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Technological Innovation and Organizational Change: The Navy's Adoption of Radio, 1899–1919

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Radiobroadcasting is a critical ingredient of modern military communications systems. Yet despite the opportunity to employ wireless telegraphy as early as 1899, the Navy shied away from the new technology and had little to do with it until the outbreak of World War I. In this essay Susan Douglas examines why it took the Navy so long to adopt the radio as standard operating equipment. Her account provides an instructive analysis of the tensions that arise when a bureaucracy is confronted with an innovation that threatens to alter the traditional hierarchical arrangements of command and control. Her history of the Navy's adoption of radio underscores the significance of entrepreneurship in innovative activity while illuminating the meaning of technological change as a social process.

In 1919, at the close of World War I, the United States Navy controlled and operated America's radio communications network, which consisted of stations aboard ship, medium-range shore stations, and several high-powered, long-distance stations capable of signaling over thousands of miles. The day after the United States declared war against Germany, President Wilson invoked the authority granted him in the 1912 Radio Act and placed all radio stations under naval control. But the Navy did not merely assume a custodial role; rather, it presided over a "technological revolution" that helped create a "coordinated industry."[1] Having orchestrated such a technological and organizational coda, Navy officials then assumed a central role in the negotiations leading to the formation of an "all-American" communications company, the Radio Corporation of America. By simultaneously promoting technological innovation and envisioning a reorganization of this important industry, the Navy in 1919 displayed considerable entrepreneurial talent and vision. In the RCA-sanctioned history of radio written in the late 1930s, Gleason Archer praised this vision, asserting that from the beginning wireless telegraphy and radio broadcasting owed the Navy "an everlasting debt." He elaborated, adding: "Not only did Navy technicians contribute to the development of the art, but private inventors and private manufacturers with their research departments found in Navy patronage the encouragement and inspiration that led them to persevere in their endeavors."[2]

Archer's portrait of naval patronage has been accepted by historians who have then focused on other important eras and events in the history of broadcasting.[3] Indeed, the extent to

I am indebted to Taylor R. Durham and Hugh G. J. Aitken for their advice and support.

The correspondence and memoranda cited are from two archival collections: The Clark Collection in the Division of Electricity, National Museum of American History, Smithsonian; and the Files of the Bureau of Equipment, National Archives. The Clark Collection is now only partially catalogued and was not catalogued at all when I did my research there; material from the Clark Collection is simply marked "SI." All the material from the Archives is from Record Group 19, File 18301. The box number in which the material was found is indicated after each letter.

1. Erik Barnouw, *A Tower in Babel: A History of Broadcasting in the United States,* Vol. I (New York: Oxford University Press, 1966), p. 52.

2. Gleason Archer, *History of Radio to 1926* (New York: The American Historical Society, Inc., 1938), p. 76.

3. See, for example, Barnouw, *A Tower in Babel,* and Christopher H. Sterling and John M. Kittross, *Stay Tuned: A Concise History of American Broadcasting* (Belmont, CA: Wadsworth Publishing Co., 1978), p. 36; Daniel J. Czitrom, *Media and the American Mind* (Chapel Hill: University of North Carolina Press, 1982).

which radio's technical and institutional fortunes depended almost entirely on military enterprise both during and just after the war and the repeated avowals of the importance of this debt by men such as David Sarnoff and Lee De Forest have suggested a long-standing and harmonious relationship between the Navy and radio unblemished by conflict or change. The progress achieved during the war thus eclipsed the Navy's earlier work with radio, and the events of three very intense years came to overshadow the preceding seventeen-year relationship between one fledgling industry and America's "new Navy." A more detailed examination of those seventeen years, however, suggests there might be much more to this story and that military enterprise in this case did not occur spontaneously nor always willingly, but was the culmination of a protracted and often uneasy process.

The Navy was introduced to radio in 1899, the year before William S. Sims met with resistance over adopting a system of continuous-aim firing on naval ships.[4] Would the same Navy whose members balked at changes in a certain type of weaponry introduced by someone not in Ordnance, but a naval officer nonetheless, embrace a revolutionary new communications technology presented to them by a half-Italian, half-Irish civilian inventor? Even Archer admits that certain officers "opposed with might and main the new agency of communications."[5] Commander Bradley A. Fiske, for example, an officer noted for his technical foresight and expertise, published an article in 1904 which asserted that radio had "no military usefulness whatever."[6] Impatient magazine and newspaper editorials from the early 1900s, such as those in *Electrical World,* strongly criticized the Navy's "moss-backed bureaucrats" and their "procrastination bureau" for taking too long to adopt radio while European navies were eagerly exploiting the invention.[7] As late as 1911 one commanding officer wrote, "We have failed to develop or employ the wireless, as a means of signaling" and urged that "The present systems [of tactical signaling],

4. Elting E. Morison, *Men, Machines and Modern Times* (Cambridge, MA: The MIT Press, 1966), pp. 17–44.

5. Archer, *History of Radio,* p. 73.

6. The article was initially published in the *Proceedings of the United States Naval Institute* and is summarized in Captain L. S. Howeth, USN, *History of Communications-Electronics in the United States Navy* (Washington, D.C.: Government Printing Office, 1963), p. 65.

7. *Electrical World* XXXVI, 5 (August 4, 1900): 157; 8 (August 25, 1900): 273; XL, 10 (September 6, 1902): 354.

so far as they relate to preparations for battle should be blown sky-high."[8]

Clearly, then, the Navy's attitude toward the use of radio changed dramatically between the early 1900s and 1917. Such different stances were separated by nearly twenty years and were bridged by the tortuous process of technical and institutional adaption. What was the nature of this adaptation and how did it occur? If there was initial resistance to radio, as the previous citations suggest, what prompted it and who voiced it? How was such resistance overcome? It is the purpose of this essay to examine how one military organization, the United States Navy, eventually integrated a revolutionary new communications technology, radio, into its operations and how its officers shifted from skeptics to sponsors. Several factors played critical roles in this process. The technical capabilities of radio, which improved dramatically during this twenty-year period, no doubt enhanced military receptivity in certain quarters. But examining the technical changes is not sufficient for understanding how a particular technical system fit into a particular social system over time. Certainly individual officers, with their own attitudes and goals, who served in key positions at critical moments influenced how and when the invention would be used. But possibly the most important factor was the organizational structure of which these men were part and into which this technology had to fit. For organizations can and do, through their traditions, structures, and reward systems, reinforce certain behavior and outlooks among their members while undercutting others. Organizations also consist of hierarchies and of niches, and new technologies can be consigned to the basement or showcased in executive offices.

How was the Navy organized at the turn of the century, and how did this structure affect the introduction of radio into the service? Did radio, in turn, alter the organization? Did the integration of radio mandate innovations in the organizational hierarchy and in managerial roles? Hugh Aitken has suggested that in times of technical uncertainty, and before exchanges of information between the realms of science, technology, and the economy were bureaucratized, individuals he calls "translators" transferred information between differently oriented and

8. Capt. W. F. Fullam, USN, Commanding Officer of the U.S.S. *Mississippi,* to R. D. White, Flag Lieutenant, Atlantic Fleet, 2 January 1911, cited in Howeth, *History of Communications-Electronics,* p. 193.

sometimes antagonistic sectors of society.[9] Such people were "bilingual" in that they understood the language and demands of more than one realm, and this facility made them indispensable to the innovation process. In the case of radio and the Navy, by 1899 the Navy was already a bureaucracy; the invention was the product of independent inventors and their fledgling companies. And the Navy, as a hierarchical organization, imposed constraints on the innovation process at the same time that it possessed resources capable of sustaining technical change. Could a translator sensitive to both the constraints and the opportunities emerge *within* this bureaucratic setting and mediate between technical change and institutional realignment? If so, what sort of a man would he be and how would he achieve his goals?

Wireless telegraphy, as radio was initially called, made its debut before a Navy adjusting to the physical transformation of its fleet. After resisting the adoption of steam propulsion and steel hulls for twelve years, the Navy of the 1880s, prodded by Congress, began acquiring bigger, faster, more impervious steel ships.[10] By 1900 the new fleet was nearly complete. The change from canvas to steam and from wood to steel profoundly affected the way a ship was run, what its needs were in port, and how officers thought of their duties and command. The reconstruction, though much needed, was unsettling to the men and to the department, and thus any concomitant alterations in the bureaucracy that might have made this "new Navy" more efficient were not readily forthcoming. The metamorphosis from old to new was initially cosmetic: while the hardware was being modernized, changes in naval administration, organization, and tactics lagged behind.[11] Much as the first steam-powered ships still retained rigging for sails, the naval organization sought to at least preserve a familiar structure during such major, unsettling changes.

In 1899 the Navy Department was comprised of eight

9. Hugh G. J. Aitken, *Syntony and Spark—The Origins of Radio* (New York: John Wiley and Sons, 1976), pp. 330–32.

10. Morison, *Men, Machines and Modern Times,* pp. 98–122; Harold and Margaret Sprout, *The Rise of American Naval Power, 1776–1918* (Princeton: Princeton University Press, 1939), pp. 165–82; Lance C. Buhl, "Mariners and Machines: Resistance to Technological Change in the American Navy, 1865–1869," *Journal of American History* 61, 4 (December 1974): 704; Robert Greenhalgh Albion, *Makers of Naval Policy, 1798–1947* (Annapolis, MD: Naval Institute Press, 1980), pp. 9–10.

11. Sprout, *The Rise of American Naval Power,* illus. facing p. 218 and pp. 270–80.

bureaus, each headed by a bureau chief.[12] The chiefs were responsible to the Secretary of the Navy, a civilian political appointee who usually knew little or nothing about naval affairs and who served at the pleasure of the President.[13] The responsibilities and jurisdiction of the bureaus often overlapped, yet there were no men, committees, or offices facilitating interbureau cooperation.[14] Jealously guarding their territory and prerogatives, the bureau chiefs were often embroiled in internecine squabbles that generated "friction, circumlocution, and delay."[15] The difficulty of reconciling and coordinating the duties and objectives of the bureaus was a constant source of frustration to the secretaries.[16] The bureaus, on the other hand, could not count on long-term or informed guidance from their chief executive.

This lack of departmental coordination and direction was exacerbated during the first decade of the twentieth century. The Navy was in an organizationally vulnerable position between 1900 and 1912, weakened, ironically, by the activities of its commander-in-chief. President Roosevelt, a staunch Navy booster, took such an active interest in the department that he became its de facto secretary. Between 1902 and 1909, there were six secretaries of the Navy, none of whom had much power or influence.[17] Even someone as energetic as Roosevelt could not provide the department with sustained leadership and continuity while serving as President, and as a result the Navy's top management and public relations position was compromised. This leadership vacuum, coupled with bureau separatism, worsened the organizational isolation of the bureau chiefs. Thus they learned to rely on "precedent and routine,"[18] and the department was guided by the daily grinding of the bureaucracy, which "ruled with an iron hand, usually ignoring,

12. At the turn of the century, these were: Bureau of Navigation, Bureau of Ordnance, Bureau of Equipment, Bureau of Construction and Repairs, Bureau of Steam Engineering, Bureau of Yards and Docks, Bureau of Medicine and Surgery, Bureau of Supplies and Accounts.

13. Charles Oscar Paullin, *Paullin's History of Naval Administration, 1775–1911* (Annapolis: U.S. Naval Institute Press, 1968), p. 438; Sprout, *The Rise of American Naval Power,* p. 274; Albion, *Makers of Naval Policy,* pp. 7, 12.

14. Sprout, *The Rise of American Naval Policy,* p. 193.

15. Ibid.; *Annual Report of the Secretary of the Navy,* 1905, p. 3.

16. *Annual Report of the Secretary of the Navy,* 1900; 1905.

17. Albion, *Makers of Naval Policy,* pp. 212–13; *Annual Report of the Secretary of the Navy,* 1909, p. 6.

18. Sprout, *The Rise of American Naval Policy,* p. 274.

sometimes penalizing, those who attempted to introduce reforms and innovations."[19]

Tactically, the sea-going Navy was equally decentralized until the twentieth century. Before then the fleet had been divided into "small groups of cruising vessels thousands of miles apart," although in reality each ship usually cruised by itself. "Even when in company, the ships rarely engaged in group maneuvers," and the men were more accustomed to thinking of each ship as a "potential solitary raider than as a unit of a fighting fleet."[20] Although the department began mandating periodic exercises and maneuvers in 1894, there was no accompanying "fleet policy," no long-term vision of coordinated activities or strategy within the Bureau of Navigation.[21] Despite Mahan's influence, there was no permanent fleet consisting of ships and commanders trained to operate cooperatively until 1907.[22]

Thus at sea and on shore autonomy and independence at the higher levels of the bureaucracy prevailed. Within each bureau, on each ship, the lines of authority and communication were clear and strong. But between ships or between bureaus, the lines, if there at all, were no more than fragile threads. And once ships were at sea, their lines literally and figuratively cast off, there was no web, either organizational or technical, to connect the ship to shore.

