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Abstract

In 1912, the Admiralty adopted a secret tactical system that was supposed to enable a British battle fleet to destroy a German opponent through five minutes shooting at medium range. The quick destruction of the Germans was to be followed by a simultaneous turn away by the British, which would counter the threat of enemy torpedoes. Belief in this scheme interfered with the development of equipment and methods suitable to battle fleet action that involved long range and maneuver while shooting, which set the stage for much that went wrong for the Royal Navy at the battle of Jutland.

> *When you have eliminated the impossible, whatever remains,* however improbable, *must be the truth.*
>
> —Sir Arthur Conan Doyle (1890)

> *There's nothing more misleading than an obvious fact.*
>
> —Arturo Pérez-Reverte (1990)

IN 1916, a British fleet that was superior in numbers and much more heavily armed than its German opponent failed to achieve a decisive victory at the battle of Jutland. It also suffered greater losses than it inflicted. Many attributed this unsatisfactory outcome to defective

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British tactics and command.[1] Arthur J. Marder, the author of the standard scholarly assessment of Jutland, reached the following conclusions. The Royal Navy lacked "a generally accepted, comprehensive, authoritative tactical doctrine in 1914" as a consequence of not having studied battle fleet tactics systematically before the outbreak of the First World War.[2] To deal with this situation, Admiral Sir John Jellicoe, who became commander-in-chief of the Grand Fleet with the onset of hostilities, formulated the Grand Fleet Battle Orders (GFBOs), which embodied three main conceptions: "a subordination of the offensive spirit to defensive precautions, especially against the torpedo; the single line, parallel course, and long range of the plan of battle; and centralized command."[3] These characterizations were based upon the following propositions. The only remedy to the torpedo threat was to fight outside its effective range.[4] A turn away from the enemy was intended as a response to torpedoes launched by destroyers.[5] Fighting between two lines of battleships would be a "hammer-and-tongs affair" that offered "no opportunities for tactics of surprise."[6] Firing at long range—that is, distances from ten thousand yards to a normal maximum of eighteen thousand yards—represented a service consensus reached before the war.[7] And finally, the chief point of tactical debate within the Royal Navy was the question of centralized versus decentralized command—that is, whether the battle fleet should move and fight together in close order or be divided into small groups that acted independently.[8]

Marder's findings, however, are difficult to accept for several reasons. In the first place, the Royal Navy expended considerable energy on battle fleet tactical experiments prior to 1914. In the second place, the portrayal of Jellicoe's tactical outlook as essentially cautious and defensive is inconsistent with his prewar reputation as a brilliant and daring fleet

1. Carlyon Bellairs, *The Battle of Jutland: The Sowing and the Reaping* (London: Hodder and Stoughton, 1920), 270–71; Langhorne Gibson and Vice Admiral J. E. T. Harper, *The Riddle of Jutland* (New York: Coward-McCann, 1934), 379; Holloway H. Frost, *The Battle of Jutland* (Annapolis, Md.: United States Naval Institute, 1964; first published 1936), 515–18; Geoffrey Bennett, *The Battle of Jutland* (London: B. T. Batsford, 1964), 169–73; and Andrew Gordon, *The Rules of the Game: Jutland and British Naval Command* (Annapolis, Md.: Naval Institute Press, 1996), especially ch. 25.

2. Arthur J. Marder, *From the Dreadnought to Scapa Flow: The Royal Navy in the Fisher Era, 1904–1919,* 5 vols. (London: Oxford University Press, 1961–70; vol. 3, 1966; rev. ed. vol. 3, 1978), rev. ed., 3:4.

3. Marder, *Dreadnought to Scapa Flow,* rev. ed., 3:5.

4. Ibid., 3:17.

5. Ibid., 3:9.

6. Ibid., 3:11–12.

7. Ibid., 3:17–18.

8. Ibid., 3:18–23.

commander comparable to Horatio Nelson. In the third place, the Royal Navy's procurement of fire control equipment, development of gunnery technique, and conduct of firing practice from 1912 to 1914 were all directed towards the maximization of performance at medium ranges—that is, seven thousand to ten thousand yards—which were well within the reach of fast-moving torpedoes. And in the fourth place, disagreement within the Royal Navy over tactics was not just about the question of fleet command and control, but also was concerned with the relative merits of deliberate shooting at long range as opposed to rapid fire at medium range. These propositions raise the following major questions. What did the Royal Navy learn about battle fleet tactics before the First World War and what was the effect of such knowledge on later practice? Did Jellicoe intend to fight and win a decisive fleet engagement while in charge of the Grand Fleet and if so, how? Why did British admirals believe that medium-range actions were practicable in spite of the torpedo threat? And finally, what was the precise tactical significance of big-gun accuracy and rate of fire?

Neither the prewar Home Fleets General Orders (HFGOs) nor the wartime Grand Fleet Battle Orders give a complete picture of British tactical thinking. To answer the questions just stated, therefore, required the reconstruction of highly classified tactical instructions that do not appear to have been preserved and what may have been no less confidential unwritten tactical understandings. This task was accomplished through the study of the documentary record of British naval gunnery and torpedo development before and during the war, the performance characteristics of naval heavy artillery and torpedoes under the conditions that British admirals thought would arise in a fleet action, fragments of British intelligence about German gunnery capabilities and tactical intentions, and revealing statements by senior naval officers and officials.[9] The objective of this article is to describe the tactical mind of the Royal Navy's *responsible leadership* between 1912 and 1916 in order to explain major shortcomings in the capabilities of the Grand Fleet exposed when it encountered the Germans at Jutland. The main argument is that these defects were not the result of a failed attempt to develop tactics for a long-range battle, but of a successful effort to prepare tactics for a medium-range battle that might have occurred but did not. The story has not been told before because influential men had

9. For the methodology employed in this article, see David Alan Rosenberg, "Process: The Realities of Formulating Modern Naval Strategy," in James Goldrick and John B. Hattendorf, eds., *Mahan Is Not Enough: The Proceedings of a Conference on the Works of Sir Julian Corbett and Admiral Sir Herbert Richmond* (Newport, R.I.: Naval War College Press, 1993): 141–75; and Jon Tetsuro Sumida, "Sir John Fisher and the *Dreadnought*: the Sources of Naval Mythology," *Journal of Military History* 59 (October 1995): 619–38.

much to hide. The present effort is thus meant to be the critical history of the Admiralty's preparations to fight a general fleet engagement that was beyond the power of the post–First World War British naval staff—or perhaps any naval staff under similar politicized circumstances—to produce and ponder.[10]

The Long-Range Torpedo Threat

The displacement of predreadnought by dreadnought capital ships coincided with improvements in torpedoes that threatened the tactical viability of the line of battle. In 1906, the year in which the first all-big-gun battleship was commissioned, the most up-to-date torpedoes were 18 inches in diameter. These weapons, when set to run at thirty knots, had a maximum range of 5,000 yards. In late 1908, secret trials revealed that an experimental 21-inch torpedo could travel 7,500 yards at thirty knots, and that a lengthened 21-inch model might have a reach of 12,000 yards at the same speed.[11] Even longer ranges were possible at lower speed settings. Both the Assistant Director of Torpedoes and the Director of Naval Ordnance thus argued that in the near future, torpedoes launched from battleships would be capable of causing serious damage to an enemy fleet at distances that were greater than the effective range of heavy-caliber artillery.[12] Changes in capital ship design that reflected recognition of the increased potency of torpedoes soon followed. From 1909 onwards, new British battleships incorporated provision for 21-inch rather than 18-inch torpedoes. By 1914, the short Mark I model had been replaced by the lengthened Mark II, which was set to run at twenty-eight knots to a maximum distance of 10,000 yards.[13] Capital ships from the 1911 program onwards were given an additional torpedo tube on

10. This article is an expanded and revised version of a paper given for a restricted workshop of the Royal Australian Navy's Maritime Studies Program at H.M.A.S. *Creswell,* Jervis Bay, 26–27 July 1999. I am indebted to Arthur Eckstein, James Goldrick, Andrew Gordon, Paul Halpern, Paul Kennedy, Ruddock Mackay, and Dennis Showalter, for their reading of the manuscript in draft and helpful advice. Nicholas Lambert, in particular, provided a great deal of information from his own research, and repeatedly scrutinized the text in all stages of writing, offering much needed critical perspective.

11. Captain Bernard Currey, Assistant Director of Torpedoes (ADT), Memorandum, 17 December 1908, Ship's Cover *Australia/New Zealand,* 324, National Maritime Museum annex, Woolwich.

12. Minute by Currey, ADT, 17 December 1908, and Comment by Captain R. H. S. Bacon, 17 December 1908, in Ship's Cover *Australia/New Zealand,* 324, National Maritime Museum annex, Woolwich.

13. Handwritten table of battle cruiser force torpedo outfits attached to "First Fleet Temporary Memorandum," 20 May 1914, DRAX 1/10, Drax Papers, Roskill Archive Centre, Churchill College, Cambridge; and Great Britain, Admiralty, Gun-

each broadside, which doubled their torpedo-power in a fleet engagement.[14] In 1912, the adoption of precision-adjustable gyroscopes allowed torpedoes fired from fixed angle torpedo tubes to be aimed at targets across a wide arc.[15] The torpedoes of foreign powers were little less capable than those of the Royal Navy. The German G/7 model 19.7-inch torpedo, which was adopted for capital ships during the winter of 1913–14, had a maximum range of 10,178 yards when set at twenty-seven knots. It was also fitted with an adjustable gyroscope.[16]

The Royal Navy had responded to previous increases in the range of torpedoes by extensions in the range of accurate gunnery. This was supposed to enable a battle line moving on a straight and unchanging course to engage an enemy moving similarly in the same direction at distances beyond the reach of underwater ordnance. From March 1909 to March 1911, Admiral Sir William H. May conducted a series of experiments in the Home Fleet that, among other things, addressed the tactical problems posed by longer-range torpedoes fired from battleships.[17] May assumed that in the future, the British battle fleet would consist of dreadnoughts only, firing would be deliberate (that is, one projectile per gun per minute), the maximum gun range in clear weather would be ten thousand yards, and torpedoes fired from battleships would be capable of thirty knots at ranges of seven thousand yards.[18] In addition to exercises that dealt with the tactical characteristics of the single-line-ahead formation, May's work investigated the possibilities of dividing the fleet into small independently maneuverable units, a form of deployment that allowed what was known as "divisional attack."[19] Such a system, May argued, was more likely to produce a decisive victory than the single line ahead because "detachment of command lends itself directly to offence." But May also maintained that a subdivided fleet was less vulnerable to

nery Branch, *Notes on Naval Guns and Torpedoes, Their Mountings, Stores, and Fittings* (1914), 96, ADM 186/367, Public Record Office, Kew. (Hereafter, ADM refers to documents in the Public Record Office, Kew, England.)

14. R. A. Burt, *British Battleships of World War One* (Annapolis, Md.: Naval Institute Press, 1986), 193, 212, 257, 276.

15. Great Britain, Naval Torpedo School, *Thirty-Third Annual Report on the Instruction and Practice of Torpedo Warfare in H.M. Navy 1912* (London: HMSO, 1913), 15–16, Naval Library, Ministry of Defence, London (hereafter, Naval Library).

16. Eberhard Rössler, *Die Torpedo der deutschen U-Boote: Entwicklung, Herstellung und Eigenschaften der deutschen Marine-Torpedos* (Herford: Koehlers Verlagsgessellschaft, 1984), 42–43.

17. Nicholas Lambert, *Sir John Fisher's Naval Revolution* (Columbia: University of South Carolina Press, 1999), 221, 370 n. 172.

18. Great Britain, Admiralty, *Notes on Tactical Exercises. Home Fleet. 1909–1911* (19 September 1911), 2, 3, 7, Naval Library.

19. Or alternatively, "variable course theory," for which see Lieutenant R. A. R. Plunkett, *Modern Naval Tactics, 1909* (London: HMSO, 1910), 52, Naval Library.

torpedoes. "A long line cannot be missed by a torpedo," he observed

> if the director will bear on any part between the bow of the leader and the stern of the rear ship, and the chance of hitting one of the ships in the line depends on the closeness of the formation, but small bodies of ships offering smaller targets may be missed altogether. . . . This factor is one of great importance in view of the development of the long-range torpedo.[20]

May recognized that while "theoretically the divisional attack may seem simple enough," it was "found to be much more difficult in practice." He nonetheless called for further investigation of its possibilities.[21]

One of the difficulties that May must have had in mind was the complication of gunnery by changes in course. When the distance to the target was greater than point-blank, the range information needed to set sights for elevation had to be obtained through a combination of optical range-finding, calculation of the change of range rate, and the inputting of the observed range and calculated change of range rate on a machine that generated a steady stream of ranges. Mechanical range generation was essential because when courses were not parallel, the pace at which the range changed could outstrip the speed of optical range-taking. But because observed ranges were frequently inaccurate, mechanically generated range estimates were likely to be wrong at first, and had to be corrected through observation of the fall of shot. The entire process took time (see Appendix, "Gun-layer Permissive or Director Salvos"), and had to be restarted whenever the firing ship changed course. As a consequence, shifts in the direction of travel every few minutes made hitting practically impossible. Captain Frederick Ogilvy, a highly respected gunnery expert and an enthusiastic proponent of divisional attack,[22] thus encouraged Arthur Hungerford Pollen, a civilian inventor, to develop a mechanical system of generating sight-setting data that was not disruptable by alterations in course—that is, a fire control system that would be "helm free." Ogilvy's sudden death in late 1909, however, deprived the divisional attack school of a strong leader and Pollen's work of powerful support.[23] In 1911, a downturn in both battle practice and gun-layer's test scores, and other difficulties, seems to have provoked a serious crisis in confidence within the Royal Navy about the practicability of accu-

20. *Notes on Tactical Exercises. Home Fleet. 1909–1911,* 237.

21. Ibid.

22. Gordon, *The Rules of the Game,* 360.

23. Jon Tetsuro Sumida, *In Defence of Naval Supremacy: Finance, Technology and British Naval Policy, 1889–1914* (Boston: Unwin Hyman, 1989; paperback edition, Routledge, 1992), 171–76.

rate shooting under difficult conditions.[24] And in the summer of 1912, shortcomings in tactical communications may have been the cause of a breakdown in the control of the fleet when divisional attack was attempted in maneuvers.[25] By the time Pollen had perfected the leading elements of his "helm-free" mechanized system of fire control in the fall of 1912, divisional attack had lost considerable ground.

Prince Louis of Battenberg, the Second Sea Lord, however, was deeply troubled by the drawbacks of steaming on a straight course in a fleet engagement. On 25 November 1912, Battenberg warned Winston Churchill, the First Lord, that the threat posed by long-range torpedoes launched from battleships, as well as those from submarines and destroyers, was extremely dangerous. A British battle fleet, Battenberg argued,

> can offer no defence against being hit [by battleship-launched torpedoes] other than that provided by the squadron being kept out of torpedo range. This will be most difficult in view of the advent of the angle gyro, and the necessity of keeping within gun range and ships are certain to come within range at some period of the action.

Battenberg observed that in the case of battleship-launched torpedoes,

> there is no doubt but that of all the torpedoes fired a definite percentage will hit. A line of ships in close order is so long that if the enemy knows the course and speed approximately a very large proportion of all torpedoes fired will strike that line . . . . I believe that the percentage of hits expected may be deduced from last year's torpedo returns and that about 30% of hits were made under the conditions of long range firing.[26]

Churchill replied that he agreed with Battenberg's remarks and that the "weakness of the big ship in the face of the under-water attack is mercilessly exposed."[27]

24. Jon Tetsuro Sumida, "The Quest for Reach: the Development of Long-Range Gunnery in the Royal Navy, 1901–1912," in Stephen D. Chiabotti, ed., *Tooling for War: Military Transformation in the Industrial Age* (Chicago: Imprint, 1996), 69.

