had more opportunities than the British to showcase its aggression. As soon as it had anti-espionage legislation at its disposal in the form of the National Defense Act of 1911, the U.S. government used it to prosecute the Bliss Company. The government showed equal cynicism in its attitude towards patent law, taking entirely contradictory positions in its cases against the Bliss Company and the Electric Boat Company.

Command technology was only one subset of a larger class of technologies likely to elicit predatory behavior from governments. Command technology invited such behavior because it was developed in collaboration between the state and society, and because it was militarily sensitive. Other probable triggers for state interest in technology would include dual-use (civilian and military) potential or, in the case of purely civilian technology developed with government aid, the potential for commercial profits. It is not at all surprising to find a government trumpeting the inviolability of property rights when

¹⁸ See Jon Sumida, *In Defence of Naval Supremacy: Finance, Technology, and British Naval Policy, 1889–1914* (Boston: Unwin Hyman, 1989), 220–49, especially 237–38.

it had nothing to lose.¹⁹ The real test of its commitment to property rights came when security or money was at stake.

Realizing that the state was unlikely to resist temptation, the classical liberal political philosophy on which Britain and the United States were putatively founded sought to limit the state's ability to abridge property rights under any circumstances. John Locke, the father of liberalism, grew up during the English Civil War and later had to flee abroad because of his belief. He took for granted that the state oppresses civil liberties when it feels threatened. For him, the fundamental civil liberty was not free speech but private property. The U.S. government's use of the National Defense Act of 1911 against the Bliss Company's property rights thus represented the ultimate betrayal of Lockean principles—yet it has received far less attention than the use of the Espionage Act of 1917 against the free speech of Eugene Debs.²⁰

The readiness of the British and American governments to abridge property rights associated with command technology serves as a reminder that states do not always rely on sophisticated Gramscian hegemony: sometimes they wield their power openly, bluntly, crudely. The warfare state, after all, has been around much longer than the welfare state. Historians do not need Foucault to recognize the regulation of commercial and proprietary rights through anti-espionage legislation as an abuse of state power. With a little classical political philosophy, a lot of time in the archives, and a sense that war is central to the human experience, historians have all the ingredients they need to produce

¹⁹ A point that is neglected throughout B. Zorina Zhan, *The Democratization of Invention: Patents and Copyrights in American Economic Development, 1790–1920* (New York: Cambridge University Press, 2005); see especially p. 51.

²⁰ Ironically, one of the reasons that the government found Debs so threatening was his Socialist hostility to property rights—perhaps he reminded the government too much of itself.

major insights into the relationship between the state and society.

Appendix A: General Overview of Torpedo Technology

Launching the Second Industrial Revolution (in Miniature)

Consider the launch of a primitive American torpedo, the 45-centimeter x 3.55-meter Mark I Whitehead torpedo, from an above-water tube. As can be seen in Figure A.1 below, the torpedo consisted of five main parts: the warhead (“A”), air flask (“B”), balance chamber (“B’”), engine room (“C”), and tail (“I”).²¹ The space between the engine room and the tail, along with the engine room itself, was known as the afterbody (“CC”).

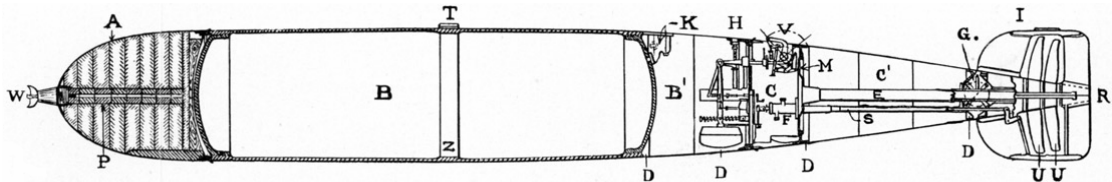


Figure A.1: General outline of the torpedo.²²

For propulsion, the Mark I carried an air charge in an **air flask** (“B”), which operated a

²¹ The British referred to some of the space between the engine room and the tail as the “buoyancy chamber,” but the Americans did not. Together, the engine room and buoyancy chamber made up the “afterbody.” Depending on which country’s terminology is used, the gyroscope, discussed below, went in either the buoyancy chamber or afterbody.

²² Plate 1, *The Whitehead Torpedo. U.S.N., 45cm x 3.55m. Mark I, Mark II, Mark III, and 45cm x 5m. Mark I* (1898), downloaded from <http://hnsa.org/doc/whitehead/plates2.htm>, 21 April 2009.

three-cylinder reciprocating **engine** (located in the **engine room**, “C”). The engine rotated a **shaft** (“E”), which was geared (“G”) in such a way as to operate a pair of contra-rotating **propellers** (“UU”). Figure A.2, below, shows what the engine looked like from the side (the same perspective as Figure A.1 above), as well as what it looked like from the front.

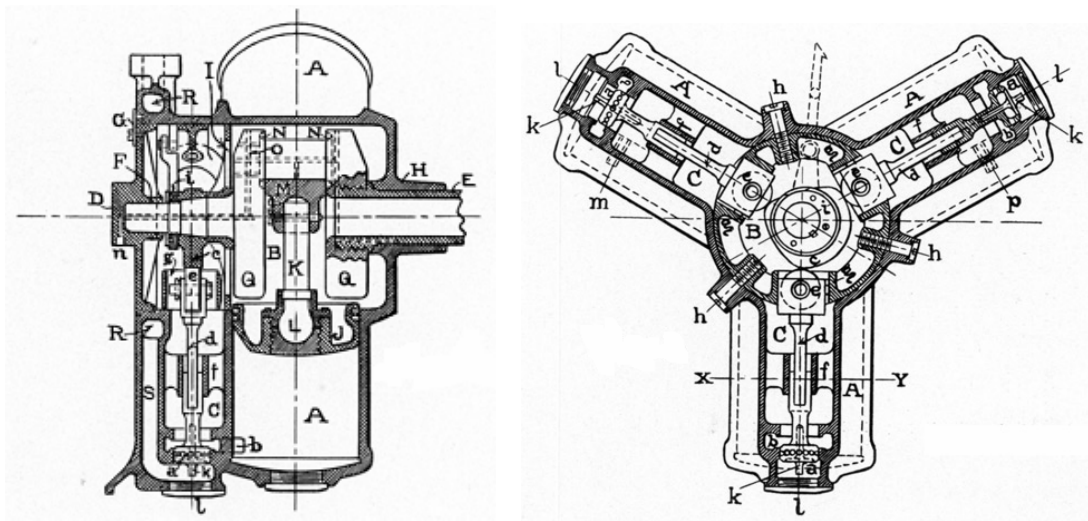


Figure A.2: The engine.²³ The view on the left is a side view, and the view on the right is a front view.