The Navy's rank and reward systems were structured to preserve this luxurious autonomy for ship commanders. After the Civil War, which had enhanced the importance and prestige of the staff departments in general and the engineers in particular, the line officers sought to "humble the engineer corps."[23] Mere "mechanics" could not be allowed to enjoy the same status and perquisites as the line. These efforts included a reduction in 1869 of the relative rank of each grade in the engineer corps as compared to the corresponding grade in the line.[24] This act, which of course outraged the staff, served to devalue the engineers and their work just at the time when the Navy was

19. Ibid., p. 271.

20. Ibid., p. 168; A. T. Mahan, *From Sail to Steam; Recollections on Naval Life* (New York: Harper, 1908), p. 270.

21. Sprout, *The Rise of American Naval Policy,* pp. 277–79.

22. Prior to 1907, squadrons were organized into fleets on a temporary basis, as during the Spanish-American War.

23. Sprout, *The Rise of American Naval Policy,* p. 177.

24. "The History of the Naval Staff Question," *The Nation* 295 (February 23, 1871): 121–22.

modernizing and becoming increasingly dependent on technology and hence on technical competence. The animosity between the two groups smoldered for over thirty years, with predictable repercussions for technical innovation. In addition, the promotion system in the Navy was notoriously slow, so that line officers arrived at command rank late in their careers and "grew grey as lieutenants while their sons caught up with them in the same rank."[25] These older officers were, like most older members of an organization, particularly resistant to new devices and procedures and nostalgic for the old sailing Navy. Their authority and prestige rested on tactical skills and decision making, not on technical mastery, and they were disconcerted by those who challenged this basis of command. But as the secretary noted in 1899, recognition of the engineer's importance had become essential: "A modern ship of war is one of the most complicated machines in existence. It is filled with machinery of various sorts from one end to the other. The finished ship, ready for service is of great cost and enormous value to the government. It is worth nothing unless efficiently handled, cared for, and kept in readiness for immediate service."[26] The Naval Personnel Act of 1899 amalgamated the engineers with the line in an attempt to make "every line officer an engineer, and also every engineer a line officer."[27] The engineers were awarded commensurate rank and salary. In practice, only a few young officers were given the duties of engineers, and it took over ten years for thirty years of tradition to begin changing.[28] Until officers saw engineering expertise as a route to promotion and prestige, few would switch from strategy to technology. Technology would have to advance strategy for total acceptance to occur. Six years after the amalgamation, the secretary complained that "some officers have not yet outgrown the idea that the engines of a ship are, in some sort, an excrescence, and those in charge of them rather auxiliaries to the fighting force than members of it."[29]

The communications systems available to the Navy both served and reinforced its decentralized administration. By 1890 telegraphic or cable communication was available in most

25. Albion, *Makers of Naval Policy,* p. 10; Paullin, *Paullin's History,* pp. 418–19.
26. *Annual Report of the Secretary of the Navy,* 1899, p. 326.
27. *Annual Report of the Secretary of the Navy,* 1905, p. 7.
28. Paullin, *Paullin's History,* p. 463.
29. *Annual Report of the Secretary of the Navy,* 1905, p. 7.

ports and Navy yards. This somewhat eroded autonomy: when squadron commanders were in port, it was possible for them to be more closely in touch with Washington. Although by the turn of the century there was a "growing tendency to make naval strategic decisions at Washington instead of the theater of operations," it was still only a tendency and not a practice that could be enforced when ships were incommunicado.[30] Between ships, flag signaling by day and newly installed light signaling by night were used for intership communications. During rain or fog, or across long distances, intership communication was impossible. Many ships were not equipped with the Ardois lights and could not signal at night.[31] And no ship could communicate with the shore once out at sea.

Responsibility for providing ships with signaling apparatus fell to the Bureau of Equipment, which furnished the vessels with other supplies including coal, rigging, navigation instruments, cordage, and hammocks.[32] Thus the Bureau of Equipment, a procurement and supplies division with no authority over or expertise in engineering, ship construction, and redesign or in maneuvers and fleet tactics, would be responsible for assessing and acquiring wireless telegraphy, which would alter all three.

In addition to these internal organizational constraints, the Navy would find itself in an increasingly delicate political position. President Roosevelt, the Navy's primary lobbyist, began to encounter well-organized Congressional opposition to extending the "New Navy." Senators and congressmen opposed to Roosevelt's brand of imperialism (and allied with others opposed to his liberal reforms) succeeded in reducing several of Roosevelt's requests for large naval appropriations.[33] These budgetary battles increased financial uncertainty and reinforced departmental caution. Thus, even if a bureau chief was technically sophisticated and sought to sponsor a particular innovation, he would confront obstacles above, below, and lateral to him in the organization. On the other hand, an officer's reluctance to make use of a particular technology was protected by the Navy's decentralized structure.

30. Howeth, *History of Communications-Electronics,* p. 13.
31. Ibid., p. 11.
32. Paullin, *Paullin's History,* p. 447.
33. Albion, *Makers of Naval Policy,* pp. 212–17.

Elting Morison and others have portrayed the Navy of this era as conservative and tradition-bound, its officers adhering to the time-honored way of doing things and distrustful of new devices or procedures. A review of the Navy's organization at the turn of the century helps explain this state of affairs. A weak and uninformed titular head of the department presided over an organization consisting of jealously guarded bureaucratic fiefdoms. Those with the most power were men who had been promoted slowly and late and were set in their ways. Autonomy was valued as independence, not bemoaned as isolation. The lack of communication between ship and shore was central to the whole spirit and idea of commanding a ship because it required and ensured freedom of action. This was not the sort of organization in which technical sponsorship, especially of an invention that threatened autonomy and decentralization, was either desired or possible. Yet this was the bureaucracy that wireless and its inventors would confront. The inventors were working at the forefront of electrical engineering, tackling both scientific and technical mysteries. But cracking this organizational enigma would elude them.

Guglielmo Marconi, who had first publicly demonstrated wireless telegraphy in England in 1896, brought his apparatus to the United States in the autumn of 1899. As a publicity stunt designed to promote his invention and provide *The New York Herald* with yet another "scoop," Marconi was to report the progress of the America Cup Race by wireless. With his apparatus set up aboard the *Mackay-Bennett,* Marconi "wirelessed" daily developments to *Herald* reporters on shore. Marconi's success was widely celebrated in the press;[34] *The New York Times* declared that if ship-to-shore transmission were the only use for wireless telegraphy, "it would still be one of the greatest and most beneficient discoveries of all time."[35]

The Navy was about to embark upon the first simple but necessary phase of technical adoption, introduction to the invention. Taking advantage of Marconi's American visit, and aware of Marconi's recent contract with the British Admiralty, the Bureau of Equipment sought to inspect his apparatus on

34. See *Electrical World* XXXV, 15 (October 7, 1899) and *The New York Times* and *The New York Herald* for October 1899.

35. *The New York Times,* December 17, 1901, p. 8.

behalf of the Navy. Marconi agreed to allow four officers, all electrical experts, to witness the operation of his equipment throughout the races.[36] In his report to the bureau, Lieutenant J. B. Blish stated that the demonstrations "were most convincing that the system was already excellently adapted for use on board ship; and my investigations since then have strengthened that conviction."[37]

During these observations Marconi was persuaded to allow further naval testing of the apparatus after the yacht races ended. Marconi agreed to the tests only after issuing several disclaimers: he had not expected to give such a demonstration and thus the equipment he had with him was not "sufficient for a government test . . . on a large scale." Nor did he have with him his "devices for preventing interference" from competing transmitters because these devices were not yet "completely patented."[38] Marconi wanted it understood that this was not his standard demonstration for naval vessels, that he did not have all of his state-of-the-art equipment with him, and that consequently he could not guarantee the same success in these tests that he had achieved during the yacht races. Marconi was on the verge of patenting his method of tuning, whereby several wavelengths could be used with a given antenna. Because he was the only one signaling during the yacht races, he had no need for tuning and had not brought the additional apparatus to America. While Marconi may have been seeking only to protect himself from unjust criticism, the Navy eventually came to feel he was trying to cover up a major and unavoidable defect of the system.[39]

Marconi's apparatus was dismantled from the press boats in October 1899 and installed on the armored cruiser *New York* and the battleship *Massachusetts,* both anchored in the New York Harbor. A third set at the Navesink Lighthouse in New Jersey served as the shore station. The members of the "Marconi Board" were to assess the equipment's accuracy, establish maximum operating distance, determine the best location for the instruments, and report on interference. After several days of tests, one of the board members, Lieutenant Commander

36. Howeth, *History of Communications-Electronics,* p. 26.

37. Lieut. J. B. Blish, Report to Bureau of Equipment, November 13, 1899, NA, box 83.

38. Guglielmo Marconi to Wireless Board, 29 October 1899, NA, box 83.

39. George H. Clark, "Radio in War and Peace," unpub. ms., 1940, SI, p. 14.

J. T. Newton, advised the bureau that sending accuracy was not always achieved and that Marconi's temporary set-up aboard the ships would be inadequate for a permanent installation. Transmission speed averaged twelve words per minute. While the two ships exchanged messages over a distance of 36.5 miles, and the *Massachusetts* received the *New York*'s transmissions up to 46.3 miles, this success was overshadowed by a persistent drawback: "In every case, under a great number of varied conditions, the attempted interference was complete,"[40] meaning that whenever they tried to interfere with the messages, they succeeded. Interference had occurred whenever more than one set was signaling, because only one wavelength was being used for all transmissions. Although Marconi had claimed that he could prevent interference, "he never explained how nor made any attempt to demonstrate that it could be done."[41]

Yet despite these failings, Newton and the board recommended that "the system be given a trial in the Navy." Newton pointed out that the system could be adapted for use on all Navy vessels and had the distinct advantage of performing well in "rain, fog, darkness, and motion of ship . . . excessive vibration at high speed apparently produced no bad effect on the instruments." Within the working ranges, "accuracy was good." He noted that the best location for the instruments would be "below, well protected, in easy communication with the commanding officer."[42] Another Board member wrote that "even in its present state the instruments can be made useful in signaling between ships, and ship and shore."[43]

Admiral R. B. Bradford, Chief of the Bureau of Equipment and himself quite knowledgeable about electrical technology, was persuaded by this report and appealed to the Secretary of the Navy on December 1, 1899. "This system is successful and well adapted for Navy use. The chief objection to it is known as 'interference'. . . . Notwithstanding this fact, the Bureau is of the opinion that the system promises to be very useful in the future for the naval service." Citing Marconi as the recognized inventor and noting that no other "makers of electrical instru-

40. Lieut. Comdr. J. T. Newton, Report on the Marconi System, 13 November 1899, NA, box 83.

41. Ibid.

42. Ibid.

43. Lieut. G. W. Denfeld to Chief, Bureau of Equipment, 1 November 1899, NA, box 83.

ments have been able to successfully duplicate Marconi's apparatus," Bradford recommended acquiring sets from Marconi for continued naval experimentation.[44]

Despite this favorable endorsement from the Bureau of Equipment, no such acquisition of Marconi apparatus occurred. The breakdown of relations between the Marconi Company and the U.S. Navy following the preliminary tests and the board's favorable recommendation had far-reaching and long-term repercussions that affected both organizations as well as other fledgling wireless companies.

Why was such an admittedly imperfect, yet extremely promising invention not acquired by the "New Navy"? Not enough evidence exists to answer this question with complete assurance. The reason most often cited explains that the Navy rejected Marconi's contract specifications as too expensive and restrictive. The dispute over the terms of purchase reflected misunderstanding on each side about the needs of and constraints upon the other party to the contractual negotiations.

Marconi would not sell his apparatus to the Navy or to anyone without royalties. Under his terms, the Navy would purchase not less than twenty sets at a total cost of $10,000 and agree to pay a $10,000 annual royalty. The royalty would be reduced if a greater number of sets were purchased.[45] These terms, for Marconi, represented a concession: the Navy got to keep the sets, while other customers could only lease the apparatus. The Marconi Company had decided on this leasing policy after three disappointing and expensive years trying to market wireless in England through outright sales.

When the company was formed in 1897, Marconi had hoped it would become economically viable by selling wireless apparatus, especially to shipping firms. But a customer could not merely buy the equipment: the client would need trained operators; intermittent adjustments, repairs, and improvements; and shore stations with which to communicate. No firm was prepared to make that large an investment in such a new device, and sales were discouraging.[46] Marconi, like Western Union and Bell Telephone, would have to provide an entire

44. Adm. R. B. Bradford, Chief, Bureau of Equipment to Secretary of the Navy, 1 December 1899, NA, box 83.

45. Ibid.

46. Susan J. Douglas, "Exploring Pathways in the Ether: The Formative Years of Radio in America, 1896–1912" (Ph.D. dissertation, Brown University, 1979), p. 75.

communications network and then lease access to the system. Leasing encouraged more firms to give wireless a try, and it ensured that the company retained control over both the apparatus and the personnel upon whom its success depended. As Hugh Aitken has observed, "It is hard to conceive of any other market strategy available at that time that would have sustained the growth of the company."[47]

In addition, the Marconi Company had begun to promulgate its nonintercommunication policy. The company continued to invest thousands in shore stations and apparatus. Yet by the very nature of wireless and wave propagation, anyone with a transmitting or receiving set could tap into the system free of charge. Marconi simply could not allow free access to all and realize a return on his investment at the same time. Consequently, all Marconi operators at all Marconi stations were strictly instructed to exchange messages only with other Marconi stations.[48] Without control over a network of wires or cables, to which he could physically have controlled access, what else could Marconi have done to ensure that his system survive financially?

The Navy's reaction to Marconi's terms and policies was influenced by precedent and law, by nationalism, and by an apparent suspicion of inventors and business firms. The Bureau of Equipment did not have enough money to pay Marconi's price and the department was constrained, by law, from obligating funds beyond the current fiscal year.[49] But in addition the Navy viewed the leasing and nonintercommunication policies as unnecessary and grasping monopolistic ploys designed solely for the purpose of granting yet another British company complete control over international communications. As one official noted, "Such a monopoly will be worse than the English submarine cable monopolies which all Europe is groaning under and I hope the Navy Department of the U.S. will not be caught in its meshes."[50] From the Navy's point of view, Marconi was trying to prevent anyone else from gaining access to a resource—"the air"—that had traditionally been free. The

47. Aitken, *Syntony and Spark,* pp. 230–40.

48. Douglas, "Exploring Pathways in the Ether," pp. 77–78.

49. William Moody, Secretary of the Navy to the American Marconi Wireless Telegraph Co., 25 September 1903, NA, box 85.

50. Comdr. F. M. Barber to Chief, Bureau of Equipment, 6 December 1901, NA, box 83.

Navy, however, had not experienced firsthand the financial difficulties surrounding wireless: the research expenses, the patent and legal fees, and the revenue problem. To the Navy, the Marconi financing strategy was not protective but avaricious. As an independent entrepreneur, Marconi, in turn, was often not sympathetic to the financial, legal, and political constraints operating on the Navy.

During the next twelve years, negotiations between the Navy and Marconi rarely transcended this early stalemate. But the Marconi Company was not alone in provoking negative reaction from Navy officials over prices and contract terms. During the acquisition process, every company trying to do business with the Navy encountered an attitude inhospitable to inventors and unappreciative of their technical goals and financial needs.