25. For the failure of divisional attack in inter-fleet maneuvers in 1912, see Admiral Frederic Dreyer, *The Sea Heritage: A Study of Maritime Warfare* (London: Museum Press, 1955), 68. For the unreliability and inadequate numbers of "short distance" wireless sets, which were essential for communications when divisional attack resulted in the separation of the divisions, see *Thirty-Third Annual Report on the Instruction and Practice of Torpedo Warfare in H. M. Navy 1912,* "Wireless Telegraphy Appendix," 8. For the unsatisfactory outcomes when divisional attack was tried in staff "paper" exercises, see Anonymous [Captain W. R. Hall], "The Fleet in Action," *Naval Review* 2 (1914): 57. For the authorship of *Naval Review* articles, which were published anonymously, see James Goldrick, "Author List for the Naval Review, 1913–1930," in Goldrick and Hattendorf, eds., *Mahan is Not Enough,* 344–46.

26. Battenberg to Churchill, 25 November 1912, in *Important Questions dealt with by D.N.O.; copies, précis, etc.,* vol. 2, *1913,* Naval Library.

27. Churchill to Battenberg, 30 November 1912, in *Important Questions dealt with by D.N.O.,* vol. 2, 1913.

Such pessimism, however, was largely dispelled by the deliberations of the War Staff and Board of Admiralty that took place between mid-1912 and early 1913. These discussions reached conclusions about operational procedures for an integrated combined arms force consisting of capital ships, cruisers, and destroyers, which was known as a "grand fleet of battle."[28] According to this scheme, light cruisers and destroyers would prevent fast surface craft from launching effective torpedo attacks before the opposing battle lines engaged, while secondary batteries and big guns firing shrapnel would counter flotilla that attacked by moving through the enemy battle line during the main fighting between battleships.[29] The tactical function of cruisers and destroyers, and battleship antitorpedo craft artillery, was not merely to protect the battleships from harm, but to enable them to steam on a straight course without having to maneuver to avoid torpedoes from enemy flotilla, which was essential for accurate shooting given existing methods of gunnery. No active remedy for attacks from submarines existed, but their lack of speed, which prevented them from accompanying a battle fleet, meant that the threat posed by such warships in a general engagement was probably regarded as negligible, at least for the time being. This left the immediate and major danger posed by long-range torpedoes launched by enemy battleships. But here, the advent of new technology offered the Royal Navy the alluring prospects of not only greater big-gun hitting power, but tactics that neutralized the threat of torpedoes fired from an opposing line of battle.

The British Naval Gunnery Revolution of 1912–14

By 1912, the standard means of correcting sight settings through the observation of the fall of shot was based upon firing several guns more or less simultaneously in what was known as a salvo. (See Appendix, "Gunlayer Permissive or Director Salvos.") Spacing salvos produced groups of splashes that could be distinguished from one another, which facilitated accurate identification and evaluation. But salvo firing had several drawbacks. First, gun-laying errors occasionally meant that the sight setting and the actual pointing of the guns did not correspond. When this happened, the correction of sights on the basis of spotting shell splashes

28. Lambert, *Fisher's Naval Revolution,* 216.

29. Henry G. Thursfield, "Development of Tactics in the Grand Fleet: Three Lectures," delivered 2, 3, 7 February 1922, 2–3, in THU 107, Thursfield Papers, National Maritime Museum, Greenwich; Edgar J. March, *British Destroyers, 1892–1953* (London: Seeley Service, 1966), 160–62; and Nicholas A. Lambert, "'Our Bloody Ships' or 'Our Bloody System'? Jutland and the Loss of the Battle Cruisers, 1916," *Journal of Military History* 62 (January 1998): 36.

would throw guns off the target. Second, heavy-caliber artillery salvos were fired with guns whose elevation and train were fixed in such a way that they were correctly pointed at the target only for a few seconds at the end of the ship's roll and when its longitudinal axis was aligned with its mean course, which was also more or less periodic because of yaw. For this reason, even guns that were ready to fire could not be discharged until the ship's roll and yaw had brought them into the right position, which could reduce the quickness of shooting. Third, the need to shoot several guns together restricted the rate of fire to the slowest loading team. And fourth, the combination of the time it took for the shells to travel to the target, and the time required by observers to communicate their spotting information to the gunners, added further delay.[30] The inaccuracy and slowness of deliberate firing with salvos meant that a gunnery exchange was likely to take some time before critical damage could be inflicted.

Repeated aim correction through salvo firing was indispensable so long as optical range-finding was unreliable. In 1912, however, British capital ships began to be equipped with a range-finder on a gyroscopically stabilized range-finder mounting. The new mounting, which had been invented by Pollen and manufactured by his Argo company, increased the rate of range-taking by as much as a factor of five, and improved the accuracy of the readings as well. In addition to the stabilized range-finder, which was positioned in the superstructure, all British dreadnoughts before the 1910–11 program received an unstabilized instrument mounted on the top of the forward gun turret, while units from the 1910–11 program onwards were given range-finders on the top of every turret.[31] The improvements in the provisions for range-finding were magnified by the advent of a system of fire control invented by Commander Frederic Dreyer. In early 1910, Dreyer had built a machine that marked range observations on a sheet of paper, which could then be averaged quickly to produce what was called a "mean range-finder range of the moment." The average of several plotted observed ranges was likely to be more accurate than a single observed range. If firing ship and target were moving in the same direction on courses that were straight and parallel, which would result in the distance between them remaining constant, sights could be set with the mean range-finder range of the moment. If courses were straight but not parallel, and the range thus changing, sights could be set by ranges produced by a mechanical range-generator that had been fed the mean range-finder range of the moment and a change of range rate obtained through a simple measurement of

30. Sumida, "Quest for Reach," 53–54, 68–69.

31. Great Britain, Admiralty, Gunnery Branch, "Paper Prepared by the Director of Naval Ordnance and Torpedoes for the Information of His Successor" (June 1912), 7, Naval Library.

the range plot. In 1911, Dreyer combined his plotting mechanism with a range-generating machine that he had devised after inspection of an instrument being developed by Pollen. In 1912, the Admiralty adopted the arrangement, which was known as the Dreyer table, in place of the complete "helm-free" Pollen system. By the end of 1913, nine battleships and three battle cruisers had received this equipment. Pollen's range generator, however, had features that made it attractive in spite of the fact that it was much more expensive than Dreyer's simpler derivative, and thus half of the tables were fitted with the device, which was known as the Argo clock.[32]

When ranges were no more than ten thousand yards, which was the maximum optimal range of the nine-foot base range-finders then standard, and when the firing ship and target were moving in the same direction on straight courses, improved optical range-finding and the Dreyer table provided gunners with data that was so accurate that only one or two ranging shots or salvos would be required to fine-tune sight settings,[33] after which frequent correction through spotting would be unnecessary. This allowed the use of a method of firing that was known as "continuous-aim" gun-laying. Continuous-aim required gunners to elevate and depress their guns, and also swing them from side to side, in a way that eliminated the effect of a ship's roll and yaw on the pointing of the gun with respect to the target. The result was that a gun was always pointed correctly. Without having to wait on roll and yaw, for evaluations of the fall of shot, or for other guns to finish loading, each gun could be discharged as soon as it was ready. This method of shooting was known as "rapid-independent fire." (See Appendix, "Rapid independent.") Imperfect continuous-aim gun-laying from time to time produced "wild shots," which did not affect general accuracy because sight-setting and observation of fire effect were not connected. And the great increase in the rate of shooting outweighed occasional misses caused by inadequate compensation being made for roll or yaw. But rapid-independent fire was only practicable when wave action was slight, and roll and yaw thus not so great as to exceed the capacity of the gun-layers to move their guns up and down, and back and forth, with sufficient speed.

32. These were the Dreyer Table Marks II and III, the Dreyer Table Mark I not being produced until 1914, for which see John Roberts, *Battle Cruisers* (Annapolis, Md.: Naval Institute Press, 1997), 92, 126.

33. For the use of ranging shots rather than salvos, see Vice Admiral C. V. Usborne, *Blast and Counterblast: A Naval Impression of the War* (London: John Murray, 1935), 9. For the drawback of using single shots as opposed to salvos, which was understood as early as 1909, see Captain C. Hughes-Onslow, *Fire Control,* "Section 1: Spotting" (Portsmouth: Royal Naval War College, c. May 1909 with additions in June and August 1909), 9–11, Pollen Papers, courtesy of Anne Pollen.

In 1912, the improvements in range-finders, when combined with the lowering of Battle Practice ranges from over nine thousand yards to less than eight thousand yards, resulted in a considerable increase in the rate of hitting. In the battle practice of 1909, the average scores of the fleet were about 20 percent; the fleet average in 1912 is not known, but it seems to have been better than in 1911, and the top eight ships scored well above 30 percent.[34] From 1913, ships equipped with the Dreyer table were not only able to hit with greater accuracy, but also faster because only one or at most two shots or salvos were needed to adjust the initial sight settings, and then firing could be switched to rapid independent. And if range taking was favored by unusually good visibility, sights could be set accurately from the plot without recourse to correction from observation of the fall of shot, which would allow hitting with rapid independent from the beginning of firing. The practice of firing through sight setting from data provided by the Dreyer table unassisted by continuous spotting correction was known as "range-finder control." On 22 April 1914, the Director of Naval Ordnance wrote that determining the "mean range-finder range of the moment" was "the chief advantage of the present Dreyer's Fire Control Table, and has become the foundation of that system of fire control known as range-finder control, which has produced such excellent results, and which will increase in importance as range-finders increase in numbers and accuracy."[35] In the fall of 1912, trials demonstrated that Percy Scott's director system, which increased the accuracy of salvo firing in all but stormy conditions, would enable a battleship to shoot well with salvos even when the seas were turbulent enough to make rapid-independent fire ineffective. (See Appendix, "Gun-layer Permissive or Director Salvos.") The Admiralty thus adopted director firing with salvos as a back-up to rapid independent in the event of a battle taking place in poor weather.[36]

In late 1911, the Royal Navy began to commission the battleships and battle cruisers of the 1909–10 program. In place of the 12-inch gun that had previously been standard, the new vessels were fitted with a 13.5-inch gun. This piece fired a projectile that was 40 percent heavier than those fired from the 12-inch guns that equipped the latest German dreadnoughts. In 1912, the Admiralty ordered the modification of the 13.5-inch guns of the capital ships of the 1911–12 program in a way that

34. Sumida, "The Quest for Reach," 67, 73, and 93 (note 175). For the use of salvo fire and an average hitting rate of 10 percent in 1912 in one group of ships, see Captain C. Fuller, "Recent Gunnery Practices" (6 June 1912), DRAX 1/9, Drax Papers.

35. Quoted in Sumida, *In Defence of Naval Supremacy,* 250.

36. For the development of director firing, see John Brooks, "Percy Scott and the Director," in *Warship 1996* (London: Conway Maritime Press, 1996), 150–70.

would enable them to fire an improved armor-piercing projectile that was nearly 60 percent heavier than the German 12-inch projectile. At ranges of ten thousand yards or less, the new model ammunition was thought to be capable of penetrating easily the thickest armor of any battleship.[37] Moreover, a change in the disposition of the gun turrets increased the effective number of guns by 20 percent—a 12-inch-gun British dreadnought battleship could bring only eight guns to bear on its broadside, a 13.5-inch-gun unit ten. The Germans were further overmatched by the British adoption of the 15-inch gun for the capital ships of the 1912–13 and 1913–14 estimates. These weapons fired shells that were nearly double the weight of the German 12-inch gun, which was not superseded by a 15-inch gun until the year after the British move.[38] By the time Germany authorized her first two 15-inch-gun battleships in 1913, Britain had initiated the construction of ten such units.

In 1912, Royal Navy officers with knowledge of forthcoming developments in gunnery had good reason to believe that the British battle fleet would soon be able to strike with far greater power under favorable conditions. A battleship with ten 13.5-inch guns or eight 15-inch guns on the broadside using rapid-independent fire with an accuracy rate of 30 percent would be able to place four to five times the weight of projectile on target for a given time period—depending upon the weight of the projectile used—than a battleship with an eight 12-inch-gun broadside firing double salvos (see Appendix, "Double Salvos") with an accuracy rate of no more than 20 percent, which had been the standard in 1909. (See Tables 1, 2, and 3.) And because gunners in 1909 had needed several minutes of ranging with single shots or salvos before shifting to double salvos, while range-finder control might allow rapid independent from the onset of firing, the expected gain in weight of projectiles on target might have been even higher—perhaps by as much as a factor of ten. (See Table 3.) On the presumption that the shooting capability of the German fleet was at the level of the Royal Navy in 1909, and that an engagement would take place at medium range between fleets moving in the same direction on straight and unchanging courses, individual British capital ships would enjoy at least a four or five to one advantage in hitting power over their opponents. Moreover, given the likelihood that all 13.5-inch and 15-inch armor-piercing high explosive shell hits would penetrate German armor, the expected effect of even a few such

37. Winston Churchill to Sir John Fisher, 12 April 1912, F.P. 568, FISR1/11, Fisher Papers, Roskill Archive Centre, Churchill College, Cambridge.

38. British projectile weights: 12-inch (850 pounds), 13.5-inch light (1,250 pounds)/heavy (1,400 pounds), and 15-inch (1,920 pounds). The German 12-inch projectile weighed 893 pounds. Source: Peter Hodges, *The Big Gun: Battleships Main Armament, 1860–1945* (Annapolis, Md.: Naval Institute Press, 1981), 122, 124.

Table 1
Big-Gun Hits (Eight-Gun Broadside)
20/30 Percent Accuracy (fractional hits rounded down)

	Four-Gun Salvos, 50-second Interval		Double Salvos, 50-second Interval		Rapid Independent Fire 35-second Loading Interval	Rapid Independent Fire 30-second Loading Interval
% of hits	20%	30%	20%	30%	30%	30%
3 minutes	2	4	5	8	12	14
4 minutes	3	5	7	11	16	19
5 minutes	4	7	9	14	20	24
6 minutes	5	8	11	17	24	28
7 minutes	6	10	13	20	28	33
8 minutes	7	11	15	23	32	38
9 minutes	8	13	17	26	37	43

Table 2
Big-Gun Hits (Ten-Gun Broadside)
20/30 Percent Accuracy (fractional hits rounded down)

	Four-Gun Salvos, 50-second Interval		Double Salvos, 50-second Interval		Rapid Independent Fire 35-second Loading Interval	Rapid Independent Fire 30-second Loading Interval
% of hits	20%	30%	20%	30%	30%	30%
3 minutes	3	5	7	10	15	18
4 minutes	4	7	9	14	20	24
5 minutes	6	9	12	18	25	30
6 minutes	7	10	14	21	30	36
7 minutes	8	12	16	25	36	42
8 minutes	9	14	19	28	41	48
9 minutes	10	16	21	32	46	54

Table 3

Differential Projectile Weights (in pounds) on Target Depending upon Method of Fire, and Number and Caliber of Guns

Time	Eight 12-inch Gun Broadside, Four- or Eight-Gun Salvos at 50-second Intervals, 20 % Accuracy		Rapid-Independent Fire at 35-second Loading Intervals, 30 % Accuracy		
	Single Salvo	Double Salvo	Ten 13.5-inch Guns Light Projectile	Ten 13.5-inch Guns Heavy Projectile	Eight 15-inch Guns
3 minutes	1,700	4,250	18,750	21,000	23,040
4 minutes	2,550	5,950	25,000	28,000	30,720
5 minutes	3,400	7,650	31,250	35,000	38,400
6 minutes	4,250	9,350	37,500	42,000	46,080
7 minutes	5,100	11,050	45,000	50,400	53,760
8 minutes	5,950	12,750	51,250	57,400	61,440
9 minutes	6,800	14,450	57,500	64,400	71,040

Table 4

Torpedo Time of Travel (in minutes)

Torpedo Run to Point of Aim	20 knots	25 knots	30 knots	35 knots	40 knots	45 knots
4,000 yards	5.9	4.7	4.0	3.4	3.0	2.6
5,000 yards	7.4	5.9	4.9	4.2	3.7	*
6,000 yards	8.9	7.1	5.9	5.1	4.4	*
7,000 yards	10.4	8.3	6.9	5.9	*	*
8,000 yards	11.8	9.5	7.9	*	*	*
9,000 yards	13.3	10.7	8.9	*	*	*
10,000 yards	14.8	11.9	9.8	*	*	*
11,000 yards	16.3	13.0	*	*	*	*
12,000 yards	17.8	14.2	*	*	*	*
13,000 yards	19.2	15.4	*	*	*	*
14,000 yards	20.7	16.6	*	*	*	*
15,000 yards	22.2	17.8	*	*	*	*
18,000 yards	26.6	*	*	*	*	*

strikes would be catastrophic.[39] And if the signaling equipment in the German flagship were damaged early on, which was likely given its exposed position in the superstructure and on masts, orders to change course could not be transmitted, which would mean the enemy battle line could not be maneuvered as a body. Under such circumstances, the Germans would either have to continue steaming together on a straight course, in which case the initial sight settings from the Dreyer table would remain valid and British fire would stay effective, or German ships would be compelled to change course individually to avoid being hit, in which case their formation would disintegrate.