The engine of the Mark I had three **cylinders** (“AAA”). Each cylinder had a **cylinder valve** (“aaa”), around which a disc called the **engine cam** (“c”) rotated in such a way that, at any given time, one valve was open to admit air into its cylinder and move the **piston** (“JJJ”), another was closed to cut off the admission of air to its cylinder, and the third was open to allow air to be exhausted from its cylinder.

²³ Plate 8, *The Whitehead Torpedo. U.S.N., 45cm x 3.55m. Mark I, Mark II, Mark III, and 45cm x 5m. Mark I* (1898), downloaded from <http://hnsa.org/doc/whitehead/plates2.htm>, 21 April 2009.

After an air or powder impulse ejected the torpedo from the tube, various arrangements prevented parts of the torpedo from starting before they were supposed to. One, called the locking gear, prevented the derangement of the depth mechanism; it is discussed with the depth mechanism below. Another prevented the engine from starting until it was fully immersed in the water, since starting the engines while the torpedo was in the tube or in the air wasted the precious air charge and interfered with the torpedo's accuracy. Figure A.3 shows the arrangement, which was known as the **retarding (or delaying) gear**.

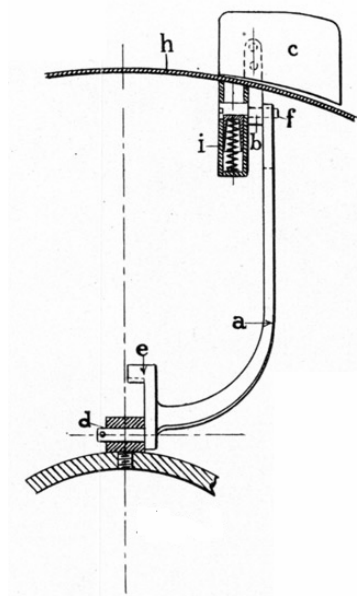


Figure A.3: The retarding gear.²⁴

Contact with the water released (or “tripped”) the **water tripper** (“c”), which released the **bell-crank lever** (“b”), which released the **retarding lever** (“a”). The release of the

²⁴ Plate 12, *The Whitehead Torpedo. U.S.N., 45cm x 3.55m. Mark I, Mark II, Mark III, and 45cm x 5m. Mark I* (1898), downloaded from <http://hnsa.org/doc/whitehead/plates2.htm>, 21 April 2009.

retarding lever lifted the **controlling valve** (so-called because it controlled the reducing valve), which allowed air to begin flowing through the **reducing valve**.²⁵ In Figure A.1, the general outline of the torpedo, these valves are in the valve group (“V”). They are shown in more detail in Figure A.4 below.

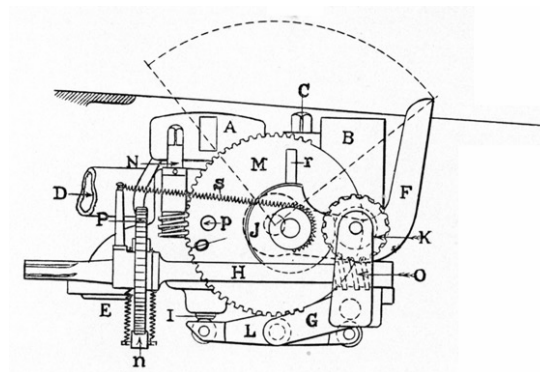


Figure A.4: The valve group (side view).²⁶

The reducing valve (“A” in Figure A.4) was the most important valve in the torpedo. It reduced the air pressure from its storage pressure in the air flask to the working pressure of the engine. By controlling the air pressure reaching the engine, the reducing valve controlled the torpedo’s speed. Figure A.5 shows the reducing valve in more detail.

²⁵ The British 14-inch Mark VIII torpedo had an additional retarding arrangement.

²⁶ Plate 10, *The Whitehead Torpedo. U.S.N., 45cm x 3.55m. Mark I, Mark II, Mark III, and 45cm x 5m. Mark I* (1898), downloaded from <http://hnsa.org/doc/whitehead/plates2.htm>, 21 April 2009.

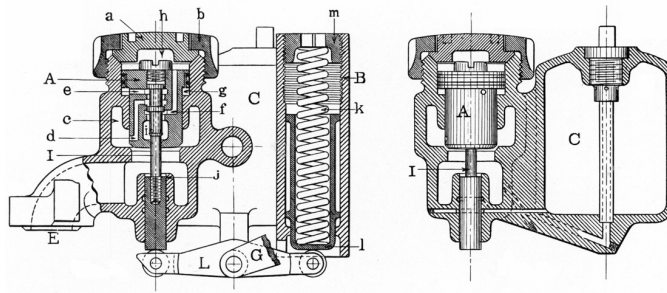


Figure A.5: The reducing valve.²⁷

As the torpedo moved through the water, a **depth mechanism** (sometimes referred to as the immersion mechanism or balance mechanism) controlled its depth and trim.²⁸ Figure A.6 shows the depth mechanism.

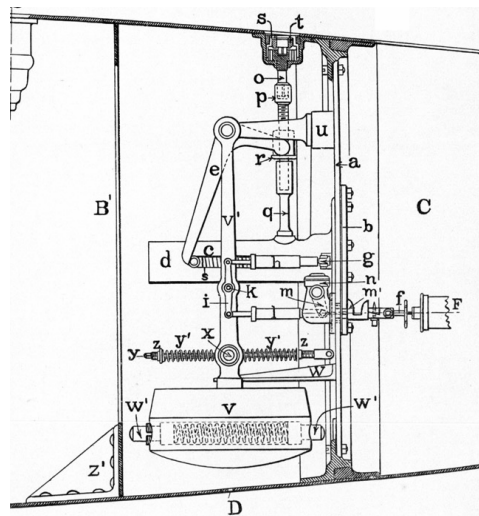


Figure A.6: The depth mechanism.²⁹

²⁷ Plate 11, *The Whitehead Torpedo. U.S.N., 45cm x 3.55m. Mark I, Mark II, Mark III, and 45cm x 5m. Mark I* (1898), downloaded from <http://hnsa.org/doc/whitehead/plates2.htm>, 21 April 2009.

²⁸ The balance mechanism was “The Secret” behind Robert Whitehead’s torpedoes; see Edwyn Gray, *The Devil’s Device: Robert Whitehead and the History of the Torpedo* (Annapolis: Naval Institute Press, 1991; first edn. 1975), 57–58.

²⁹ Plate 6, *The Whitehead Torpedo. U.S.N., 45cm x 3.55m. Mark I, Mark II, Mark III, and 45cm x 5m. Mark I* (1898), downloaded from <http://hnsa.org/doc/whitehead/plates2.htm>, 21 April 2009.