Naval officers and the wireless inventors were, in fact, approaching each other from two strong but opposite cultural traditions, traditions that influenced self-image and behavior and were laden with prejudice and sterotypes that often affected negotiations between the two. A Navy man and an inventor were very different types of people, differently socialized, with contrary and often conflicting orientations. The Navy officer was an organization man. He spent his life both obeying and giving orders within an institutional context, moving up gradually through the ranks, preserving and identifying with the status quo, honoring tradition, defending the organization that provided him with security and recognition. Except during wartime, "making it" involved diligence and diplomacy, keeping a low profile. Organizational stability surrounded and insulated him, and that was what he came to prize.

The inventor, on the other hand, had no such large organizational affiliation. Often he was a loner, sometimes seeing himself as an outcast who would redeem himself through his inventions.[51] Driven by a desire for fame, money, love, or all three, the inventor sought to make his mark on history by making change possible, by disrupting the status quo. Initially, sometimes continually, plagued by the problems of financing or even of remaining solvent and determined that his contributions remain distinctive, the independent inventor built

51. Morison, *Men, Machines and Modern Times*, pp. 9, 27; see also the diaries of Lee De Forest, Manuscript Collection, Library of Congress.

his reputation and career on technical change and improvement. Stability, established ways of doing things, existing schemes—these were what the inventor disrupted, sometimes deliberately, sometimes inadvertently.[52] Because he lived on possibilities, he was of necessity overoptimistic, often given to exaggeration.

Each group acquired and used money differently, an additional and powerful source of mutual distrust. To paraphrase Aitken, inventors responded to market demands, to "signals" they received from the economy, while military men, not usually subject to such outside forces, responded more to "internally generated signals" rarely tied to the marketplace.[53] Their contrasting pecuniary orientations, coupled with widely divergent socializations, induced each group to view the other with suspicion and, occasionally, contempt. While the wireless inventors expressed impatience over what they saw as a constricted and unimaginative bureaucratic outlook, naval officials had to assess the often inflated claims of a range of inventors, some of whom were indeed crackpots. As the Navy continued to investigate wireless over the next ten years, these conflicting traditions, cultures, and attitudes played a salient part in contract disputes. Certainly there were exceptions in both groups to these characterizations; but it is important to remember that membership in a long-standing and tradition-bound institution was a critical factor in the careers and outlooks of one group and that such membership was missing from or anathema to the orientation of the other.

For the next two years, until the autumn of 1901, the Navy took "no active steps . . . with a view of investigating the merits of any particular design of wireless telegraphy."[54] That fall, however, the department decided to explore what European inventors other than Marconi had to offer. By this time the bureau had become concerned that "most naval powers are far in advance of the United States in the installation of wireless telegraphy appliances on board of naval ships."[55] Although Reginald Fessenden had been experimenting with wireless under the auspices of the Weather Bureau and Lee De Forest

52. Morison, *Men, Machines and Modern Times,* p. 9.
53. Aitken, *Syntony and Spark,* p. 322.
54. *Annual Report of the Secretary of the Navy,* 1902, p. 375.
55. Ibid., p. 376.

had recently formed his own company, the Navy believed that there was "no American wireless telegraph company ready to furnish apparatus."[56]

Commander Francis M. Barber, USN, retired, an old classmate and friend of Bradford, was living in Paris at this time. Well connected in diplomatic circles, knowledgeable about electrical engineering, and fluent in French and German, Barber seemed the perfect "translator" between the European inventors and the U.S. Navy. From 1901 until 1908, he monitored the European technical press, solicited information from inventors and naval officers, visited the various companies, and sent extensive and lively reports on all aspects of wireless to the Bureau of Equipment. His thirty-year tenure with the Navy had given him a keen appreciation of how to get technical information from foreign military organizations. He ingratiated himself with the senior officers first, and after he had won them over, he then felt free to go to the real source of information. As he wrote to Bradford, "It's no use commencing with junior officers anyway. They have all the knowledge; but the old busters have to be coddled first."[57]

Barber's correspondence provides a fascinating view of how the bureau's official representative felt about and dealt with the inventors and the still young wireless industry. During 1901 and 1902, he investigated the apparatus of two French inventors, Rochefort and Ducretet, and of two German firms, Slaby-Arco and Braun-Siemens-Halske. He liked Rochefort because "he is a modest gentlemanly little man and not at all captious and prejudiced as inventors usually are."[58] Barber also observed that "An inventor is a visionary, a visionary is a genius, and a genius is a lunatic or next door to it."[59] Some inventors he heard about aroused his interest, but he decided against satisfying his curiosity: "One better have the itch than encounter an impecunious inventor. He never lets up once he makes your acquaintance."[60] One day he would visit Ducretet, who would

56. Comdr. F. M. Barber to Chief, Bureau of Equipment, 2 April 1902, NA, box 85.

57. Comdr. F. M. Barber to Chief, Bureau of Equipment, 31 December 1901, NA, box 84.

58. Comdr. F. M. Barber to Chief, Bureau of Equipment, 30 January 1902, NA, box 84.

59. Comdr. F. M. Barber to Chief, Bureau of Equipment, 15 April 1902, NA, box 85.

60. Comdr. F. M. Barber to Chief, Bureau of Equipment, 19 February 1902, NA, box 84.

call Rochefort a liar and a thief, and the next day hear Rochefort say the same thing about Ducretet.[61] Barber found sorting out the wireless situation in Germany particularly frustrating because he could not get what he felt was reliable information: "These manufacturers are such liars that one often wonders with St. Paul 'What is truth?' "[62] Barber's suspicion of inventors was compounded by his attitudes toward many foreigners. He was unimpressed with the German company Slaby-Arco, which he found "too slippery."[63] This reaction seems to have been reinforced by his impression of Count Arco, whom he described as "a weedy little chap with a great big head—he looks like a tadpole."[64] In his assessment of the British, Barber commented, "You can't hint to an Englishman, you must *kick* him. In my long business experience the English are the most dishonest people I know."[65]

But Barber reserved his most stinging scorn for Marconi. Any information, whether rumor or fact, that reflected badly on Marconi's apparatus or his business was eagerly reported to the Bureau of Equipment. Barber heard—and believed—that in developing wireless, Marconi had "walked off" with others' inventions and therefore was operating with an extremely vulnerable patent structure. Thus he would ultimately fail, but in the meantime his "system" deserved to be circumvented because it was all stolen anyway.[66] Barber doubted the accuracy of press accounts hailing signaling successes, such as Marconi's celebrated transatlantic S in December of 1901.[67] He took particular delight in recounting a conversation he had with Colonel Hozier, the Secretary of Lloyds and a director of the Marconi Company. "He thinks Marconi had never yet got a signal across the Atlantic or 2000 miles at sea either. The whole thing was a stock-jobbing operation worked in the interest of 'a lot of Jews.' This from a director of the company is rather

61. Ibid.

62. Comdr. F. M. Barber to Chief, Bureau of Equipment, 31 December 1901, NA, box 84.

63. Comdr. F. M. Barber to Chief, Bureau of Equipment, 29 July 1902, NA, box 85.

64. Comdr. F. M. Barber to Chief, Bureau of Equipment, 17 June 1902, NA, box 85.

65. Comdr. F. M. Barber to Chief, Bureau of Equipment, 22 May 1908, NA, box 89.

66. Comdr. F. M. Barber to Chief, Bureau of Equipment, 28 November 1901, NA, box 83.

67. Comdr. F. M. Barber to Chief, Bureau of Equipment, 15 January 1902, NA, box 84.

good."[68] He continued to hope and expect that the U.S. Navy would "be able to drive the American Marconi Company out of business."[69]

These are the words and attitudes of the man who was the Navy's primary source of information on the European wireless community. As the bureau's eyes and ears in Europe, he was in a highly influential position. The inventors, no doubt unaware of his true feelings, opened their laboratories and factories to him, advised him, confided in him, boasted to him, and, of course, tried to win him over. While transmitting important technical and business information to the bureau in the United States, Barber was also reflecting, and reinforcing, a particular way of viewing and dealing with inventors. To Barber and the bureau officials, inventors were those eccentric and frequently deceptive people the department was forced to deal with to get the apparatus it needed.[70] The bureau's subsequent business practices were certainly consonant with the overall spirit and outlook of Barber's correspondence.

During the next several years, the Navy experimented with various kinds of wireless, both European and American. These sets were usually tested between the Washington Navy Yard and the Naval Academy at Annapolis as well as between Annapolis and one or more ships. The distance between Annapolis and the Yard was only thirty miles, so, as Barber noted, "almost anything ought to work there."[71] In the spring of 1902, Barber arranged for the Navy to purchase two sets each from Ducretet, Rochefort, Slaby-Arco, and Braun-Siemens-

68. Comdr. F. M. Barber to Chief, Bureau of Equipment, 22 April 1902, NA, box 85.

69. Comdr. F. M. Barber to Chief, Bureau of Equipment, 11 February 1907, NA, box 89.

70. Barber's letters, which comprise the most sustained and detailed record of the Navy's side of naval-civilian wireless correspondence during this period, cannot be dismissed as the idiosyncratic observations and opinions of one officer. In fact, Barber's letters both corroborate and make explicit the views implicit in more bureaucratically constrained correspondence. This is especially true of letters sent from the bureau and the secretary's office to the American Marconi Company and to Reginald Fessenden's company, NESCO. In these letters, naval representatives were wary, brusque, and sometimes antagonistic. This tone was frequently not unprovoked, but it does indicate the level of misunderstanding that existed between these two groups. See, for example, Chief, Bureau of Equipment to Marconi Wireless Telegraphy Company of America, 4 May 1904, NA, box 89; 25 July 1902, NA, box 12; William Moody, Secretary, Navy Department to Marconi Company, 25 September 1903, box 85; Chief, Bureau of Equipment to Fessenden, 14 April 1904; Charles Bonaparte, Secretary, Department of the Navy to Fessenden, 19 April 1906.

71. Comdr. F. M. Barber to Chief, Bureau of Equipment, 20 January 1902, NA, box 84.

Halske.[72] These were tested between August and October 1902. That autumn, two De Forest sets were also purchased and tested. These trials were hindered by a dearth of skilled operators and officers knowledgeable about radio.[73] A Wireless Telegraph Board was established to oversee and report on the tests, but its members had other, conflicting duties and were unable to continue with the board for long. Three of the five members had to be replaced during the course of the tests. The officers ultimately "went their respective ways," leaving three enlisted men to oversee the tests and then notify their superiors of the results.[74]

Admiral Bradford, Chief of the Bureau of Equipment, complained to the Secretary of the Navy about the lack of departmental commitment to the experiments: "The Bureau desires to express its great regret that these important experiments have been interrupted for the want of vessels necessary for the work; also that two members of the Board are under orders for sea. It is feared that no important results can be reached unless a Board can give its uninterrupted attention to the subject."[75]

The early negotiations leading to the purchase and testing of these sets indicated how the Navy would do business with the wireless companies over the next eight years. The Navy enjoyed a buyer's market, and Barber seemed well aware of his advantages. To ensure that their apparatus performed well, the various companies wanted their own engineers to be present at the tests. They expected the Navy to subsidize the travel expenses, especially since the Navy operators and engineers would need the sort of instructions and advice not conveyed in written specifications. From the inventors' perspective, the Navy would be getting the best possible results as well as free training and should therefore feel obliged to cover the travel expenses. The Navy, of course, did not see it that way and refused financial support.[76]

On instructions from Bradford, Barber indicated to the companies that the Navy would not employ the services of any

72. Chief, Bureau of Equipment to Comdr. F. M. Barber, 13 January 1902, box 84; 6 December 1901, box 83; 14 December 1901, box 83.

73. Howeth, *History of Communications-Electronics,* pp. 52, 43.

74. Clark, "Radio in War and Peace," p. 33.

75. Adm. Bradford, Chief, Bureau of Equipment to the Secretary of the Navy, 13 December 1902, NA, box 85.

76. Chief, Bureau of Equipment to Comdr. F. M. Barber, 19 April 1902, NA, box 84.

private specialists, and while it would be helpful to have experts on hand when the tests occurred, the Navy engineers would probably be able to figure out the apparatus.[77] Of course the thought of amateurs tinkering with their instruments drove the inventors wild, especially because proper performance could mean a big contract. Barber knew this and made them quickly see that sending representatives at their own expense was better than sending none at all. By April of 1902 he was able to advise Bradford that "I have them all corralled and they will go at their own expense rather than not at all."[78] Extra expenditures had not been the only consideration: naval pride was operating as well. Barber acknowledged that "it is rather humiliating to be obliged to have 'square heads' come over and show us how to run things, but after all the main idea is to succeed and to get the best apparatus."[79] The Navy spent nearly $12,000 on the eight sets of wireless, with prices ranging between $2250 and $3500 for two sets.[80] When Slaby-Arco, citing recent improvements, tried to raise its prices, Barber notified the company that it could either return to its previous prices or cancel the Navy's order.[81]

During the tests, both the Slaby-Arco and De Forest apparatus out-performed the others.[82] The Slaby-Arco Company, hearing of its success, wrote Barber what he described as a "very cheeky letter." "They wanted to know how soon now they might expect the orders which would repay them for the vast expenditure to which they had been subjected in sending engineers to the U.S. and they wanted me to write and urge that the orders be placed immediately. I replied laconically."[83] Slaby-Arco was eventually awarded a contract. Its prices were low but, more importantly, its apparatus was better suited to the Navy's need for easily adjustable instruments. The receiver used by Marconi and Slaby-Arco, a filings coherer, was con-

77. Ibid.

78. Comdr. F. M. Barber to Chief, Bureau of Equipment, 4 April 1902, NA, box 86.

79. Comdr. F. M. Barber to Chief, Bureau of Equipment, 6 December 1902, NA, box 86.

80. Comdr. F. M. Barber to Chief, Bureau of Equipment, 30 January 1902, box 84; 14 May 1902, box 88; Chief, Bureau of Equipment to Barber, 11 February 1902, box 84.