The New Technical-Tactical Synthesis

In February 1913, Pollen recalled that "in a recent discussion with an officer highly distinguished for his gunnery services, I was informed that any Captain who changed course to keep station, while within fighting ranges of his enemy, would deserve to be hung at his own yard arm, and that any Admiral ordering such a manoeuvre was unfit to command."[40] Not long afterwards, Dreyer, who may have been the officer quoted by Pollen, expressed similar views in a report that justified the adoption of his fire-control methods. A major part of Dreyer's argument consisted of a condemnation of "helm-free" gunnery and *en passant* "divisional attack." His fundamental assumption was that "an Admiral will always be fully cognizant of the capabilities and limitations of the guns and fire control fittings and arrangements of his fleet" and thus would "guide his tactics accordingly, endeavouring so to control the tactical situation that the task of the guns will always be one to which they are fully equal." The "accuracy and rapidity of gunfire is greatly interfered with by alterations of course," he declared, "and that while a ship is under helm her gunnery must suffer in both respects, owing to increased difficulty of aiming." Thus for this and other reasons, "alterations of course whilst engaged will be avoided by Admirals unless a material advantage is to be gained thereby, and adjustment of intervals in the line by Captains of ships will only be made where absolutely nec-

39. Churchill to Fisher, 12 April 1912.

40. Arthur Hungerford Pollen, "The Gun in Battle" (February 1913), in Jon Tetsuro Sumida, ed., *The Pollen Papers: The Privately Circulated Printed Works of Arthur Hungerford Pollen, 1901–1916* (London: George Allen and Unwin for the Navy Records Society, 1984), 301. See also Captain A. E. M. Chatfield memorandum, "Fast Division Work from a Gunnery Standpoint" (October 1913), in Bryan Ranft, ed., *The Beatty Papers: Selections from the Private and Official Correspondence of Admiral of the Fleet Earl Beatty,* 2 vols. (London: Scolar Press for the Navy Records Society, 1989–93), 1:90–94.

essary."[41] Steaming at a constant speed on a straight course, however, exposed a battle fleet to many hits from long-range torpedoes, a problem that Dreyer did not address. But the tactical reasoning of Dreyer and others like him, who would not have ignored the torpedo threat, can be reconstructed through careful consideration of artillery and torpedo performance, and their relationship.

Besides firing outside the effective range of torpedoes while steaming on a straight course, or firing within the effective range of torpedoes while maneuvering to avoid them, there was a tactical option that dealt with the torpedo threat in yet a third way. This was to fight within range of torpedoes by firing without maneuver for a time period that was less than that needed by even fast-moving enemy torpedoes to complete their run to their target, followed by a change of course. Many officers in the Royal Navy believed that the German battle line would close at high speed and then turn on to a course parallel to that of the British battle line in order to fight at medium ranges, with both fleets moving in the same direction.[42] During the approach phase, the change of range rate would be high enough to prevent either side from inflicting serious damage. During the parallel course phase, if the distance between the opposing battle lines was long enough to allow several minutes of shooting, the signaling of a turn away, and the execution of the order for a change of course before enemy torpedoes could reach their targets—and if gunnery during the period when the firing ships were steaming on a straight course was rapid and accurate—an enemy battle fleet could be hit very hard with minimal risk of being hit in return by torpedoes. Simultaneous turns by each ship would transform the single line ahead into line abreast. Such an action, if executed after the enemy had launched its torpedoes, would have four positive effects. First, all torpedoes would miss because their targets avoided the point of aim. Second, a turn that was sharp enough to put the retreating fleet and advancing torpedoes on parallel courses reduced the target size substantially (80 percent) by offering the width rather than the length of a ship. Third, if the turn were made soon enough, the retreating fleet would be able to "outrun" the tor-

41. Great Britain, Admiralty, Gunnery Branch, *Pollen Aim Corrector System. Part I. Technical History and Technical Comparison with Commander F. C. Dreyer's Fire Control System* (London: HMSO, 1919), 18, Naval Library. For A. K. Wilson's dislike of divisional attack and his influence on Dreyer, see Dreyer to Admiral Sir Dudley de Chair, 19 September 1952, DRYR 4/3, Dreyer Papers, Roskill Archive Centre, Churchill College, Cambridge.

42. "Fundamental Basis of Naval Warfare Adopted by the German Navy" [British Naval Attaché Report, Berlin], 23 April 1909, MCKN 3/19, McKenna Papers, Roskill Archive Centre, Churchill College, Cambridge; Pollen, "Gun in Battle" (1913), in Sumida, ed., *Pollen Papers,* 299; Anonymous [Hall], "The Fleet in Action," 68–69; Anonymous [Captain W. H. Richmond], "Comments on Strategy and Tactics," *Naval Review* 2 (1914): 373–74.

pedoes by opening the distance to a point that was greater than their high or even medium speed range. And fourth, movement away from the enemy would facilitate an orderly transition from line-abreast back into the more easily manageable single-line-ahead formation by allowing the fleet to reform in an area clear of gun smoke and away from hostile fire from guns or torpedoes.

The key factors were the speed of torpedoes and the rapidity of accurate shooting with big-guns. At seven thousand to ten thousand yards, the latest model 21-inch torpedoes could move at approximately thirty knots. At the lower distance, this took nearly seven minutes, at the greater nearly ten. (See Table 4.) On the presumption that the enemy would seek to engage at medium ranges—that is, seven thousand to ten thousand yards—and would not launch torpedoes from their battleships until courses were nearly parallel in order to maximize the probability of hitting, and given the fact that a simultaneous turn required two minutes at most to order and execute,[43] British battleships would have a firing time envelope of roughly five to eight minutes during which the range would be constant or very nearly so. With accurate knowledge of that range through the use of multiple range-finders and the Dreyer table, guns could be brought on the target on the first or second salvo—a matter of less than a minute—after which fire could be shifted to rapid independent. Under ideal range-finding conditions and given time to plot before opening fire, rapid independent could be utilized from the start. The firing interval (which included loading and spotting) between four-gun salvos was fifty seconds, but the loading and shooting cycle of individual guns was probably no more than thirty-five seconds and with crack crews even less. (See Appendix, "Gun-layer Permissive or Director Salvos" and "Rapid Independent.") A British capital ship with an eight-gun broadside using rapid-independent firing with thirty-five-second loading intervals could thus fling thirteen projectiles a minute and, on the basis of battle practice hitting rates at seven thousand to ten thousand yards of 30 percent, strike the target at least four times every sixty seconds. (See Table 1.) In five to eight minutes, a British battleship using rapid-independent firing with thirty-five-second loading intervals—and assuming no hits were made in the first minute of salvo shooting—could place from sixteen to twenty-eight heavy caliber projectiles on its target; a shorter loading interval of thirty seconds, which could be achieved by

43. A fleet of twenty-four ships moving at twelve knots in line abreast required two minutes to form a single line ahead on a course that was eight points (ninety degrees) from the original course. The same number of ships moving in three parallel divisions at the same speed required nine minutes to form a single line ahead on a course that was eight points (ninety degrees) from the original course. It has been assumed that reverse action would take the same amount of time. For this data, see *Notes on Tactical Exercises. Home Fleet 1909–1911,* 11.

crack gunnery ships, would produce from nineteen to thirty-three hits. If accurate sight setting from plotted ranges made opening salvo fire unnecessary, in five to eight minutes a British battleship using rapid-independent firing at thirty-second loading intervals would make twenty-four to thirty-eight hits. British battleships with ten guns on the broadside could, of course, do even better. (See Table 1.)

If the sea was rough enough to prevent continuous-aim gun-laying, or the view of gunners was blocked by sea spray or smoke from firing or funnels, salvo firing with directors whose sight was set with data from the Dreyer table was still capable of producing a large number of hits in a short time. Double salvos at fifty-second intervals with 30 percent accuracy would result in hitting at the rate of just under three per minute. In five to eight minutes, director firing with double salvos after a minute of trial shooting could place from eleven to twenty heavy-caliber projectiles on its target. (See Table 1.) Even the lower figures produced by director salvo firing were great enough to wreck an opposing battle line. In relative terms, range-finder control with rapid independent produced more than quintuple the number of hits that could have been achieved before 1912 with single salvo firing and lower hitting percentages, while range-finder control with directors was nearly four times more effective. (See Table 1.) Battle practice conditions were unrealistic in the sense that single ships fired at a solitary target, which meant that gunners were not forced to contend with the funnel and gun smoke of other ships in line. In a special squadron firing in 1913, however, shooting with rapid-independent and director-salvo firing produced results that seemed to confirm conclusions that could be drawn from battle practice hitting rates.[44] Although the exercise was conducted under circumstances that did not replicate those of a battle in important respects—for example, the target was stationary—the Admiralty appears to have been encouraged by the performances of the participating ships.[45] And finally, intelligence information that was probably gathered at this time indicated that under con-

44. Using single salvos and director laying, H.M.S. *Thunderer* hit with its first or second salvo and made seven hits overall in about five minutes; H.M.S. *Orion,* using independent laying, hit with her second salvo and made ten hits in just over four minutes, which was considered disappointing because an avoidable error at the plotting table temporarily upset sight setting. For the foregoing, see Captain Arthur Craig, "Remarks on the 'Empress of India' Firings," n.d. but probably November 1913, Craig-Waller Papers, Naval Library.

45. "'Empress of India' Experimental Firings Against; Remarks of D.N.O. on the nature of the experiments and the results realised; Particulars of previous firing trials against obsolete ships," 7 November 1913, and "Firings Carried out at 'Empress of India,'" 16 January 1914, both in *Important Questions dealt with by D.N.O.,* vol. 2, *1913*; and Admiralty, Gunnery Branch, *Report on Firings at H.M.S. 'Empress of India,' carried out by First Fleet on the 4th November 1913* (London: HMSO, 1914), Naval Library.

ditions comparable to Royal Navy battle practice, the average scores of German capital ships in 1912–13 was 15 percent, or in other words half that achieved by British capital ships in 1912 under similar conditions.[46]

The New Technical-Tactical Synthesis as Secret Admiralty Policy

As Director of Naval Ordnance from 1905 to 1907, Captain John Jellicoe had tried to develop methods of gunnery that would enable a British battle fleet to fight outside the effective range of torpedoes. These efforts included support for Pollen's early work on fire control instruments, which were designed to suit a straight-course engagement. When Jellicoe became a Rear Admiral and served as Third Sea Lord and Controller in 1909 and 1910, his backing for Pollen was expanded to include the "helm-free" methods of gunnery essential to the efficacy of divisional attack.[47] In 1911, while Vice Admiral in command of the Second Division, Home Fleet, he issued instructions that called for the maximization of the rate of firing at ranges of twelve thousand to thirteen thousand yards, which was the extreme outer limit of accurate shooting with existing methods of gunnery. These same instructions stated an intention to fight at ranges that were as low as seven thousand yards and contained provision for divisional attack.[48] Jellicoe employed divisional attack with great success in the spring maneuvers of 1912.[49] By the end of the year, however, his tactical views had changed fundamentally. While information is sparse, there can be little doubt that the shift had a great deal to do with his fleet experience during the summer and fall of 1912.

In May 1912, the Second Division was renamed the Second Squadron of the First Fleet. By June 1912, this force included the first two 12-inch-gun battleships to be equipped with 21-inch torpedo tubes, and the first three 13.5-inch-gun battleships to be commissioned, which

46. For detailed accounts of German firing practice from 1910 to 1914, see Great Britain, Admiralty, Admiralty War Staff, Intelligence Division, *German Navy; Part IV: . . . Gunnery Information Section 4: Target Practice, Range-Finders, and Control of Fire* (July 1917), Naval Library. According to this source, the average hitting rate in the 1912–13 German shooting exercise was roughly 15 percent under conditions resembling that of British battle practice. British naval intelligence seems to have had ready access to reports of German firing practice, and although it is impossible to say for certain, it is likely that the material in the 1917 print on prewar German shoots was gathered well before the war.

47. Sumida, *In Defence of Naval Supremacy,* 83–100, 163–76, 196–206.

48. "War Orders and Dispositions. . . . Prepared when in [command] of 2nd Division, Home Fleet," n.d. but c. 1911, in A. Temple Patterson, ed., *The Jellicoe Papers: Selections from the private and official correspondence of Admiral of the Fleet Earl Jellicoe of Scapa,* 2 vols. (London: Navy Records Society, 1966–8), 1:23–25.

49. A. Temple Patterson, *Jellicoe: A Biography* (London: Macmillan, 1969), 48–49.

were also armed with 21-inch torpedoes. Jellicoe remained in command and was assisted by Dreyer.[50] During the summer of 1912, the Second Squadron of the First Fleet conducted trials with torpedoes.[51] At the same time, the three 13.5-inch-gun battleships were each fitted with a different experimental gunnery system—Pollen's Argo Clock, the first production prototype of the Dreyer table, and Scott's director—whose operations Jellicoe observed. Experiments with divisional attack, which revealed serious command and control problems, were carried out as well.[52] By the fall, Jellicoe had switched his support from Pollen to Dreyer,[53] a move tantamount to the repudiation of divisional attack. He must have learned from personal observation of torpedo exercises that a battle fleet that steamed on a straight course within reach of the new longer-range torpedoes would suffer heavy losses. He was thus left with no other means of being able to fire with effect while safeguarding the British battle line from torpedoes launched by enemy battleships except a medium-range fight with rapid accurate shooting followed by a turn away. The selection of this option was favored by his first-hand knowledge of the Dreyer table and Scott director, and what was probably his belief that the German battle fleet intended to fight while moving in the same direction on a parallel course at medium range. Indeed, given the fact that he had commanded what was in effect the Royal Navy's battle fleet tactics development squadron, Jellicoe probably not only embraced the new technical-tactical synthesis, he invented it.

The conversion of Churchill and Battenberg can be dated with precision. In the fall of 1912, both men were still undecided about the Pollen system, and their remarks about the vulnerability of battleships to torpedoes of November 1912, quoted previously, indicate that they had yet to subscribe to the new technical-tactical synthesis. Not long after their exchange of views, Jellicoe, as Second Sea Lord, joined a reconstituted Board of Admiralty which met on 9 December.[54] Within two weeks of this event, Battenberg, who had become First Sea Lord, informed Pollen that the board had rejected his system on unspecified tactical grounds, with

50. Dreyer, *Sea Heritage,* 65.

51. For the experiments with long-range torpedoes in the First and Second Squadrons of the First Fleet in the summer of 1912, see *Thirty-Third Annual Report on the Instruction and Practice of Torpedo Warfare in H.M. Navy 1912,* 29–35. Seventy-five percent of the torpedoes fired in long-range torpedo practice in 1912 were regarded as "dangerous to the enemy," for which see "Abstracts of Results of Long Range Torpedo Firing 1911 and 1912" (December 1912), DRAX 1/10, Drax Papers.

52. Dreyer, *Sea Heritage,* 68. For the failure of divisional attack in paper exercises and the influence on Royal Navy thinking on this subject, see Anonymous [Hall], "The Fleet in Action," 57.