The depth mechanism consisted of two main parts: the **hydrostatic piston** (“c”) and the **pendulum** (“vv”). By responding to changes in the pressure of the surrounding water, the former controlled the torpedo’s depth, while the latter controlled its trim. The movement of the hydrostatic piston was amplified by a **steering engine** (“F,” in Figure A.1 above) and transmitted through a series of **levers and rods** (primarily “S” in Figure A.7 below) to operate the **horizontal rudders** (“R,” in Figure A.7 below). The steering engine was located in the engine room rather than the balance chamber, and the levers and rods passed through the afterbody. Figure A.7 shows the system by which the motion of the hydrostatic piston was transmitted to the horizontal rudders.

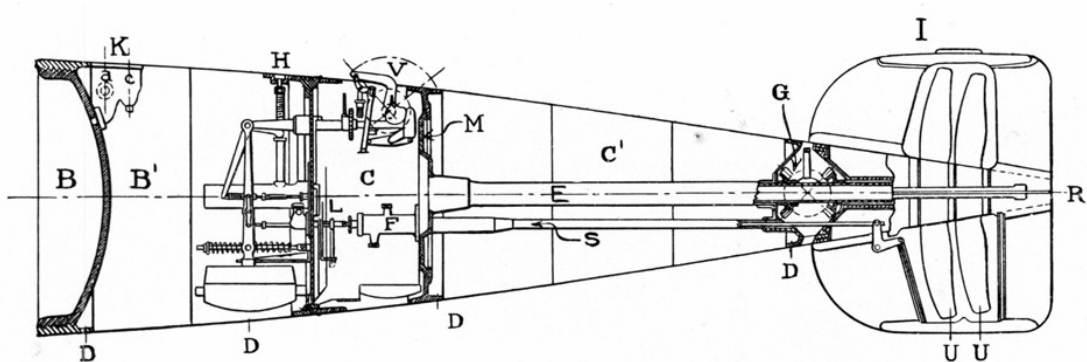


Figure A.7: The system for controlling the depth.

Like the main torpedo engine, the depth mechanism had a system that prevented it from beginning to operate at the moment of the torpedo launch. The delaying gear for the depth mechanism was known as the **locking gear** (because it “locked” the depth mechanism in place; the British called it the “controlling gear”). When the torpedo was

launched, the inertia of the pendulum caused it to lag as the rest of the torpedo moved forward, and the pendulum would only recover its proper position once the torpedo stopped accelerating and attained its final speed. If allowed to occur, this lag would put the horizontal rudders down and cause the torpedo to take a steep initial dive, which might run it into the bottom in shallow waters or imperil recovery of its proper depth. To prevent this lag-induced dive, the locking gear locked the steering engine in place until enough time passed (corresponding to a given number of revolutions of the engine shaft) to allow the pendulum to operate normally.

If none of the many working parts malfunctioned and the torpedo ran true, contact with its target detonated the **warhead**.³⁰ Figure A.8 shows the detonation system.

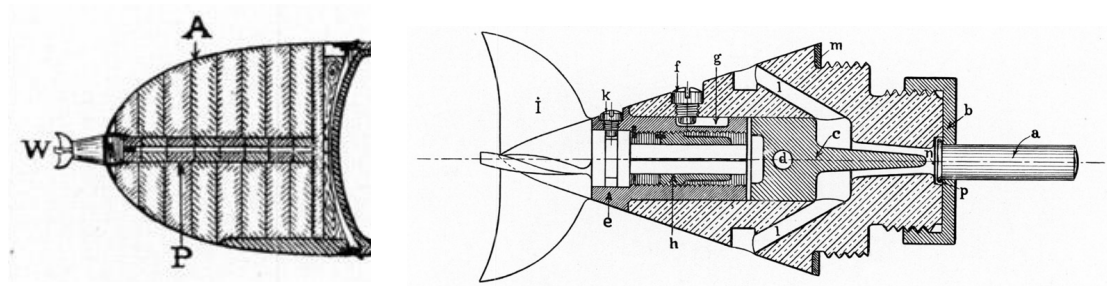


Figure A.8: Warhead (left) and war nose (right).³¹ The figure on the right is a close-up of “W” in the figure on the left.

The warhead (“A”) carried the wet gun-cotton explosive, and the **primer-case** (“P”) carried a dry gun-cotton **primer**. The **exploder** (“a”) was a copper tube containing a

³⁰ American torpedoes infamously suffered from detonator problems in World War II; see Frederick Milford, “US Navy Torpedoes—Part Two: The Great Torpedo Scandal, 1941–43,” *The Submarine Review* (October 1996).

³¹ Plates 1 and 4, *The Whitehead Torpedo. U.S.N., 45cm x 3.55m. Mark I, Mark II, Mark III, and 45cm x 5m. Mark I* (1898), downloaded from <http://hnsa.org/doc/whitehead/plates2.htm>, 21 April 2009.

mixture of mercury fulminate and gun-cotton, capped with a **percussion cap** at its forward end. The **firing pin** (“c”) was held clear of the percussion cap by a **shearing pin** (“d”). The rotation of the **screw fan** (“i”) as the torpedo moved through the water turned a **traveling nut** (“h”), which moved aft along the screw fan’s shaft until it pressed up against the firing pin, such that only the shearing pin resisted the pressure of the firing pin against the exploder. Contact with the target provided enough force to break (“shear”) the shearing pin, allowing the firing pin to strike the percussion cap at the forward end of the exploder. The subsequent flash from the exploder detonated first the primer and then the explosive.

Of course, the Mark I was a relatively simple torpedo. It had no means for ensuring accuracy in the horizontal plane, and its speed and range were only 28 knots for 800 yards.³² Later torpedoes included two complicated pieces of technology to address these shortcomings: a **gyroscope** and a **superheater**.

The gyroscope was first introduced in the late 1890s to improve torpedoes’ horizontal accuracy. Although gyroscopes were constantly modified over subsequent decades, they all had the same basic structure, which is shown in Figure A.9 below.

³² “Specifications for the Manufacture of Whitehead Automobile Torpedoes,” 23 January 1891, B7-137, NTS.