81. Slaby-Arco to Comdr. F. M. Barber, 19 July 1902, NA, box 84.

82. Report, Wireless Telegraph Board to Chief, Bureau of Equipment, 3 December 1902, NA, box 85.

83. Comdr. F. M. Barber to Chief, Bureau of Equipment, 7 November 1902, NA, box 83.

nected to a recorder which printed signals on a strip of paper. The coherer was insensitive and erratic and would often print static as well as signals, but it provided a written record and required little skill to operate. Marconi quickly found the coherer to be an unsatisfactory detector, and after many futile attempts to improve it, abandoned it in 1903 in favor of his magnetic detector, which relied on a skilled operator wearing headphones to record the signals. De Forest and the other American inventors had also begun to improve on the weakest part of Marconi's system,[84] and De Forest had substituted headphones for the tape as well. He found that the operator could distinguish between true and false signals the way a printer never could and therefore eliminated the coherer by 1902. But the Navy chose Slaby-Arco and the older method: "The De Forest method had the advantage of enabling any speed of reception to be used, depending on the skill of the operator, but the very fact that the Navy did not have even one operator that was skilled militated against the De Forest method."[85]

Thus, the needs of the Navy and the goals of the inventors, particularly the Americans seeking to "invent around" and improve on Marconi, were completely at odds. The inventors were striving for greater distance, greater selectivity, and faster reception. The inventors assumed that any client, including the Navy, would welcome all three. The Navy, on the other hand, preferred apparatus that required little skill to adjust and operate, even if it was less sensitive, far-reaching, or accurate, for the one thing the Navy knew it could not yet provide were skilled, experienced operators. In addition, naval officers may have wanted apparatus that supplied a written record if it were going to be operated by enlisted men. But the inventors' work was guided by the desire for technical improvement, not for organizational accommodation. They assumed the Navy would want the most up-to-date apparatus available. The Navy, however, needed equipment that would compensate for its organizational idiosyncrasies, a factor the inventors were slow to grasp and reluctant to address, especially if it meant supplying components the inventors had already discarded as inadequate.

In March 1903 the Navy ordered twenty sets of Slaby-Arco apparatus. The purchase prompted *Electrical World* to con-

84. Douglas, "Exploring Pathways in the Ether," pp. 99–103.

85. Clark, "Radio in War and Peace," p. 35.

demn the Navy for the "cold shoulder it had consistently turned to American workers in the field" and to refer to the system the Navy favored as "that of the German Emperor's court jester."[86] Reginald Fessenden, who in 1902 had formed the National Electric Signaling Company, wrote to the Bureau of Equipment and the Secretary of the Navy suggesting that before buying foreign equipment, the Navy should test his apparatus. Fessenden quoted Bradford a price of $4000 for two sets and offered "to send a couple of men with a pair of sets" to wherever the Navy desired.[87] Bradford agreed, being careful to specify that the entire test would be "at your own expense." The bureau would not, as it had done before, purchase two sets.[88] Why should it? It had already spent approximately $6000 on French apparatus that barely worked. The Americans were here, and if they wanted the business, they would have to take risks.

Fessenden and De Forest continued to brag about their apparatus, particularly to the press. Navy officials, and Barber in particular, believed the claims to be hyperbolic public relations statements, which they sometimes were.[89] Yet if the inventors were going to boast, the Navy was going to hold them to their word in subsequent tests. More frankness on both sides might have better served all concerned. But none of the inventors behaved as if they believed that candor would sell wireless.

Bradford subsequently notified Fessenden of two additional conditions for the tests. The Navy had no rooms available on board ship for Fessenden's apparatus, so he would have to set it up in a hallway. And the specifications for the apparatus included the filings coherer,[90] which Fessenden had replaced with a superior detector in 1901. Fessenden complained that the Slaby-Arco people had not been relegated to a hall and said his company was disinclined to supply the Navy with special—and outdated—apparatus at the company's expense.[91] No experiments with Fessenden apparatus were made until August

86. *Electrical World* XLIII, 24 (June 11, 1904).

87. Reginald Fessenden to Chief, Bureau of Equipment, 8 May 1903, NA, box 85.

88. Chief, Bureau of Equipment to Reginald Fessenden, 21 May 1903, NA, box 85.

89. Comdr. F. M. Barber to Chief, Bureau of Equipment, 18 February 1908, NA, box 89.

90. Adm. Bradford, Chief, Bureau of Equipment to Fessenden, 21 May 1903, SI.

91. Reginald Fessenden to Lieut. Hudgins, USS Topeka, 26 May 1903; Fessenden to Adm. Henry N. Manney, June 13, 1903, SI.

and September of 1904, when the department conducted tests of American apparatus between the Brooklyn Navy Yard and the Navesink Highlands.[92]

The provisions for these tests were different from those of the 1902 demonstrations. Now all expenses related to the demonstration (except for supplying the necessary current) were to be assumed by the companies. The companies were allowed to send their specialists to help with the tests, but "the Bureau's operators must be given every opportunity necessary for it to determine whether the system can be successfully operated by them." In addition, the Americans' apparatus had to conform to the technical standards previously set by Slaby-Arco, a system inferior to and different from their own.[93] By qualifying performance specifications with rather specific and continuing technical specifications, the Navy initially eliminated certain types of apparatus from the experiments.

The American Marconi Company scoffed at the terms of the tests. The company said it would participate only if the bureau would guarantee that successful performance would lead to a contract. "In view of the fact that we are working on a commercial basis over greater distances and under varying conditions all over the world . . . no outlay for the purpose of demonstration only commends itself to us."[94] The Bureau would not consider contingent contracts, and the Marconi Company saw no reason to "incur an expense which, in our opinion, would be out of proportion to the value of the result."[95] The chief of the bureau suggested that by not participating in the tests, "you might even be open to suspicion of not desiring to submit to the conditions of interference in the vicinity of New York in competition with the other systems."[96] This warning did not seem to impress the Marconi Company, and the antagonism between the two continued.

Fessenden was anxious about the nearly $1000 he estimated the demonstrations would cost his small company. He tried to

92. Charles Darling, Acting Secretary of the Navy to NESCO, 15 December 1903, SI.

93. Ibid.

94. Marconi Wireless Telegraph Company of America to Chief, Bureau of Equipment, 9 May 1904, NA, box 89.

95. Marconi Wireless Telegraph Co. of America to Chief, Bureau of Equipment, 2 May 1904, NA, box 89.

96. Chief, Bureau of Equipment to Marconi Wireless Telegraph Co. of America, 4 May 1904, NA, box 89.

arrange for an alternative method of testing, preferably at his own stations, but the Navy refused.[97] The Navy had its own needs and requirements: only by testing wireless on its ships and at the Navy yards could it determine suitability. Its men had to be able to operate the equipment. And continued mistrust of inventors' claims reinforced the Navy's desire to test the apparatus on its own turf. As Admiral Manney wrote, the bureau "prefers to conduct the tests in its own way."[98]

The conditions the Navy imposed during these and subsequent tests were, from the inventors' point of view, niggardly and demoralizing. But the Navy demonstrated even less faith in the inventors when negotiating over purchases and contract specifications. The wireless market was still small and the various inventors competed fiercely against each other. Pride as well as money was at stake, and the mutual hostilities provided the Navy with bargaining advantages.

Once the Navy had decided to acquire apparatus, its first goal was to get the price reduced, and its policy was to buy from the lowest bidder. Barber took great pride in his negotiating skills, reporting that Slaby-Arco lost about $7000 on the first twenty sets it sold the Navy. "The company inferred from my letters that they were competing with other people, especially with Braun-Siemens (I *did* mislead them intentionally in that respect) and the result was an impossibly low bid which I accepted by telegraph before they had time to think it over."[99] A year later he got Telefunken (an amalgamation of Slaby-Arco and Braun-Siemens-Halske) to lower its price for the strategically important Nantucket lightship station by threatening to buy from the French at lower prices. Barber exulted: "Evidently they are red hot on the subject and the Bureau can name its own figure—It isn't often that you get a German down on his stomach like that."[100] The Navy paid nothing in advance; in fact, no payment was sent until the apparatus was installed and operating. If the apparatus arrived late, was damaged in transit, or if the enlisted men mishandled the installation, the

97. Reginald Fessenden to Adm. Henry N. Manney, March 8, 1904; Manney to Fessenden, 14 April 1902, SI.

98. Chief, Bureau of Equipment to Marconi Wireless Telegraph Co. of America, 10 May 1904, NA, box 89.

99. Comdr. F. M. Barber to Chief, Bureau of Equipment, 25 July 1903, NA, box 90. Barber was able to get Slaby-Arco down to $1077.50 a set.

100. Comdr. F. M. Barber to Chief, Bureau of Equipment, 8 July 1904, NA, box 12.

payment to the supplier was reduced.[101] While it was clearly in the Navy's interest to get the best possible price and not pay until the apparatus was working, its tactics compounded financial uncertainty for the inventors.

The Navy soon added to its contracts other provisions that imposed additional risks and burdens on the fledgling companies. The equipment had to be guaranteed to signal over a certain distance under all conditions, and failure to supply such a guarantee meant elimination from consideration. Once awarded a contract, the wireless company was required to "bond" its apparatus: it paid a security deposit, and if the apparatus failed, the bond was forfeited.[102] Lee De Forest, who was awarded a contract to erect four high-powered stations in the Caribbean, had to guarantee that the stations would be able to maintain communication "at all times and under all atmospheric conditions" over a distance of 1000 miles. He had to put up a bond of over $16,000 and complete all four stations within six months.[103] These were very stringent requirements to impose on a small company erecting radio stations far away from its base of operations and sources of supply. The territory was unknown to De Forest, and there were increasing reports that static was particularly relentless in the tropical regions. Even Barber questioned the Navy's specifications: "When I said some time ago that I did not think that his contract with the Department was legal, I meant that if it came into court, the court would decide against the Department."[104]

If an inventor would not reduce his prices, the Navy got a competitor to copy the invention and supply it at lower cost. Fessenden introduced the Navy to his new receiver, the "electrolytic detector," during the 1904 demonstrations. Fessenden's assistant wrote that naval officials were "highly pleased with the results, we having done very much better than any other system tested by the Navy."[105] Subsequent evidence bears out this re-

101. Chief, Bureau of Equipment to Commandant, Navy Yard, New York, 25 November 1903, NA, box 88; Barber to Chief, Bureau of Equipment, 10 July 1904, NA, box 12.

102. Douglas, "Exploring Pathways in the Ether," p. 159; Chief, Bureau of Equipment to Comdr. F. M. Barber, 9 July 1904, NA, box 12.

103. *The New York Times,* 10 July 1904, pt. 5, p. 26; H. W. Young to Hay Walker, Jr., June 29, 1904; NESCO Memo, "In Regard to the West India Wireless Contract," 7 May 1906, SI.

104. Comdr. F. M. Barber to Chief, Bureau of Equipment, 29 November 1904, NA, box 89.

105. James Boyle to Reginald Fessenden, 17 September 1904, SI.

port: by 1905, the electrolytic detector was the Navy's standard receiver. But Fessenden's prices ($2000 to $5000 per set) were considered too high, so the Navy arranged for De Forest and Telefunken to supply copied receivers at a lower cost.[106] Fessenden was outraged. Yes, his apparatus was more expensive than the Germans', who received government support. Didn't the Navy understand research and development costs? Didn't the Navy respect patents? For over two years he wrote letters of complaint to the bureau and even demanded that the Secretary of the Navy be impeached.[107] The Secretary informed Fessenden that his prices allowed the department to be "relieved of any moral obligation" to honor Fessenden's patents.[108] By 1906 Fessenden refused to have any further dealings with the Navy. "If we do not communicate any more of our inventions to the government, the government cannot steal them."[109] Other inventors complained as well about the bureau's knowingly buying, and even encouraging the manufacture of, pirated goods.[110]

To inventors, patents were central: they established priority in scientific and technical circles, in history books, and in the courtroom. Their strength could ensure one's prestige and fortunes. With so much riding on them, patents were considered inviolate by their owners. The Navy, on the other hand, felt it could not be constrained by patents and, in fact, it had no legal obligation to honor them. Amid all the press releases, claims, charges, and countercharges, how could the Navy really tell who the legitimate patent holder was? The Navy's policy was to

106. George Clark, who became a naval radio technician in 1907, acknowledged that the Navy made "free use of" Fessenden's patent. Full documentation of the dispute between Fessenden and the Navy over the electrolytic detector can be found in the box containing NESCO-Navy correspondence in the Clark Collection. Walter Massie, a wireless entrepreneur based in Providence, also warned Fessenden about the Navy's efforts to circumvent his patents. See George H. Clark, "The Life and Creations of John Stone Stone," unpub. ms., 1946, pp. 92–94; Reginald Fessenden to James Hall of *The New York Tribune,* 9 December 1905; Charles Bonaparte to Fessenden, 19 April 1906; and Fessenden to James Hayden, 11 January 1907; all in the Clark Collection; and Comdr. F. M. Barber to Chief, Bureau of Equipment, 20 February 1906, NA, box 89.

107. Reginald Fessenden to Charles Bonaparte, Secretary of the Navy, 5 May 1906; Fessenden to President Theodore Roosevelt, 14 May 1906; NESCO to Adm. Henry N. Manney, 14 June 1905, SI.

108. Charles Bonaparte to Fessenden, 19 April 1906, SI.

109. Fessenden to Lieut. Comdr. Cleland Davis, 30 November 1906, SI.

110. John Firth, "The Story of My Life," unpub. ms., n.d.; John Firth to Cleland Davis, 11 June 1908, SI; H. W. Sullivan to Barber, 30 May 1908, NA, box 89.

acquire apparatus "independently of patents."[111] Barber advised the bureau that he doubted whether anyone really had a defensible patent on a wireless telegraph system. He did not think Fessenden, who was threatening to sue the government for back royalties, should be taken seriously and doubted "if any of the present owners of wireless telegraph patents will ever do anything more than they have done in serving these preliminary notices."[112] Fessenden's threats against the Navy were in fact empty; the government at this time could not be sued for using patents without permission.

Even when priority was established in court, however, the Navy did not acknowledge the rights of the patent holder. Fessenden, after being advised by the Secretary of the Navy that his first successful infringement suit against De Forest was not "conclusive," had to win three more consecutive decisions and file an injunction and contempt of court citation against both De Forest and Telefunken before the Navy would stop purchasing pirated electrolytic detectors from Fessenden's competitors.[113]

Another point of considerable controversy between the inventors and the Navy was the notion that wireless was a "system" and that different wireless systems existed. Since 1900 the Marconi Company's strategy had been to market wireless as a complete system or network. The company erected the shore stations, equipped the ships, and established channels for communication. Other companies followed suit. Although this systems policy was motivated primarily by business considerations, technical considerations played an important part as well.