53. Sumida, *In Defence of Naval Supremacy,* 220–21, 232.

54. Great Britain, Admiralty, *Board Minutes, 1912,* ADM 167/46.

which he had concurred.[55] The particulars of the battleships of the 1913–14 program are perhaps the strongest sign of the emergence of a consensus in favor of the new technical-tactical synthesis at the Admiralty in late 1912. The basic design of what was to become known as the "R" class was approved by the board in the spring of 1913.[56] In comparison with the battleships of the year before, the new vessels were given better vertical protection against big-gun armor-piercing projectiles, and steadier motion in a seaway that improved the accuracy of rapid-independent fire but slowed the rate of salvo fire; the second feature was obtained by adopting a hull design that would be less stable in the event of underwater damage.[57] The "R" class, in other words, was engineered to be better at fighting enemy battleships at medium range using range-finder control while being more liable to sinking if struck by torpedoes. Greater vulnerability would not matter, however, if the risk of being hit was minimized by maneuver. Knowledge of the foregoing might have alerted an astute observer to the change in the Admiralty's tactical thinking, but information of this kind was kept secret.[58]

Open consideration of the new technical-tactical synthesis would have given the game away to the Germans, who would then have changed their tactics.[59] In 1912, the discovery that a British naval warrant officer had provided German intelligence with detailed information about the gunnery methods used in the 1909 and 1910 battle practices provided a timely warning of the security danger.[60] Discussion of gunnery within and without the navy was thus tightly restricted: the Admiralty declined to explain its fire control procurement policy in Parliament, abolished the Inspectorate of Target Practice, and vigorously discouraged communications between officers and civilian technical

55. Sumida, *In Defence of Naval Supremacy,* 234.

56. Great Britain, Admiralty, *Board Minutes, 1913,* ADM 167/47.

57. Burt, *British Battleships of World War One,* 273; and Norman Friedman, *Battleship: Design and Development, 1905–1945* (Greenwich: Conway Maritime Press, 1987), 49–51.

58. For the lack of detailed information about the "R" class in the standard warship references of the day, see Fred T. Jane, ed., *Fighting Ships* (London: Sampson Low, Marston, 1914; Arco reprint, 1969), 32a; and Viscount Hythe and John Leyland, eds., *The Naval Annual 1914* (Portsmouth: J. Griffin, 1914), 10–11.

59. For the concern that this might occur, and the proposal of a tactical system that did not suffer from this drawback, see Commodore Trevylyan Napier, "Proposed scheme of Battle Tactics for 1st Fleet" (n.d., but after May 1912 and before the outbreak of war), TN/1/1, Trevylyan Napier Papers, Imperial War Museum, London. I am indebted to Dr. Nicholas Lambert from bringing this collection to my attention.

60. A. H. Pollen, "The Tragedy of Lord Fisher of Kilverstone" (privately circulated print, 1930), 19, courtesy of the late Anthony Pollen (also published under a pseudonym in the restricted Royal Navy journal *The Naval Review,* in February 1930); and Christopher Andrew, *Secret Service: The Making of the British Intelligence Community* (London: Heinemann, 1985), 66–67.

experts.[61] The 1913 published report on naval gunnery in the *Naval Annual,* Britain's leading journal on naval affairs, made no mention of the Dreyer table or rapid-independent fire.[62] In 1914, the same periodical informed its readers that the torpedo threat to the battle line would be dealt with through "high speed and "quick and frequent changes of course."[63] In 1914, a long article on the role of long-range torpedoes in a future fleet action published in the Royal Navy's *Naval Review* did not discuss the possibility of combining rapid fire followed by a turn away as an antidote to the torpedo threat.[64] As far as the general public, the Germans, and even most British naval officers were concerned, in the event of war a maneuvering British battle fleet would engage its opponent with sight setting accomplished through a combination of optical range-finding, unspecified methods of mechanical calculation, and the observation of salvos. Such a battle, an intelligent reader might conclude, would involve a series of exchanges of gunfire over a protracted period. Information that was unavailable to anyone outside of a select few of the Royal Navy's senior officers and their assistants, however, would have revealed preparations for a very different kind of event.

In the 1912 battle practice, British dreadnoughts fired their allotment of ammunition over a period of from five to eight minutes at ranges of from 7,000 to 8,000 yards while steaming on a straight course that was near parallel to that of a target moving in the same direction, achieving a hitting rate that was above 30 percent.[65] In the November 1912 rough weather trials with director firing, H.M.S. *Thunderer* made thirteen hits out of thirty-nine rounds fired during a shooting period of three-and-one-half minutes.[66] In the special squadron shoot of November 1913, the participating dreadnoughts appear to have fired over a five-minute period at ranges that were as great as 9,800 yards, which was considered "long," achieving hitting rates of roughly 30 percent.[67] In October 1913, Captain A. E. M. Chatfield, who was in charge of the gunnery of the Battle Cruiser

61. Admiralty Permanent Secretary to major naval commands, 29 July 1913, in *Important Questions dealt with by D.N.O.,* vol. 2, *1913*; Pollen, "The Tragedy of Lord Fisher of Kilverstone," 18–20; and Sumida, *In Defence of Naval Supremacy,* 243, 246.

62. Viscount Hythe, ed., *The Naval Annual 1913* (Portsmouth: J. Griffin, 1913; reprint edition, New York: Arco, 1970), 309–23.

63. *Naval Annual 1914,* 290.

64. Anonymous [Commander T. H. M. Maurice], "Torpedo Fire in Future Fleet Actions," *Naval Review* 2 (1914):72–89.

65. Battle Practice Chart, H.M.S. *Orion,* dated 1912, and Typescript Battle Practice Score Table of 1912 for "Class I Ships," Craig-Waller Papers.

66. Percy Scott, Memorandum of 30 November 1914, in DEY/36, D'Eyncourt Papers, National Maritime Museum, Greenwich.

67. "Remarks on the 'Empress of India' Firings" (n.d., but almost certainly November 1913), Craig-Waller Papers; and Admiral Sir George Callaghan to Director of Naval Ordnance, 8 December 1913, Enclosure No. 1 in ADM 1/8346.

squadron, observed that getting "a decisive effect with gun fire in the first phase of an action" was "undoubtedly a matter of minutes," and that "whether it is 5, 10, or 30 minutes is a matter of the utmost importance."[68]

By 1913, the Admiralty's confidence in the ability of a British battle fleet to establish *very* quickly fire superiority over a German opponent seems to have been considerable. In February 1913, an Admiralty instruction to the fleet instigated by the Director of Naval Ordnance discouraged "the seemingly popular belief" that the disablement of the primary system of fire control by enemy fire would "necessarily occur early in an action." "If effective gunfire is developed with rapidity," the memorandum declared, "there appears every likelihood" that the back-up systems of local fire control would not be needed, and thus "in no case should the primary organization be permitted to suffer for the benefit of secondary."[69] In 1914, a Russian naval officer informed Pollen that the leaders of the Royal Navy,

> are no longer relying on the hope, that future battles will be fought at very long ranges, and that their policy of adopting more powerful guns has, as its primary motive, the capacity to destroy an enemy by a single blow. That the heavier shell may give an advantage at long ranges in favourable conditions, appears to be only a secondary consideration.[70]

The promise of individual battleships having an overwhelming fire power advantage over their German counterparts under the conditions that were expected to prevail in a fleet engagement probably retarded the development of methods of concentrating the fire of two or more ships on one. Dreyer seems to have believed that giving single units fire power that was superior to that of any enemy vessel was a better means of concentrating force than coordinating the fire of several ships on one.[71] Although some effort was devoted to formulating standard procedures for concentration of fire in 1912 and 1913, the practice does not seem to

68. Chatfield to Beatty, "Fast Division Work from a Gunnery Standpoint," in Ranft, ed., *Beatty Papers,* 1:91.

69. Admiralty Permanent Secretary to H.M. Ships, 14 February 1913, in *Important Questions Dealt with by D.N.O.,* vol. 2, *1913.*

70. Quoted in Sumida, *In Defence of Naval Supremacy,* 253. For Churchill's belief that new armor-piercing 13.5-inch-gun projectiles would enable British capital ships to sink their opponents in "a single blow," see Churchill to Fisher, 12 April 1912.

71. Great Britain, Admiralty, "The One Calibre Big Gun Armament for Ships" (June 1908), 39, FISR 8/31, Fisher Papers. For Dreyer's role in the authorship of this print, see Jon Tetsuro Sumida, "Sir Julian Corbett and Admiral Sir John Fisher," in Goldrick and Hattendorf, eds., *Mahan is Not Enough,* 132–34.

have been a central feature of the British battle fleet's tactical repertoire.[72]

The crucial significance of rapidity and accuracy of big guns on the one hand, and the relatively slow speed of torpedoes on the other, was explained by Sir Cyprian Bridge, a retired British admiral, in his 1914 commentary on a paper on battleship design given by T. G. Owens at the Institution of Naval Architects. Owens suggested that the torpedo armament of battleships should be increased substantially. Bridge disagreed. "The present-day torpedo," he argued

> had, it was believed, a velocity that would enable it to reach an object 6500 yards distant in a little over four minutes. A projectile fired from a 12-in. 50-calibre gun could reach an object at that distance in about 9 seconds. The gun in question could be fired so as to admit of her projectile reaching the object at least six times before the torpedoes got there, although the gun firing did not start until the discharge of the torpedoes had taken place. The ship, as described in the paper, would have three torpedo-tubes on a broadside, and not one heavy gun only, but eight heavy guns. Consequently, if all three tubes were discharged, there would be time to fire forty-eight gun projectiles, all capable of reaching the object before any of the torpedoes could reach it. Suppose we allowed 66 per cent. of misses for the guns, there would still be sixteen hits, against which neither the belt armour nor the gun position armour would afford a real protection; and when the torpedoes got there they would find that the work they were meant to do had already been done.[73]

Post–First World War testimony is also revealing. A 1922 lecture given by Captain Henry G. Thursfield at the Naval Staff College at Greenwich noted that "the whole of our pre-war tactics" had been based upon the "firm conviction" that the Germans would seek a close range action.[74] In 1927, Churchill, who had been First Lord of the Admiralty when the critical changes in Royal Navy tactics took place, wrote in the third volume of *The World Crisis* that before the First World War, "every-

72. Dreyer, *Sea Heritage,* 86; and Sumida, "Quest for Reach," 65, 73, 89 (note 113), 93 (note 182). For the concentration of fire instructions of the British battle fleet early in the war, see Great Britain, Admiralty, Naval Staff, T. and S. D. [Training and Staff Duties] Division, *Grand Fleet Battle Orders,* 3 vols. (July 1919), 1: "Gunnery Addendum" (revised March 1915), 97 (hereafter *GFBO*), ADM 116/1341. For the post–First World War view that little had been achieved with respect to the development of concentration of fire technique prior to Jutland, see Great Britain, Admiralty, Technical History Section, *Fire Control in H.M. Ships* (December 1919), 23, Naval Library.

73. Admiral Sir Cyprian Bridge in T. G. Owens, "Some Questions Relating to Battleship Designs," *Transactions of the Institution of Naval Architects* 56 (1914): 25.

74. Thursfield, "Development of Tactics in the Grand Fleet," 2–3.

thing had been lavished upon the drawing out of a line of batteries of such a preponderance and in such an order that the German battle fleet would be blasted and shattered *for certain* [italics in the original] in a very short space of time." According to Churchill, firing was to take place within ten thousand yards between two parallel lines of battle, which would then be followed by "defensive action against torpedo attack," by which he must have meant a change of course. "Everything beyond this opening phase," Churchill observed, "was speculative and complicated. If the opening phase were satisfactory, everything else would probably follow from it."[75] The one seemingly problematical element in the former First Lord's recollection of the prewar tactical mindset of the Royal Navy was his contention that firing would take place over thirty minutes. It is likely, however, that Churchill intended this to apply to the entire engagement and not just the opening phase, because a change of course after thirty minutes steaming parallel to an enemy moving in the same direction had no value with respect to the avoidance of torpedoes. Alternatively, he may have conflated the timings under consideration before the war (see remarks of Chatfield quoted above), the result being a mistake of the kind that prompted Admiral Reginald Bacon to remark that Churchill's writing on naval matters in *The World Crisis* could be described as "a tissue of factual inexactitudes."[76]

Unreadiness, Improvisation, and Dissimulation

Reaching a consensus about the new technical-tactical synthesis at the Admiralty was one thing, putting it into effect another. The appointment of Jellicoe to take over command of the Home Fleet, which would have placed him in a position to implement his ideas, was probably decided in May 1914 and scheduled for that December.[77] In the meanwhile, the acquisition of the matériel essential to the employment of range-finder control was slow. By the summer of 1914, less than half the fleet was equipped with Dreyer tables or directors. Moreover, pre-dreadnoughts still formed a significant proportion of the Royal Navy's strength,

75. Winston S. Churchill, *The World Crisis,* 6 vols. (New York: Charles Scribner's, 1923–31), 3:131.

76. Admiral Sir Reginald Bacon, "Mr. Churchill and Jutland," in *The World Crisis by Winston Churchill: A Criticism* (London: Hutchinson, 1927), 122. Later on, Bacon refers to "the vagueness of Mr. Churchill's knowledge of naval tactics" (p. 163). Bacon did not, however, take issue with Churchill's rendition of prewar British naval tactical thinking.

77. Fisher to Jellicoe, 25 May 1914, in Arthur J. Marder, ed., *Fear God and Dread Nought: The Correspondence of Admiral of the Fleet Lord Fisher of Kilverstone,* 3 vols. (London: Jonathan Cape, 1952–59), 2:506; Dreyer, *Sea Heritage,* 96; and Lambert, *Fisher's Naval Revolution,* 300.

the majority of the dreadnoughts in service were armed with 12-inch guns, several 13.5-inch-gun units had yet to commission, and all of the 15-inch-gun ships were under construction. Most of the capital ships of Britain's battle fleet, in short, were either ill suited or ill equipped to execute the new technical-tactical synthesis. For this reason, Admiral Sir George Callaghan, the commander-in-chief of the Home Fleets from 1912 to 1914, had called for practices that differed from those advocated by the Admiralty. Callaghan discouraged exclusive reliance on range-finder control; kept an open mind about what the opening range of a fleet engagement would be; favored some form of "divisional attack"; and believed that British destroyers should be used to attack the enemy battle line, indicating that he lacked confidence in the ability of battleships to achieve decisive results on their own.[78]

German naval espionage in 1913, which was assisted by a former Royal Navy commissioned officer, gained considerable information about British operational procedures,[79] but the state of tactical affairs in the Home Fleets would have obscured the significance of the Dreyer table and range-finder control. This factor, and also the tight security precautions with regard to fire control practices, meant that the German navy was probably ignorant of the new technical-tactical synthesis when war began in the summer of 1914. On 4 August, the day before the outbreak of hostilities with Germany, the Admiralty ordered Jellicoe to take command of the most modern units of the Home Fleets, which became known as "The Grand Fleet," while older vessels constituted a separate force known as the Channel Fleet. Jellicoe objected strenuously to the timing of the transfer. Given the expectation that the British and German battle fleets would fight a major engagement in the first weeks of war,[80] the incapacity of the British battle fleet in the near-term to use the kind of tactics that Jellicoe had envisioned, and Callaghan's familiarity with the material and methods in hand, Jellicoe's response was reasonable.[81] His request

78. Sumida, *In Defence of Naval Supremacy,* 255; Lambert, "Jutland and the Loss of the Battle Cruisers," 32–33; and Lambert, *Fisher's Naval Revolution,* 287–89. For a suggestive remembrance of the divide between the Fleet's views on tactics and the Admiralty's views on gunnery, see A. E. M. Chatfield, *The Navy and Defence: The Autobiography of Admiral of the Fleet Lord Chatfield* (London: William Heineman, 1942), 114.