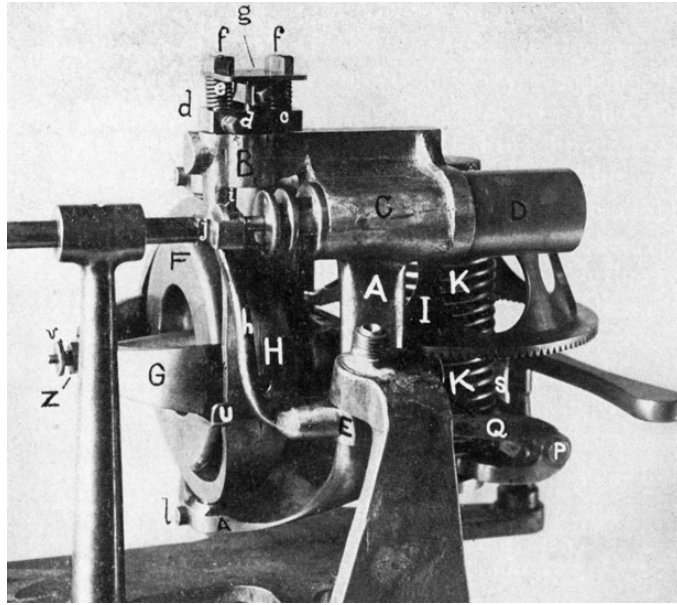


Figure A.9: Obry gyroscope (named after its inventor, Ludwig Obry) used in early American Whitehead torpedoes.³³

The **gyroscope wheel** (“F”) spun around an **axle**, which was connected by bearings to an **inner gimbal** (or inner ring or horizontal ring) (“G”). The inner gimbal was connected to the **outer gimbal** (or outer ring or vertical ring) (“H”) by another set of bearings, and the **outer gimbal** was in turn connected to the **gyroscope frame** (“A”) by a third set of bearings. Thus there were three sets of two bearings each. The bearings connecting the inner gimbal to the outer gimbal were sometimes known as the **side bearings**, and those connecting the outer gimbal to the frame as **top and bottom bearings**, due to their relative position. Some gyroscopes used pivot bearings, while others used ball bearings; some drew their initial impulse from a **spring** (“K,” in Figure A.9 above), while others drew it from air; and some drew a continuing impulse from air, while others had only an

³³ *The Whitehead Torpedo. U.S.N., 45cm x 3.55m. Mark I, Mark II, Mark III, and 45cm x 5m. Mark I.* (Naval Torpedo Station, 1898), plate 21, <http://hnsa.org/doc/whitehead/plates4.htm> (accessed May 6, 2010).

initial impulse.

The gyroscope relied on the angular momentum created by the spinning gyroscope wheel to control and correct the torpedo's position in the horizontal plane—a counterpart to the depth mechanism, which relied on the pressure of the surrounding water to control and correct position in the vertical plane. Just as a steering engine amplified the action of the depth mechanism to move the horizontal rudders (which moved the torpedo up and down), so another **steering engine** (“C”) amplified the action to move the **vertical rudders** (which moved the torpedo in from side to side).

While the gyroscope dramatically improved the accuracy of torpedoes, a device known as the superheater dramatically improved their speed and range. Without a superheater, the pressure and the temperature of the remaining air in the flask fell as the air in the air flask was used over the course of a torpedo's run. Because the air was colder, it could perform less work per unit of weight in driving the engine. Heating the air as it passed to the engine allowed the air to perform more work.

The superheater passed through three distinct phases of development. The first and most primitive superheater, shown in Figure A.10 below, was invented by an American engineer named F. M. Leavitt in 1901. It was known as an **inside superheater**, because the superheater was located inside the air flask.

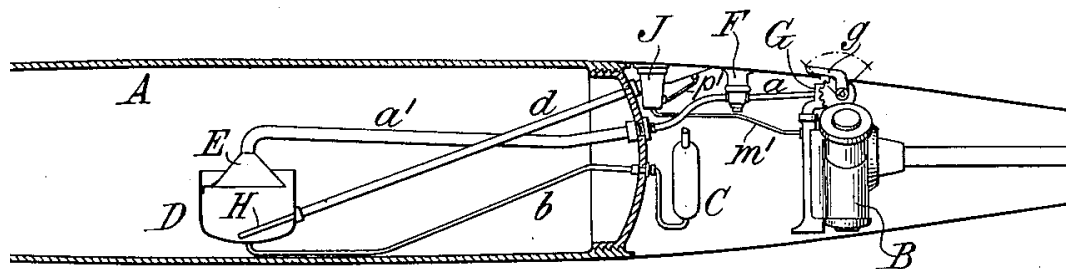


Figure A.10: Leavitt's inside superheater.³⁴

The fuel for supporting combustion was stored in a **fuel reservoir** (“C”) outside the flask, and it was connected by a **fuel-feed pipe** (“b”) to the **combustion chamber** (“D”), where it was ignited by an **igniter** (“H”). Air was heated in the combustion chamber, sucked into an inverted funnel (“E”), whence it passed through a pipe (“a”) to the reducing valve and engine (“B”).

While Leavitt's inside superheater increased the speed and range of torpedoes, it had a serious disadvantage which limited the scale of these increases: when the air passed through the reducing valve on its way to the engine, the air lost pressure and therefore grew colder, meaning that it could do less work on the engine once it got there than if it remained as hot at the engine as it had been while inside the flask. To avoid this problem, superheaters could instead heat the air after it passed through the reducing valve. Such superheaters were known as **outside superheaters**, because they were outside the flask.

The first phase of outside superheater development was the **dry (or “hot-air”)** **outside superheater**, so-called because water was not introduced during the combustion process. The earliest successful dry outside superheater, shown in Figure A.11, was

³⁴ Leavitt's USP 693,872 (applied for 12 April 1900, issued 25 February 1902), Figure 1.

patented by the Armstrong Company in 1906.

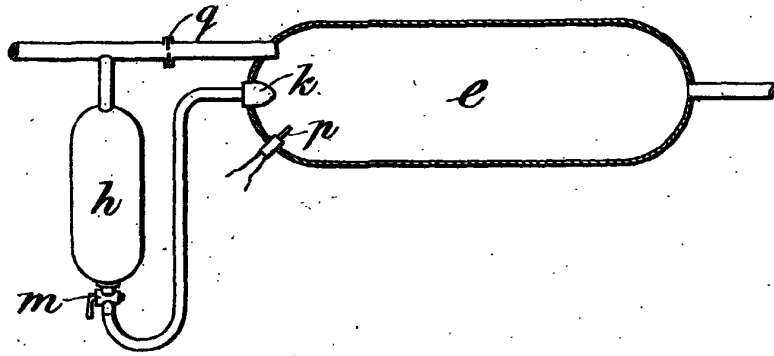


Figure A.11: The Armstrong dry outside superheater.³⁵

In Armstrong's dry outside superheater, the **combustion chamber** ("e") took the form of a bulge in the pipe ("q") leading from the air flask to the engine. The fuel for supporting combustion was stored in a **fuel reservoir** ("h") outside the flask, and it was connected by a fuel-feed pipe to the combustion chamber, where it was sprayed through a **nozzle** ("k") and ignited by the firing of a **primer** ("n").