In each competing wireless set the various components were carefully engineered and adjusted with the efficient operation of the entire system in mind. Not only were the components themselves special, but the adjustments and arrangements between them were also crucial to superior performance. From the number of turns in the induction coil to the type and num-

111. Comdr. F. M. Barber to Chief, Bureau of Equipment, 23 June 1904, NA, box 12.

112. Comdr. F. M. Barber to Chief, Bureau of Equipment, 14 September 1903, NA, box 89.

113. Charles Bonaparte to Reginald Fessenden, 19 April 1906; NESCO v. De Forest *Wireless Telegraph Co.* et al., Circuit Court of United States, So. District of New York, May, 1906, SI. This was not the only time an agency of the U.S. government tried to circumvent or appropriate patents. See the account of Herman Hollerith's struggle with the Census Bureau in Geoffrey D. Austrian, *Herman Hollerith* (New York: Columbia University Press, 1982), pp. 260–62, 275–78.

ber of condensers and the aerial arrangement, all the interconnections were designed to meet the system's special needs. One could have a very sensitive and reliable detector, but if it were connected to incompatible or second-rate headphones, the receiver would appear to be inferior also. Chances were excellent that rival apparatus would not integrate well into a competing system and would cause poor performance. No inventor could allow alien and possibly inferior components to discredit his system or the merits of wireless. While inventors were trying to protect their business, they took pride in the distinctiveness of their apparatus and recoiled at the thought of it being dismantled and recombined with competitors' devices.

To Navy officials, wireless components were individual inventions like telephones or light bulbs. The Navy considered the inventors' systems rationale nothing more than a justification for monopoly. Was the Navy to buy from only one company and ignore all others? Naval officials sought to squelch any maneuverings that resembled Marconi's tactics, including any attempt to treat wireless as a system. Consequently, the Navy determined to buy only components, to establish its own "composite" system, and to ignore the inventors' systems approach. The way the Navy pursued this goal was not to buy complete sets of transmitters and receivers from several companies, preserving the integrity of those sets, and installing them in different navy yards or ships. Rather, the Navy began buying only components and had naval personnel combine the different devices together on an ad hoc basis. As the chief of the bureau advised Barber in 1902, "It is proposed to conduct tests of composite sets, made up of portions supplied by different makers and such a combination may be adopted as standard for the service in case it is found to work better than an entire set supplied by a single maker."[114]

The bureau, which didn't think civilian "squareheads" were attuned to the needs of the Navy and which out of pride may have wanted to develop its own system, no doubt sought to achieve standardization through the composite route. The bureau may also have been trying to reduce technical uncertainty; if it mastered the components and controlled its own system, maybe it could either anticipate or avoid too rapid technological turnover. From the bureau's point of view, acquiesc-

114. Chief, Bureau of Equipment to Barber, 15 August 1902, NA, box 85.

ing to the systems notion meant fostering monopolistic goals. Thus the Navy would try to prove that there were no distinct, incompatible systems. But acquiring various components made by competing firms and then successfully combining them into a composite system were two very different processes indeed.

While wireless in the first decade of the twentieth century still had many shortcomings, each year brought improvements in reliability and range that enhanced the invention's military potential. During the 1904 World's Fair, De Forest succeeded in transmitting messages hundreds of miles over land; by 1907, Marconi was providing *The New York Times* with a transatlantic wireless news service. Cunard and the White Star Line had begun installing apparatus on their ocean liners as early as 1900 and found the invention to be highly useful.[115] While the Navy had reason to criticize wireless because of the still unsolved interference and lack of secrecy problems, the invention nonetheless provided a method of intership and ship-to-shore communications superior to anything else then available. While technical uncertainty cannot be discounted as a factor in the Navy's position, neither can it fully explain the lack of harmony between the Navy and the inventors.

The chief of the Bureau of Equipment had little support from the rest of the organization for adopting wireless. To the secretary the first major experiments were of low priority. The other bureau chiefs had their own concerns and had no reason, bureaucratically, to be interested in wireless. Bradford had no organizational allies actively interested in the new technology whose support or influence he could enlist.

Because the Navy was, along with steamship companies and several newspapers, one of the few wireless customers, it was able to impose its uncompromising terms on the fledgling industry. The inventors clearly assumed too much: they thought the Navy would be an early and regular client but did not achieve the patronage they so desperately wanted. In addition, their dealings with the Navy, rather than reducing risks and uncertainty, increased them. The expense of the tests, the bonds, and the efforts to either ignore or subvert patents were, to the inventors, unanticipated and unwelcome costs not of actually getting but of simply trying to get government business. Unlike other innovations in industries such as steel, radio

115. Douglas, "Exploring Pathways in the Ether," pp. 104–5, 236.

was not "shielded" by the Navy "from the rigors of the marketplace."[116] The Navy did not assume risks here, it exacerbated them.

During the acquisition phase, inventors and naval officers failed to establish a mutually beneficial relationship. Their different orientations and their subsequent interactions reinforced stereotypes and distrust on both sides. De Forest, who referred to the Caribbean stations as "the hellhole of wireless," became demoralized by the "hostility, open or concealed, on the part of officials, from whom we had every reason to expect cooperation and interest." Revealing his own prejudices in a letter to his attorney, De Forest complained about these "cheap" officers, whom he characterized as men "with more gold tape than brains."[117] These two kinds of men, from two different American subcultures, were simply not communicating. Barber, the link between European inventors and the Navy, failed in his role as translator. He was not truly bilingual. Although he spoke French and German and understood the apparatus, he always maintained the Navy's point of view. He made no effort to understand and then relay to the bureau the inventors' perspectives on research and development costs, prices, marketing or contracts. As a retired officer, he had been a Navy man too long to successfully encode and translate nonmilitary views and needs. And the logistics were wrong. An officer in France could not help a bureau in Washington implement a new invention. The translator the Navy, and the inventors, needed was a different man, probably younger, more comfortable with technical mastery as a basis for power and prestige, more enthusiastic about the possibilities of wireless, and closer to the lines of authority and communication in Washington.

Although the Navy acquired wireless apparatus continually from 1902 onward, the period from 1902 to 1906 marked the initial spurt in purchasing. The panic of 1907, followed by several years of indifference, established the 1907 to 1911 period as a lull in Navy acquisition of equipment. Overlapping with the acquisition phase was the implementation phase, which was also characterized by individual and organizational

116. See Merritt Roe Smith's introductory essay.

117. See Frank E. Butler, "How Wireless Came to Cuba," *Radio Broadcast* (November–April, 1924–25): 916–20; Lee De Forest to Frank Butler, April 20, 1906; De Forest to Francis X. Butler, October 14, 1905, SI.

resistance. The Navy's shore command, represented by the Bureau of Equipment, had tested apparatus and ascertained what the fleet would need, independently of any advice or reaction from ship or squadron commanders. This procedure aggravated the long-standing tension between the officers at sea and those behind desks in Washington. Not all commanders liked coming aboard their ships after a brief stay in port to discover mysterious contraptions they had neither requested or desired. But when the shore command had made few provisions for personnel to set up and use the apparatus, rejection was even less surprising.

When the first twenty Slaby-Arco sets were ordered from Germany, there were no engineers who knew how to install them properly. In the summer of 1903 "the number of men in training capable of taking charge of a station" totaled eight enlisted men.[118] On board ship there were no wireless operators. And few commanders welcomed the apparatus. "No serious effort was made by the various commanders to organize, utilize, or supervise radio communications within the fleet."[119] These men, especially once out at sea, enjoyed complete control of their ships and did not want that authority subverted by wireless, which threatened to render their leadership merely titular. As George Clark observed, "The traditional power of a commanding officer to do as he felt best with his ship or command as soon as he got out of sight of land would have been completely wiped out if someone in the Bureau of Navigation or elsewhere could give him orders. So often the instructions to the wireless room were to shut down the wireless and not acknowledge calls from shore at all."[120]

Flag lieutenants were to supervise wireless on board ship, but they knew nothing about the equipment and had no incentive to learn. With the installation of wireless below decks to protect the apparatus from the rigors of battle, would the flag lieutenant now be consigned to some remote cabin, away from the captain and the action on the bridge? This prospect was hardly appealing and was quite naturally opposed. One flag lieutenant, T. P. Magruder, when inspecting a new installation on his ship, objected to the "unsymmetrical appearance" the antenna

118. Capt. C. H. Arnold, President, Wireless Telegraph Board to Chief, Bureau of Equipment, 10 July 1903, NA, box 85.

119. Howeth, *History of Communications-Electronics,* p. 65.

120. George H. Clark, "Radio in the U.S. Navy," unpub. ms., n.d., SI.

wires and guys produced and ordered the lines and wires realigned to parallel the rest of the ship's rigging. The new arrangement significantly reduced the efficiency of the apparatus. When it was suggested that the new arrangement rendered the sets nearly useless, Magruder said he "didn't give a damn about wireless . . . but he did give a damn for the appearance of the ship."[121]

The Bureau of Equipment had no authority to compel the officers to use the new invention, and the Bureau of Navigation, which oversaw the movement of the ships but had no jurisdiction over wireless, had no incentive to assist implementation. And with no permanent and experienced chief executive to enforce or encourage use, officers saw few organizational inducements countermanding their own recalcitrance. Officers on shore could not compel officers at sea to adopt the invention. The most striking example of the dissonance between the ambitions of the shore command and those of the fleet was the acquisition in 1907 of Lee De Forest's radiotelephones for the "Great White Fleet," which was about to embark on its famous cruise around the world. The bureau ordered twenty-six sets, which transmitted and received speech instead of dots and dashes, so that the commanding officers could talk directly to each other without going through the wireless operators. But Admiral Evans, the commander-in-chief, wanted nothing to do with these devices, and he issued orders to dismantle and stow the apparatus shortly after the fleet set sail.[122]

The performance of wireless, once acquired, was also affected by the ability of the enlisted men and the facilities available for maintenance and repair of the apparatus. Lieutenant J. M. Hudgins, who had helped Barber investigate European apparatus, complained to the secretary in 1904 that "we are not getting one-half the service possible out of the apparatus in use, owing to the lack of skilled operators."[123] He warned that few of the men assigned to take charge of the Navy's new stations were really qualified for such duty, particularly since they had

121. Howeth, *History of Communications-Electronics,* p. 65.

122. G. H. Clark, "Why the De Forest Radiophone Failed," unpub. ms., n.d.; Lieut. Comdr. H. J. Meneratti, "Story of the De Forest Wireless Telephone in the U.S. Navy," unpub. ms., n.d.; Meneratti, "Log of installation and operation of De Forest Radiophones in the U.S. Navy in 1907," SI.

123. Lieut. J. M. Hudgins to Secretary of the Navy, 15 February 1904, NA, box 83.

no experience adjusting or making quick repairs to the sets.[124] Strong criticism of the operators' general incompetence came from both civilian and military quarters and persisted for ten years.[125]

Wireless was installed aboard ships while docked at either the New York or Washington Navy Yards. The apparatus could theoretically be repaired at all the Navy yards. And the yards were also the sites for Navy shore stations. But the nature of the work and supervision at the yards did not promise to provide wireless with a favorable environment. Administration of the Navy yards epitomized the department's decentralized structure and management. Although nominally controlled by the Bureau of Yards and Docks, the yards contained offices and staffs affiliated with and loyal to the other bureaus. Predictably, this led to confusion and waste. For example, several different engineering departments and machine shops, each working for a different bureau, were dispersed throughout the yard. This arrangement militated against concentration of effort and combination of expertise.[126] The inexperienced operators charged with installing and repairing wireless might have carried out their duties more efficiently had they been part of a unified engineering department at the yard. Under the existing arrangement, they had little supervision and often found themselves caught between conflicting orders, one set from the Bureau of Equipment, another from the commandant of the yard.[127] And there was no technical standardization or uniformity from one Navy yard to the next. Disregarding whatever standard plans the bureau may have tried to issue, each Navy yard pursued its own method of wireless installation and repair.[128]

Exacerbating this organizational lack of continuity and fragmentation was the composite system. "Composite" did not mean that the Navy used only one sort of transmitter or one

124. Ibid.

125. Chief, Bureau of Equipment to Commander in Chief, North Atlantic Fleet, 22 March 1905, NA, box 32; F. S. Doane, Master of Light-Vessel no. 85 to Capt. W. G. Cutler, Inspector, July 20, 1909; Cutler to Lighthouse Board, 21 July 1909, NA, box 79; Douglas, "Exploring Pathways in the Ether," pp. 306–12.

126. Paullin, *Paullin's History*, p. 406; *Annual Report of the Secretary of the Navy*, 1883, pp. 17, 107; 1884, pp. 16–19.

127. Commandant, Navy Yard, Washington, D.C. to Chief, Bureau of Equipment, 9 March 1909, NA, box 76.

128. Clark, "Radio in War and Peace," pp. 316–17.

sort of receiver connected according to standard specifications. The Navy concocted these systems from whichever components were available at the time at the lowest price and left it to the operators to piece them together. This encouraged untrained and inexperienced men to tinker with the apparatus and to conduct their own trial and error experiments. The use of the "composite system" also meant that an operator transferred from one yard to another or from one ship to another "had to learn an entirely different run of wiring and placement of apparatus in many cases, which not infrequently resulted in his total ignorance of the status of his new assignment."[129] The composite system and the independence of each Navy yard and of each wireless station led to a proliferation of many different types of wireless sets throughout the service. The chief of the Bureau of Equipment in 1907 described the costs imposed by lack of supervision and standardization:

> Certain operators when first ordered to a station, and who were perhaps familiar with other systems, would not use that provided but improvised systems of their own. The original instruments would thus fall into disuse and deteriorate, and when these operators were detached they would take away the improvised instruments. The stations would thus remain inefficient for a considerable period and in some cases could hardly be operated at all until new instruments were provided.[130]

Wireless entrepreneurs were not pleased with the situation, which caused their apparatus to be "abused frightfully."[131] One company claimed that after loaning some apparatus to the Navy "it was in such a condition that we had to throw it aside as a lot of junk."[132]

Some Navy yards, particularly those on the west coast, complained of hand-me-down equipment and unsuitable facilities. And once a ship or station was equipped, little effort was made to update the apparatus. The commandant of the Mare Island

129. Ibid., p. 317.

130. Chief, Bureau of Equipment to Commandant, Navy Yard, Washington, D.C., 5 June 1907, NA, box 13.

131. S. M. Kintner, General Manager, NESCO to General Storekeeper, Navy Yard, Brooklyn, 5 October 1911, NA, box 13.

132. John Firth, WSA, to Chief, Bureau of Equipment, 9 November 1909, NA, box 82, see also complaints from William Walker, Massachusetts Wireless Equipment Co. to Chief, Bureau of Equipment, 31 December 1908, NA, box 75; and Douglas, "Exploring Pathways in the Ether," pp. 159–60.