79. Andrew, *Secret Service,* 69.

80. Jellicoe, *Grand Fleet,* 38–39.

81. For Jellicoe's reservations about the quality of British capital ships with respect to their German counterparts, see Jellicoe to Churchill, 14 July 1914, in Patterson, ed., *Jellicoe Papers,* 1:37. Jellicoe's unflattering analysis of the early dreadnoughts, however, was almost certainly intended to counter Churchill's plan to reduce the 1914–15 battleship program, an action that would have curtailed the construction of further "R" class battleships, whose design had been tailored to suit Jellicoe's tactical concepts. For Churchill's plan to abandon the battleship standard in

for a staged transition, however, was rejected.[82] Jellicoe's first set of fleet instructions, the Grand Fleet Battle Orders, were issued on 18 August 1914. These were intended as an addition to the existing Home Fleets General Orders, many of which seem to have remained in force through the fall of 1916.[83] An addendum dated 31 August 1914 stated

> on a clear day and unless the enemy opens fire earlier 13.5-inch gun ships will open deliberate fire at 15,000 yards, 12-inch gun ships at 13,000 yards. . . . At extreme ranges fire should be by deliberate salvos until the enemy is hit or straddled; the rate of fire should then be increased, but ships should not employ rapid fire at ranges over 10,000 yards without occasional checks to a slower rate until they are certain they are hitting.[84]

A later addendum of 1914 declared

> the greatest importance [was attached] to making full use of the fire of our heavier guns in the early stages at long range. Close action is to the German advantage if they intend to use large numbers of auxiliary craft to strengthen their attack on our fleet, but . . . if our long range fire is effective there is a good chance of the German fleet being thrown into partial confusion before its attack can be developed, with consequent loss of initiative and interference with their prearranged plan.[85]

The same addendum, however, left open the possibility that Jellicoe would close the range. In a later passage, he noted "generally speaking, so long as the action is being fought on approximately parallel courses, the whole fleet should form one line of battle, and the range should be between 12,000 and 9000 yards." Jellicoe also stated "action on parallel course is one of the underlying objects of my tactics . . . because it is the form of action likely to give the most decisive results" and "it may be necessary to close the range or otherwise manoeuvre the fleet to avoid

favor of building submarines, see Lambert, *Fisher's Naval Revolution,* 296–300. For Jellicoe's belief that maintaining the battleship standard was essential, see Fisher to Jellicoe, 25 May 1914, *Fear God and Dread Nought,* 2:506–7; and Lambert, *Fisher's Naval Revolution,* 302. For Churchill's scathing reaction to Jellicoe's memorandum, see "British and German Dreadnought Battleships; relative gun power," ADM 116/3091.

82. Patterson, *Jellicoe,* 56–58.

83. See markings throughout Great Britain, Home Fleet, *Home Fleets General Orders in Force 15 May 1914,* ADM 137/260; and DRAX 1/9, Drax Papers.

84. *GFBO,* "Addendum No. 1" (31 August 1914), in Patterson, ed., *Jellicoe Papers,* 1:59. Patterson is given as the source of the Grand Fleet Battle Orders for the sake of convenience, except for material not included in the Navy Records Society volume. The original sets consulted were in the Public Record Office (ADM 116/1341-3 and ADM 186/595-7) and the Naval Library.

85. *GFBO,* "Addendum No. 5" (n.d.), in Patterson, ed., *Jellicoe Papers,* 1:63.

indecisive action."[86] And in a revised gunnery addendum to the GFBOs of March 1915, Jellicoe warned "when the range of visibility is less than 10,000 yards, ships must be prepared to open rapid fire from the outset in order to make sure of establishing initial superiority." Under the special circumstances of a surprise meeting engagement when visibility was poor, he furthermore insisted that the commencement of firing be immediate, and if necessary unassisted by either plotted data from the Dreyer table or even range-finder ranges if use of such data would cause delay.[87]

These qualifications notwithstanding, the GFBOs of 1914 seem to indicate a significant change in Jellicoe's tactical thinking. No mention is made of an opening phase of rapid fire at medium range followed by a turn away to avoid torpedo attack. Instead, Jellicoe called for an initial period of deliberate fire with salvos at ranges that were much greater than ten thousand yards, followed by fighting at lower ranges only after German fighting capability had been degraded by hits achieved in the initial exchange of long-distance shooting. Moreover, emphasis on long-range firing increased in a later edition of the GFBOs that was in effect at the battle of Jutland. In the generally revised GFBOs of December 1915, Jellicoe maintained that

> in weather of good visibility, the range should be between 15,000 and 10,000 yards; the latter being reached as the enemy's fire is overcome; in the early stages of action I do not desire to close the range much inside 14,000 yards. . . . Until the enemy is beaten by gunfire it is not my intention to risk attack from his torpedoes, although it is always possible that if we were inferior in strength on meeting it might become necessary to close sufficiently to attack by torpedoes. Such a movement would, however, be ordered by me, and generally speaking it is to be understood that my intention is to keep outside torpedo range of the enemy's battle line.[88]

These remarks, however, did not mean that Jellicoe believed that decisive results could be achieved by long-range firing. "In clear weather," he observed, "we hope that deployment at long range may give us the initial advantage in gunfire which it is so important to obtain, but there can be no doubt that we must gradually close the range to obtain decisive results."[89] Jellicoe's considered response to the torpedo threat, in short, appears to have been long-range bombardment while steaming on a straight course followed by a decisive gunnery exchange at medium range while steaming on a straight course rather than a combination of fire and maneuver at medium range.

86. Ibid., 62–63.

87. *GFBO,* 1: "Gunnery Addendum," 96.

88. *GFBO,* "Battle Tactics" (December 1915), in Patterson, ed., *Jellicoe Papers,* 1:244–45.

89. *GFBO,* December 1915, in Patterson, ed., *Jellicoe Papers,* 1:247.

The apparent difference between what were almost certainly Jellicoe's prewar and wartime tactical views may be explained in part by his sudden accession to the command of a force that was not prepared to execute the former and yet might soon be in action. Jellicoe had to avoid drastic changes in practice that the fleet was not equipped to implement, that would have disquieted subordinates, and that would have upset established procedures, all to the serious detriment of combat efficiency. Changes that reflected his conception of tactics could be introduced over time. This appears to have been the case with divisional attack. Instructions for this form of action had been given in the HFGOs, and the first redaction of the GFBOs seemed to endorse such tactics. The revised GFBOs of 1915, however, added a paragraph that discouraged divisional attack in no uncertain terms, and indeed for all intents and purposes prohibited it.[90] From the very beginning, Jellicoe removed any ambiguity that may have existed about the function of destroyers in a fleet action. While Callaghan had favored the offensive use of such vessels against enemy battleships, Jellicoe made it clear in the first set of GFBOs that the primary function of destroyers was the protection of the British battleships from attacks by enemy flotilla.[91] This position was repeated in the revised GFBOs of 1915.[92] In addition, Jellicoe issued instructions in early 1915 to cover the possibility of battle line maneuver to evade torpedoes in the event of attack from German flotilla during the fighting between capital ships, which probably reflected decreased confidence in the ability of gunfire to stop a determined thrust.[93] But in spite of more than enough time to make needed changes in matériel and to accustom his subordinates to new tactics, the instructions on gunnery and tactics in the GFBOs of 1915 differed little from those expressed in 1914, or indeed from the instructions given in the HFGOs, which may still have been in force. Jellicoe changed his mind about many things in light of war experience, and fighting a long-range action from the outset was undoubtedly one option that he believed appropriate under certain circumstances. The GFBOs, however, do not give a complete picture of Jellicoe's tactical intent during the first eighteen months of the war.

The GFBOs were widely circulated—no distribution list is given, but the print run of the 1915 revision, which was issued in January 1916 and

90. *GFBO,* "Addendum No. 5" (n.d.), and *GFBO,* "Battle Tactics" (December 1915) in Patterson, ed., *Jellicoe Papers,* 1:61, 243.

91. *GFBO,* "Addendum No. 2" (31 August 1914), in Patterson, ed., *Jellicoe Papers,* 1:60. See also Jellicoe to the Secretary of the Admiralty, 13 September 1914, in Patterson, ed., *Jellicoe Papers,* 1:66.

92. "General Instructions by which our destroyers are to be guided" (January 1916) in *GFBO,* 3:335, ADM 116/1343.

93. "Turning Away to Avoid Attack or to Throw out the Enemy's Range" (23 February 1915) in *GFBO,* 1:44, ADM 116/1341.

was the edition in force at the battle of Jutland,[94] appears to have been 250 copies, which suggests an audience that encompassed all admirals, commodores, and captains as in the case of the HFGOs. German knowledge of the new technical-tactical synthesis would have compromised its effectiveness, and for this reason it is unlikely that its existence would have been revealed in a document that could have been captured in the event of any battleship, cruiser, or even destroyer flotilla leader being lost.[95] While there are no internal references to supplementary instructions dealing with tactics as in the HFGOs,[96] there were at least two sets of these whose security classification was higher than that of the GFBOs.[97] The "Grand Fleet Orders" were issued in 1914 and 1915. The less important items were printed and saved, but those concerned with such sensitive operational questions as gunnery were not even listed, and only fragments appear to have been preserved.[98] There were also memoranda considered "Most Secret" that were "issued personally" by Jellicoe to his admirals and commodores only, a group of fourteen.[99] No copies are known to exist,[100] but the tightly restricted circulation indi-

94. *GFBO,* 1: Introduction, ADM 116/1341.

95. The Admiralty received an object lesson in the dangers such a contingency posed from the enormous benefits derived from papers recovered from the German light cruiser *Magdeburg* in August 1914, for which see Patrick Beesly, *Room 40: British Naval Intelligence 1914–18* (London: Hamish Hamilton, 1982), 4–6.

96. *HFGO,* ADM 137/260; and DRAX 1/9, Drax Papers. The *HFGO*'s table of contents refers to "supplementary instructions" of the commander-in-chief related to "Conduct of a Fleet, in action" which were to be "Kept in Steel Chest." A set of these restricted instructions has yet to be discovered.

97. This does not include the "Secret Fleet Orders (Grand Fleet)," which contain nothing on the tactical intentions of the commander-in-chief in the event of a fleet action, for which see "Secret Orders. (Grand Fleet.)" (24 May 1915 with reissues, corrections, and additional and revised pages up to 7 November 1918), ADM 137/265.

98. The *Grand Fleet Orders* for 1914 and 1915 are listed as the "Grand Fleet Secret Orders" by the Public Record Office, for which see ADM 137/4050 and ADM 137/4051. The table of contents of the 1914 print lists fewer than a quarter of the total number of orders indicated by the numbering system. For references to "Grand Fleet Orders" not included in the Public Record Office texts, see Lambert, "Our Bloody Ships," 41 nn. 30–31.

99. Memorandum from Jellicoe on hectograph (ditto) to his flag officers ordering the destruction of "Most Secret" memoranda of 21 December 1914 and 4 January 1915 (20 October 1915), ADM 137/2020.

100. See entry "Instructions regarding battle tactics, and other tactical matters" (H.F. 0034), in Great Britain, Admiralty, Historical Section, "List of Grand Fleet Secret Packs, 1914–1918," 37, ADM 137/1881, which includes references to "Papers on tactical questions," "Alterations to Battle Orders and Manoeuvering Orders," and "Deployment Signals." It may be significant that while the numbering of the secret packs indicates the existence of at least fifty topics (H.F. 001-0050), consecutive progression is frequently interrupted, resulting in a list that names only thirty-one top-

cates that they were concerned with matters both important and secret. And finally, Jellicoe conducted meetings not only with his subordinate senior commanders, but also with the gunnery officers of the fleet.[101] In the absence of any written record, the exact nature of the matters discussed in the "Grand Fleet Orders," "Most Secret" memoranda, and Grand Fleet officer conferences cannot be determined with certainty. Their probable general character, however, can be discerned by examining material on wartime torpedo methods and gunnery, as well as guarded private correspondence between Jellicoe and Vice Admiral Sir David Beatty, the leader of the separate battle cruiser force, which indicate strongly that Jellicoe considered a medium-range engagement against the German navy to be a serious possibility and even a desirable objective.

British Gunnery and Torpedo Matériel and Method, 1914–16

If Jellicoe's tactical plan was to have the Grand Fleet fire at ranges that were above ten thousand yards and not close to ranges that were within those of fast-moving torpedoes until the fighting capability of the Germans had been significantly reduced, he would have made certain changes in the gunnery and torpedo equipment and techniques of the Grand Fleet. First, the standard nine-foot base range-finders would have been replaced by fifteen-foot range-finders in all first-line battleships and battle cruisers. Second, the most advanced form of the Dreyer table would have been supplied to the many heavy ships that had not received any such gear before the outbreak of war. Third, firing in salvos using directors and perhaps improved spotting rules would have become the central feature of British naval gunnery. Fourth, a new armor-piercing projectile would have been developed to replace the existing ammunition, which Jellicoe knew was liable to premature detonation or break up when ranges were greater than ten thousand yards. And fifth, the range settings on British capital ship torpedoes would have been adjusted to allow firing to distances of fifteen thousand yards or more. None of these

ics. Inspection of H.F. 0034 category documents in the Grand Fleet Secret Packs series reveals papers contained in the *GFBO*s, but the disordered distribution of papers in the several hundred volumes in the Historical Section series makes it extremely difficult to ascertain the whereabouts of all tactical material.

101. Marder maintained that no meetings between Jellicoe and his senior subordinates took place, for which see Marder, *Dreadnought to Scapa Flow,* rev. ed., 3:5. But Jellicoe met regularly with fleet gunnery officers from 1914 through 1916, for which see Dreyer, *Sea Heritage,* 80, 91. For the fact of private discussions between Jellicoe and Beatty on tactics, and their mutual preference for face-to-face talks over letter writing, see Patterson, *Jellicoe,* 87–88.

actions were taken except for the last, and that not until the spring of 1916.

The maximum optimal range of a fifteen-foot base range-finder was fifteen thousand yards. Although instruments of this type were on order before the outbreak of the war, they did not begin to enter general service until early 1915 with the commissioning of the first battleships of the 1912 program (*Queen Elizabeth* class). Forty-five fifteen-foot range-finders had been delivered by August 1915, and eighty-four by August 1916. The distribution of this gear was generally limited to the new 15-inch-gun battleships and battle cruisers.[102] The former received five and the latter from three to four instruments, leaving much if not most of the British battle fleet equipped with only nine-foot base range-finders.[103] Increasing the numbers of nine-foot base range-finders, on the other hand, appears to have been a high-priority task. On the outbreak of war, twenty dreadnoughts—that is, the overwhelming majority of units composing the battle line—had only two nine-foot base range-finders. Over the course of the next year, nine-foot instruments were "fitted with all speed" to every turret in all of these vessels, which in effect tripled the number of range-finders per unit.[104] Although such an increase did not improve the capacity to fire accurately at ranges above ten thousand yards,[105] it magnified the reliability of the "mean range-finder range of the moment" derived from the Dreyer table at ranges of less than ten thousand yards, which was probably the intent.

By August 1914, only one of the 12-inch-gun dreadnoughts had received a Dreyer table. This situation was rectified in 1915 and 1916, but with a variant that was much simpler and thus in important respects less capable than the prewar models. What was later misleadingly named the Dreyer Table Mark I possessed the same mechanical means of averaging ranges, but in place of the Argo or Dreyer clock that had been fitted previously,[106] received the Vickers clock.[107] This machine had been

102. *Fire Control in H.M. Ships,* 32–33, and Great Britain, Admiralty, Naval Staff, Gunnery and Torpedo Division, *Progress in Naval Gunnery, 1914 to 1918* (July 1919), 39, ADM 186/238.

103. This meant sixty-seven fifteen-foot range finders were allocated to new capital ships, leaving a balance of twenty-two instruments as of August 1916, which was certainly less prior to May. Thus it is likely that only a minority of the Grand Fleet's older dreadnoughts received a single fifteen-foot range finder, and impossible that more than a very few were fitted with complete sets. See also Battle Cruiser Gunnery Committee Report, "Gunnery Lessons learnt from Action 31 May" (22 June 1916), 371, ADM 137/2139.

104. *Technical History,* part 23, 32–33.

105. "Report of Proceedings by Commander Richard T. Down, R.N. during visit to Washington—6th May to 27th June" (5 July 1917), 6, ADM 137/1621.

106. Sumida, *In Defence of Naval Supremacy,* 208–20.

107. Roberts, *Battlecruisers,* 92, 126.

standard prior to 1912, and thus was a convenient substitute from the standpoint of being available in quantity. In terms of performance, however, the Vickers clock was both less accurate and less reliable than its predecessors, which mattered a great deal at longer ranges where the allowable margin for error in sight-setting data was much smaller than at shorter ranges.[108] Although the 15-inch-gun capital ships that entered service during the war received the most advanced form of Dreyer table, in May 1916, no less than one-third of the Grand Fleet's battleships and half its battle cruisers had to make do with inferior equipment. That being said, the capacity of the reduced model Dreyer table to average ranges to obtain a "mean range-finder range of the moment" at ranges of less than ten thousand yards was more or less equal to the earlier variants, which would have been sufficient for the kind of battle for which the new technical-tactical synthesis had been conceived.