Although heating the air after it passed through the reducing valve increased speeds and ranges beyond what Leavitt's original inside superheater could achieve, the inability of the engines to withstand temperatures above a certain point still limited the potential increases. To cool the products of combustion and avoid over-heating the engines, water could be injected into the fluid passing to the engines. Water injection had another benefit, which was to increase the volume of the fluid passing to the engine. Thus water injection allowed higher-calorie fuels to be used and greater speeds and ranges to

³⁵ Armstrong's GBP 3,945/1905 (applied for 20 February 1905, issued 1 February 1906), Figure 2.

be achieved.

Superheaters with water injection were known as **wet (or “steam”) outside superheaters**, and they marked the third phase of superheater development. There were several successful wet outside superheaters. The first was invented and patented in 1908 by a British naval officer named S. U. Hardcastle. Figure A.12 below shows the general arrangement of Hardcastle’s superheater.

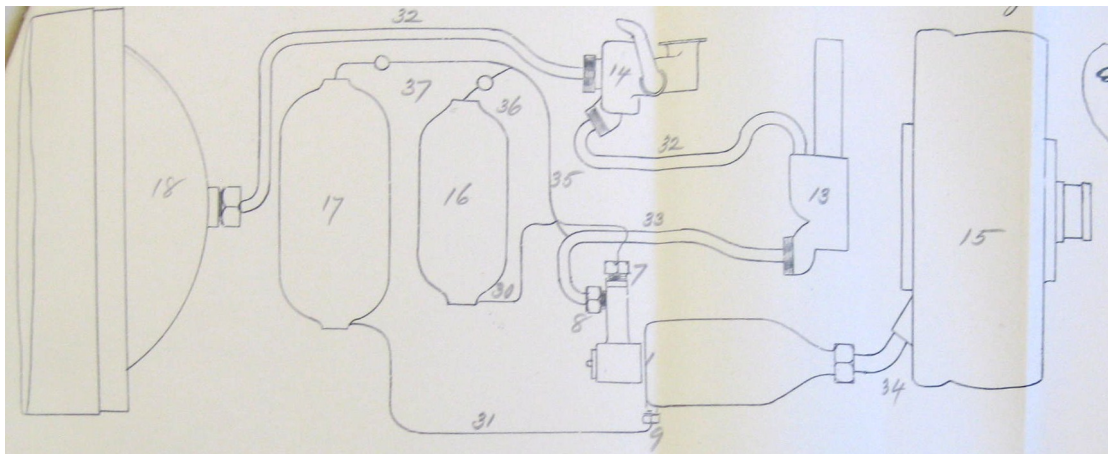


Figure A.12: Hardcastle’s wet outside superheater.³⁶

In Hardcastle’s wet outside superheater, air flowed from the air flask (“18”) through the valve group (including the reducing valve, “15”) and into the **combustion chamber** (“1”). Water was stored in the **water reservoir** (“17”) and fuel in the **fuel reservoir** (“16”), whence they passed through separate pipes (“30” and “31”) to the combustion chamber. Figure A.13 shows the combustion chamber in greater detail.

³⁶ Hardcastle’s secret GBP 27347/1908 (issued December 1908), Figure 2, copy in T 173/257, TNA.

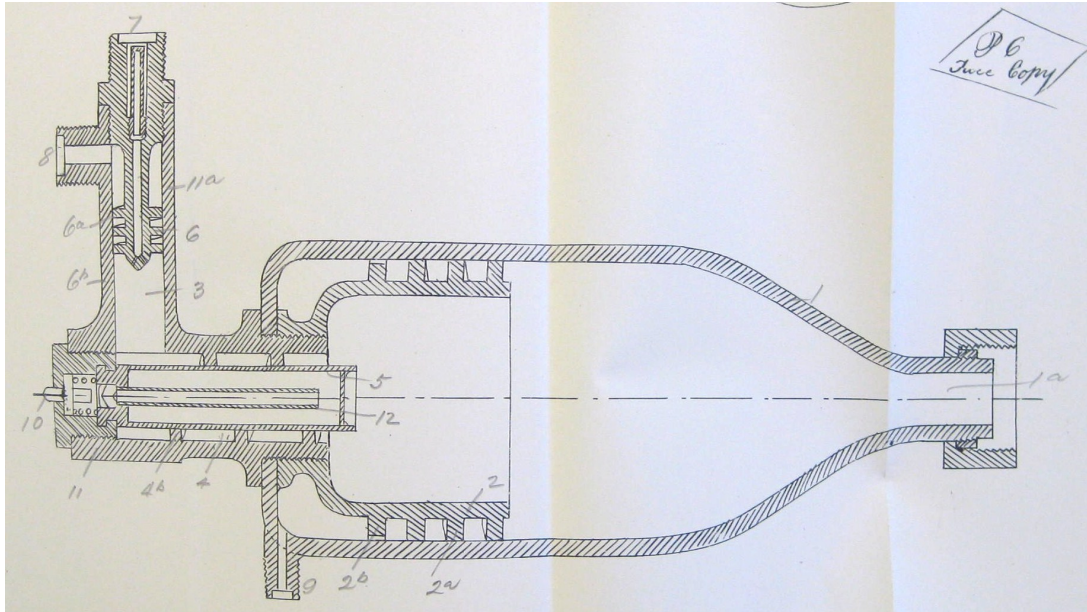


Figure A.13: Hardcastle's combustion chamber.³⁷

Air from the air flask and fuel from the fuel reservoir passed through two inlets (“8” and “7” respectively) into a **mixing and atomizing chamber** (“3”). On its way, **spiral ribs** (“6a”) around the **fuel sprayer** (“6”) gave a spiral motion to the air, which helped to atomize the air and support efficient combustion. From the mixing and atomizing chamber, the air and fuel mixture passed into an **annular passage** (“4”) around a burning **fire tube** (“12”), which vaporized it. The vaporized fluid passed into the combustion chamber proper, where it met water entering through a pipe (“9”) and converted it to steam. The combustion chamber consisted of an **outer casing** (“1”) and an **inner casing** (“2”), which carried **spiral ribs** (“2a”) on its exterior. These ribs gave a spiral motion to the steam, causing it to cling to the edges of the combustion chamber and thereby protecting the chamber from excessive temperatures. The steam also mixed with the fuel

³⁷ Hardcastle's secret GBP 27347/1908 (issued December 1908), Figure 1, copy in T 173/257, TNA.

and air mixture, reducing its temperature and increasing its volume before it exited the combustion chamber through a pipe (“1a”) and passed to the engine (“15” in Figure A.12).