Navy Yard suggested in 1904 that the yard's wireless station be moved from the deteriorating pigeon coop in which it was first installed.[133] Six years later, the wireless building was so decrepit and leaky that it was too dangerous for the operators to work there.[134] The commandant of the Philadelphia Navy Yard was informed in 1910 that the apparatus at his station was all jerry-built and obsolete. In fact, the files of the Bureau of Equipment for the years 1909 and 1910 are filled with reports from Navy yards around the country criticizing the obsolete, poorly maintained, and barely functioning wireless sets at the shore stations.[135] By 1910 wireless telegraphy, now more frequently referred to as radio, was hardly being used to its full advantage in the Navy. Radio had reached an organizational dead end.

Several changes, both within and outside the Navy, began to pave the way for improvement. For decades the various secretaries had recommended that the number of bureaus be reduced and their duties consolidated. While this much-needed reform was not enacted until World War II, in 1910 the Bureau of Equipment was abolished and its duties distributed among the remaining bureaus.[136] The Bureau of Steam Engineering, in existence since 1862, had long been the department's center for steam and then for electrical engineering, and it assumed control of radio in 1910. The Bureau of Steam Engineering was responsible for designing, constructing, maintaining, and repairing the machinery on board naval vessels. It was not just a procurement bureau but one actively involved in the building and successful mechanical operation of the ships. With its strong engineering tradition and greater influence within the fleet, it provided a more propitious organizational niche for radio's deployment.

In 1909 Secretary Newberry began reorganizing the Navy yards. All the previously dispersed mechanical departments and their personnel were placed under the direction of a man-

133. Commandant, Navy Yard, Mare Island to Chief, Bureau of Equipment, 16 April 1904, NA, box 83.

134. Lieut. E. H. Dodd, Mare Island to Chief, Bureau of Equipment, 6 April 1910, NA, box 81.

135. W. L. Howard, Inspection Officer to Commandant, U.S. Navy Yard, Philadelphia, 16 June 1910, box 80; C. D. Mills, Chief Electrician, Tatoosh Island, Washington to Inspector, Navy Yard, Puget Sound, 19 January 1910, box 80; Inspector of Equipment to Commandant, Navy Yard, Norfolk, 29 June 1909, box 80; Chief Electrician, Navy Yard to Inspector of Equipment, Navy Yard, Charleston, SC, 10 June 1909, box 78.

136. *Annual Report of the Secretary of the Navy,* 1910.

ager who consolidated both manufacture and repair work. Eventually the manager was replaced by a line officer.[137] Secretary Meyer, Newberry's successor, appointed four aides with specialized expertise to advise him on operations, personnel, materiel, and inspections and to coordinate the work of the bureaus.[138] Meyer also sought to improve the business methods of the department.[139] This effort may have been propelled by a law enacted in 1910 (partly as a result of Fessenden's lobbying) which authorized the owners of patents that were used by the government without permission to sue in the Court of Claims.[140]

Between 1907 and 1912 significant improvements in both transmitters and receivers were introduced by De Forest, Fessenden, Marconi, and Telefunken. Radio signals now had more power behind them and were higher pitched and easier to read. Reliability, durability, and transmission distance had been greatly enhanced. The Navy had not helped foster these changes, but for the department technical uncertainty was being reduced dramatically.

Most importantly, new legislation required the Navy to increase its radio activities. Prior to 1912 radio in America was unregulated. Anyone with a transmitter could send messages whenever he wanted, and as a result the airwaves were frequently congested. This anarchy in the spectrum had drastic repercussions. On April 16, 1912, America learned that the *Titanic* had sunk, and hundreds of radio stations along the northeast coast of North America clogged the airwaves with inquiries and messages. The resulting interference prevented speedy, efficient communication and produced misinformation as well. Within four months of the *Titanic* disaster, Congress enacted the 1912 Radio Act, which prohibited independent "amateur" operators from transmitting in the preferred portion of the spectrum.[141] The Act also sought to ensure that ships' passengers would always have access to wireless services, even if they were not near a commercial wireless station. Thus Navy radio stations were now required to transmit and receive commercial messages if there was no commercial station within

137. Paullin, *Paullin's History,* p. 479.
138. Ibid., p. 442.
139. Ibid.
140. *Annual Report of the Secretary of the Navy,* 1911.
141. Douglas, "Exploring Pathways in the Ether," pp. 337–48.

a 100-mile radius.[142] As Secretary Meyer observed in his Annual Report for 1912, "The radio work and expenses of the department will be largely increased. It will be necessary to modernize and improve the apparatus of coast stations so that the commercial work may be successfully handled . . . the added work will undoubtedly prove an incentive to increased efficiency."[143]

By mid-1912 this new constellation of technical, legal, and organizational changes confronted the department. But the changes did not guarantee that radio would be efficiently integrated into naval operations. Radio, with the potential to establish new and strong channels of communication in the Navy, had been forced to operate within a nineteenth-century organizational structure. Only the efforts of a very enterprising translator, adept at exploiting unusual external pressures, would compel this structure to yield to and be realigned by this technology.

Stanford C. Hooper has been called the "Father of Naval Radio."[144] It is a title he enjoyed and believed he had earned. His version of the Navy's ultimate adoption of radio has the self-aggrandizing tone not uncommon to the autobiographies of many people who were pioneers in their field,[145] yet the record does support Hooper's story of his efforts to integrate radio into naval operations. He achieved this integration at a propitious moment in naval history, but this does not detract from the adroitness and ultimate success of his strategy or methods. He was a man who read his organization—and the times—very shrewdly indeed.

The son of a banker and named after Leland Stanford, Hooper grew up in an entrepreneurial environment. When he was eight, his father built him a telegraph sender and key and taught Hooper the Morse Code. By the age of ten he was working part time for the railroad as a relief ticket agent and then

142. *Annual Report of the Secretary of the Navy,* 1912, pp. 38–39.

143. Ibid.

144. Howeth, *History of Communications-Electronics,* p. 114.

145. See, for example, Lee De Forest, *Father of Radio* (Chicago: Wilcox & Follet Co., 1950) or Helen Fessenden, *Fessenden—Builder of Tomorrows* (New York: Coward-McCann, Inc., 1940). Material on Hooper from George H. Clark, "Radio in War and Peace." In 1940, Clark, who had worked as a radio inspector for the Navy between 1907 and 1919, persuaded Hooper to dictate his memoirs to him. Some of the material is based on Clark's own recollections of this period and some on Hooper's reminiscences.

relief telegraph operator. His seven years experience with telegraphy provided a necessary foundation for his later radio work. He saw at a young age how a transportation and communication network were integrated and operated cooperatively. In 1901 his father arranged for Hooper to attend the Naval Academy, and at the age of fifteen he entered Annapolis and was embarked upon his career. One of his earliest challenges was studying to become proficient in Navy signaling. Because Hooper had grown up with the Morse Code, learning another code, also based on dots and dashes but completely different, proved confusing and difficult. Yet by mastering both, Hooper began to build the "bilingualism" that would later prove so important. To get Navy signalmen and officers to switch ultimately from one code to another, Hooper had to understand and be proficient in both.[146]

After graduating from the Academy in 1905, Hooper served on various ships of the Pacific Fleet. He began to read about and tinker with wireless. Sometime between 1907 and 1908 Hooper put in a request for postgraduate training at the Naval Academy, specializing in wireless. This request was denied by Lieutenant Commander S. S. Robison, who believed "wireless would never be enough to warrant an officer giving it his full attention."[147] Hooper continued to pursue his goal, trying various tactics and routes, and finally was sent to the Academy in 1910 as an instructor in electrical engineering, with wireless instruction added to his regular duties.[148] Thus, not unlike many teachers, Hooper was to learn his subject matter shortly before teaching it to a class. But his assignment, as George Clark noted, marked a turning point in his career: "From then on he was in charge of a 'radio division' of the Navy, be it of the Department of Electrical Engineering at the Academy, or the Bureau of Steam Engineering in Washington, or of the Fleet."[149]

Now a lieutenant, Hooper was one of the few officers in the Navy who had experience as an operator. By 1911 several commanders working in the Bureau of Steam Engineering had begun to consider more seriously the use of radio for com-

146. Ibid., p. 74.
147. Ibid., p. 70.
148. Ibid., p. 71.
149. Ibid.

municating between vessels when in battle formation but could not adequately implement this plan without firsthand knowledge of radio communication. Consequently Hooper was assigned to develop and write up instructions for tactical signaling between battleships. His plan would be tested during Spring Target Practice of 1912, when radio signals would accompany all visual signals.[150]

Meanwhile another young officer, who also had childhood experience with telegraphy, was assigned to report on the use of wireless during the Autumn Battle Practice of 1911. Ensign C. H. Maddox assessed the technical merits of the apparatus and analyzed wireless's potential for tactical signaling. Much of his information was intended for Dr. Louis Austin at the Naval Radio Lab and not for those with authority over the fleet. Yet Maddox became less concerned with technical problems than with organizational matters. In his first report he urged that wireless have its own set of tests rather than be tested in conjunction with target practice. Only then would wireless "get the full consideration that it deserves." During target practice, "a wireless test is too liable to be relegated to the list of those things that can be slighted for the sake of possible increase of 'hits per gun per minute.' "[151]

Maddox saw as the most immediate and pressing need "officers in the fleet who possess a thorough practical and theoretical knowledge of wireless and who are themselves expert operators. At present the real head of the fleet's wireless system is the enlisted operating force of the flagship." He found these operators to be "mediocre," in part because no specialization existed in the electrical force aboard ship. Wireless operators and dynamo tenders were often rotated between these two jobs and thus there was "small chance for improvement." He also recommended that the Atlantic Fleet have an officer in charge of the fleet's wireless "who will systematize and control this important factor in naval efficiency." He looked forward to the day when the Navy would possess enough officers proficient in wireless that "one might be assigned to each division of the fleet, and eventually one to each battleship."[152]

150. Howeth, *History of Communications-Electronics,* p. 181.

151. Ensign C. H. Maddox, "Report of Battle Practice, Autumn 1911," USN, Washington, GPO: 1911, SI, p. 230.

152. Ibid.

Reportedly, Hooper did not see Maddox's report or recommendations. In the spring of 1912, Hooper would reiterate the same suggestions. But Hooper, now twenty-six, was about four years older than Maddox, more experienced, higher in rank, and better connected. One important ally was Lieutenant Commander D. W. Todd, head of the Radio Division of the Bureau of Steam Engineering. Hooper's observations and report would have more sway when passed through him.

Prior to the April 1912 tests, Hooper devised a tactical signaling code and made several other specific recommendations. From the earliest demonstrations in 1899, Navy observers had suggested protecting the wireless apparatus by placing it below decks. For tactical signaling the distance between the captain on the bridge and the apparatus below caused an unacceptable delay between orders given and orders sent. Others had tried speeding up the communication between the bridge and the radio room with voice tubes or telephones. Hooper's suggestion was characteristic of his unconstrained view of naval organization: move the operator up to the bridge. Portable equipment would be installed quickly and the transmitting key on the bridge could be connected to the main transmitter below decks. This move, while eliminating any delay between the captain's message and transmission of that message, symbolically and actually demonstrated the importance of tying radio directly to the chain of command.

Hooper's tactical signals and instructions on general signaling procedure for the maneuvers were printed up and included in a booklet of general instructions written by Commander Craven, in charge of fleet training in the Division of Operations, Bureau of Navigation. When the tests began, Hooper and Craven went to the flagship to observe results. Hooper began to monitor the radio signals and heard nothing all day. All the signaling was done by flag. At the end of the day, he visited several of the ships in the fleet to investigate what had happened. The only encouraging discovery Hooper made was that the Bureau of Steam Engineering had set up radio apparatus on the bridge. But no other steps in Hooper's plan were followed:

> The Navy, as usual up to that date, did not take radio seriously. The commanding officers had handed the instruction pamphlet to the officer in charge of communications, but he, in every case not at all

familiar with radio, did nothing more with it, probably not having faith in the ability of radio to do the work. In a few cases, the booklet had found its way down to the radio cabin, but the Chief had not had time to read and understand the scheme, nor did he have it explained to him.[153]

Thus, responsibility for testing radio signaling had been passed down to those in the organization with no authority or accountability, particularly in the sphere of tactics or strategy. It was 1912, and radio was still being treated as an afterthought.