On the outbreak of war in August 1914, only eight British dreadnoughts were equipped with directors. By June 1915, the total number of ships with directors was seventeen, or little more than half of the Grand Fleet's dreadnought force in spite of the passage of nearly a year. By December 1915, twenty-four dreadnoughts had been fitted with directors, but some fourteen director sets had been diverted to shore-bombardment monitors, leaving eleven dreadnoughts and all seven predreadnoughts of the Grand Fleet without. By May 1916, two dreadnoughts were still lacking their directors.[109] Production difficulties offer a partial explanation for the pace of director installation in the Grand Fleet, but the priority given to the monitors over first-line capital ships indicates that director firing was not considered to be an essential feature of British capital ship gunnery, and certainly could not have been through the end of 1915 given the absence of means insofar as a large proportion of the dreadnought force was concerned.[110] And the effectiveness of even director-equipped ships was reduced by the inefficiency of spotting procedures. This condition was probably the result of the fact that in the Royal Navy, target acquisition had been the main property of range-finders and the Dreyer table.

In 1910, Jellicoe had known that British armor-piercing projectiles were prone to malfunction when striking armor plates at an oblique angle, which would always be the case at ranges that were above ten thousand yards. In 1911, the development of a remedy was put off on the grounds that high-explosive shells would be fired at longer ranges, with

108. Sumida, "Quest for Reach," 50.

109. *Fire Control in H.M. Ships,* 9–11.

110. For Jellicoe's order disallowing the improvisation of directors as a response to the delays in director deliveries to the Grand Fleet, see "Improvised director firing" (20 April 1915), in Section "B," *Grand Fleet Orders, 1915* (16 April 1915), 33, ADM 137/4051.

armor-piercing projectiles reserved for action at shorter distances where oblique angle impact would not occur when engaged fleets were on parallel courses.[111] Jellicoe did not ask for better armor-piercing projectiles upon taking command of the Grand Fleet. And while his GFBOs recommended using common shell for 12-inch guns because of the weak penetrative power of their relatively small projectile at extended ranges, they called for the use of armor-piercing ammunition in the case of 13.5-inch and 15-inch guns at the outset of battle in spite of their unreliable fuses.[112] The latter instruction does not make sense unless Jellicoe supposed that serious shooting would take place primarily at medium ranges.[113]

The speed and range settings of the torpedoes carried by British capital ships were a sign of Jellicoe's intention to fight a medium-range fleet action for at least the first seventeen months of his command of the Grand Fleet. In May 1914, British 21-inch torpedoes had two settings: 4,000 yards at forty-four knots, and 10,000 yards at twenty-eight knots.[114] Ten thousand yards was still the extreme firing range of the Grand Fleet's torpedoes as late as December 1915, the month in which the GFBOs that were to be in force at Jutland were redacted.[115] In late 1915, intelligence reports of longer-range settings of standard German torpedoes and the German adoption of larger torpedoes with improved performance prompted Jellicoe to request that torpedoes be given a longer-range setting of 18,000 yards at nineteen to twenty knots,[116] which was implemented by April 1916.[117] But if German torpedoes that were set to run to a range of 13,100 yards were fired during a fleet action taking place at under 10,000 yards, the slower speed of the 19.7-inch model would only mean that the British would have even more time to

111. Sumida, *In Defence of Naval Supremacy,* 207.

112. "Projectiles to be used in Action Between Armoured Ships" (March 1915) in *GFBO,* 1:98–99, ADM 116/1341; and "Projectiles to be used in Action Between Armoured Ships" (December 1915), in *GFBO,* 3:304, ADM 116/1343.

113. For Jellicoe's belief in the importance of engaging at ranges at which armor-piercing projectiles were effective, see Memoranda and Minute: "Type of gun to be adopted for the armoured vessels of the 1907–8 Programme. Whether a 13.5″ gun or a 12″ triple gun turret" (20 June 1906), Ship's Cover *Bellerophon,* 223, National Maritime Museum Annex, Woolwich. I am indebted to Dr. Nicholas Lambert for bringing this document to my attention.

114. Handwritten table attached to "First Fleet Temporary Memorandum" (20 May 1914), in DRAX 1/10, Drax Papers.

115. Jellicoe to Flag Officers, Commodores, Captains (D), and officers in command of H.M. ships and destroyers of the Grand Fleet, "Memorandum H.F. 13/114" (18 September 1915), ADM 137/2005; and Great Britain, Admiralty, Naval Torpedo School, *Thirty-sixth Annual Report of the Instruction and Practice of Torpedo Warfare in H.M. Navy. 1915* (London: HMSO, 1916), 24, 37, 86.

116. *Annual Report of Torpedo Warfare 1915,* 37.

117. Jellicoe to Beatty, 1 April 1916, in Patterson, ed., *Jellicoe Papers,* 1:231.

fire before being able to turn away safely, while the somewhat faster 21.6- or 23.6-inch models would not be swift enough to reduce the British safety interval to below minimum requirements. The existence of German torpedoes with longer-range settings did not, in other words, vitiate the concept of medium-range action for a brief period followed by evasive action.

By mid-1915, it was apparent that the German fleet would attempt to avoid action, and that a great deal of firing would take place at ranges above ten thousand yards. For various reasons, which have been described at length by Dr. Nicholas Lambert and thus will not be repeated here, the Grand Fleet responded by placing even greater emphasis on fast shooting.[118] But Jellicoe also continued to stress the importance of rapid firing at medium ranges. In the spring of 1915, Jellicoe declared that "at all ranges, action will be decided by rate of hitting, but at short and medium ranges, when hitting may be expected to commence almost at once, a ship which is slow in opening fire may be smothered by her opponent in the first minute or two, and [be] unable to recover herself."[119] To facilitate faster shooting at all ranges, the Grand Fleet adopted new methods of salvo shooting. (See Appendix, "Gun-layer Ripple Salvos" and "Rapid Salvos.")

In August 1915, Beatty suggested that Royal Navy officers had overemphasized the big gun and undervalued the torpedo as a method of attack, thus resurrecting the arguments of Callaghan.[120] Jellicoe conceded that the offensive torpedo capability of the British battle fleet was inferior to that of the German navy, and that this would not change "for a long time to come," but he emphatically rejected the notion that the Grand Fleet was afflicted by a case of overconfidence in the efficacy of gunfire. "I do not think that anybody, at any rate in the Grand Fleet," he wrote to Beatty on 7 August,

> is obsessed with the idea . . . that we place reliance in our guns alone. I am quite certain, indeed, that exactly the reverse is the case. There are some who are inclined even to magnify the danger of the torpedo from destroyers and submarines, and of the mine, and to place too little reliance on the gun.[121]

Beatty responded to Jellicoe's unmistakable rebuke with assurances of his concurrence with his superior's tactical perspectives. On 12 August,

118. Jellicoe to Admiralty, 26 April 1915, quoted in Nicholas A. Lambert, "Jutland and the Loss of the Battle Cruisers, 1916," 40.

119. *Section "A," Grand Fleet Orders, 1915,* "Fire Control in Action," quoted in Lambert, "Jutland and the Loss of the Battle Cruisers, 1916," 41. See also *GFBO,* 1: "Gunnery Addendum," 96.

120. For Beatty's agreement with Callaghan's point of view before the war, see Ranft, ed., *The Beatty Papers,* 1:55, 68–72, 88–89.

121. Jellicoe to Beatty, 7 August 1915, in Patterson, ed., *Jellicoe Papers,* 1:176.

he wrote a letter to Jellicoe in which he made a veiled reference to a tactical surprise involving naval gunnery and pledging his commitment to the goal of achieving a decisive victory in a fleet action. "We have the gun," Beatty noted, "with a possible superiority which we are entitled to keep up our sleeve." "Decisive victory is the only thing to aim at," he later declared, then added "we must keep our Gunnery up . . . at present, it is our only asset."[122]

Range-finder control at ranges of 10,000 yards or less was still a major concern in December 1915, the month in which the GFBOs in force at the battle of Jutland were prepared. On 14 December, Jellicoe ordered a target practice involving eight dreadnought battleships, which took place on 20 December. Seven of these were ordered to fire at ranges that were well above 10,000 yards. *Iron Duke,* Jellicoe's flagship, however, had special instructions. Her practice was to be carried out at 7,500 yards.[123] In the actual shoot, the Dreyer table plotted at least ten range observations per minute, which enabled *Iron Duke* to make twelve hits out of forty rounds fired at a mean range of 7,000 yards.[124] There can be little doubt that the purpose of such an exercise was to provide proof of the fleet's ability to fire rapidly through minimal dependence upon observation of the fall of shot at medium ranges. Two days after the exercise, Jellicoe informed Beatty that "I made *Iron Duke* fire 3/4 charges at 7500 (equivalent to about 10,000 at full charges) so as to see by actual *hits* that we are not living in a fool's paradise by firing so much by plotted results at long ranges. I took *Iron Duke* as a typical ship and the result is satisfactory."[125] Choice of the fleet flagship as a "typical ship" was disingenuous—*Iron Duke*'s captain was Dreyer, whose proprietary interest in the success of the gunnery method that he invented practically guaranteed an impressive performance. Such an event may, indeed, have been staged to boost flagging confidence in the practicability of the new technical-tactical synthesis.

122. Beatty to Jellicoe, 12 August 1915, in Ranft, ed., *Beatty Papers,* 1:279–81.

123. Memorandum: "Full Calibre Target Practice in the Moray Firth, Monday, 20th December, 1915" in ADM 137/2020. This document was marked "SECRET" and also stamped with the instruction "TO BE DESTROYED WHEN COMPLIED WITH."

124. Great Britain, Admiralty, Naval Staff, Gunnery Division, *Extract of Gunnery Practices in Grand Fleet, 1914 to 1918: Battleships and Battle Cruisers* (March 1922), 2, Naval Library.

125. Patterson, ed., *Jellicoe Papers,* 1:190–91. For the importance of range-finder control in Royal Navy gunnery as late as December 1915, see Great Britain, Admiralty, Gunnery Branch, *Manual of Gunnery,* vol. 3, for His Majesty's Fleet, 1915 (December 1915), 5–6, Naval Library.

Operational Crisis and Aftermath

In 1913, Jellicoe had expressed reservations about the clumsiness of Royal Navy signaling methods with flags.[126] The communications requirements of the new technical-tactical synthesis, however, were simple because the fleet did not have to be maneuvered while engaged with the enemy and the breakaway could be executed with a single signal. While in command of the Grand Fleet from 1914 to 1916 Jellicoe thus appears to have been confident that the combination of skilled flag signalers, radio back-up, and the use of cruisers steaming alongside the battle line to repeat signals, would be enough to insure that the critical order to turn could be communicated,[127] and that his well-drilled captains would respond as ordered even if ignorant of the tactical reasoning underlying the command.[128] British gunnery and signaling capabilities aside, the practicability of Jellicoe's concept of medium-range action to achieve decisive victory depended upon four things: the willingness of the German commander to close to less than ten thousand yards and engage on a straight course; the German initiation of mass torpedo fire only after the fleets were facing each other on near parallel courses and not before, in order to give British gunners sufficient time to inflict heavy damage before the turn away; the inability of the Germans to inflict serious damage with heavy artillery during the approach because of the effect of changing range; and the significant inferiority of German rates, compared to British, of hitting at medium ranges when the two fleets were on near parallel courses moving in the same direction at similar speeds.

126. Gordon, *Rules of the Game,* 362.

127. "Memorandum," H.F. 0037/1 (6 March 1915), in Backhouse Papers, Naval Library; Jellicoe, *Grand Fleet,* 58–59; Marder, *Dreadnought to Scapa Flow,* rev. ed., 3:34–36; Captain Barrie Kent, *Signal!: A History of Signalling in the Royal Navy* (Clanfield: Hyden House, 1993), 43–44; and Gordon, *Rules of the Game,* 354–64. Jellicoe's known dislike of simultaneous turning on the grounds of collision risk was probably not applicable to circumstances when a formation of undamaged battleships was in a well-formed single line ahead, and required to do no more than execute a turn that would take the fleet away from the enemy into an area that was likely to be clear of gunsmoke.

128. Even under the more Nelsonic regime of Beatty, capital ship captains seem to have had little knowledge of the higher tactical intentions of their commander-in-chief, and indeed carried out the kind of maneuvers required by Jellicoe's secret technical-tactical synthesis. A senior captain under Beatty's command recalled that he knew "nothing, absolutely, of Fleet Tactics, or of handling a Fleet," and that in eighteen months with the Grand Fleet (1917–19) "all the Tactics called for at sea were practically embraced in 'turn together four Points to Port,' and, ten minutes later, 'Turn together four Points to Starboard.'" For the foregoing, see Vice Admiral John D. Kelly to Admiral Sir Roger Keyes, 14 April 1926, in Paul G. Halpern, ed., *The Keyes Papers: Selections from the Private and Official Correspondence of Admiral of the Fleet Baron Keyes of Zeebrugge,* 3 vols. (London: Navy Records Society, 1979-81), 2:177–78.

The German intelligence effort in Britain after the outbreak of war was no more effectual than before, and almost certainly failed to give warning of the major British gunnery breakthroughs of 1912–14.[129] British intelligence, for its part, provided Jellicoe with reports about German capabilities and intentions that would have encouraged faith in the likelihood that the new technical-tactical synthesis would work in battle. In September 1914, the Admiralty sent Jellicoe a memorandum about the German day-firing practice of 1913–14 that indicated an intention to fight at 8,000 yards.[130] At this time or no later than December, the Director of Naval Ordnance reported that the existing German fire control system "could not compete with a high and varying change of range."[131] In December 1914, the Intelligence Division of the Admiralty War Staff printed a facsimile of the German report on firing practice in 1912–13, whose contents indicated that hitting was poor when the range was changing, firing inaccurate at ranges above 10,000 yards, and gunnery at 5,000 to 8,000 yards inferior to that of British battleships in the same year (1912), albeit under more difficult circumstances.[132] In January 1915, the Intelligence Department printed a confidential Admiralty translation of a presumably up-to-date copy of the *German Tactical Orders,* which stated that the German battle fleet intended to fight at ranges of from 8,800 to 6,600 yards, contained technical information that suggested that German battleships would limit their use of torpedoes to the optimum aiming conditions offered by an action on near parallel courses rather than launching during their oblique approach, and declared that the German tactical objective was a decisive victory at any cost.[133] Dreyer, and undoubtedly Jellicoe as well as others, believed this information to be sound.[134]

129. Andrew, *Secret Service,* 73, 187–88.

130. W. Graham Greene, Admiralty Permanent Secretary, to Admiral Sir John Jellicoe, Commander-in-Chief Grand Fleet, "Copy of a Translation of a German Report on the Annual Battle Practice of Certain German Ships" (30 September 1914), 2, in "Secret Packs of the Commander-in-Chief 1914–1918," vol. 26, Packs 0017, ADM 137/1906.

131. Memorandum by Captain [from October 1914 Rear Admiral] Morgan Singer, Director of Naval Ordnance, "Intelligence Information Obtained at Kiel" in "Intelligence, 1914," 155, ADM 137/1013.

132. Great Britain, Admiralty, War Staff, Intelligence Division, *Germany. Results of Firing Practices, 1912–13* (December 1914), Naval Library.

133. Great Britain, Admiralty, Intelligence Department, *German Tactical Orders* (January 1915), 5, 7, 8, ADM 137/17.

134. Captain Frederic Dreyer, "A Few Notes on the Determination of the Most Advantageous Range at which the Grand Fleet should engage the High Sea Fleet," (n.d., but probably September 1915, for which see reply by Captain Roger Backhouse, special assistant to Jellicoe, dated September [1915]), Jellicoe Papers, Additional Manuscripts 49012, British Library, London.