As is evident from the pictures, the wet outside superheater was mechanically much more complicated than the dry outside or inside superheaters. Without any superheaters in the late 1890s, torpedoes struggled to make 29 knots for 1,000 yards. With wet superheaters on the eve of World War I, torpedoes could make 29 knots for nearly 7 miles, or almost 50 knots for 1,000 yards.

Appendix B: Note on Citations, United States

In general, I have observed Chicago style, but there are a few peculiarities of the Navy's filing system—specifically, those for the Bureau of Ordnance (BuOrd) and the Naval Torpedo Station (NTS), to whose files many of my citations refer—that Chicago does not cover.

The BuOrd files are held at the National Archives and Records Administration (NARA) in Washington, DC. NARA organizes its records according to a record group (RG)/entry (E)/box (B)/[and sometimes volume (V)/ and page (P)] system, going from largest unit to smallest. NARA's filing system does not coincide with the Navy's original filing system but is rather an artificial framework placed over it.

Until 1904, the BuOrd filing system for incoming letters worked as follows: the letters were stamped consecutively with what I will call "file numbers" (so as to distinguish them from the "LS numbers," discussed below), regardless of their subject matter—thus, for example, a letter on armor plating on 21 February 1895 might be stamped #1056/95 (the number after the slash indicating the year), and a letter on fuzes arriving the same day might be stamped #1057/95. The numbering started over each year. Letters relating to the same subject were often filed together, rather than individually, creating a bundle, which frequently contained correspondence from multiple years. Thus, for instance, there is a bundle on the initial negotiations for the Whitehead torpedo among

the Navy, the Bliss Company, and the Whitehead Company, in which the “parent” file, so to speak, is BuOrd 3134/90, a telegram from the Whitehead Company to BuOrd offering their terms. All the letters in the bundle are with 3134/90 in Box 91, rather than scattered among many different boxes as they would be if they were filed separately. A letter in the bundle with BuOrd 3134/90 would appear in my citations as, for example, “BuOrd 1980/91 with 3134/90.” BuOrd kept track of the ultimate locations of its files—whether they were filed by themselves, or with another letter—in a series of leather-bound letter registers.

In 1904, BuOrd’s filing system for incoming letters changed. Instead of assigning letters on the same subject with different file numbers and then bundling them together, BuOrd began assigning them the same file number plus an additional number to indicate their place in the sequence. Thus, for example, in a bundle on Bliss-Leavitt torpedoes under file number 15157, the first letter in the bundle was simply “15157,” the next incoming letter was “15157/1,” the next “15157/2,” and so on. After 1904, therefore, the number after the backslash in my BuOrd citations does not refer to the year but to the letter’s place in a sequence, and there is no need to say that a letter is “with” another letter, since the number before the backslash indicates the letter bundle.

Two important bundles at NARA are partly misfiled; these are noted in my citations. One is BuOrd 9404/00, relating to the development of the superheater, part of which is filed as 9404/01 in Box 479, instead of with 9404/00 in Box 434. The other is BuOrd 12865/03, relating to early Bliss-Leavitt torpedoes, part of which is filed as 12865/04 in Box 664, instead of with 12865/03 in Box 575.

Most of BuOrd’s correspondence was initiated by an incoming letter, but on the

rare occasions that BuOrd initiated correspondence, its out-going letter would also be stamped with its own number. Otherwise, out-going letters from BuOrd in response to incoming letters would receive the same file number as the incoming letters they responded to. In addition, all out-going letters—whether initiated by BuOrd or in response to incoming letters—received an “LS” number (presumably standing either for “Letter Series” or “Letter Sent”). These LS numbers were in the form “#A/#B”: #A, the number before the slash, was like a series number, and #B, after the slash, was a page number. Thus the reference for a one-page reply to the imaginary letter of 21 February 1895 above might look like BuOrd 1056/97-LS35/76, while the reference for a two-page reply might look like BuOrd 1056/97-LS35/77–78. (I have used hyphens to connect text and en-dashes to connect numbers, as per Chicago style.) The LS numbers ran independently of the file numbers discussed above and did not restart every year but instead when the page count for a particular series reached about 500. Press copies of BuOrd’s replies were kept on tissue-like paper and folded together with the letters that they replied to. While the BuOrd numbers are essential to tracking documents, the LS numbers are not.

In NARA storage, the boxes containing the BuOrd correspondence files are labeled with both the NARA box number and the original BuOrd file numbers contained therein. Technically, therefore, citing just the BuOrd file number would be enough to enable researchers to find the materials I used, but I give the box number as well in order for convenience’s sake. (The box number without the BuOrd file number is not enough, since within the boxes the organization is by file number.) Beginning with letters from 1912, NARA switched from filing letters in folded dockets to filing them flat, and began

renumbering its boxes; thus the box numbers in my citations go up to Box 1268 (from 1911) and then back down to Box 1 (from 1912).

My citations for the NTS records are different because these records are organized differently from NARA's. Technically the NTS records are part of the Naval War College's larger Naval Historical Collection (NHC), but they do not share the NHC filing system, and therefore they lack an NHC record-group number. Accordingly, in my footnotes, I have given them the archival designation "NTS" rather than "NHC." The only identifying information for the NTS records is a box number, of which there are about 90 for my period. These numbers proceed more or less in chronological order, though with some large exceptions—for instance, there is an important bundle of files from 1898 in Box 5, which otherwise contains files from 1890–1891. Unlike the other records in the NHC, the NTS boxes are stored off-site by a records management company, which gives its own chronologically meaningless number to each box. To request the boxes, one needs to have the storage company's number rather than the NHC's number. In my footnotes, I give both box numbers, in the format "NTS [NHC Box #]-[storage company #]" (using a hyphen instead of a slash so as not to indicate that the relationship is hierarchical).

Like BuOrd, the NTS also maintained a filing system whereby it stamped each letter with a file number. I note them occasionally. Unfortunately, there are no surviving letter registers from the NTS. Aside from the boxes being in loose chronological order, there is no organization to the NTS records. There are some bundles of related correspondence scattered throughout the boxes, indicating that they were better organized at one time, but these can only be discovered by chance, not by reference to a letter

register as with the BuOrd records.

I occasionally found copies in the BuOrd records of files that I had seen in the NTS records. Where this was the case, I have let the BuOrd citation govern, since the BuOrd files are better-organized and more accessible, while also noting the NTS box in which a copy exists.

Appendix C: Note on Citations, Great Britain

As with the citations in my American chapters, the notes in my British chapters reflect a few archival and file idiosyncrasies in need of explanation.