Hooper reported his discoveries to Craven, who in turn took the issue up with the commander-in-chief. The commander ordered that Hooper's instructions be followed the next day. Hooper tried to ensure better performance by personally instructing some of the officers and men in the use of his plan. The next two days proved disappointing and on the fourth day the flagship's transmitter died, bringing the experiment to a close. Hooper's report reflected his disappointment. He criticized the officers for not incorporating the operators into the tactical signaling process aboard ship. "The operators did not understand what they were to do," he stated, adding "there was no inter-ship teamwork." He also wanted the skills of the operators upgraded. "About one-third of the operators are not operators and delay the general business about one-half." He urged that the operators increase their transmission speed from their current ten to eighteen words per minute as "our standard is about half the commercial standard." Noting that "the wireless is running away from us in certain regards," Hooper also recommended that "there should be an officer in charge of radio matters in the Fleet who is an expert operator."[154]

Again, the spur for improvement came from the officers on shore, in Washington, not from ships' commanders. Craven persuaded the chief of the Bureau of Navigation to add to the staff of the fleet commander-in-chief the position of Fleet Radio Officer. Craven and his friend Todd in Steam Engineering both recommended Hooper, who, in August of 1912, became the Navy's first officer in charge of coordinating the use

153. Clark, "Radio in War and Peace," pp. 84–85.

154. Lieut. S. C. Hooper to Chief, Bureau of Steam Engineering, "Report on Radio-Telegraphy in the Atlantic Fleet, Spring Target Practice of 1912," Hooper Papers, Library of Congress.

of radio at sea.[155] Rear Admiral Hugo Osterhaus "objected strenuously" to having such an officer on his staff and then arranged for Hooper's duties to include tactics and athletics as well.[156] Having to organize and supervise boat races and boxing matches helped to delay Hooper's work and to undermine the importance and prestige of his main task. Only by working extra hours was Hooper able to perform his radio duties adequately.[157] Thus, despite the efforts of the Navy's equivalent of "mid-management," recalcitrant top executives could still preserve the status quo. No fleet officer could do it alone. He needed allies not only on shore, but also within the fleet. Hooper and Maddox had recognized the need for a new organizational tier in the fleet: officers, and not enlisted men, had to have control over radio. In the fall of 1912 Hooper recommended to Osterhaus that commanding officers of all battleships, flagships, or cruiser and gunboat divisions, and flotilla flagships of destroyers designate an ensign as radio officer and require him to become a proficient operator. Osterhaus followed Hooper's suggestion and issued the order.[158]

This was Hooper's first shrewd strategic move as Fleet Radio Officer. Young officers would be less bound by naval tradition; unhindered by years of flag-signaling, they would be more open to the new technology. They had, at this juncture in their careers, little to lose and much to gain by becoming proficient in radio. And Hooper would shortly have dozens of officers just junior to him in rank, bound to his authority, competent with and sold on the new technology. He was arranging the beginnings of his network by creating an organizational cadre which would both permit and benefit from full integration of radio use within Navy operations.

In 1913 Rear Admiral Charles J. Badger, who had served on the 1902 Wireless Telegraph Board, became Commander-in-Chief of the Atlantic Fleet. His chief of staff, Commander Charles F. Hughes, was more sympathetic to Hooper's goals and recommended that Hooper be relieved of his duties as fleet athletic and tactical officer. Hooper was now free to concentrate completely on radio, and his attempts to incorporate radio

155. Clark, "Radio in War and Peace," p. 118.
156. Howeth, *History of Communications-Electronics,* p. 195.
157. Ibid.
158. Ibid.

more fully into the daily functioning of the fleet would be more sympathetically and seriously considered.[159]

While the ensigns were learning about radio, Hooper had another, more difficult task. He had to upgrade the performance of the operators while simultaneously wresting control of fleet radio from them. Because wireless had been kicked down the naval hierarchy from its earliest introduction, it was now controlled almost entirely by the enlisted men.

From rear admiral to ensign, few officers had considered wireless important and therefore few sought to learn how to use it. But the bureau kept sending the instruments to the ships and someone had to oversee them. The "technological buck" stopped with the enlisted men who worked under the broad heading of electrical engineer. At this level of the Navy, wireless did not mean subversion of autonomy or tradition. On the contrary, an enlisted man who knew about radio gained some small distinction. He enjoyed a certain degree of autonomy—he could transmit whatever he wanted—and he often possessed privileged information. Most of the messages sent out by naval operators before 1913 were personal messages such as this one cited by Clark: "Longing for you darling, and waiting for the fog to lift. Lieutenant _____."[160] The ship's operator also conversed with other naval and commercial operators in the vicinity and could eavesdrop on various conversations.

As radio apparatus began to proliferate in the fleet, control of wireless was often maintained by the chief engineer of the flagship. "Friends of his among the Fleet operators could use their sets anytime they wished to do so; those who were not 'in' with the Chiefs had to wait until the 'Flag' was good and ready to let them open up." Use of the airwaves came to be dispensed by the chief as a privilege, a perquisite.[161] Radio technology provided the chief and the operators with control and diversion, two things often denied aboard ship, and they were not about to relinquish these easily.

Hooper's goal was to compel the operators to "use their station for nothing but official business, to make use of a military routine whose first requirement was obedience to orders, and

159. Ibid., p. 196; Clark, "Radio in War and Peace," p. 118.

160. Clark, "Radio in War and Peace," p. 115. This is one of many examples cited by Clark.

161. Ibid., p. 121.

to improve their operating ability."[162] The Fleet Radio Officer ordered that operators were to send and receive only official messages using official Navy forms and that personal conversations were to stop. Operators responded to this reform both by ignoring the orders and denigrating Hooper over the air. Commanding officers had shown little interest in radio before and certainly were not monitoring sending and receiving, so the operators were apparently not convinced that the new officer could truly enforce change. Hooper listened in to this initial reaction, which evidently included some Darwinian speculation on his true origins.[163]

Hooper spent his evenings learning to distinguish the sound of each ship's spark and the "fist" of each operator in order to determine which operators were violating his new regulations. He then devised a scheme he hoped would end all resistance. Admiral Badger authorized Hooper to send the following message to the commanding officer of any ship guilty of disobeying Hooper's rules: "Your attention is invited to Fleet Regulations. . . . Your radio operator is disregarding instructions and is using unofficial language. Badger, C-in-C."[164] By transmitting this message, Hooper set up the operator, who had to deliver himself to his commander for disciplinary action. The first operator who refused to acknowledge receipt of such a message was court-martialed.[165] Early control of the technology was no match for access to the lines of authority. Hooper gradually began to enforce the discipline and obedience he needed. His next task was to build from the bottom up an efficient operating network that commanding officers at the top would eventually be convinced was indispensable.

While the enlisted men had enjoyed control over radio until Hooper's reforms, they had had no need to be fast or efficient operators. Commanding officers had placed no premium on speed or accuracy, so why should the operators? They had been given no compelling reason to make this technology work well for the organization. They were not rewarded for doing so nor chastised for failing. Hooper had to structure an incentive system that would give the operators a continuing interest in good signaling.

162. Ibid., p. 120.
163. Ibid., p. 121.
164. Ibid., p. 122.
165. Howeth, *History of Communications-Electronics,* p. 195.

The most frequently given excuse for poor reception was static.[166] This excuse worked well for preserving the autonomy of the operators. It cited an outside, uncontrollable element for which the operator could not be blamed and thus protected the operator against personal rebuke. In addition, it served to perpetuate the notion among the officers that radio was not very reliable or flexible and thus was not a signaling system worth taking seriously. Such an attitude would naturally keep ultimate control of radio in the operators' hands.

Though static was indeed a problem, an experienced and attentive operator could "weed it out." Hooper began making surprise visits to radio rooms in the fleet, and if static was listed on the log, Hooper would show up the operator by putting on the headphones and reading the message himself. He then issued an order that was posted in every radio room of the fleet: "Henceforth static disturbance will not be considered as an excuse for non-reception of a message."[167] In addition, Hooper introduced a rating system whereby every operator would be labeled according to his level of proficiency. Linking their performance to organizational rewards, Hooper also initiated sending and receiving competitions among the operators with "promotions as prizes." He began drilling the operators in learning and using his battle signal code. He standardized the number of operators on each ship, thus eliminating the practice of one ship having only one operator while another had six.[168]

By 1913 Hooper had succeeded in having an officer on every ship in the fleet assigned to oversee the radio room. Removing control over radio from the enlisted men, who had no role in strategy and planning, and assigning control instead to a new managerial tier of young officers was probably Hooper's most important reorganizational ploy as Fleet Radio Officer.

Hooper also sought to physically reorganize radio aboard ship. The permanent radio installations were in cabins on the main deck, a spot most vulnerable to enemy shells.[169] This exposed position did solve a technical problem, however: the apparatus was not far from the antennas. Hooper wanted to move the radio rooms below the protective deck and below the water-

166. Clark, "Radio in War and Peace," p. 125.
167. Ibid., p. 126.
168. Ibid., p. 127.
169. Ibid., p. 161.

line. In doing this he would sacrifice some efficiency because of losses along the great length of under-deck wiring connecting the set to the aerial. Yet Hooper preferred to have a less efficient set that was less likely to be knocked out during battle.

Space aboard ship was jealously protected, yet Hooper managed to get different territory for radio. He ultimately moved the radio rooms to coal bunkers and similar protected places. In 1913 these first reinstallations were "very crude indeed," an improvisation which Hooper would correct later. He also added permanent installations on the bridge, so the commander would always have radio at his side for tactical signaling.[170]

By 1913 Hooper had realigned and disciplined the lower levels of the fleet hierarchy. He needed this tier of enlisted men, ensigns, and lieutenants to be efficient, coordinated, and obedient to his authority in order to impress the men at the top levels that the new technology could be an invaluable tool for commanders. Hooper had recognized that men and "machines" had to be fully integrated at the lower levels first for an organizational resource to exist and for it to be perceived as such. Only then could the top brass legitimize the system through successful and continued use of this new communications and personnel network.

Hooper got his critical opportunity in 1913. Admiral Osterhaus "would not permit his ships to be maneuvered by radio and would only execute his signals by flaghoist."[171] Admiral Badger, a younger officer, was more inclined to try radio. We have no exact dates, but sometime in 1913 Badger ordered that during one day's exercises all maneuvering would be handled by radio. For the first time, no flags were to be used at all. All of the commander-in-chief's instructions were accurately relayed and carried out, and the maneuvers were, for radio, a complete success. The next week a similar but unexpected test occurred. While en route in Chesapeake Bay, the fleet hit a sudden squall, and visibility was reduced to zero: the flags were of no use. Radio had to transmit all instructions. The storm lasted for half an hour, and when it cleared all the ships could be seen in formation, exactly as they had been ordered. Tactical signaling by radio, done previously only on an experimental basis, now

170. Ibid., pp. 131, 161.

171. Howeth, *History of Communications-Electronics,* p. 196.

became regular practice in the fleet.[172] In this transition period, as during others in the Navy, the old and the new would operate side by side: flags and radio would transmit tactical signals simultaneously. Hooper had achieved an important breakthrough: commanders saw firsthand how radio could avert disaster. This was a major step toward gaining full acceptance. Another incident illustrates how Hooper, with both experience and luck, succeeded in convincing commanding officers that radio could give them a decided advantage in their area of expertise and challenge, strategy. During the war games of January 1914, Badger asked Hooper if it was possible to locate the position of the "enemy" with radio. At this time Hooper had no direction finder, so he had to determine location by the strength of the enemy destroyer's radio signals. After monitoring their transmissions for several hours, Hooper predicted that the "enemy" was moving closer and would strike around 2:00 a.m. His prediction was uncannily close: shortly after two, the destroyers sent up rockets, signaling that they had "torpedoed" the fleet. Badger was extremely impressed, as were the other officers, who began to view radio as more instrumental to their own victories and advancement.[173] By 1913 the chief of the Bureau of Steam Engineering was able to report that "more careful control and the extended use of radio for signaling, especially in the Atlantic Fleet, have resulted in the development of clearer ideas as to the ultimate value of radiotelegraphy for military purposes." The annual report for 1914 praised "the personal interest of the fleet radio officer, Lieut. S. C. Hooper, who has assiduously labored to bring about this high state of efficiency."[174]

Hooper's reorganization of radio operations within the fleet took place between August 1912 and August 1914. This was also the period when the Navy had to respond to the provisions of the Radio Act of 1912. The Act became effective in December and designated naval radio stations were required to handle commercial business as of February 1913. This increased participation in the spectrum had less to do with engineering and more to do with the movement of ships at sea. Consequently, in late 1912 the department established the Naval

172. Ibid., pp. 196–97; Clark, "Radio in War and Peace," pp. 141A–141D.
173. Ibid.
174. *Annual Report of the Secretary of the Navy,* 1913, p. 225; 1914, p. 215.

Radio Service in the Bureau of Navigation. The Bureau of Steam Engineering concentrated on the technical development of radio,[175] while the Radio Service handled the administrative and accounting chores generated by commercial operation and worked to establish "the adoption of standard practices in the matter of operating."[176] The separation of these two very different but highly interdependent duties was important to improved management of naval radio. The traditionally most influential bureau, Navigation, now supervised radio operations. Steam Engineering was free to "modernize and improve the apparatus of coast stations so that the commercial work may be successfully handled."[177] The two bureaus central to the successful deployment of the "New Navy" were now organizationally allied by their clearly delineated and reciprocal radio duties. While this arrangement produced more efficient and technically upgraded stations, the Navy's shore station network still lacked systematic coordination.

In August 1914 Hooper was ordered to Europe to observe the use of radio during the early months of the war. In early 1915 he returned to Washington, where he served for two weeks in February with three other officers, all with radio experience, on a radio reorganization committee. The committee concentrated on the need to strengthen and better coordinate the Navy's "coastal chain." At that time each shore station communicated with ships at sea, listened for distress calls, and worked with the two stations adjacent to it along the chain.[178] Messages were relayed from one station to the next along the north-south linkage. Thus a message from Boston to Pensacola would be relayed many times.[179] The stations were set up in series: if one link broke down, no transmissions were relayed beyond that point. In addition, most of the stations were at the Navy yards, under the control of the commandant, an officer with multiple responsibilities and concerns and little reason or incentive to seek improvement in the use of radio. The commandant's influence was confined to the yard; he had no jurisdiction over the radio waves beyond it. Under this structure, coastal radio could not be coordinated.

175. *Annual Report of the Secretary of the Navy,* 1914, p. 226.
176. Ibid., pp. 213–14.
177. *Annual Report of the Secretary of the Navy,* 1912, p. 38.
178. Clark, "Radio in War and Peace," p. 158.
179. Ibid., p. 212.

Hooper found such a situation antiquated and potentially dangerous. Again he proposed a marriage of technical improvement and organization building. No one oversaw the coordination of the shore stations because no slot existed in the organization for this purpose and because no one had conceived of the "airwaves" as an appropriate jurisdictional "turf" for an officer. Through the committee, Hooper proposed a series of high-powered stations, preferably with a range of a thousand miles or more; these large areas would be called Naval Communication Districts and each would be supervised by a District Communications Officer. The existing coastal stations would have their power and apparatus upgraded and serve as a secondary signaling tier. Again Hooper devised a highly centralized network, with clearly defined and articulated lines of authority leading from the bottom to the top of the hierarchy and from the "field units" to the "central office" and with a specific scope of responsibility in the organization's adoption of radio.