British intelligence about German gunnery was overly optimistic. The Germans did not use a system of plotting ranges, but did have the mechanical means to average the results of several range-finder observations. German range-finders were probably little better than British ones at ranges that were greater than ten thousand yards, but German gunnery training and technique placed greater emphasis on finding the target quickly with salvos and firing accurately in spite of changes in course.[135] The excellence of German gunnery at ranges above ten thousand yards in skirmishes that took place in the early months of the war in fact prompted Jellicoe to warn his command in June 1915 that the enemy's abilities with respect to long-range shooting were better than had been supposed.[136] That being said, the German fleet was still not capable of taking on the British when moving in the same direction on parallel courses at medium range without being battered severely or destroyed. The critical issue, therefore, was not with the British assessment of German capabilities, but with German intentions. The German determination to fight a medium-range action had been based upon the belief that Britain would impose a close blockade with its battle fleet, and that losses inflicted on this force by fast surface torpedo craft and submarines would eliminate the Royal Navy's numerical superiority in capital ships.[137] When this did not happen because of the British strategy of distant blockade, which was meant to prevent such a situation from arising, the German fleet did its best to avoid a show-down. Thus the British problem was not that its intelligence about German tactical practice was wrong, but that the reported intentions were contingent upon changeable circumstances rather than a reflection of a commitment to an operational principle. Or put another way, British misapprehension of German tactical intentions was the product of German misapprehension of British strategic intentions.

The Germans' failure to deploy their battle fleet aggressively surprised the Royal Navy,[138] and in particular invalidated the assumptions of the secret technical-tactical synthesis formulated before the war.

135. Rear Admiral D. Mahrholz, *Der Artillerieoffizier eines Grosskampfschiffes im Kriege 1914/18* (Berlin: Der Führergehilfenaussbildung der Marine, 1930), 19–30 (I am indebted to Captain Werner Rahn for a copy of this invaluable source, and to Mr. Ingo Trauschweizer for providing a translation of the text); and Sumida, *In Defence of Naval Supremacy,* 301–2, 323 (note 79).

136. "Gunnery drills and instructions" (19 June 1915) in *Grand Fleet Orders 1915,* 56, ADM 137/4051; for a low opinion of German ammunition, however, see Beatty to Jellicoe, January 1915, in Patterson, ed., *Jellicoe Papers,* 1:131.

137. Admiral Scheer, *Germany's High Seas Fleet in the World War* (New York: Peter Smith, 1934), 11.

138. Memorandum by Vice Admiral F. C. D. Sturdee, commander of the Fourth Battle Squadron (1915–18), 24 November 1916, in Jellicoe Papers, Additional Manuscripts 49012, British Library.

From the spring of 1915, therefore, the Grand Fleet was compelled to explore the possibility of developing an alternative. Between March and September 1915, the Grand Fleet carried out several major experimental gunnery exercises that involved shooting at ranges of from 10,000 to 17,000 yards. Those of late July and September involved firing ship and target courses and speeds that set up a relatively difficult change of range problems. Generally, however, firing with "continuous-aim" was specified as preferable to director laying.[139] In the fall of 1915, Dreyer produced a memorandum on the range at which a fleet engagement between the British and German battle lines should be fought. "The experience of the War," he observed, "must have shown the Germans that they have little or no hope in clear weather of getting their Battle Line to so close a range as 8,800 to 6,000 yards from the Grand Fleet." Given the unwillingness of the Germans to close, the assumption that the superior speed of the British battle fleet would enable it to choose the battle range, and the supposition that excellent ranges could be obtained up to 15,000 yards, Dreyer argued that in clear weather fire should be opened at 15,000 yards and the action fought at 13,500 yards.[140] Decisive results could not, however, be achieved quickly at such distances. This could give the Germans enough time to use slower speed but longer-range torpedoes, which would cause heavy losses if the British battle line did not take evasive action. (See Table 4.)

At the start of the war, Jellicoe believed that a retreating German battle fleet might drop mines and fire torpedoes to their rear. Such tactics would not only damage or sink pursuing British ships, but would probably create serious disorder in their formation. In October 1914, therefore, Jellicoe had informed the Admiralty that in the event of a German "turn away from an advancing Fleet, I should assume that the intention was to lead us over mines and submarines, and should decline to be so drawn." Such a course, he conceded, "might possibly result in failure to bring the enemy to action as soon as is expected and hoped." At this time, however, Jellicoe still believed that his secret operational procedure could be applied. He thus stated his intention "to pursue what is, in

139. H.F. 0037/2, Memorandum: "Exercise 'C,'" 12 March 1915; "H.F. 0035/1 Memorandum: Grand Fleet Firings—5th April 1915" (2 April 1915); "Enclosure No. 1 in Memorandum H.F. 0037/7 of 6 June 1915: Orders for Full Calibre Day Firing"; H.F. 44/59, Memorandum: "Orders for Target Practice from Cromarty, Monday, 2nd August, 1915" (30 July 1915); Memorandum H.F. 0011/17, "Exercise No. 5 to deal with circumstances of a German fleet refusing action" (31 August 1915); H.F. 44/88, Memorandum: "Orders for Full Calibre Target Practice from Cromarty, Tuesday, 5th October, 1915" (29 September 1915); all in Backhouse Papers. I am indebted to Dr. Nicholas Lambert for bringing these valuable papers to my attention.

140. Dreyer, "A Few Notes on the Determination of the Most Advantageous Range at which the Grand Fleet should engage the High Sea Fleet."

my considered opinion, the proper course *to defeat and annihilate* the enemy's battlefleet, without regard *to uninstructed opinion or criticism*"[141] (italics added). Jellicoe's remarks of December 1915 about shooting at less than 10,000 yards indicate that he retained at least some faith in the possibility that a battle could be fought and won through rapid fire at medium range more than a year later. But by the spring of 1916, he had concluded that a decisive battle was unachievable—barring a radical change in German operational practice—because the aggressive fleet handling that would be required to bring about a fight at the distances that were best suited to British gunnery, would expose the Grand Fleet's line of battle to unacceptable losses. Tactical stalemate, however, was in Jellicoe's mind not incompatible with strategic accomplishment. In April, he informed Admiral Sir Henry Jackson, the First Sea Lord, that the Anglo-German naval stand-off provided all the major benefits of a victory because essential British maritime interests remained secure. It was not, therefore, "wise to risk unduly the heavy ships of the Grand Fleet in an attempt to hasten the end of the High Sea Fleet, particularly if the risks come, not from the High Sea Fleet itself, but from such attributes as mines and submarines."[142]

On 31 May 1916, after nearly two years of waiting, the Grand Fleet intercepted its German counterpart in the North Sea. The inapplicability of medium-range tactics, the inability of British capital ships to shoot accurately at long range when visibility was poor and change of range rates were high and changing, and Jellicoe's conclusion that the game of decisive victory was not worth the candle, set the stage for a highly unsatisfactory outcome from the British point of view. The action opened with fighting between the battle cruisers at ranges that were always well above ten thousand yards and which involved several changes in course as well as non-parallel courses. These conditions were unsuitable for range-finder control, which meant that the British battle cruisers resorted to salvo rather than rapid-independent fire.[143] The British method of using salvos to establish the position of the enemy ship, however, was much slower than that used by the Germans. German gunners thus found their targets more quickly,[144] an advantage that was magnified by the exposed stowage of the augmented ammunition loads ordered by Callaghan before the war and continued by Jellicoe in order to facilitate fast shooting. The combination of inferior gunnery and

141. Jellicoe to the Secretary of the Admiralty, 30 October 1914, in Patterson, ed., *Jellicoe Papers,* 1:76.

142. Jellicoe to Jackson, 12 April 1916, in Patterson, ed., *Jellicoe Papers,* 1:232.

143. Beatty to Pollen, 14 August 1916, Pollen Papers, quoted in Anthony Pollen, *The Great Gunnery Scandal: The Mystery of Jutland* (London: Collins, 1980), 170.

144. "Gunnery Lessons learnt from Action of 31st May" (22 June 1916), 369, ADM 137/2139. I am indebted to Dr. Nicholas Lambert for this reference.

heightened vulnerability is probably the main explanation for the loss of three British battle cruisers.[145] In the later stages of the action in which the battleships were engaged, ranges were frequently less than ten thousand yards, but visibility was poor, courses were nonparallel, and the Germans maneuvered to break off the fighting. German capital ships were heavily damaged, and one would eventually sink. But German command and control arrangements survived, enabling the ships to retreat in good order under the cover of night and thus escape destruction.

The Grand Fleet subsequently made large alterations in its gunnery technique and equipment, torpedo range and speed settings, and tactical practice. Salvo-firing methods were modified to enable British gunners to find the correct sight settings for target range and bearing more quickly using director control,[146] which was made standard in good as well as poor weather when ranges were well above ten thousand yards.[147] Given the future unlikelihood of achieving a decisive fire power superiority in individual British units at medium range, interest in concentrating the fire of several ships on one target at long range grew and a serious process of experiment began in 1917.[148] Fifteen-foot range-finders were fitted rapidly in every capital ship, and the production of longer-base instruments initiated.[149] The belief that British armor-piercing projectiles had failed to detonate because their fuses had been designed for medium-range action prompted the development and production of new model ammunition suitable for use in long-range engagements.[150] Storage of ammunition outside of the magazine to facilitate rapid firing was prohibited.[151] The setting of torpedoes to run at twenty-nine knots at ranges up to ten thousand yards was replaced by two longer-range settings of twenty-four knots to fourteen thousand yards, and eighteen knots to seventeen thousand yards.[152] By 1917, remaining outside the range of torpedoes launched from the German battle line—a distance that was considered to be fifteen thousand yards—was a basic assump-

145. Lambert, "Jutland and the Loss of the Battle Cruisers, 1916."

146. Great Britain, Admiralty, Gunnery Branch, *Spotting Rules, 1916* (November 1916), Naval Library.

147. Great Britain, Admiralty, Gunnery Branch, *The Director Firing Handbook 1917* (October 1917), 5, Naval Library.

148. *Fire control in H.M. Ships,* 23–24.

149. Ibid., 32–35.

150. Great Britain, Admiralty, Gunnery Branch, *Final Report of the President, Projectile Committee, 1917* (June 1917), and Great Britain, Admiralty, Technical History Section, *Ammunition for Naval Guns; The Technical History and Index, Part 29* (May 1920), 10–15, Naval Library.

151. Admiralty to Vice Admiral commanding Battle Cruiser Fleet (Beatty), 4 September 1916, ADM 131/2021.

152. "Information Required Regarding Weights & Lengths of 18" and 21" Naval Torpedoes," 15 November 1917, ADM 137/2706.

tion of fleet tactical experiments.[153] Destroyer instructions were altered so that defense of the battle line became secondary to attacks on the enemy battle line.[154] Orders were given to widen the hulls of the "R" class battleships very substantially in order to decrease their vulnerability to torpedoes and to alter rolling characteristics in a manner that it was probably supposed would improve salvo firing.[155] And in 1919, a special Grand Fleet committee recommended the replacement of the Dreyer table by a much more sophisticated machine that could generate accurate sight-setting information without continuous range-finder observation. The new instrument was designed by Pollen's engineers and was installed in Britain's first postwar battleships, which entered service in 1927.[156]

Jellicoe and Dreyer had been the chief advocates of the secret technical-tactical synthesis that had shaped the matériel and methods of the Grand Fleet through mid-1916. This was a dangerous association in light of what had happened at Jutland,[157] and probably explains their efforts to conceal its existence. Jellicoe's memoirs, which were published in 1919, did not refer to an intention to fight a decisive engagement at medium range using rapid-independent fire, characterized the Dreyer table as a success, and connected the author to the improvements in spotting rules, armor-piercing projectiles, and director firing.[158] Dreyer worked assiduously to obfuscate the historical record from the inside. As Director of Naval Ordnance (1917–18), Naval Artillery and Torpedoes (1918–19), and the Gunnery Division (1920–22), he was in a position to influence if not control the Royal Navy's assessment of its prewar and wartime gunnery. That may explain why in confidential printed studies circulated within the navy not long after the war, criticism of the Dreyer table was muted and the relationship between range-finder control and rapid-independent fire in a medium-range engagement was difficult if not

153. Great Britain, Grand Fleet, *Tactics* (June 1917), EG 011, Naval Library.

154. *GFBO,* "Instructions for Destroyers after Deployment" (1 January 1918), in Ranft, ed., *Beatty Papers,* 1:475–76; and Marder, *Dreadnought to Scapa Flow,* rev. ed., 3:274–75; 4:35.

155. For the March 1915 decision to fit bulges experimentally to *Ramillies,* the order to fit the balance of the class similarly, and subsequent modification of *Revenge* and *Resolution* in 1917 and 1918, see Burt, *British Battleships of World War One,* 277–81.

156. Sumida, "Quest for Reach," 77–78.

157. For example, see Beatty to his wife, 17 February 1917, in Ranft, ed., *Beatty Papers,* 1:406–7; and Admiral Sir Charles Madden to Dreyer, 3 March 1924, DRYR 4/3, Dreyer Papers.

158. Jellicoe, *Grand Fleet,* 64–70.

impossible to discern.[159] In 1938, Dreyer produced a typescript history of surface fire control for use at H.M.S. *Excellent,* the Royal Navy's gunnery school. Dreyer depicted the story of fire control in the Royal Navy as one of steady progress in hitting at long ranges through the development of the Dreyer table, salvo shooting, and the director system.[160] A copy of this work was sent to Hugh Clausen, one of the Royal Navy's leading gunnery engineers, when he was at work on a planned official history of fire control, which he then gave up because it was "such a dangerous thing to write about."[161]

In memoirs published in 1955, Dreyer claimed that an experimental firing in 1912 at fifteen thousand yards was proof of "the sound lines on which naval gunnery was developing" before the war,[162] in spite of the fact that this was the only occurrence of shooting by a British battleship before 1914 at a range longer than ten thousand yards.[163] Furthermore, he maintained that the postwar fire control system formulated by Pollen's men was "only a rearrangement of my 'Dreyer Table,'"[164] although this was plainly not so. And Dreyer also informed his readers that Jellicoe's battle fleet instructions had given his subordinates clear authority to use divisional attack,[165] an assertion contradicted by the record. As was the case in his pre–Second World War pamphlet, Dreyer did not discuss medium-range action, range-finder control, or the use of rapid-independent fire. Historical misrepresentation of this kind does not seem to have affected the development of British operational practice between the World Wars, whose course was directed in large part by technical expertise and recent combat experience.[166] But it did make it

159. Great Britain, Admiralty, Naval Staff, Gunnery and Torpedo Division, *Progress in Naval Gunnery, 1914 to 1918* (July 1919), ADM 186/238; Great Britain, Admiralty, Technical History Section, *Fire Control in H.M. Ships* (December 1919); [Naval Staff, Gunnery Division], *Extract of Gunnery Practices in Grand Fleet, 1914 to 1918: Battleships and Battle Cruisers*; and Great Britain, Admiralty, Naval Staff, Gunnery Division, *Grand Fleet Gunnery and Torpedo Memoranda on Naval Actions, 1914–1918* (April 1922), Naval Library.

160. H.M.S. *Excellent* [Admiral Frederic Dreyer], *A Brief History of the Development of Fire Control in the Royal Navy* (n.d., but 1938), copy of pamphlet and associated correspondence from H.M.S. *Excellent* Library, courtesy of Dr. Nicholas Lambert.

161. Clausen to Anthony Pollen, 5 April 1970, Pollen Papers; and Sumida, *Quest for Reach,* 78.

162. Dreyer, *Sea Heritage,* 86.

163. Jellicoe, *Grand Fleet,* 38.

164. Dreyer, *Sea Heritage,* 59.

165. Ibid., 66–67.

166. Jon Tetsuro Sumida, "'The Best Laid Plans': The Development of British Battle-Fleet Tactics, 1919–1942," *International History Review* 14 (November 1992): 681–700.

extremely difficult to understand the fundamental causes of major shortcomings in the performance of the Grand Fleet at Jutland.