To begin with, citations of the Annual Reports of the Torpedo School (*Vernon*) and to the various “Paper[s] prepared by the Director of Naval Ordnance and Torpedoes for the Information of his Successor” do not provide archival references because I got all of my copies from Jon Sumida. That said, copies of the Annual Reports can be found in ADM 189 at The National Archives in Kew; at the Admiralty Library in Portsmouth; at the HMS *Collingwood* Communications and Radar Museum in Portsmouth; and at the Hampshire Record Office, in Winchester. Copies of the “Papers prepared by the DNO” can be found at the Admiralty Library in Portsmouth.

I spent the majority of my time in England at The National Archives (TNA), where the two main record groups I used were ADM 1, the Admiralty Secretariat files, and ADM 116, the Admiralty case files. Both of these groups generally consist of two references numbers, the class number (1 or 116) followed by a sub-dividing number (a box number, in the case of ADM 1, and a volume number, in the case of ADM 116), but there is occasionally a third sub-dividing number. Files in ADM 1 come in brown boxes which contain multiple docket; thus it is necessary to specify not only the box number but also the docket, which is conventionally done by the title on the first page in the

docket. For instance, references for ADM 1 appear in the format, “Docket ‘Proposed Experiments with the view of finding the best means of protecting bottoms of ships against explosive effects of Torpedoes,’ ADM 1/7687, TNA.” Files in ADM 116 generally require no identification beyond the volume number, because the volumes are generally not further sub-divided—which is unfortunate, since some of the volumes are huge. Thus references to ADM 116 appear in the format, “ADM 116/518”

In my citations for Admiralty records, I have included not only the archival reference, but the Admiralty’s original file numbers. The latter, though perhaps not strictly necessary, are extremely helpful in attempting to navigate Admiralty correspondence, because Navy officials used them as a sort of shorthand, often without any other information (like an author or date), to refer to files relevant to the subject at hand. For instance, one frequently sees the formulation, “On G588/97, it was decided that...,” and it helps to know what G588/97 was.

I also relied heavily on Ships’ Covers (SC). These belong to the National Maritime Museum, Greenwich, but are held at the Brass Foundry of Woolwich Arsenal. Ships’ Covers are bound volumes divided into numbered folios; both the volume number and the folio number are necessary to identify material. Page numbers are not used. The bound volumes have two sets of reference numbers, which can be translated from one to the other. One is the original Admiralty number, conventionally preceded by the initials “SC” (for Ships’ Cover) to indicate that the original Admiralty reference is being used. The other is a number assigned by The National Archives, which once held the Covers as record group ADM 138; the TNA numbers are in the format “ADM 138/37,” for example. A full reference (with “F” for “folio”) appears in the format “SC146/F8” or “ADM

138/37/F8.” The staff at the Brass Foundry can find volumes by either the original Admiralty reference or the later TNA reference, so I have supplied only the former.

The *Principal Questions Dealt with by the Director of Naval Ordnance (PQDNO)* formed another major source. These were bound, printed volumes dealing, as the title indicates, with important questions dealt with by the DNO. Copies can be seen at the Admiralty Library in Portsmouth (where they form call number Ja 397), in the Priddy’s Hard archive at the Hampshire Record Office in Winchester (where they form record group 109M1/PQ), and at The National Archives (where they are in record group ADM 256). I saw most copies at the Admiralty Library, and only a few at TNA.

In addition to the archival reference information to find a volume, the *PQDNO* require additional information to navigate within volumes. Each volume, whose pages were numbered, was divided into consecutively numbered “minutes.” These *PQDNO* minute numbers bore no relation to the original Admiralty minute numbers, which were often given in the margin. I have given my citations in the format “PQ/last two digits of year/minute number/page number.” Thus, for example, a citation to *PQDNO* minute 1207, on page 107, in the 1902 volume appears as “PQ/02/1207/107.” In terms of ease of finding the source, giving both the *PQDNO* minute numbers and page numbers is redundant, but I have included both because page numbers are conventional, and minute numbers are helpful for the same reason that the original Admiralty minute numbers are helpful—namely, they were used as shorthand at the time, for instance in the formulation, “See previous [PQ] Minute 2217.” (*PQDNO* page numbers were not used as shorthand.)

The *PQDNO* did not always reproduce minutes with perfect faithfulness—I noticed one originally multi-paragraph minute that the *PQDNO* compressed to “Concurs

generally.” The *PQDNO* are wonderfully convenient and often reliable—and they provide insight into what the DNO considered important—but the originals are more reliable.

Appendix D: List of Torpedo Marks and Contracts, United States

The information contained in this table comes from correspondence and contracts in the records of the Bureau of Ordnance (RG74/E25, NARA) and the Naval Torpedo Station.

The table uses the following abbreviations:

BL = Bliss-Leavitt

Conv = converted to

Diam. = Diameter

Elec Boat Co = Electric Boat Company

Expl = experimental

Mod = Modification

NTS = Naval Torpedo Station

W = Whitehead

W Co Wey = Whitehead Company Weymouth

#	Source	Length	Diam.	Mark	Order Date
100	Bliss Co	3.55m	18"	W Mk I	19 May 1891
50	Bliss Co	3.55m	18"	W Mk II	5 Dec 1894
100	Bliss Co	5m	18"	W Mk I [conv to Mod 1]	21 Oct 1896
50	Bliss Co	3.55m	18"	W Mk III	22 Oct 1896
9	Bliss Co	3.55m	18"	W Mk III	30 Mar 1897
25	Bliss Co	5m	18"	W Mk I [conv to Mod 1]	10 Dec 1897
50	Bliss Co	3.55m	18"	W Mk III	27 Apr 1898
30	Bliss Co	5m	18"	W Mk II	21 Feb 1900
2	Bliss Co	5m	21"	BL Mk I Mod 1	28 Dec 1903
50	Bliss Co	5m	18"	BL Mk III [conv to Mod 1]	11 Jan 1904
50	Bliss Co	5m	18"	BL Mk IV	29 Mar 1905
50	Bliss Co	5m	21"	BL Mk I [conv to Mod 1]	22 Nov 1905
50	Bliss Co	5m	21"	BL Mk II Mod 1	ditto
200	Bliss Co	5m	21"	BL Mk II	ditto
50	W Co Wey	5.2m	18"	W Mk V	3 Jul 1907
64	W Co Wey	5.2m	18"	W Mk V Mod 1	7 Jul 1908
66	W Co Wey	5.2m	18"	W Mk V Mod 2	ditto
20	NTS	5.2m	18"	W Mk V [Mod 1?]	1 Jan 1909
42	Bliss Co	5m	21"	BL Mk III	20 Apr 1909