When the secretary approved these recommendations in February 1915, some elements of the plan were already in place: the government took over two high-powered stations under German control, one at Tuckerton, New Jersey in 1914 and the other in Sayville, New York in 1915. In April Hooper became head of the Radio Division of the Bureau of Steam Engineering. He held this position until July 1917. Under his leadership, "a coordination plan" was instituted, "whereby each yard is kept informed of the experimental work of every other yard, by interchange of information of work at various yards and at the bureau, with consequent prevention of duplication and increase in efficiency and economy."[180]

In 1915 Congress enacted a bill creating the post of Chief of Naval Operations. This officer would serve as the much needed liaison between the Secretary of the Navy and the bureau chiefs, gathering information on material, operations, and personnel, which would help the secretary develop more informed and long-range strategy. Although the Chief of Naval Operations was the ranking active officer of the Navy, he was not empowered with direct authority over the bureaus. Nonetheless, the creation of this influential advisory position just above the bureaus and just below the secretary provided the de-

180. *Annual Report of the Secretary of the Navy,* 1915, p. 270.

partment with "professional coordination and operational direction."[181] During the same year, the Radio Service was reorganized and became the Office of Communications, which supervised telegraph, telephone, cable, and radio communications. The service was moved out of the Bureau of Navigation and became an important department office, its director reporting not to a bureau chief but to the Chief of Naval Operations.[182] These elevations in title, location, and organizational niche indicated how far up the hierarchy this technology had come. The centralization and consolidation of radio operations and their placement much closer to the center of power ensured radio's progress under naval auspices. Radio's portent at the turn of the century had been fulfilled: it had brought about a more centralized structure at sea and on shore and had become central to naval strategy.

While Hooper's influence and prestige had increased considerably, his role as translator became less critical between 1915 and 1919. Hooper had been instrumental in laying the structural groundwork for change, and his contributions continued to be important. But as the outside pressures generated by the European war to modernize and reorganize increased, the need for a translator was eclipsed. More and more officers in the Navy were persuaded by the war that whatever technical improvements the Navy could adopt, should be adopted.

Alfred Chandler cites rapid growth and increased competition as two external factors which prompt changes in strategy and structure. For the military, such rapid growth and competition occurred during wartime: for the Navy, war was competition and of the fiercest sort. Under these circumstances, the Navy behaved not like the resistant bureaucracy Elting Morison found, but like a modern industrial enterprise.

On April 6, 1917, the United States entered the Great War. Under section three of the 1912 Radio Act, President Wilson was authorized "in time of war or public peril or disaster" either to close down private radio stations or to place these stations under the control of "any department of the government, upon just compensation to the owners."[183] Consequently, on April 7 all radio stations in the United States, except those already

181. Albion, *Makers of Naval Policy,* p. 13, 218–19.

182. *Annual Report of the Secretary of the Navy,* 1915, pp. 10, 263; 1916, p. 27.

183. Frank J. Kahn, ed., *Documents of American Broadcasting* (New York: Appleton-Century-Crofts, 1972), p. 9.

under Army control, were taken over by the Navy. The progressive and gradual growth Navy radio had been undergoing turned into sudden, very rapid expansion. The Navy suddenly had five high-powered stations (two Marconi, two German, and its own at Arlington) plus the entire network of private stations, most of them American Marconi, at its disposal. In addition, it required increased numbers of efficient and sturdy transmitters and receivers as well as portable sets. Rapid production and rapid integration, with centralized coordination, were essential. The Navy could not just focus on day-to-day operations: now there was a critical need for "coordinating, appraising, and planning."[184]

During the war the Navy controlled the design, purchase, installation, and upkeep of all governmental radio except the Army's. This centralization led to standardization of apparatus, the Navy's long-sought goal, and better control over suppliers, rate of production and delivery, and "competition" from other agencies needing radio. For example, while there had always been several suppliers of most radio components, the Crocker-Wheeler Company enjoyed a near monopoly in the production of motor-generators. When demand increased during the war, Crocker-Wheeler was deluged with orders from various companies all demanding to be supplied immediately because of war contracts. Hooper intervened and set up a schedule for production and delivery based on the Navy's needs.[185] This incident prompted Hooper to view production more like a corporate executive: he wanted to ensure that he had at least two sources of supply for whatever he might need. He demanded that Crocker-Wheeler turn their blueprints over to General Electric. Failure to do so could mean government takeover of Crocker-Wheeler. In the face of this threat, Crocker-Wheeler naturally compromised and suggested the Triumph Electric Company as second supplier.[186]

Hooper also contrived to eliminate competition over the limited output of radio equipment. He learned of a plan to build a new merchant fleet, called the Emergency Fleet Corporation. Hooper saw this fleet as a potential competing buyer and feared that civilian (and in his view inexperienced) purchasers

184. Alfred D. Chandler, Jr., *Strategy and Structure: Chapters in the History of the American Industrial Enterprise* (Cambridge, MA: The MIT Press, 1962), p. 4.

185. Clark, "Radio in War and Peace," p. 301.

186. Ibid., p. 302.

would be willing to pay more for radio apparatus and thus both raise prices and deprive the Navy of needed equipment. He intervened even before construction began and persuaded the chief engineer of the Emergency Fleet Corporation to let the Navy supply it with radio.[187]

Because of the great demand for radio, American companies producing radio apparatus, such as General Electric, Western Electric, De Forest, and AT & T, now began to enjoy Navy patronage. One of the American companies' major competitors, the German company Telefunken, would obviously no longer be supplying the Navy. The government's patent moratorium instructed all suppliers to make use of the best components, no matter who owned the patent. The government guaranteed to protect all suppliers against infringement claims and encouraged the inventors not to be oversensitive to relatively free use of their apparatus during the national emergency.[188] Under this arrangement, with the inventors and radio companies concentrating less on marketing strategies and litigation and more on research and development, significant advances in continuous wave technology were achieved. Civilian-military cooperation produced apparatus more ideally suited to the Navy's special needs.

At the end of the war, the American radio companies, technically strong and confident, were ready to embark on new commercial ventures Navy sponsorship had made possible. During the teens, the General Electric Company had supplied the Navy with a powerful, long-distance transmitter, the high-frequency alternator. When the war ended, GE was eager to find a customer for this machine and entered into negotiations with the Marconi Company, which was trying to bargain for exclusive rights. The Marconi Company, never popular with the Navy, now symbolized British domination over international communications. When Hooper learned of the GE-Marconi negotiations, he warned Secretary Daniels that Marconi's acquisition of exclusive rights to the alternator would ensure foreign control of radio communications in America. On behalf of the Navy, and to their minds, the country's national interest, Hooper and his colleagues approached GE executives and persuaded them to suspend the negotiations. In a

187. Ibid.

188. Archer, *History of Radio,* p. 138.

subsequent meeting, the Navy's officials went one step further: they suggested that GE itself take advantage of the alternator and form an international communications company. If GE would buy out American Marconi and form such a corporation, the Navy would help the new company negotiate for other necessary and related patents and licenses. These talks, which led in October 1919 to the formation of an American-controlled company, the Radio Corporation of America, demonstrated how far the Navy's vision of radio's value and potential had come. Through a long and unsettling process, shaped by extraordinary external events and shrewd individuals, this military organization had indeed evolved from resistant skeptic to farsighted entrepreneur.

The most critical factor in this twenty-year process of technical adaptation was organizational realignment. Technical improvements, legislative mandates, and the European war all pushed the Navy closer to implementation. But the Navy would not have been able to exploit the invention properly or expeditiously without restructuring how and where the technology fit into the bureaucracy. The Navy was a relatively decentralized organization in 1899, and the absence of communications links between ships, and between ships and the shore, reinforced autonomous action and the jealous protection of institutional turf. Radio, with the potential to establish invisible yet powerful links between previously poorly connected or unconnected segments of the service, portended nothing less than structural revolution. Lines of authority both on ship and shore were disrupted, redefined, or strengthened as the invention was deployed, a change some welcomed and others deplored. Command and control relationships in any military service are sacrosanct, being simultaneously delicate and firmly enforced, and radio, a command and control technology, got to the heart of these relationships. Certainly the fact that radio was a new *communications* technology goes a long way towards explaining why it was not immediately embraced by many naval officers. For radio directly affected organizational interactions, redefining who had to communicate with whom and under what circumstances. It transformed how activities central to naval strategy were coordinated. Such profound transformations required institutional realignment, for the

decentralized Navy of 1899 could not coordinate or facilitate such change.

Elting Morison's analysis of military resistance to technical change was a landmark study. But it is time for historians to extend his work. Individuals who shunned innovations because of their personal, psychological outlooks were also members of organizations. To understand their resistance more fully, we must understand the organizations in which they operated. Only then can we appreciate how personal interests and organizational direction reverberate, often furthering insularity and reaction. Both the acquisition and the implementation of radio were frustrated not only by tradition-minded officers, but also by a bureaucratic structure which, through its procedures and rewards, preserved stasis and retarded innovation. We must also examine when particular individuals became members of their organization, for organizations emphasize and value different types of activities and skills in different eras and often exacerbate tensions between older members, invested in one ethos, and younger members encouraged to embrace quite another.

Because organizations themselves experience change through growth, elaboration, or decline, we must assess what stage of development an organization has reached and how that stage has been shaped by larger political and socio-economic forces to determine how, or whether, technical adaptation will occur. In this particular case, it is critical to note that the reorganization within the Navy, which occurred in the early teens and the war years, was part of a much larger push towards centralization and the consolidation of management then transforming both the government and the corporate sphere. Business executives came to appreciate the importance to managerial power of technical control, a realization manifested during this time in the rise of automation, the assembly line, and Taylorism. Although the Navy lagged behind the corporations in recognizing the advantages of technical control from the top, when it did so during the war, the Navy became in fact another powerful agent in the institutional movement towards centralized control over both technology and people.

Hugh Aitken's concept of the translator is also compelling and instructive. The function and role of such an individual remained unexplored prior to Aitken's work. Yet the term

"translator" suggests a middleman who passively conveys information from one sector of society to another. There is not sufficient emphasis on the importance of pushing, of marketing. This is what Hooper did: he served as a broker. In 1912 he confronted an Atlantic Fleet which had not integrated radio into its strategic operations. Through persistent and astute management and salesmanship, he redefined the technology's relationship to the organization. He sold the methods and management of commercial radio to the Navy. By developing radio as an organizational resource, with a distinct tier of operations and outlets on both ship and shore, he created and then marketed an in-house communications system. By 1915 the jealous protection of autonomy at sea had been replaced by a desire to ensure that the commander-in-chief, fleet commanders, and the department be "in communication at all times."[189] Ironically, Hooper did for the Navy what Marconi, the inventor he distrusted, did for the commerical market. They each built their networks, got them operating, and then showed the important buyers how the system would serve their special needs. Hooper did not do all this in a vacuum: technically and organizationally, the Navy was beginning to change. Yet Hooper must be credited with discerning the change in the organizational tide and both harnessing and accelerating that change to radio's—and his own—advantage. Hooper's role as broker was especially crucial in the case of radio, because this invention initially came from a civilian and a foreigner, two factors which would compromise its ready acceptance. The invention also required a certain level of technical mastery and learning a code. Hooper had to sell a new, technically based method of coordinating the fleet and the service to men who had, they firmly believed, run the Navy just fine for decades without such contraptions. Hooper thus mediated between a technical system and a social system and also between the innovations of civilians and the ongoing needs of the military. He successfully challenged institutional constraints while exploiting opportunities and resources others had neglected.

What does Hooper's success and the naval experience with radio teach us? This account offers several lessons about what organizations need to do to integrate a new communications technology successfully into their structure. Management of

189. *Annual Report of the Secretary of the Navy,* 1915, p. 274.

the technology must be sufficiently high up in the organization's hierarchy to ensure maximum exploitation of the technology's potential. Integration into strategic operations could not occur when radio was managed by enlisted men. The organization may need to create a position of relative independence and authority—such as Fleet Radio Officer—to oversee and evaluate the performance of the technology, both technically and as part of the organization. The person in this position must be familiar with and sympathetic to the technology and knowledgeable about his or her organization's structure and requirements. Finding such a person, who is both organizationally and technically sophisticated, may not be easy. The technology's implementation must be directly linked to the organization's long-term goals and strategies. And once the organization adopts the technology, it must participate in and support innovations. If the technology is going to disrupt or realign the organization's structure, then top management must be convinced that this realignment will better serve them and their careers. Older and higher ranking executives may be especially reluctant to adopt a technology that was first used only by members of the organization's lower tiers. Thus, integration may have to be handled by newer, younger executives who have no hard and fast associations between specific duties and power. These lessons appear to be as important today as they were seventy years ago. Researchers have recently determined that companies wishing to successfully integrate computer systems into their management and long-term planning need to follow the strategies just listed.[190]

As historians continue to study the innovation process and to explore what circumstances contribute to military enterprise and technological change, a more detailed analysis of organizational structure and mission may help our understanding of when and how such enterprise occurs. Institutions, both military and civilian, have assumed greater importance in American society, and by examining their dynamics and the personalities that guide them, we may enrich our appreciation of the complex interactions between technology and culture.

190. Study completed by Robert Mautz, Alan Merten, and Dennis Severance of the University of Michigan Business School described in *The New York Times,* November 28. 1982, Section F, p. 21

4

Ford Eagle Boats and Mass Production during World War I

David A. Hounshell

There are many instances in which inventions made in the private sector find their way into military use. A prominent example, discussed in the previous essay, is radio, although one can also point to various types of aircraft, internal combustion engines, tracked vehicles, and telephones, to mention only a few. In this chapter David Hounshell examines the Ford Motor Company's ill-fated attempt to mass-produce Eagle boats for the U.S. Navy during World War I. The effort foundered for a number of reasons, but among the most prominent were the company's unbridled confidence in the wide applicability of its assembly-line methods as well as its failure to recognize that marine engineering involved design problems and construction techniques different from auto making. Hounshell provides valuable insight into the limits of technological systems by placing these issues in historical perspective.