Conclusions

In July 1920, William F. Clarke and Frank Birch, the authors of a highly classified history of German naval operations during the First World War, prefaced their three-volume study with several remarkable observations about the unreliability of not only the official naval histories produced for the public, but the internal staff and departmental histories as well. The time, they wrote, had "not yet come for a full, authentic and authoritative history of the war" because, in part, "of the necessity of keeping some things secret even from general official circles" and "the reflections which might be cast upon the reputations of living men."[167] "During the war," they noted, "the veil of mystery, which always to a certain extent overhangs the inner workings of a government department, was drawn closer. The 'Silent Service' [i.e., the navy] was specially privileged in this respect by prestige and precedent. Not the causes, but the results of policy alone, came before the public eye."[168] "The broad outlines of Admiralty action," Clarke and Birch then declared,

> may be guessed at and criticized by publicists, but the documents which must be the basis of final judgment are for obvious reasons withheld. When generations later, the historian with unrestricted freedom comes to compile the true and complete story, even if he is interested and conscientious enough to investigate the working of the machine [i.e., Admiralty organization], finds but incomplete data. So much is missing. Of the hurried consultations, the notes on slips of paper, the hundred little details that are so vital to this side of his subject, there remains no trace.[169]

The operational procedures of the world's largest and most advanced navy, however, left footprints in spite of the inherent incompleteness of the documentary record and the efforts of responsible parties to cover their trail. The performance characteristics of weapons and the exercises followed to promote their effective use reveal a great deal about tactical intent. Intelligent consideration of the range of possibility with respect to fleet fire and movement—that is, the naval historical equivalent of

167. Great Britain, Admiralty Intelligence Division [William F. Clarke and Frank Birch], *A Contribution to the History of German Naval Warfare 1914–1918 in 3 Volumes,* typescript copy [2 July 1920], 4–5, CA 1982/1, Naval Library. I am indebted to Dr. Nicholas Lambert for bringing these volumes to my attention.

168. Clarke and Birch, *Contribution,* 27.

169. Ibid., 27–28.

taking into account "inherent military probability"—suggest the existence of a tactical option that was never discussed in any policy text, but which was almost certainly the basis of Admiralty preparations to fight a decisive battle fleet engagement against the Germans.[170] Off-hand comments in contemporary papers or *post facto* recollections by individuals who had knowledge of certain things are also valuable. And even the tainted reminiscences of interested parties often say more than the author intended, especially when juxtaposed to other data. The reconstruction of motive with a high degree of confidence in the soundness of the conclusions drawn is thus possible in spite of the absence of direct evidence. The findings, moreover, are not just substantive with respect to the battle of Jutland, but address questions that are concerned with the fundamental nature of British prewar naval strategic planning and, on an even higher plane, the relationship between directed technological change and national security policy.

Several factors shaped British battle fleet tactics between 1912 and 1916. Changes in Royal Navy gunnery matériel and method increased the accuracy and rate of fire of big guns when courses were straight and ranges ten thousand yards or less. The addition of light cruisers and destroyers to the battle fleet, and the strengthening of battleship antiflotilla artillery fire power, provided security against torpedo attacks by enemy flotilla craft, which, it was supposed, would enable the British line of battle to steam on a straight course without having to maneuver. And intelligence assessments indicated that the German navy would fight at medium range on a straight course, was ignorant of British gunnery progress, and had not made similar advances. In 1912, the Admiralty thus concluded that a British battle fleet could smash an unsuspecting German opponent moving in the same direction at medium range with rapid and effective fire, and then turn away before torpedoes launched from the enemy battleships could reach their targets. By countering what were believed to be German tactical intentions, which had previously been regarded as very dangerous, the new technical-tactical synthesis minimally provided an antidote to defeat. Moreover, by incorporating surprise, the new technical-tactical synthesis promised decisive victory, while alternatives that were based upon more advanced methods of gunnery combined with divisional attack offered no more than a greater degree of offensive leverage under conditions that would remain highly uncertain. The plan was thus adopted in spite of the technical superiority and tactical advantages of the competing options.

170. John Keegan, *The Face of Battle* (New York: Penguin, 1978; first published 1976), 32.

The Admiralty's secret scheme, however, had two major drawbacks. First, it required the German navy to behave as expected. And second, the acquisition of gunnery equipment suitable to a battle fought at medium range and on straight courses disrupted British efforts to develop the ability to shoot accurately at long range and while maneuvering. During the First World War, the Germans did not act as Britain's naval leadership had anticipated; the new technical-tactical synthesis, as a consequence, was never tested in battle. But the Royal Navy's failure to acquire gunnery equipment appropriate to an action involving frequent changes of course and shooting at long range—which it might well have had—imposed serious operational limitations and created vulnerabilities, the price of which was paid at Jutland.

Between 1912 and 1914, the development of British gunnery technology was focused upon the maximization of fire effect at medium ranges, not the improvement of accuracy at long ranges. During this period, the Admiralty's seeming lack of concern with tactical doctrine was prompted by the need to keep the new technical-tactical synthesis secret in order to forestall German countermeasures, not intellectual lethargy. In August 1914, the improvisation of additional fleet instructions was necessary because the Royal Navy was ill equipped to put its carefully prepared battle plan into effect, not because it was bereft of a coherent concept of how to fight a general engagement. In the first year of war, British hopes were betrayed by the inapplicability of a tactical scheme whose objective was decisive victory through daring action, not the unimaginativeness and timidity of intended practice. At the battle of Jutland in May 1916, Jellicoe was cautious in large part because he could not be daring in the way he had wanted to be, not because he was not daring at all. And the problems in British gunnery equipment and method exposed at Jutland were the product of what turned out to be mistaken decisions by naval officers about complex and difficult technical and tactical issues, not manifestations of industrial failure or cultural conservatism.

Britain may have been generally backward in technical development, social organization, and cultural attitudes, but evidence for such indictments must be found elsewhere than through criticism of Royal Navy engineering and doctrine.[171] Indeed, the new technical-tactical synthesis could be regarded as having advanced features for its time in two important respects. From the standpoint of large-scale industrial organization, the Grand Fleet was a model of responsive discipline, capable of

171. Correlli Barnett, *The Swordbearers: Supreme Command in the First World War* (Bloomington: Indiana University Press, 1975; first published 1963), 178–89; and Robert L. O'Connell, *Sacred Vessels: The Cult of the Battleship and the Rise of the U.S. Navy* (Boulder, Colo.: Westview Press, 1991), 153–89.

acting quickly and decisively to orders from its chief executive officer. And insofar as tactical dynamics were concerned, the Royal Navy's plan was a harbinger of future practice. Its ideal was not a fight to the finish through "simultaneous erosive attrition"—that is, the reduction of the enemy by means of an exchange of gunfire over a prolonged period as in the age of sailing ships—but rather the unleashing of "one large pulse of fire power"—that is, the destruction of the enemy in a single blow in the manner of a carrier-launched air strike.[172] Jellicoe was cautious and a worrier, and he may have flinched on the day of decision, but the character of his tactical principles for much of his tenure as commander-in-chief of the Grand Fleet was the opposite of what has been supposed.

During the first half of World War I, Britain's battle fleet was commanded by a man who had played a major role in the design and production of the capital ships that made up its main fighting strength, and in the formulation of its tactics. Like Air Chief Marshal Hugh Dowding, who was to direct the build-up of Fighter Command before World War II and subsequently led the force he had created into battle in 1940, Jellicoe unified the weapons producer and user in a single person. But Jutland, unlike the Battle of Britain, could not be regarded as a clear victory, and if not a strategic or even tactical defeat, nonetheless yielded an unsatisfying outcome. Had Jellicoe triumphed using the matériel and methods he had prepared, it is likely that the new technical-tactical synthesis would have been regarded in terms comparable to the innovations in air defense that were to defeat German air power in the next great conflict. But contingent circumstances and the fortunes of war decreed otherwise. What was to have been the instrument of a second Trafalgar and the vindicator of a decade of radical naval reform was transformed by events into an emblem of inadequacy and a potential platform for partisan attacks on present and past Admiralty administrations. For Jellicoe and other distinguished persons, suppressing the story of the Royal Navy's intention to fight a medium-range naval engagement was thus imperative; the restriction of critical information to a few because of justifiable secrecy requirements made it possible. But with the exposure of what has long been concealed, a more accurate understanding of what Marder called the "Fisher era" may emerge through the penumbra of Jutland.

Admiral Sir John Fisher had been the navy's service chief from 1904 to 1910. During this period, his main objective had been to improve Britain's capacity to contain a continental naval coalition that could threaten simultaneously home waters and vital interests in distant seas. This goal was to be achieved using flotillas of submarines to prevent the invasion of the British Isles, while squadrons of battle cruisers would

172. Wayne P. Hughes, *Fleet Tactics: Theory and Practice* (Annapolis, Md.: Naval Institute Press, 1986), 93.

deal with cruisers that attacked commerce or battleships covering enemy sea-borne expeditions against colonial territory.[173] By 1912, the rapid expansion of the German battle fleet had caused a shift in the Admiralty's immediate strategic priorities—the development of submarine flotilla defense continued, but the emphasis of capital ship policy was placed on battleship construction and the adoption of tactics that would enable a British battle fleet to win a decisive victory in the North Sea. The new policies incorporated much of the matériel that had been developed earlier, but were tailored to meet different strategic requirements using new model fleet tactics that were antithetical to those envisioned for the battle cruisers. The "Fisher era," in short, was not a coherent strategic and tactical whole, but divided into at least two separate regimes, neither of whose operational practices proved wholly suitable to the circumstances that arose during the First World War. Confidence in the power of new technology and innovative tactics to transform naval warfare was indeed a prominent feature of pre-1914 British naval policy, but the story of the attempts of Fisher and his successors to achieve a "Revolution in Naval Affairs" is a cautionary tale, not a model for emulation.

173. Sumida, *In Defence of Naval Supremacy*; and Lambert, *Fisher's Naval Revolution.*

APPENDIX
Methods of Firing

Gun-layer Permissive or Director Salvos

A single salvo consisted of projectiles fired from four to five guns (four in a ship with an eight-gun broadside, five in a ship with a ten-gun broadside), laid at a fixed angle of elevation. Salvos were fired at the end of the roll, where the ship's rolling motion was slow or had stopped. With gun-layer permissive, a bell would be sounded in all gun stations during the roll, with individual layers firing at the end of the roll, which would produce near simultaneous firing (firing over a two-second interval).[174] With director firing, the firing mechanisms of all guns were activated by the director layer using a master trigger, which caused all guns to be discharged simultaneously. The salvo cycle was minimally defined by (1) the time of flight of the projectile; (2) the time required to communicate observation of the shell splashes and reset the sights accordingly; (3) any additional time required by loading if loading took longer than the time of flight and sight setting; and (4) additional allowance for a ship's rolling and yawing periods. A 12-inch-gun projectile took thirteen seconds to travel ten thousand yards, while a 13.5-inch or 15-inch projectile took just over fourteen seconds.[175] Applying corrections to the sights on the basis of observation of the fall of shot was time-consuming: with big-guns twenty seconds at least and often more.[176] The period of roll for a 12-inch-gun dreadnought battleship under average conditions was twelve seconds, while that for the 15-inch-gun vessels of the "R" Class—which were considered slow rollers—was nineteen seconds.[177] The period of yaw was variable depending upon the hull dimensions and form, roughness of the sea, ship speed, and the skill of the helmsman.[178] The fifty-second interval is, all in the foregoing considered, probably optimistic, which explains the general prewar practice of allowing a full minute

174. For gun-layer's permissive method of salvo firing, which was probably standard until at least 1909, see Hughes-Onslow, *Fire Control,* "Section IV: Modern Naval Gun Practice" (Portsmouth: Royal Naval War College, c. May 1909 with additions in June and August 1909), 11, Pollen Papers.

175. Great Britain, Admiralty, Gunnery Branch, *Range Tables for His Majesty's Fleet, 1910,* and *Range Tables for His Majesty's Fleet, 1910. Addenda, 1913* (London: HMSO, 1911, 1913), Naval Library; and ibid., *Range Tables for His Majesty's Fleet, vol. 1, 1918 (9.2-inch guns and Above)* (1918), 63, ADM 186/236.

176. *Manual of Gunnery, 1915,* 15.

177. "H.M.S. 'Bellerophon' Rough Weather Gunnery Exercises 30th. April 1911," TN/1/4, Trevylyan Napier Papers; and "Model Rolling Experiments-Complete Report" (9 March 1923), in Ship's Cover *Royal Sovereign,* 305A, National Maritime Museum annex, Woolwich.

178. Hughes-Onslow, *Fire Control,* "Section IV: Modern Naval Gun Practice," 5.

between salvos.[179] Note that the effect of assuming a sixty-second firing interval would worsen the case for salvo firing relative to rapid-independent.

Gun-layer Ripple Salvos

A single salvo consisted of projectiles fired from four to five guns (four in a ship with an eight-gun broadside, five in a ship with a ten-gun broadside). Guns would be laid by continuous-aim, which meant that they would be pointed at the target through the rolling and yawing motion of the firing ship. After a bell signal in all firing stations, guns would be fired in succession over a period of approximately nine seconds, beginning with the gun that was furthest down wind and proceeding up wind in order to prevent gun smoke from obscuring the view of gunners who had yet to fire their piece. Because waiting for the ship's roll and yaw to bring guns onto the target was unnecessary, gun-layer ripple salvos could be fired more frequently than director or gun-layer permissive salvos. The drawback of gun-layer ripple salvos was that poor laying—the propensity for which increased in rough seas—would cause the shots of a salvo to scatter, reducing the probability of making hits and possibly prompting faulty changes in sight setting that would further degrade accurate shooting.[180] In 1915, use of gun-layer ripple salvos seems to have reduced the interval between salvos to as low as forty seconds.[181]

Double salvos

A double salvo meant firing the entire broadside more or less at the same time—that is, two salvos simultaneously, whose splashes could be observed and, if necessary, corrections to the sight setting made. In effect, double salvos increased the rate of fire by a factor of two, but wasted twice as many shots as a single salvo if the sights were incorrectly set.

Rapid independent

Rapid independent meant firing each gun independently as fast as it could be loaded—that is, no pauses for spotting and correcting sight settings—using continuous-aim laying. During the *Dreadnought*'s experimental cruise, with a crack crew and expert supervision, the loading cycle for most of her 12-inch guns was twenty-nine seconds.[182] In 1915, the average rate of loading for 13.5-inch guns in newly commissioned

179. Great Britain, Admiralty, *Notes on Tactical Exercises. Home Fleet. 1909–1911* (1911), 2.

180. Hughes-Onslow, *Fire Control,* "Section IV: Modern Naval Gun Practice,"12.

181. *Battle Cruiser Orders* (18 February 1915), DRAX 1/3, Drax Papers.

182. Great Britain, Admiralty, Captain R. H. S. Bacon, *Report on Experimental Cruise* (March 1907), 84, ADM 116/1059.

ships was thirty-five seconds.[183] The rate of loading for 15-inch guns with a crack crew appears to have been thirty seconds.[184] In 1912, the adoption of improved elevating and training gear, which made it much easier to lay guns by continuous-aim, favored the use of rapid-independent.[185]

Rapid salvos

Rapid salvos meant firing a second salvo before the fall of the first salvo had been observed, evaluated, and sights corrected accordingly.[186] If sight settings were assumed to be correct, salvos could be fired without delays for corrections based upon the observation of the fall of shot, in which case the rate of fire appears to have approached that of rapid independent.[187] Rapid salvos of this kind using a director would have been preferable to rapid independent if poor visibility at gun level, rough seas, or longer ranges made continuous-aim laying ineffective.

183. *Battle Cruiser Orders* (18 February 1915), DRAX 1/3, Drax Papers.

184. Hodges, *The Big Gun,* 74.

185. For the mechanical changes that in 1912 resulted in a substantial increase in the rapidity with which guns could be elevated and depressed, and improved control of turret training, see *Paper Prepared by the Director of Naval Ordnance and Torpedoes for the Information of His Successor* (June 1912), 8, and Hodges, *The Big Gun,* 22–23, 62, 64.

186. Lambert, "Jutland and the Loss of the Battle Cruisers, 1916," 41.

187. "Spotting and rangefinding" (9 July 1915), in *Grand Fleet Orders, 1915 Section "B",* 89, ADM 137/4051.