60	Bliss Co	5m	21"	BL Mk III	16 Jun 1909
100	Bliss Co	5.2m	18"	BL Mk VI	22 Oct 1909
25	NTS	5.2m	18"	W Mk V Mod 3	1 Feb 1910
24	Bliss Co	5m	21"	BL Mk III	27 Jul 1910
30	NTS	5.2m	18"	W Mk V Mod 3	20 Oct 1910
32	Bliss Co	5m	21"	BL Mk III	24 Dec 1910
50	Bliss Co	5m	21"	BL Mk III	24 Dec 1910
1	Elec Boat Co	5.2m	18"	expl	17 Jan 1911
1	Elec Boat Co	21'	21"	expl	23 Jan 1911
20	NTS	5.2m	18"	W Mk V Mod 3	11 Feb 1911
1	Bliss Co	5.2m	18"	expl	16 Feb 1911
1	Bliss Co	21'	21"	expl	16 Feb 1911
180	W Co Wey	5.2m	18"	W Mk V Mod 4	29 Mar 1911
50	W Co Wey	5.2m	18"	W Mk V Mod 4	25 Oct 1911
2	Elec Boat Co	5.2m	18"	W Mk V conversion	29 Dec 1911
75	NTS	5.2m	18"	W Mk V Mod 5	30 Dec 1911
1	Elec Boat Co			shop license	3 Apr 1912
120	Bliss Co	5.2m	18"	BL Mk VII	12 Jun 1912
120	Bliss Co	5.2m	18"	BL Mk VII Mod 1	26 Jun 1912
50	Bliss Co	21'	21"	BL Mk VIII	26 Jun 1912
8	Bliss Co	21'	21"	BL Mk VIII	9 May 1913
144	Bliss Co	5.2m	18"	BL Mk VII Mod 1	20 Jun 1913
60	Bliss Co	5m	21"	BL Mk IX	20 Jun 1913
20	Bliss Co	5m	21"	BL Mk IX	21 Jun 1913
90	NTS	5.2m	18"	BL Mk VII Mod 2	22 Jul 1913
198	Bliss Co	21'	21"	BL Mk VIII	27 Mar 1914
70	Bliss Co	5m	21"	BL Mk IX	6 Apr 1914
96	Bliss Co	21'	21"	BL Mk VIII	9 Apr 1914
200	NTS	5m	21"	BL Mk IX Mod 1	18 Jul 1914

Appendix E: List of Torpedo Marks and Contracts, Great Britain

The information contained in this table comes primarily from the Annual Reports of the Torpedo School, HMS *Vernon*. It is full of holes and unreliable compared to the table in Appendix D, because most of the relevant contracts and correspondence on the British side have not survived. I have not included the occasional small orders placed with Greenwood & Batley.

The exchange rate during this period was roughly \$5 = £1.

The table uses the following abbreviations:

conv = conversion

Diam. = Diameter

expl = experimental

FY = Fiscal Year

L = long

RGF = Royal Gunpowder Factory

S = short

W Co Wey = Whitehead Company Weymouth

FY	Diam	Mark	Total	Sub-total	RGF	Price	W Co Wey	Price
1891/2	14"		302	102	52		0	
	18"			200	100		100	
1892/3	14"	RGF Mk VIII			96	£297.00		£340.00
	18" L							
	18" S						30	£385.00
1893/4	14"	RGF Mk IX			100		0	
	18" L	RGF Mk II			30		0	
	18" S				19			
1894/5	14"	RGF Mk IX			100			
	18" L	RGF Mk II			62			
	18" S							
1895/6	14"	RGF Mk IX	429	180	30		150	£320.00
	18"	RGF Mk IV		249	189	£392.00	60	£400.00
1896/7	14"	RGF Mk IX	605	240	120		120	£350.00
	18"	RGF Mk IV		365	215		100	£430.00
1897/8	14"	RGF Mk IX	410	80	80		0	

	18"	RGF Mk IV		330	180		100	
1898/9	14"	RGF Mk X	450	50	50		0	
		Wey Mk I		100	0		100	
	18"	RGF Mk IV		300	150		100	
1899/0	14"	RGF Mk X	465	130	130		0	
		Wey Mk I		100	0		100	
	18"	RGF Mk IV		235	85		100	
1900/1	14"	RGF Mk X						
		Wey Mk I						
	18"	RGF Mk IV		225	200	£408.00	200	£455.00
1901/2	14"	RGF Mk X	490	140	140		0	
		Wey Mk I		85	0		85	
	18"	RGF Mk IV		265	5		210	
1902/3	14"	RGF Mk X	235	51				
		RGF Mk X*		59				
	18"	RGF Mk V		100				
		RGF Mk V*		25				
1903/4	14"	RGF Mk X*	315	100				
		RGF Mk XI						
	18"	RGF Mk V*		215	65		68	82
1904/5	14"	RGF Mk XI	458	77				
	18"	RGF Mk V*		106				
				175				
		Fiume Mk III		100				
1905/6	14"	Mk XI	607	54				
	18"	RGF Mk V*		111				
				146				
				11				
		RGF Mk VI		24				
				25				
				0				
		Fiume Mk III**		100				
		Fiume Mk III*		22				
	Fiume Mk III*	114						
1906/7	14"	n/a	551	0				
	18"	RGF Mk VI		31				
				336				
				144				
		Fiume Mk III		40				

1907/8	18"	RGF Mk VI*	113	7				
				74				
		RGF Mk VII [H]		6				
		Fiume Mk III**		24				
		RGF Mk VI* H	conv	17				
			conv	12				
1908/9	18"	RGF Mk VII [H]	139	79				
		RGF Mk VII* [H]		40				
		Wey Mk I [H]		20				
		RGF Mk VI* H	conv	17				
		Fiume Mk III** H	conv	38				
		Fiume Mk III** H	conv	12				
1909/10	21"	RGF Mk I	expl	2				
	18"	RGF Mk VII*	228	118	58		60	
	21"	RGF Mk I		106				
		RGF Mk II		4	4			
18"	RGF Mk VI** H	conv	143					
1910/11	18"	Mk VII*-VII*	808	243	183		60	
	21"	RGF Mk I		106	106		0	
		RGF Mk II		459				
1911/12	18"	Mk VII*	1138	280	183		97	
		Wey Mk I*		84	0		84	
	21"	Mk I		106	106		0	
		Mk II		668	267		401	
1912/13	18"	Mk VII* - VII**	987	125	25		100	
		Wey Mk I*		118	0		118	
	21"	Mk I-II*		56	56		0	
		Mk II-II*		688	308		380	
		Fiume	expl	2	0		2	
1913/14	18"	Mk VII* - VII**	1003	243	77		166	
		Wey Mk I*		34	0		34	
	21"	Mk I*		16	16		0	
		Mk II*		710	316		394	
	18"	Mk VIII	expl	2	2		0	

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